Carnaby's Cockatoo and other Birds Baseline Monitoring Report 2018: Badgingarra Wind Farm

APA

ecoscape

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SUMMARY

Ecoscape conducted baseline monitoring surveys for Carnaby's Cockatoos and other birds at APA Group's Badgingarra Wind Farm Development Project from October 2017 to April 2018. Carnaby's Cockatoo were found to utilise the Badgingarra Wind Farm (BWF) site more frequently than counts completed 10 years earlier by Brett Lane & Associates (2008). The wind farm site was used as part of daily foraging flight patterns with counts ranging from individual birds up to flocks of 300 to 400 birds. Carnaby's Cockatoo was the most recorded species accounting for 36.1% of observation (3,541 counted) followed by Australian Ravens (9.1%), Galahs (6.9%), Straw-necked Ibis (5.7%) and White-cheeked Honeyeaters (5.6%). Despite the high number of Carnaby's Cockatoo relative to other bird species, it is anticipated that the operational windfarm will have a limited impact as the majority of individuals from the 2017/2018 surveys were observed flying at heights expected to be below rotor height. However, further observations will be taken from subsequent surveys for confirmation of flight heights. If any impact is detected from future surveys, species-specific trigger points would require development in conjunction with the Western Australian Department of Biodiversity, Conservation and Attractions (DBCA) Science & Conservation Division. The 'trigger' management options would minