Woolgoolga to Ballina Pacific Highway upgrade

Coastal Emu Monitoring Program

Annual Report 2022

Operational Phase (Year 2/3)

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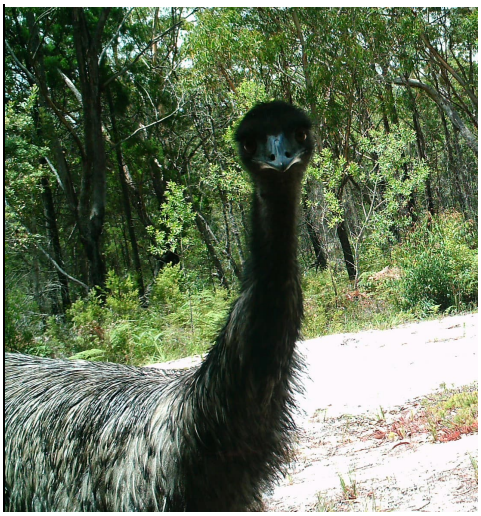
Woolgoolga to Ballina Pacific Highway Upgrade

Coastal Emu Monitoring Program – Annual Report 2022

Year 2/3 Operation

19 October 2023

Transport for NSW



W2B Biodiversity Monitoring

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1. Introduction

1.1 Background and objectives

The Pacific Highway upgrade from Woolgoolga to Ballina (W2B) was approved in 2014 under the NSW *Environmental Planning and Assessment Act,* 1979 and the Commonwealth *Environment Protection and Biodiversity Conservation Act*, 1999. The conditions of approval included a requirement to prepare and implement a Coastal Emu Management Plan (Plan). The Plan outlines objectives and a methodology for conducting a monitoring program to monitor the effectiveness of mitigation measures planned for Coastal Emus (*Dromaius novaehollandiae*). The monitoring program commenced prior to construction of the upgrade to gather baseline (pre-construction) data and is to continue through the construction and early operational stages of the highway. The results of the monitoring are required to inform any adaptive mitigation measures 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 outlined 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 over 13 monitoring events and the results reported in three pre-construction phase 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 (Year 1). The construction phase of the Emu monitoring program commenced concurrently. Completion of the construction phase monitoring ended in May-June 2020 and operation of the highway in section 3 and 4 commenced in June 2020. This report outlines the methods and results of Emu monitoring (population and structure use) in year 2 of the operational phase (Q1&2 2022) with the inclusion of data from two sampling periods in the year 3 operational phase Q3&4 2022.

1.2 Overview of the monitoring program

The Coastal Emu 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 the effectiveness of mitigation measures and ongoing monitoring. The program is based on a BACI approach (Before, After, Control, Impact), monitoring Emu presence at impact sites in proximity to the highway and control sites in coastal areas to the east of the highway. The program compares the 3-year baseline dataset with monitoring data collected seasonally during construction and operational monitoring and will continue for five years after opening 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 are 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 identified likely Emu crossing zones (heightened bridges). Control sites were selected in coastal forest and grassland habitats which resemble the impact sites and are expected to have regular Emu presence, all sites are greater than 15 km from the project. 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. Temporary fencing and emu crossing zones were found to be effective, and the results are reported in Jacobs (2017).

Monitoring of a subset of the Emu crossing zones continued during construction where purpose-built Emu races were provided to monitor if emus were able to cross the construction corridor. A number of raised bridge structures have been constructed at Emu crossing zones to facilitate crossing below the highway during operation. These structures are combined with permanent exclusion fencing and will be monitored during operation in conjunction with emu occupation surveys east and west of the project corridor.

Operational phase monitoring has incorporated a program to monitor eighteen bridge structures within Section 3 and Section 4 of the highway and the adjacent exclusion fences to determine the effectiveness of these mitigation measures for facilitating movements of Emus across the highway corridor.

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. Methods

2.1 Site occupation surveys

2.1.1 Study area

Monitoring Emu site occupancy commenced in 2013 and has continued at impact and control sites focused on five survey areas:

1) Pillar Valley west (PV), including land east and west of the Tucabia-Tyndale Road and portions of the Coldstream River floodplain, 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 floodplain (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).

2.1.2 Survey transects

The intent of the sampling is to monitor Emu presence/absence over time within each of these survey areas relative to the different project phases (pre-construction, construction and operation) rather than a comparison between areas. This is achieved by repeat sampling of between 2 and 5 transects in each survey area using transects that range between 800 and 2000 metres in length. In total 24.7 km of transects are sampled from 13 impact sites and 7 control sites (Table 2.1). Sites were stratified to sample a range of different habitat types including pastoral land, forest, riparian, and wetland areas. The location of survey areas is shown on Figure 1 and the location of impact transects in relation to the highway corridor and bridge locations is shown on Figure 2.

As the Emu population in the study area is small and occupies large areas, the absence of emu sign from a transect over time may not necessarily reflect the absence of emus in the study area, but rather a shift in emu activity away from the transect. To account for this, transects are occasionally modified to improve the detectability of emus. This may also occur where access permission to private property has changed over the course of the program. This has included extending transect lengths, combining transects and in some cases, adding new transects. Where this has occurred, effort has been made not to distort the integrity of the data by keeping transects in the same proximal area and similar transect lengths and search areas.

Table 2.1: Study areas, survey sites and details of Emu monitoring transects

Survey area	Transect	Status	Habitat	Transect length (m)	Search area (ha) based on 10 m transect width	Transect position relative to road	Adaptive monitoring approaches
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	Shifted start of transect to neighbouring property to east in 2020
	PV-D	Impact	Grazing / forest	2425	2.42	East	
			Total	*6220 m*	*6.2 ha*		

Survey area	Transect	Status	Habitat	Transect length (m)	Search area (ha) based on 10 m transect width	Transect position relative to road	Adaptive monitoring approaches
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	Shifted 300 m south to new fence line in 2019
	MR-E	Impact	Open forest	1400	1.40	East	Shifted 200 m to the north from easement to riparian corridor in 2019
			Total	*4645 m*	*4.6 ha*		
Tucabia North (TN)	TN-A	Impact	Open forest	2080	2.08	West	
	TN-B	Impact	Open forest / wetland	645	0.64	West	
	TN-C	Impact	Open forest	1365	1.36	East	Start of transect moved to edge of new road in 2018
	TN-D	Impact	Open forest	1200	1.20	East	
			Total	*5290 m*	*5.28 ha*		
Yuraygir South (YS)	YS-A	Control	Forest / heath	1155	1.15	-	
	YS-B	Control	Forest / heath	1255	1.25	-	Transect extended further 500 m
	YS-C	Control	Open forest	1030	1.03	-	
	YS-D	Control	Open forest	730	0.73	-	Original YS-D and YS_E combined in 2019
	YS-E	Control	Open forest	1250	1.25	-	YS-E changed to new location
			Total	*5420 m*	*5.4 ha*		
Yuraygir North (YN)	YN-A	Control	Forest / heath	1850	1.85	-	
	YN-B	Control	Open forest	1270	1.27	-	
			Total	*3120 m*	*3.1 ha*		

Figure 1: Coastal Emu monitoring survey areas

Figure 2: Impact Transects

Figure 2 | Impact Transects

2.1.3 Timing

Monitoring of the spatial and temporal presence/absence of Emus relied on two methods centred on each transect and included 1) searches for Emu signs and 2) camera trapping. Sign searches and the download of photographs from camera traps is conducted at four quarterly events targeting the last week 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. Travel restrictions due to covid lockdown affected sampling in the winter period of 2021 (OP5). Transect and crossing structure surveys were not able to be conducted and any impact of this on the sign and camera data is discussed in the subsequent results of this report.

2.1.4 Sign searches

Each of the 20 transects is walked once over a week-long (5 days) survey during each season and sampling period. Transects are searched throughout daylight hours (0730 to 1700) and involve 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 where possible, as barbed wire has been found to be an effective means of snagging feathers from Emus passing through the fence (refer Jacobs 2014) and hence a reliable method of observing signs to monitor presence at a site.

The number of signs detected is counted and then removed from each transect. For footprints this means raking over sand and mud and for feathers and droppings removing from the transect. This is 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 are recorded and contact with landowners where possible during the course of the survey week to document any observations of Emus made by the property owner since the last monitoring event.

Plate 1. Example of 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

2.1.5 Camera trapping

The use of motion sensor cameras provides a second technique for confirming presence and also captures information on actual date present on the transect, confirms whether multiple birds were present and breeding success through recording images of juveniles with adult males. Camera trapping used fixed cameras (Stealth Cam GN45 and Swift Enduro), triggered by motion sensors, to 'trap' images of passing Emus. Up to two camera traps were maintained semi-systematically along each transect, to provide a total of between 4-12 cameras per survey area. Cameras are occasionally moved to new locations along transects during subsequent surveys if found to be unsuccessful from the preceding survey period or stolen or in response to finding Emu signs in a new location.

Details on camera trapping effort during each project phase are summarised in

Table 2.2. The summary data shows a comparison of the trap effort during the construction years 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 has been comparable across each survey 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 are 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 (quarterly) as discussed previously in timing. Broken, malfunctioning and stolen cameras are replaced as required during each quarterly inspection.

Cameras are also used to detect the presence and trap rates of wild dogs within each study area. This information is used to understand any correlation between the presence/absence of Emus and monitor changes in dog activity around crossing zones.

Table 2.2: Summary and comparison of camera trapping effort during the course of the monitoring program

Sampling period	Survey effort	Impact areas			Control areas	
		Pillar Valley	Tucabia south	Tucabia north	Yuraygir north	Yuraygir south
Pre-construction (data shown is the means recorded over 13 quarterly monitoring sessions)	Camera monitoring days per season	90.3	90.3	90.3	90.3	90.3
	No. successful cameras (mean)	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*
Construction (data shown is the means recorded over 14 quarterly monitoring sessions.	Camera monitoring days per season	91.1	91.1	91.1	91.1	91.1
	No. successful cameras (mean)	6.4	9.6	6.9	3.6	7.4
	Mean trapping days per camera	72.4	79.2	78.4	78.9	73.8
	Total camera trap effort (days)	*473.3*	*773.7*	*584.8*	*370.9*	*543.2*
Operation (data shown is the mean recorded over 10 quarterly (seasonal) monitoring periods (op1-op10)	Camera monitoring days per season	91.0	91.0	91.0	91.0	91.0
	No. successful cameras	5.8	9.7	6.7	3.5	7.9
	Mean trapping days per camera	81.2	81.1	77.2	76.2	86.5
	Total camera trap effort (days)	*514.9*	*813.2*	*622.2*	*310.6*	*741.8*

2.2 Monitoring crossing zones

2.2.1 Bridge structures

Potential highway crossing zones (bridges) and exclusion fencing targeted at Emus have been provided between chainage 42.500 and 74.500 (Section 3 and 4 of the project) and include:

- Raised bridges with a minimum height of 3.6 metres and a minimum width of 4 metres of dry passage retained along both banks of the creek channel and abutments.
- Purpose built exclusion fencing strategically located in areas surrounding the crossing structures to direct emus to the structure, and elsewhere in emu habitat areas to prevent emus from entering the highway corridor.

According to the Emu Management Plan, the monitoring program is to be designed to compare a range of these crossing types to determine their effectiveness at allowing emu passage across the road and inform management decisions, this would include:

- Structure type (raised versus non-raised (standard) bridges)
- Landscape type surrounding the structure (riparian habitat, cropping land, open grazed landscapes, and structures with landscape plantings added)
- Attractant type (cleared easement or tracks leading to bridge, and no attractants)

Thirty (30) potential crossing locations are identified in the Coastal Emu Management Plan (Table 5-1), this included 21 bridges over creeks, drains and floodplain and 9 incidental structures such as road overpasses, property access and culverts which may potentially be used by emus to cross the highway. From these, the operational monitoring focuses on 18 bridge structures in locations where emus have historically been recorded between the Coldstream River in the south (Section 3), north to Shark Creek (Section 4). Structures to be monitored have been selected to maximise the chance of recording emus on motion detection cameras, considering bridge location relative to landscape / habitat, comparing structure size and attractants, as follows

- Of the 18 structures, 14 of these have been designed with a minimum 3.6 m clearance from ground (raised bridges). Bridges in Section 3 of the project were raised above their functional requirements to allow for

emu passage, and 4 bridges retained a standard functional design, that were not designed specifically for targeting emu passage (non-raised bridges).

- A range of landscape and habitat types was selected for monitoring, including Swamp Forest (2 sites), Dry Forest (3 sites), Riparian Forest (2 sites), Grazing Land (4 sites), Cropping Land (3 sites), and mixed forest and grazing land occurring east and west of the structure (4 sites).
- There are no sites with obvious tracks or attractants secured or leading to a bridge structure, although 18 sites have used landscape plantings below the bridge targeting emu food plants, and this has been considered an attractant for the purpose of monitoring usage. Consideration of additional attractants may occur as the program progresses and if structures are found not to be effective.
- Four sites comprise rural stock fencing parallel with and below the road and bridge, which is used for excluding cattle entering different property owners on both sides of the highway, or selective exclusion of cattle from un-grazed areas. These are referred to as 'Emu Hybrid Fencing' and have been designed as 4 strand fences with adequate spacing to allow emu passage but exclude cattle, and two of these sites have included an 'Emu Gate' as part of the hybrid fence design.

Details of the structures selected for the operational phase monitoring are presented in Table 2-4 and shown n Figure 3.

Table 2.3: Details of bridges monitored the operational phase of the highway (* identifies Emu / Cattle hybrid fence is associated with structure)

Site ref No.	Design ref	Project section (Chainage)	Waterway	Landscape/ Habitat type	Bridge / site specifications and monitoring details	Design raised for emu passage	Emu food plants used in landscaping^	No. cameras (camera id)
A	Bridge A08	S3 (43.881)	None, floodplain	Swamp forest	200 m x 3.6 m ground clearance dual carriageways with opening between bridges. Exclusion fencing adjoining. Monitoring commenced end of 2nd Quarter 2020 (26.05)	Yes	Yes	5 (A1-A5)
B	Bridge A10	S3 (46.325)	Pillar Valley Creek.	Swamp forest	80 m x 3.6 m ground clearance dual carriageways with opening between bridges. Exclusion fencing adjoining. Corresponds with T1 construction monitoring site. Monitoring commenced end of 2nd Quarter 2020 (26.05) two cameras.	Yes	Yes	4 (B1-B4)
C	Bridge A11	S3 (46.342)	Pillar Valley Creek	Grazing land	93 m x 3.6 m ground clearance dual carriageways with opening between bridges. Exclusion fencing adjoining. Corresponds with T2 construction monitoring site. Monitoring commenced end of 2nd Quarter 2020 (26.05) two cameras.	Yes	Yes	4 (C1-C4)
D	Bridge A12	S3 (46.628)	Black Snake Creek	Grazing land	60 m x 3.6 m ground clearance dual carriageways with opening between bridges. Exclusion fencing adjoining. Corresponds with T3 construction monitoring site. Monitoring commenced end of 2nd Quarter 2020 (26.05) one camera, then second camera 25.08.2020.	Yes	Yes	2 (D1, D2)
E	Bridge A54	S3 (47.190)	None, floodplain	Grazing land	20 m x 3.6 m ground clearance dual carriageways with opening between bridges. Exclusion fencing adjoining. Corresponds with T4 construction monitoring site. Monitoring commenced end of 2nd Quarter 2020 (26.05) two cameras.	Yes	No	2 (E1, E2)
F	Bridge A13	S3 (47.620)	Unnamed creek, open flats	Grazing land	60 m x 3.6 m ground clearance dual carriageways with opening between bridges. Exclusion fencing adjoining. Corresponds with T5 construction monitoring site. Monitoring commenced end of 2nd Quarter 2020 (26.05) two cameras.	Yes	Yes	4 (F1-F4)
G	Bridge A14	S3 (47.841)	Unnamed creek	Riparian forest	72 m x 3.6 m ground clearance dual carriageways with opening between bridges. Exclusion fencing adjoining. Corresponds with T6 construction monitoring site. Monitoring commenced end of 2nd Quarter 2020 (26.05) two cameras.	Yes	Yes	4 (G1-G4)

Site ref No.	Design ref	Project section (Chainage)	Waterway	Landscape/ Habitat type	Bridge / site specifications and monitoring details	Design raised for emu passage	Emu food plants used in landscaping^	No. cameras (camera id)
H	Bridge A16*	S3 (49.228)	None, floodplain	Grazing land on west, forest on east	80 m x 3.6 m ground clearance dual carriageways with opening between bridges. Exclusion fencing adjoining, and hybrid emu fence parallel with north bound carriage. Corresponds with T9 construction monitoring site. Monitoring commenced end of 2nd Quarter 2020 (26.05) four cameras.	Yes	Yes	4 (H1-H4)
I	Bridge A17	S3 (50.259)	Unnamed creek	Dry forest	45 m x 3.6 m ground clearance dual carriageways with opening between bridges. Exclusion fencing adjoining, and hybrid emu fence parallel with south bound carriage. Corresponds with T10 construction monitoring site. Monitoring commenced end of 2nd Quarter 2020 (26.05) two cameras.	Yes	Yes	2 (I1, I2)
J	Bridge A55*	S3 (51.2900)	None, floodplain	Grazing land on east, forest on west	62 m x 3.6 m ground clearance dual carriageways with opening between bridges. Exclusion fencing adjoining, and hybrid emu fence parallel with south bound carriage including emu gate. Monitoring commenced end of 3rd Quarter 2020 (25.08) one camera.	Yes	Yes	1 (J1)
K	Bridge A19*	S3 (52.423)	Chaffin Creek	Riparian and dry forest	78 m x 3.6 m ground clearance dual carriageways with opening between bridges. Exclusion fencing adjoining, and hybrid emu fence parallel with south bound carriage including emu gate. Monitoring commenced end of 3rd Quarter 2020 (25.08) one camera.	Yes	Yes	4 (K1-K4)
L	Bridge A50	S3 (53.758)	Unnamed creek	Dry forest	20 m, unknown ground clearance dual carriageways with opening between bridges. Monitoring commenced end of 2nd Quarter 2020 (26.05) one camera.	No	Yes	2 (L1, L2)
M	Bridge A20	S3 (54.696)	Unnamed creek	Dry forest	75 m x 3.6 m ground clearance dual carriageways with opening between bridges. Exclusion fencing adjoining. Monitoring commenced end of 3rd Quarter 2020 (25.08) two cameras.	Yes	Yes	4 (M1-M4)
N	Bridge A23*	S3 (57.015)	Champions Creek	Dry forest east, grazing land west	90 m x 3.6 m ground clearance dual carriageways with opening between bridges. Exclusion fencing adjoining and emu hybrid fence parallel with north bound carriage. Monitoring commenced end of 2nd Quarter 2020 (28.05) one camera.	Yes	Yes	4 (N1-N4)

Site ref No.	Design ref	Project section (Chainage)	Waterway	Landscape/ Habitat type	Bridge / site specifications and monitoring details	Design raised for emu passage	Emu food plants used in landscaping^	No. cameras (camera id)
O	Bridge A51	S3 (59.286)	Unnamed creek	Riparian forest	20 m, unknown ground clearance dual carriageways with opening between bridges. Exclusion fencing adjoining. Monitoring commenced end of 3rd Quarter 2020 (25.08) one camera.	No	Yes	2 (O1, O2)
P	Bridge A31	S4 (70.433)	Constructed drain / floodplain	Cropping land	29 m bridge over constructed drain, with 2.5 m between top of drain and bridge abutment. Opening between bridges. Monitoring commenced end of 3rd Quarter 2020 (25.08) one camera.	No	No	2 (P1, P2)
Q	Bridge A33	S4 (73.380)	Constructed drain / floodplain	Cropping land	35 m bridge x 2.9 height over constructed drain, with 2.5 m between top of drain and bridge abutment. Opening between bridges. Monitoring commenced end of 3rd Quarter 2020 (25.08) one camera.	No	No	2 (Q1, Q2)
R	Bridge A34	S4 (74.400)	Shark Creek / floodplain	Cropping land	448 m bridges x 3.6 m ground clearance with no opening between bridges and no exclusion fencing adjoining. Future monitoring proposed via searches for tracks and camera monitoring	Yes	No	1 (R1)

Figure 3: Location of bridge monitoring sites

Monitoring of Emu usage at each potential crossing structure occurred continuously through the second year of operation (January-December 2022 for 365 days ~ 52 weeks). This involved the placement of camera traps (Stealth Cam GN45 and Swift Enduro) below each structure, consisting of between 1-5 cameras depending on the width of the structure and conditions under the bridge (refer Table 2-4) and Plates 5 and 6. The number and configuration of cameras at each structure aimed to confirm Emu usage and determine the direction and frequency of Emu passes below the structure. Due the high risk of flooding, some cameras were positioned on the railing below the bridge soffit, pointing down to ground-level with the sensor set to 'extended' distance to ensure passing emus were captured (Plate 5). Cameras were also positioned on fauna furniture and trees close to the bridge, aimed at the spaces between the bridge pylons. The two combined camera positions were required for adequate spatial coverage below long bridges.

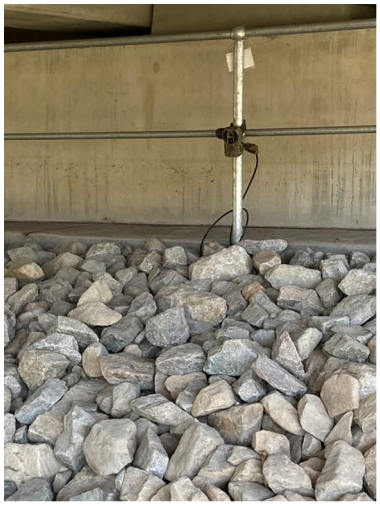


Plate 5. Example of camera traps positioned on railings and view of undercarriage


Plate 6. Example of fauna furniture used to attach multiple cameras across width of bridge opening

The cameras were set for continuous operation in daylight hours between 0500 and 2000 hours (1800 during winter) and set to take a single still image with a trigger interval of 3 seconds in attempt to capture direction of travel and pairs or groups of Emus or confirm juveniles with adults. Cameras were operational for average of 90 days per quarter, and image downloads and battery refresh were conducted at the end of each quarter in the same week as the site occupation surveys. Stolen, flooded and damaged cameras were replaced at the end of the quarter when required.

During the camera checks at each quarterly survey period, the area below the bridge was also walked to search for fresh signs of Emu activity (scats, tracks, and feathers) to determine if Emus used the structure but were not photographed in the event of a camera failure.

Table 2.5: Crossing structure camera monitoring effort during 2022 operational phase monitoring; op7 summer, op8 autumn, op9 winter, op10 spring; n.s = not set; C.F = battery fatigue, FL = camera flooded, not replaced; STL = camera stolen after setting, not replaced

Site No.	Sect	Cam	Camera days					Active weeks	Notes
			op7	*op8*	*op9*	*op10*	*total*		
A	3	A1	91	5	53	58	207	29.6	site flooded in op8 after 5 days
		A2	91	5	24	917	1037	148.1	site flooded in op8 after 5 days
		A3	91	5	84	19	199	28.4	site flooded in op8 after 5 days
		A4	65	5	n.s	n.s	70	10.0	site flooded in op8, cam failure in op9
		A5	91	5	n.s	28	124	17.7	site flooded in op8, cam failure in op9
						mean	*327*	*46.8*	
B	3	B1	91	68	84	47	290	41.4	
		B2	STL	98	84	91	273	39.0	
		B3	91	70	12	25	198	28.3	
		B4	STL	98	n.s	30	128	18.3	cam malfunction op7&9
						mean	*222*	*31.75*	
C	3	C1	27	98	84	91	300	42.9	
		C2	91	C.F	C.f	91	182	26.0	
		C3	C.F	98	84	91	273	39.0	
		C4	C.F	98	n.s	n.s	98	14.0	cam not replaced in op9&10
						mean	*213*	*30.464*	
D	3	D1	91	98	84	91	364	52.0	
		D2	STL	98	84	91	273	39.0	
						mean	*319*	*45.5*	
E	3	E1	91	98	84	91	364	52.0	
		E2	91	98	84	C.F	273	39.0	camera failure in op10
						mean	*319*	*45.5*	
F	3	F1	91	98	84	C.F	273	39.0	cam failure op10
		F2	91	98	84	91	364	52.0	
		F3	91	98	84	91	364	52.0	
		F4	91	98	84	91	364	52.0	
						mean	*341*	*48.8*	
G	3	G1	27	98	84	91	300	42.9	
		G2	91	98	0	91	280	40.0	cam failure op9
		G3	91	98	84	91	364	52.0	
		G4	91	98	84	91	364	52.0	
						mean	*327*	*46.7*	
H	3	H1	91	98	84	91	364	52.0	
		H2	91	98	84	91	364	52.0	
		H3	91	4	84	91	270	38.6	
		H4	91	98	84	91	364	52.0	
						mean	*341*	*48.6*	
I	3	I1	70	98	n.s	n.s	168	24.0	flooded op4 and op5
		I2	70	1	n.s	n.s	71	10.1	flooded op4 and op6
						mean	*120*	*17.1*	
J	3	J1	91	98	84	91	364	52	
						mean	*350*	*50.0*	

K	3	K1	91	98	84	84	357	51.0	
		K2	91	F.L	84	84	259	37.0	cam failed op8, flooded and replaced
		K3	91	F.L	84	C.F	181	25.9	Cam flooded op8, failure op10 and replaced
		K4	91	F.L	84	C.F	181	25.9	Cam flooded op8, failed op10 and replaced
						mean	*245*	*34.9*	
L	3	L1	91	42	C.F	91	224	32.0	cam replaced op9
		L2	91	98	84	91	364	52.0	
						mean	*294*	*42.0*	
M	3	M1	91	98	84	91	364	52.0	
		M2	91	98	84	91	364	52.0	
		M3	91	98	84	91	364	52.0	
		M4	91	98	84	91	364	52.0	
						mean	*364*	*52.0*	
N	3	N1	n.s	n.s	n.s	n.s	0	0.0	stolen in 2021 and not replaced yet
		N2	n.s	n.s	n.s	n.s	0	0.0	stolen in 2021 and not replaced yet
		N3	91	F.L	84	91	266	38.0	flooded op8
		N4	91	F.L	84	91	266	38.0	flooded op8
						mean	*133*	*19.0*	
O	3	O1	91	98	84	72	345	49.3	
		O2	91	98	84	91	364	52.0	
						mean	*355*	*50.6*	
P	4	P1	n.s	98	84	91	273	39.0	
		P2	91	98	n.s	91	280	40.0	
						mean	*277*	*39.5*	
Q	4	Q1	91	F.L	84	91	270	38.6	flooded op8
		Q2	91	F.L	n.s	91	186	26.6	flooded op8
Mean							*228*	*32.6*	
R	4	R1	91	F.L	n.s	n.s	91	13.0	flooded op8
						mean	*91*	*13.0*	

2.2.2 Fence and roadkill monitoring

During each quarterly camera inspection, exclusion and hybrid fences were walked north and south of the crossing structure to search for evidence of emu presence or passing through emu hybrid fences. Camera traps were also positioned facing the active emu gates. Care was taken to search for emu roadkill in the vicinity of the crossing structures, using vehicle searches, and during fence inspections. In addition, any reports of emu roadkill in the monitoring year have been collated and are discussed.

2.3 Emu sightings

A register of Emu sightings was maintained during construction by on-site personnel associated with the construction contractor. The register was maintained since the commencement of early works in Section 4 in mid-2016 and throughout the first three years of construction (2017-19). The register was an effective database for documenting sightings and observations of Emus within or adjacent to the construction corridor and had three objectives:

1) Manages potential impacts to Emus that may result from a collision with construction vehicles.
2) Informs environmental managers where additional mitigation or corrective actions may be required.
3) Provides supplementary Emu presence data to inform the monitoring program.

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 as a manually recorded excel database for the majority of 2017, towards the end of the year a mobile spatial application was released by Pacific Complete (Arc Collector) as a more efficient means of collecting Emu observational data. The app was maintained through the remainder of the construction phase (2018-20). With the end of construction in mid-2020, no further dedicated register has been retained, although sightings of emus near the highway have been maintained by the author during monitoring periods and is reported to the author by Environmental Officers from Transport for NSW.

During the operational phase, sightings of Emus will be maintained largely through direct observations captured during monitoring activities, as well as observations provided by TfNSW staff while driving sections of the highway, and other observations provided by landowners accessed during monitoring. These opportunistic observations will continue to be reported.

2.4 Data analysis and limitations

2.4.1 Site occupation data

We correlated camera trapping rates of Emus with densities estimated from counts of signs made along the search transects. Two indexes of 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 separate Emu photos.

From the combined sign, camera trapping data and observed birds 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, and trap rates of Emus during the construction and operational phases were compared with pre-construction baseline data at impact and control sites to identify any significant changes using Analysis of Variance (ANOVA). Occupations rates were compared using a t-test analysis.

Where possible transects have been placed along fence lines, and 3 and 4 strand barbed wire fences are particularly effective at 'snagging' feathers from birds, and hence identifying Emu presence. Not all transects were able to be located on suitable fence lines, which is limited where plain wire is present or there is no fence. However, this factor does not affect the long-term comparison of results, as the conditions have not changed from the baseline survey. Occasionally fences have been replaced or sections removed and resulting in a change to the effectiveness of the transect at detecting Emu presence. To overcome this limitation, small changes or additions have been made to the transect, while still maintaining a similar search length and area of the transect as discussed previously.

2.4.2 Bridge camera data

Quarterly camera data from bridges were uploaded to a computer and viewed using Windows Photo Viewer. Data as recorded for site, active camera days, number of photos, presence of emus (date/time), number of individuals and direction travelled. Data on the presence and number of wild dogs/dingoes from the monitoring period was

also gathered. As cameras are positioned centrally below the bridge, the presence of emus walking past the cameras was deemed to be a complete crossing of the highway.

The successful cameras days per monitoring period were pooled for all cameras at each site and then converted to active camera weeks for the monitoring year (year 1 operation) by dividing by seven. Presence of emus and use of the crossing zone was recorded as the number of emu detections per active week. This method for recording rate of use was considered suitable than absolute trap rates per total images captured, due to the high number of photographs of cattle and maintenance workers captured below each bridge.

2.4.3 Limitations

The site occupation surveys are influenced by changes to fenced transects, whereby some fences have been replaced with new 4 and 5 strand fencing during operation that was different to the pre-construction and construction surveys and possibly less penetrable by emus than the older fence type. Where this has occurred, the density of emu sign may be affected, and additional cameras have been used to address the limitation.

3. Results

3.1 Emu presence

3.1.1 Sign searches

Signs of Emu presence were recorded from each of the impact and control survey areas in at least one season during the second year of operation, with the exception of the Yuraygir south survey area (control). Emu sign was recorded in all three impact survey areas (Pillar Valley, Tucabia north and Tucabia south). The 2022 monitoring period reported emu sign and thus evidence of emu presence on the western side of the highway from the Tucabia south transects (MRB, MRC and MRD). These transects are in proximity to each other and it is likely that the same bird was recorded, which was recorded in the autumn-winter seasons of 2022. The bird may have crossed the highway from the Mitchell Road underpass, as there was no reported crossing of a monitored bridge undercarriage north or south of this location.

The density of Emu sign reported in the impact sites during the second year of operation has increased at the southern sites compared with the 3.5-year construction period and year one of operation impact (Fig 3). This is encouraging despite the density remaining significantly lower than the baseline (pre-construction) data at these locations (Pillar Valley west P=0.049; Tucabia south P=0.002) (

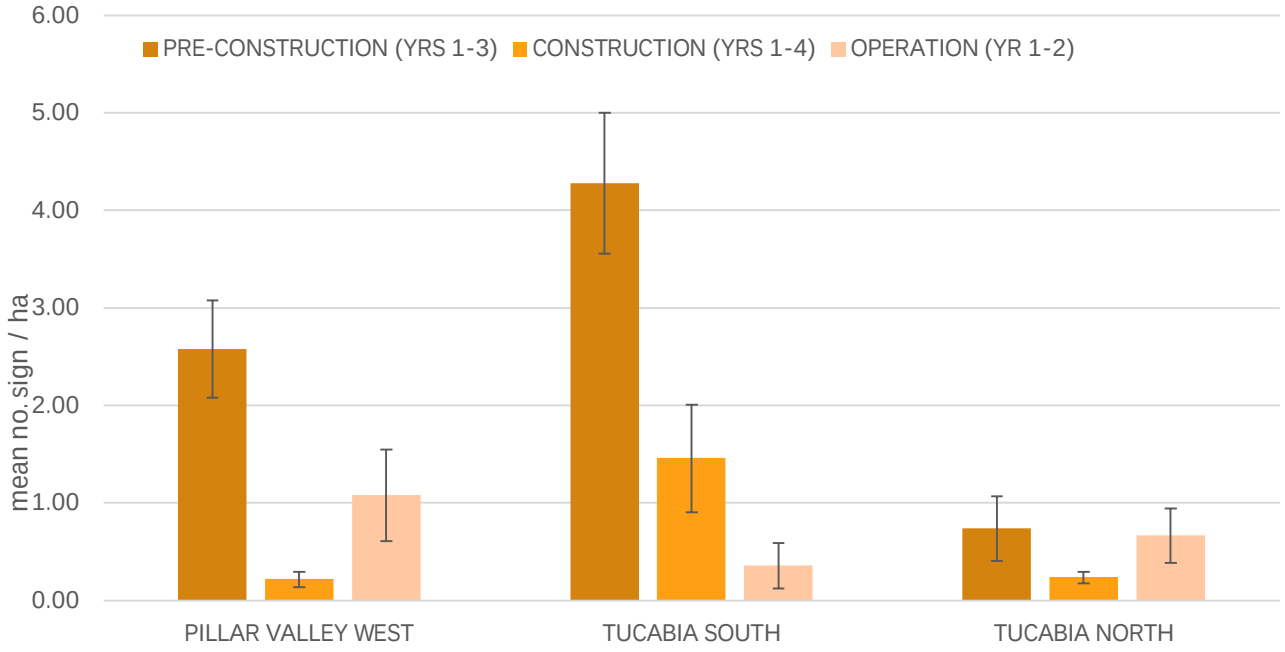

Figure 4:). This pattern of decline was first observed during construction and remains low although there has been a slight increase at both sites from year one operation, particularly at the Pillar Valley west sites. The density of emu sign in the Tucabia north impact survey area has increased in the operational phase compared with the construction phase and now comparable with the baseline data. This is an encouraging evidence of emu activity returning where absences were previously noted.

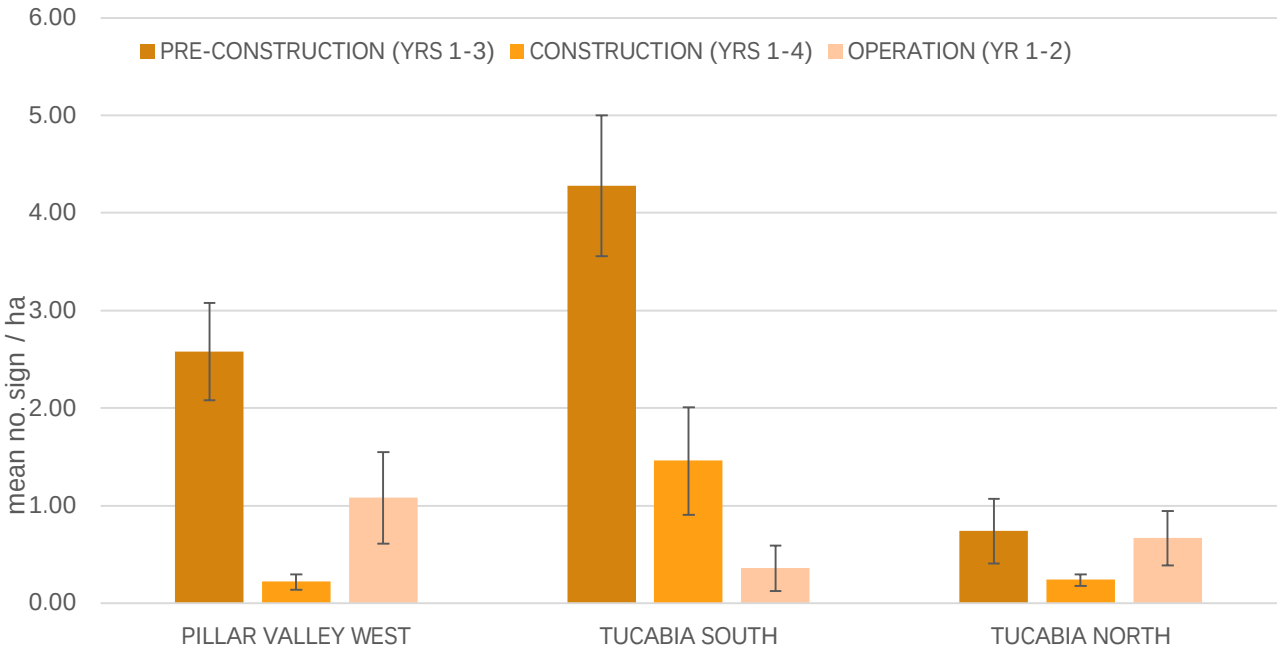

Figure 4: Mean density of Emu sign (no./ ha ±se) at impact survey areas comparing pre-construction (2014-16) and construction (2017-20), and operation (June 2020 to Dec 2022)

A similar pattern of continued temporal decline in the density of Emu sign from baseline through to operation is also evident at the 'control' survey areas, with a complete absence of Emu sign recorded in the Yuraygir south transects and a marked decline from the Yuraygir North transects during both construction and operational periods (Figure 5).

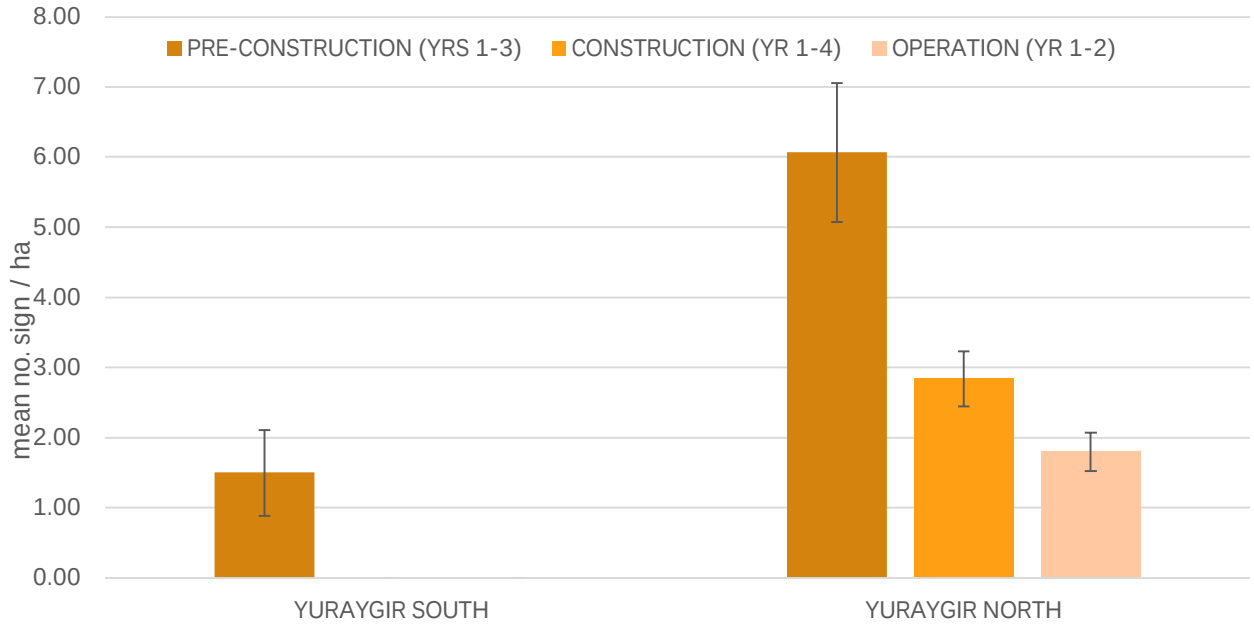

Figure 5: Mean density of Emu sign (no./ ha ±se) at control sites comparing pre-construction (2014-16) and construction (2017-20) and operation (June 2020 to Dec 2022)

Comparison of the change in density of emu sign data between baseline, construction and operation has been interpreted with consideration of the temporal patterns of Emu sign observed across the three impact study

areas since 2014, three years prior to the commencement of construction. The density of Emu sign within each survey area has varied between season and years irrespective of construction Table (3.1). For example, pre-construction sign density was highest in 2014 before declining in 2015 and 2016 (prior to construction commencing in 2017). Monitoring during construction occurred in 2017-2020 and the general trend of declining Emu sign that was noted prior to construction commencing, continued during this phase. The commencement of operation has seen a promising increase in activity in Tucabia north, however this can be attributed to one transect located on the east of the highway and likely one or two animals. The presence of emu sign on the western side of the highway in Tucabia South is a positive sign that an emu may have crossed below the highway using the Mitchell Road underpass, as no other evidence was reported from monitoring adjacent bridge structures.

The density of Emu signs has also declined significantly in the Yuraygir (north and south) control survey areas since collation of baseline data in 2014. (Table 3.2). A significant difference between the pre-construction and construction years has been noted for the southern control area ($P = 0.01$) and northern control area ($P = 0.006$). The decline is also significant between pre-construction and operation periods in the southern control ($P = 0.01$), and northern control ($P = 0.002$). These data suggest either a decline in Emu numbers at the control sites or alternatively a shift away from these specific survey areas or transects to other proximal habitat areas within the range of the population. The data from the control areas suggest that Emu presence in localised areas can change over time, likely in response to changing environmental conditions and associated resource availability or behavioural traits, or morality of individuals occupying a specific area, this is also expected to be similar with impact areas. The change in sign data may also be attributed to a change in the survey transect, for example a new fence was erected at transect YN-A in 2021 that has resulted in less signs than the original fence due to the design.

Table 3.1: Density of Emu sign per ha recorded at the three impact study areas separated into years of pre-construction (2014-16 purple), construction (2017-20 green) and operation (June 2020-Dec22 orange)

Sampling period		Summer	Autumn	Winter	Spring	Summer	*Mean*	*SE*
Pillar Valley west	*2014*	2.56	3.68	3.52	6.40	5.60	*4.35*	*0.71*
	2015	2.56	0.80	2.24	1.92	0.96	*1.70*	*0.35*
	2016	0.64	1.44	1.28	-	-	*1.12*	*0.24*
	2017	0.32	0.96	0.32	0.16	-	*0.44*	*0.18*
	2018	0.48	0.48	0.00	0.00	-	*0.24*	*0.14*
	2019	0.32	0.00	0.00	0.00	-	*0.08*	*0.08*
	2020	0.00	0.00	-	-	-	*0.00*	*0.00*
	2020	-	-	0.00	0.00	-	*0.00*	*0.00*
	2021	0.00	0.16	-	1.12	-	*0.11*	*0.35*
	2022	1.28	4.00	2.72	0.48	-	*2.12*	*0.78*
Tucabia south	*2014*	6.52	9.78	5.87	1.74	1.96	*5.17*	*1.51*
	2015	7.61	5.87	3.26	3.48	2.61	*4.57*	*0.94*
	2016	3.26	1.52	2.17	-	-	*2.32*	*0.51*
	2017	6.52	4.78	3.48	1.30	-	*4.02*	*1.10*
	2018	1.09	0.43	1.74	0.87	-	*1.03*	*0.27*
	2019	0.22	0.00	0.00	0.00	-	*0.06*	*0.06*
	2020	0.00	0.00	-	-	-	*0.00*	*0.00*
	2020	-	-	0.00	0.00	-	*0.00*	*0.00*
	2021	0.00	0.22	0.00*	0.00	-	*0.05*	*0.05*
	2022	0.43	2.17	0.22	0.22	-	*0.76*	*0.47*
Tucabia north	*2014*	0.00	0.00	3.22	1.52	3.22	*1.59*	*0.72*
	2015	0.95	0.19	0.00	0.19	0.00	*0.27*	*0.18*
	2016	0.19	0.19	0.00	-	-	*0.13*	*0.06*
	2017	0.57	0.57	0.19	0.57	-	*0.48*	*0.10*
	2018	0.19	0.38	0.00	0.38	-	*0.24*	*0.09*
	2019	0.00	0.00	0.19	0.38	-	*0.14*	*0.09*
	2020	0.00	0.00	-	-	-	*0.00*	*0.00*
	2020	-	-	0.00	2.46	-	*1.23*	*1.23*
	2021	1.70	0.38	0.00	0.38	-	*0.62*	*0.37*
	2022	0.38	0.57	0.00	0.19	-	*0.28*	*0.12*

*no survey conducted due to covid lockdown

Table 3.2: Density of Emu sign per ha recorded at the two control study areas separated into years of pre-construction (2014-16 purple), construction (2017-20 green) and operation (June 2020-Dec22 orange)

Sampling period		Summer	Autumn	Winter	Spring	Summer	*Mean*	*SE*
Yuraygir south	*2014*	5.53	4.42	3.87	4.61	0.92	*3.87*	*0.78*
	2015	0.18	0.00	0.00	0.00	0.00	*0.04*	*0.04*
	2016	0.00	0.00	0.00	-	-	*0.00*	*0.00*
	2017	0.00	0.00	0.00	0.00	-	*0.00*	*0.00*
	2018	0.00	0.00	0.00	0.00	-	*0.00*	*0.00*
	2019	0.00	0.00	0.00	0.00	-	*0.00*	*0.00*
	2020	0.00	0.00	-	-	-	*0.00*	*0.00*
	2020	-	-	0.00	0.00	-	*0.00*	*0.00*
	2021	0.00	0.00	0.00*	0.00	-	*0.00*	*0.00*
	2022	0.00	0.00	0.00	0.00	-	*0.00*	*0.00*
Yuraygir north	*2014*	1.28	5.13	4.81	11.54	14.74	*7.50*	*2.45*
	2015	7.37	4.81	3.85	5.77	4.81	*5.32*	*0.60*
	2016	2.88	5.13	6.73	-	-	*4.91*	*1.12*
	2017	5.77	4.49	2.88	4.17	-	*4.33*	*0.59*
	2018	1.28	1.60	3.53	1.92	-	*3.21*	*0.50*
	2019	1.92	2.24	1.92	1.60	-	*2.78*	*0.13*
	2020	1.68	4.81	-	-	-	*3.25*	*1.57*
	2020	-	-	1.92	1.28	-	*1.60*	*0.32*
	2021	0.64	2.88	0.00	0.96	-	*1.12*	*0.62*
	2022	1.36	2.00	3.00	2.15	-	*2.13*	*0.34*

*no survey due to covid lockdown

3.1.2 Camera trapping

During the year two operational monitoring Emus have been photographed at only 1 of the 20 transects surveyed (5 %). This is compared with 61.1 %, 40 % and 30 % recorded during the 3-year pre-construction monitoring period and 25 % in the first year of operation. Mean camera trap rates in impact and control areas are shown in Figure 6, these show comparison of pre-construction data (2014-2016) with construction (2017-2020) and years 1-2 operation (June 2020-Dec 2022). Camera trap success rates from the operational data at the impact sites has declined significantly from the baseline rate (P = 0.03). While camera trap success rates in control areas have increased during operation compared with lower construction sampling data but remain lower than the baseline. The decline between pre-construction and operation is not significant for the control areas after two years operation (P = 0.19).

The decline in Emu camera trap success rates for two years of operation, compared to pre-construction rates for the impact areas remains high at around 73 %, although is an improvement from the first year of operation which was reporting 88 %. While the difference for control areas has reduced to only 36 % decline during operation, although this is notably greater than the first year of operation at 12 % and is the result of no emus being photographed at the control areas in 2022 and for the first time since monitoring commenced in 2014. These are based on a lower operational sample size thus future monitoring will determine if rates are increasing back to baseline. These data are consistent with the trends observed from the Emu sign data. Emus were not photographed from impact transects during construction in 2019 or 2020, coinciding with the last 18 months of construction. However, an Emu was recorded in the Tucabia North impact transect in Pine Brush State Forest in the winter and spring of 2022 and abundant signs of emu presence were reported across all seasons of 2022 in the Pillar Valley west impact area.

No emus were photographed in the control areas of Yuraygir north or south in the second year of operational monitoring in 2022, which is the first occasion that cameras have not recorded emus in the control areas since monitoring began in 2014. Although signs if emus were reported in Yuraygir north.

No evidence of breeding (chicks or juveniles) was captured on camera traps at the impact or control study areas during the second year of operation.

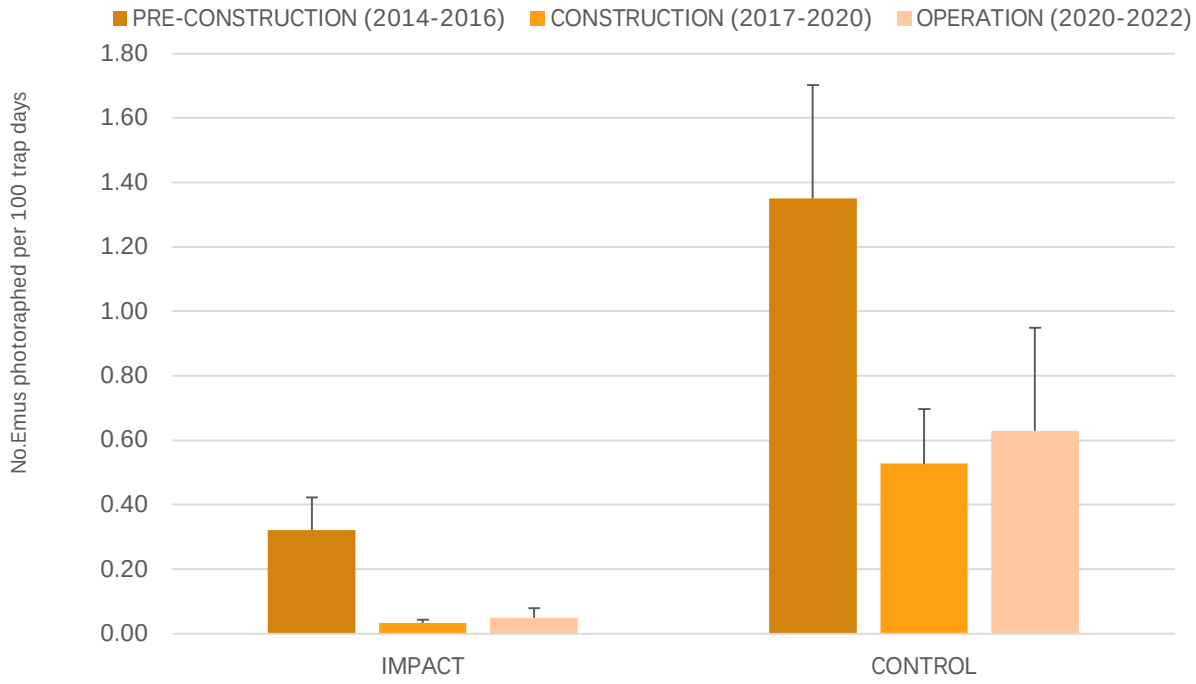

Figure 6: Mean camera trap rates (no. Emus photographed per 100 trap days ±se) at impact and control study areas for pre-construction period (2014-16), construction period (2017-20) and operation (Jun 2020-Dec 2022)

The camera trapping data is consistent with the temporal declines noted in the sign density discussed previously. These data are presented in Table 3.3 and show that a decline in trap success rates in the impact areas of between 36 – 80 % had occurred in the pre-construction years (baseline) indicating that the declines in activity around the Section 3 impact area were occurring prior to any project construction related activity commenced.

A one-way ANOVA (test of variance) was performed on the annual camera trap success rates at each impact site comparing the pre-construction years (before) with the operational data (after). There have been declines in all three impact areas, which are not statistically significant for two of the three study area, with the exception being Tucabia south (P=0.021) where Emus have not been photographed since the middle of the construction phase (winter 2018). However, the sign data reports the confirmed presence of an emu in this location in 2022.

Camera trap rates of wild dogs were also recorded to monitor temporal change in dog presence in Emu survey areas. Dogs were found to be present on all transects during all phases of the monitoring program, indicating dogs and Emus co-exist within impact and control areas. Interestingly, there has been a notable reduction in the presence of dogs during the construction and particularly operation compared with the baseline data, however this has also been noted from controls areas and the factors relating to this are unknown.

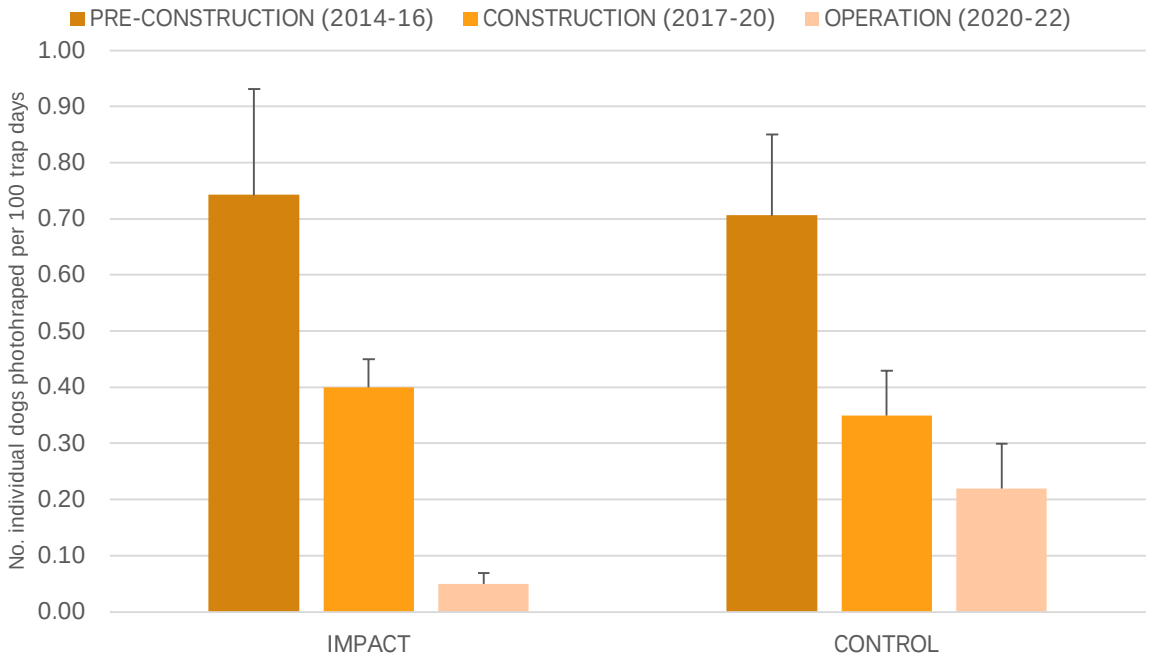

Figure 7: Mean camera trap rates (no. dogs photographed per 100 trap days ±se) at impact and control study areas for pre-construction (2014-16), construction (2017-June 20) and operation (June 2020- Dec22)

Table 3.3: Camera trap rate (no. Emu photos / 100 trap days) per study area recorded for pre-construction (2014-16), construction (2017-June 2020), and years 1-2 operation (June 2020-Dec 22)

Sampling period	Year	Summer	Autumn	Winter	Spring	Summer	*Mean*	*SE*
Pillar Valley west	*2014*	0.00	0.92	1.16	0.13		*0.55*	*0.29*
	2015	0.00	0.00	0.00	0.99	0.00	*0.20*	*0.20*
	2016	0.19	0.00	0.17			*0.12*	*0.06*
	2017	0.00	0.00	0.00	0.00		*0.00*	*0.00*
	2018	0.00	0.00	0.00	0.00		*0.00*	*0.00*
	2019	0.00	0.00	0.00			*0.00*	*0.00*
	2020	0.00	0.00				*0.00*	*0.00*
	2020			0.00	0.00		*0.00*	*0.00*
	2021	0.00	0.00	0.00*	0.00		*0.00*	*0.00*
	2022	0.00	0.00	0.00	0.00		*0.00*	*0.00*
Tucabia south	*2014*	2.99	0.96	0.24	0.54		*1.18*	*0.62*
	2015	1.51	0.12	0.00	0.43	0.14	*0.44*	*0.34*
	2016	0.51	0.41	0.19			*0.37*	*0.08*
	2017	0.17	0.54	0.00	0.15		*0.22*	*0.11*
	2018	0.00	0.18	0.00	0.00		*0.05*	*0.05*
	2019	0.00	0.00	0.00	0.00		*0.00*	*0.00*
	2020	0.00	0.00				*0.00*	*0.00*
	2020			0.00	0.00		*0.00*	*0.00*
	2021	0.00	0.00	0.00	0.00		*0.00*	*0.00*
	2022	0.00	0.00	0.00	0.00		*0.00*	*0.00*
Tucabia north	*2014*	0.00	0.00	0.00	0.00		*0.00*	*0.00*
	2015	0.00	0.00	0.00	0.00	0.00	*0.00*	*0.00*
	2016	0.00	0.00	0.00			*0.00*	*0.00*

	2017	0.00	0.00	0.17	0.00		*0.04*	*0.04*
	2018	0.00	0.00	0.00	0.00		*0.00*	*0.00*
	2019	0.00	0.00	0.00	0.00		*0.00*	*0.00*
	2020	0.00	0.00				*0.00*	*0.00*
	2020			0.00	0.26		*0.13*	*0.09*
	2021	0.00	0.00	0.00	0.00		*0.00*	*0.00*
	2022	0.00	0.00	0.34	0.48		*0.21*	*0.12*

*No survey due to covid lockdown

3.1.3 Site Occupation

Data from the sign survey and camera trapping for each period of monitoring were combined to identify the proportion of transects occupied by Emus within each survey period and each treatment (i.e., site occupation). As the home range and distance travelled by coastal Emus is not well known, the data analysis has relied on the assumption that separate individuals or groups occupy the impact and control study areas. For example, it is feasible for the three impact survey areas that the same Emus could be detected on any of the thirteen transects sampled. Therefore, for the purpose of comparing site occupation rates, the impact site data was assessed as one whole survey area. The control areas are spatially separated from the impact areas and therefore there is a low likelihood that the same Emus from the impact area would be detected in either of the control areas.

The number of sites occupied in any one survey period varied across season with more notable fluctuations in impact areas versus control areas (Table 3.4). These variations are likely to reflect seasonal movements of Emus around the project area in response to the availability of food resources rather than impacts from construction.

Interestingly, the occupation data for the operational period shows Emus returning to all three impact areas after long periods of absence during late construction, this was evident at Pillar Valley West (PVD) and Tucabia south (MRA) where Emus were reported 12 months after the start of operation after not being recorded in these impact areas for 2 years. Similarly, in Tucabia north there was a 12-month absence from near end of construction before birds had returned to these transect areas six months after operation. These data may reflect movements of Emus back to the impact areas in response to the availability of food resources and demonstrate that coastal Emus will return to locations previously reported after long periods of absence, or that new individuals may move into suitable habitat that is not occupied. Figure 8 compares the mean occupation rate for each survey area (impact and control areas), comparing 12 pre-construction surveys (baseline) with 14 construction phase surveys and 10 operation phase surveys. The pre-construction and operation means were compared using an independent t-test with the dependent variable being occupation rate and the independent variable being time (pre-construction and operation). When comparing occupation ‘before’ construction with occupation ‘after’ construction, the proportion of impact sites occupied by Emus has declined significantly by 50.6 % (*P=0.00*), while the proportion of control sites occupied by Emus has also declined significantly by 42.0 % (*P=0.01*). Importantly, for the impact sites there was a notable decline in occupation rates during the pre-construction years of 47.4 % (prior to any disturbance). For the control sites there has also been a decrease in occupation rates during the pre-construction years (65.7 %). The decline at the control sites has been most notable in 2022 (mean 10.7 refer table 3.4) and this is likely associated with a change which has occurred at the YNA transect, whereby the original fence line was replaced in 2021 with new fence that may be a barrier to emu movements. There has been no evidence of emu (feathers) reported on the new fence line since this change and additional camera traps have been added to the transect in 2023 in attempt to record emu occupation.

Table 3.4: Site occupation rates (proportion of transects occupied) recorded seasonally at the impact and control study areas comparing pre-construction (2014-16 purple), construction (2017-June 2020 green) and operation (June 2020-Dec 2022 orange)

Treatment	Sampling period	Summer	Autumn	Winter	Spring	*Mean*	*SE*
Impact	*2014*	85.60	90.00	90.90	92.30	*89.70*	*1.45*
	2015	84.60	46.20	38.50	69.20	*59.63*	*10.57*
	2016	30.80	46.20	46.20	46.20	*42.35*	*3.85*
	2017	61.50	53.80	61.50	46.20	*55.75*	*3.66*
	2018	46.20	38.50	7.70	23.10	*28.88*	*8.54*
	2019	23.10	0.00	7.70	0.00	*7.70*	*5.44*
	2020	0.00	0.00	0.00	7.69	*1.92*	*1.92*
	2021	7.69	23.08	0.00*	23.08	*13.46*	*5.77*
	2022	30.77	53.85	30.77	38.46	*38.46*	*5.44*
Control	*2014*	91.60	100.00	100.00	85.70	*94.33*	*3.49*
	2015	42.90	28.60	28.60	28.60	*32.18*	*3.58*
	2016	28.60	28.60	28.60	28.60	*28.60*	*0.00*
	2017	28.60	28.60	28.60	28.60	*28.60*	*0.00*
	2018	28.60	28.60	28.60	14.30	*25.03*	*3.57*
	2019	28.60	14.30	28.60	28.60	*25.03*	*3.58*
	2020	28.60	28.60	28.57	42.86	*32.16*	*3.57*
	2021	28.57	28.57	28.57*	28.57	*28.57*	*0.00*
	2022	14.29	14.29	0.00	14.29	*10.71*	*3.57*

*No survey due to covid lockdown, occupation determined by camera data only

Figure 8: Mean site occupation rates (±se) for impact and control sites comparing pre-construction (2014-16), construction (2017-June 20) and operation (June 2020-Dec 2022)

3.2 Crossing structures

3.2.1 Emu detections

Monitoring Emu usage of crossing structures commenced from June 2020 as the highway became operational and continued through to the end of 2022 for the current report (30 months). In total 51 cameras were deployed across 18 structures (15 bridges in Section 3 and 3 bridges in Section 4). Of these, 15 cameras were lost due to flooding in February 2022 (these cameras were gradually replaced over the subsequent 6 months), a further three cameras were stolen in January 2022 and not replaced until September 2022 and 6 cameras failed for brief periods from battery fatigue or malfunctioning equipment and were subsequently replaced with new equipment.

Emus were confirmed crossing the highway on 209 occasions from three separate bridges in section 4 of the project, relating to the large Shark Creek bridge, Site R (n=32) and the two small cane drain bridges south of shark creek, site P (n=174) and Site Q (n=3). A single adult Emu crossing was captured in section 3 in June 2022 at chainage 47620 in open grazing land (Site F). The frequency of Emu crossings in the sugar cane properties in Section 4 has increased from 35 crossings reported in 2021 to 209 crossings captured in 2022. This includes single adults, pairs and juvenile birds making regular crossings to access habitat east and west of highway. Of interest is the number of reported crossings by birds using the low bridges over the artificial cane drains. This included a crossing during a peak flood time in February 2022.

There was only a single crossing captured in Section 3 despite the reported presence of birds from the sign survey and camera trapping in habitats to the east of the project in proximity to the highway. This likely reflects the infrequent occupation of birds in this area compared to higher abundance in Section 4, although is indicating of a lack of habitat occupation to the west of the project compared with the pre-construction data. Emu presence was identified west of the project on three of the Tucabia south transects in 2022 that are all in proximity to Mitchell Road, and likely the same bird. There were no confirmed crossings at a bridge monitoring site in this area and it is likely that the bird crossed under the highway along Mitchell Road which is reported as an incidental crossing opportunity. Further monitoring is required to identify emu presence to the west of the highway in Section 3.

Table 3.5: Details of camera trap images of emus crossing under the highway at four structures in Section 3 and Section 4 during the first two years of operation

Section	Monitoring structure (*raised) (^landscape plantings)	Emu camera detections		Mean no. weeks cameras active (2022)	Mean emu crossing detections per active week
		2021	2022		
Section 3	A *^	0	0	46.8	0.0
	B *^	0	0	31.7	0.0
	C *^	0	0	30.5	0.0
	D *^	0	0	45.5	0.0
	E *	6	0	45.5	0.0
	F *^	18	1	48.8	0.04
	G *^	0	0	46.7	0.0
	H *^	0	0	48.6	0.0
	I *^	0	0	17.1	0.0
	J *^	0	0	50.0	0.0
	K *^	0	0	34.9	0.0
	L ^	0	0	42.0	0.0
	M *^	0	0	52.0	0.0
	N *^	0	0	19.0	0.0
	O ^	0	0	50.6	0.0
	total	***24***	***1***	***609.7***	***0.0 (mean section 3)***
					0.0 (se)
Section 4	P ^	4	174	39.5	4.41
	Q ^	0	3	32.6	0.09
	R*	31	32	13.0	5.31
	total	***35***	***209***	***85.1***	***2.32 (mean section 4)***
					1.25 (se)

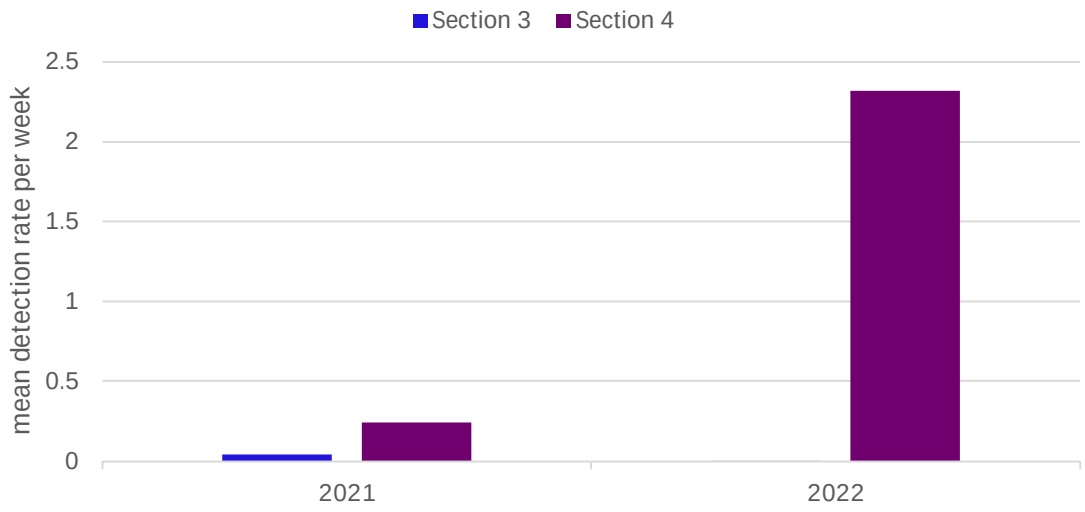

Figure 9: Mean detection rates / per week (±se) for emus photographed using bridges to cross highway in year 1 and 2 operation in section 3 and 4

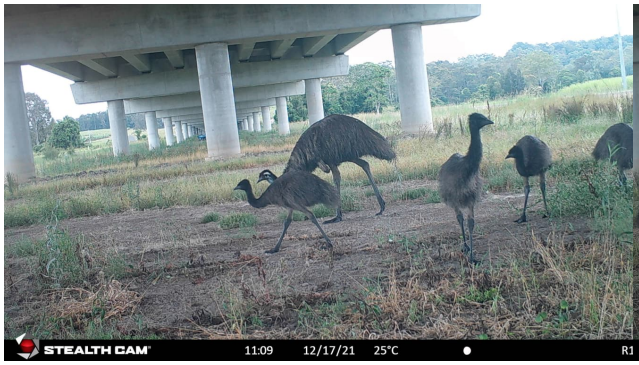

Plate 7. Shark Creek bridge (Site R) adult male and young birds in early summer period

Plate 8. Shark Creek bridge (Site R) adult male and young birds later in the summer season, likely the same birds as plate 7

Plate 9. Cane drain (site P) 28 February 2022 – Emus wading along ledge in flood waters

Plate 10. Cane drain (Site P) during late spring. Birds are using the same ledge as described in Plate 9

Plate 11. Cane drain (P) crossing to the east during spring season

Plate 12. Site F (Section 3) crossing to the west during winter

3.2.2 Fence and roadkill monitoring

There were no reported emu road strike incidents on the Pacific Highway corridor in the 2022 monitoring period. A second significant flood event occurred in late February 2022 with flood water reported over large portions of Section 4 of the project. For comparison the previous emu mortality in Section 4 in 2021 occurred during flood times in the elevated lands immediately north of the Shark Creek floodplain. Plate 3 above captured two emus crossing below the highway via the cane drain bridge south of Byrons Lane through about one metre of floodwater. There were no signs of trapped or dead emus along the exclusion fencing in proximity to any of the monitored crossing structures.

3.2.3 Dog detections

In the first two years of operation dogs were recorded using the bridge underpasses to cross the highway in grazing and forested areas of the project in section 3 but there was no evidence in the cropping lands in section 4. The absence of dogs around structures in section 4 is likely related to the open cropping land.

A total of 6 dog crossings were recorded from 3 structures in 2021, which increased to 67 crossings from 4 structures in 2022, the majority of these were associated with two bridges around 220 metres apart, site F - chainage 47620 (n=13) and site G - chainage 47841 (n=51). These structures are located adjacent to heavily grazed cattle pasture, and majority of the dog passage in 2022 was recorded in spring (84 %) and autumn (13 %), while there were only two crossings in winter (1.9 %). An Emu was also recorded crossing site F on one occasion in the winter of 2022, and it's possible that the higher abundance of dogs in the other seasons, particularly spring 2022 resulted in Emus later avoiding the site. Indeed, in the previous year (2021) during a period of lower dog activity Emus were recorded using the bridge at site F in winter and spring.

3.2.4 Emu sightings during operational phase

During the operational phase, sightings of Emus are being maintained through direct observations captured during monitoring activities, as well as observations provided by TfNSW staff while driving sections of the highway, and other observations provided by landowners accessed during monitoring. These opportunistic observations are noted in Appendix A, and do not represent all occurrences of Emus near the project but are important as they note successful breeding and confirm locations relative to east and west of the highway.

4. Discussion

The mitigation goals outlined in the Emu Management Plan for the W2B project include:

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

Specific mitigation measures were designed to achieve these goals and the monitoring program aims to determine the performance of these measures by monitoring and evaluating:

- Emu activity and distribution near the road corridor including east and west of the highway to determine if the road is creating a barrier to movements
- The trend in emu occupation in the project area and comparing this with control areas to identify if declines are related to the project
- The effectiveness of crossing structures, exclusion fences and revegetation.

The outcomes of the monitoring for the end of the second year of highway operation are discussed below.

4.1 Emu activity and site occupation

Emu activity and site occupation during the second year operation have continued to be significantly lower than the pre-construction period in both the impact and control areas, reflective of a decline in the population during this period. This is likely to be independent of the project as baseline monitoring first detected a substantial decline in Emu activity and occupation rates over the 3-year pre-construction period, which continued during the construction phase. When comparing occupancy ‘before’ construction with ‘after’ construction, the proportion of impact sites occupied by Emus has declined significantly by 50.6 %, while the proportion of control sites occupied by Emus has also declined significantly by 42.0 %.

Encouraging, is the fact the occupation data for the operational period shows Emus present in a portion of year two at each of the three impact areas, albeit in lower densities then before construction, and this has continued following the first year of operation after long periods of absence during the drought years in late construction. The density of Emu sign reported in the impact sites during the second year of operation has increased at the southern sites compared with the 3.5-year construction period and year one of operation impact. This is encouraging despite the density remaining significantly lower than the baseline (pre-construction) data at these locations and may reflect current availability of food resources in these locations following flooding rainfall events in 2021 and 2002. Emus are known to be nomadic, keeping in touch with variation in availability of food which is influenced by rainfall (Davies 1976; 1984). Since the start of the operation phase, from late 2020 to autumn 2022, above average rainfall in the W2B project area has resulted in substantial amounts of water returning to local creeks and floodplain areas and would likely account for the return of Emus to the Pillar Valley and Tucabia impact areas in proximity to the highway. The lower density of emu sign and trap rates may reflect decline in the population and is consistent with the long-term data from the impact and control sites.

Fresh sign was observed on the western side of the highway in Section 3 south of Tucabia, and at least a single bird was occupying habitat to the west of the highway for a period of up to 6 months from mid-2022. This collaborates with observations from landowners. It is likely that the bird crossed below the highway along Mitchell Road, which experiences very low traffic volumes for local residents only. There was no other reported emu occupation to the west of the highway in the second year of operation, but there was a bird captured crossing to the west at the bridge structure located north of Black Snake Creek.

In the cane properties surrounding section 4 of the project, Emu presence has been continually reported near the highway during year two of operation, as determined from direct observations made from the highway between the Tyndale interchange to Shark Creek and photographs captured on crossing structures. Pairs and small groups of birds, chicks and sub-adults were all recorded in 2022 indicating breeding success in habitats adjoining the highway, and the importance of the cane properties in providing food resources and watering points for breeding birds and juveniles. The higher density of emus in Section 4 is reflected in the bridge monitoring data.

4.1.1 Performance thresholds and corrective actions

The monitoring of emu presence has been designed to provide a baseline of emu presence and activity prior to construction, and then comparing this with operation to identify change. The monitoring program outlined in the Emu Management Plan (s.7.2.4) identifies two key performance thresholds in relation to emu activity and occupation that are to be measured, namely:

- Greater than 15% decline in Emu activity (through signs and detection rates) comparing impact and control areas and before and after data.
- No evidence of breeding through sightings of chicks and sub-adults between impact and control areas and before and after data.

The decline in Emu activity is measured using the site occupation data which compares the site occupation rate for each survey area (impact and control areas), comparing 12 pre-construction surveys (baseline) with 14 construction phase surveys and 10 operation phase surveys. When comparing occupation 'before' construction with occupation 'after' construction, the proportion of impact sites occupied by Emus has declined significantly by 50.6 %, although this is an improvement from year one operation was which 72.9 %. The proportion of control sites occupied by Emus has also declined significantly by 42.0 % compared with 28.3 % at the end of year one operation. Both declines are >15 %, although importantly, at the impact sites there was a notable decline in occupation rates during the pre-construction years of 47.4 % (prior to any disturbance). For the control sites there was also a decrease in occupation rates during the pre-construction years (65.7 %). While there is a greater reported decline at the impact sites, there is only a difference of 8 % between the treatments (i.e., <15 %). The decline at the control transect YN-A in the last 12 months is thought to be influenced by physical changes at the site with the replacement of the boundary fence and clearing which has bene done by the landowner. This warrants a change in the monitoring methodology at this site to introduce additional cameras or consider a change in the transect arrangement to detect emus that are present but not leaving sign.

The direct observations made during year two operation have recorded evidence of breeding activity in Section 4. Groups of adult birds have been observed in the autumn-winter breeding period and the presence of juveniles with male parent (see Plate 7 and Plate 8). The data over the last two years of operational monitoring suggests that the project has not impacted emu breeding success.

4.2 Monitoring effectiveness of crossing structures

The first two years of operational monitoring confirmed usage of the bridge structures by Emus crossing the highway. Birds were detected on camera travelling in both an easterly and westerly direction below bridges at four locations. The use of the bridges south of Shark Creek (section 4) has increased over the two-year operational period and demonstrates regular crossings in the last 12 months from three bridges located over a 4 km section of highway. The frequency of use is consistent with the high number of direct observations and higher emu density reported in this part of the project. The comparatively low number of crossings in the 12 months monitoring period in section 3 (i.e., one confirmed crossing) is related to the lower density of birds, but also may be reflective of the number of dogs present and also increasingly using the structures to cross the highway. An additional unconfirmed crossing along Mitchell Road is also inferred from the data and suggests that other road crossings may also be used in the future.

The three bridges in the north are located adjacent to cane properties while the confirmed crossing in section 3 is adjacent at cattle grazing property, which was also the same site used in year one operation. The decreased number of crossings in section 3 in year two of operation may be related to higher recorded dog usage of these structures and further monitoring of both species will be important to identify if any further reduction or absence of emu crossings in the future is related to dog activity. For comparison, there was no reported dog usage of structures in section 4.

4.2.1 Performance thresholds and corrective actions

The project mitigation measures for connectivity have been designed to minimise the impacts of habitat loss and fragmentation on coastal Emus and the potential barrier effect of the highway. The monitoring program outlined in the Emu Management Plan (s.7.3.2) identifies three key performance thresholds that are to be measured, namely:

- No evidence of east-west movements across the project corridor after 5 years post-construction
- Emus found on western side of the highway but no evidence of using crossing structure (i.e., isolation)
- A single dog or fox attack reported in proximity to a crossing structure or along an exclusion fence, through evidence of dogs and foxes reported on surveillance cameras and / or a dead emu found.

The year two operational monitoring confirmed usage of the crossing structures by emus, and birds were detected on camera travelling in an easterly and westerly direction below bridges at four locations (1 in Section 3; and 3 in Section 4) indicating movements across the project corridor in the first two years of operation. The emu sighting data shows emus regularly in cane fields on the east and west of the highway in Section 4. It is important to note the intent of the connectivity mitigation in Section 4 was not aimed at maintaining emu movements across the project, however this outcome is evident and should be considered in future discussion around crossing locations and habitat connectivity as it evident that the sugar cane farms provide important habitat.

Emu usage of bridges in section 3 is showing comparatively limited success, with only one confirmed crossing in a 12-month period, despite the increased evidence of emu presence in section 3 in the second year of operational monitoring. The presence of an emu was confirmed on the west side of the highway south of Tucabia around 1.5 km north of the confirmed crossing at site F. However, monitoring of the bridges directly north and south of this location did not detect this bird crossing. It is possible that the bird crossed along Mitchell Road (which is not being monitored). Importantly the fact that emus have been recorded at site F and G during operation is evidence that emus are unlikely to be isolated on the west side of the highway, and further monitoring may determine increased frequency of use.

Despite the increased usage of structures by dogs in the past 12 months, there has been no evidence of a dog or fox attack at a structure and no dead emus found.

4.3 Exclusion fence monitoring

There were no Emu road-strike incidents reported during the second year of operation monitoring, and no evidence of injured or dead emus along the exclusion fence in proximity to the bridge structures or reported breach of the exclusion fence during the monitoring period.

4.3.1 Performance thresholds and corrective actions

The project mitigation measures for exclusion fencing have been designed to minimise the impacts of vehicle strike on coastal Emus. The Monitoring Program outlined in the Emu Management Plan (s.7.4.2) identifies five key performance thresholds that are to be measured, namely:

- Evidence of an emu injured by the exclusion fencing or hybrid fence.
- Evidence of an emu breaching the exclusion fencing system and entering the roadway
- Evidence that the hybrid fence is ineffective through the camera monitoring program.

- A single road fatality recorded on the highway in Section 3 and Section 4 of the project during10 years operation.

There has been no evidence of an emu injured by exclusion fencing in year two operation or breaching the exclusion fencing and entering the road corridor.

There has been no evidence of the hybrid fences or emu gates being used in year two of operation.

5. Recommendations

This report is the second year of operational monitoring for Coastal Emu associated with the W2B project, and monitoring has indicated that performance thresholds for emu activity and occupation are being met, and that early trends for continued emu activity on the east and west of the highway are looking positive considering the confirmed usage of crossing structures in both Section 3 and Section 4 and continued evidence of emu presence in impact areas despite the declines noted between the before and after construction data.

Further monitoring is required to determine activity levels west of the highway across multiple locations and monitor the density of emus as well as usage of crossing structures by emus and dogs in Section 3.

The decline in emu density noted at the control site along the boundary of Yuraygir National Park at Taloumbi (TNA) is considered likely a function of the change in the environmental variables at this site. The change is associated with the addition of a newly constructed fence on private property and minor clearing which occurred at the end of 2021 and no emus sign has been detected since the activity. This suggests that the decline here is likely the result of bias in the survey data effecting the analysis rather than the absence of emus and could be tested by the addition of extra camera traps in the third year of operational monitoring to determine if emus are present but not being detected.

Table 5.1: Recommendation following Year 2 operational monitoring and Transport for NSW response.

No.	Recommendation	Transport for NSW
1	Continue monitoring emu and dog usage of crossing structures in section 3 to determine if the absence of emu crossings may be associated with avoidance of dogs	Adopted
2	Introduce additional camera traps at the control site TNA as a means of detecting emu presence, given the complete absence of emu sign in 2022 along the newly constructed fence on private property	Adopted

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Appendix A. Emu sign and sightings near the project during year 2 of operation

Table A.1 Opportunistic Emu observations made during operation of the highway in 2022, AD = Adult, SA = sub-adult, CH – striped chicks, Sect = project section

Date	AD	SA	CH	Sect	Easting	Northing	Location
22/02/2022	1			3	510820	6708325	Feather on barbed fence
22/02/2022	1			3	511046	6709157	Feather on barbed fence
22/02/2022	1			3	511091	6709432	Feather on barbed fence
22/02/2022	1			3	511087	6709433	Feather on barbed fence
22/02/2022	1			3	511157	6709683	Feather on barbed fence
22/02/2022	1			3	511969	6709925	Feather on barbed fence
22/02/2022	1			3	512380	6710622	Feather on barbed fence
22/02/2022	1			3	512382	6710629	Feather on barbed fence
22/02/2022	1			3	512389	6710659	Feather on barbed fence
22/02/2022	1			3	512389	6710671	Feather on barbed fence
23/02/2022	1			3	512301	6711496	Feather on barbed fence
23/02/2022	1			3	512322	6711460	Feather on barbed fence
23/02/2022	1			3	515405	6718295	Feather on barbed fence
23/02/2022	1			3	515510	6718849	Feather on barbed fence
31/05/2022	1			3	510337	6708293	Feather on barbed fence
31/05/2022	1			3	510998	6708835	Feather on barbed fence
31/05/2022	1			3	510998	6708835	Feather on barbed fence
31/05/2022	1			3	510991	6708862	Feather on barbed fence
31/05/2022	1			3	510998	6708873	Feather on barbed fence
31/05/2022	1			3	511123	6709639	Feather on barbed fence
31/05/2022	1			3	511395	6709651	Feather on barbed fence
31/05/2022	1			3	512010	6710076	Feather on barbed fence
31/05/2022	1			3	512048	6710312	Feather on barbed fence
31/05/2022	1			3	512064	6710463	Feather on barbed fence
31/05/2022	1			3	512348	6710445	Feather on barbed fence
31/05/2022	1			3	512363	6710500	Feather on barbed fence
31/05/2022	1			3	512363	6710500	Feather on barbed fence
31/05/2022	1			3	512360	6710512	Feather on barbed fence
31/05/2022	1			3	512363	6710521	Feather on barbed fence
31/05/2022	1			3	512366	6710639	Feather on barbed fence
31/05/2022	1			3	512388	6710675	Feather on barbed fence
31/05/2022	1			3	512398	6710702	Feather on barbed fence
1/06/2022	1			3	512323	6711455	Feather on barbed fence
1/06/2022	1			3	511930	6711211	Feather on barbed fence
1/06/2022	1			3	511845	6711244	Feather on barbed fence
1/06/2022	1			3	512077	6711249	Feather on barbed fence
1/06/2022	1			3	512394	6711203	Feather on barbed fence
1/06/2022	1			3	511413	6711862	Feather on barbed fence
1/06/2022	1			3	511405	6711820	Feather on barbed fence
1/06/2022	1			3	511953	6712988	Track - footprint
1/06/2022	1			3	515847	6718050	Feather on barbed fence

1/06/2022	1			3	515479	6718840	Feather on barbed fence
2/06/2022	1			3	525447	6730548	Feather on barbed fence
7/06/2022	1			3	511791	6710776	East of highway, c.800 m north of Shark Creek
7/06/2022	7			4	518752	6734328	shark creek flats in cane
7/06/2022	2			4	519397	6736564	shark creek flats in cane
22/06/2022	4			4	518847	6733656	shark creek flats in cane
23/08/2022	1			3	510808	6708193	Feather on barbed fence
23/08/2022	1			3	511289	6709668	Feather on barbed fence
23/08/2022	1			3	511303	6709663	Feather on barbed fence
23/08/2022	1			3	511326	6709677	Feather on barbed fence
23/08/2022	1			3	511994	6710021	Feather on barbed fence
23/08/2022	1			3	512352	6710458	Feather on barbed fence
23/08/2022	1			3	512371	6710515	Feather on barbed fence
23/08/2022	1			3	512361	6710516	Feather on barbed fence
23/08/2022	1			3	512372	6710557	Feather on barbed fence
23/08/2022	1			3	512381	6710644	Feather on barbed fence
23/08/2022	1			3	512397	6710699	Feather on barbed fence
24/08/2022	1			3	511395	6711801	Feather on barbed fence
25/08/2022	1			3	525482	6730769	Feather on barbed fence
25/08/2022	1			3	525471	6730720	Feather on barbed fence
29/10/2022		4		4	519261	6734103	shark creek flats in cane
22/11/2022	1			3	511048	6709200	Feather on barbed fence
22/11/2022	1			3	512382	6710592	Feather on barbed fence
22/11/2022	1			3	512387	6710641	Feather on barbed fence
23/11/2022	1			3	511809	6711244	Feather on barbed fence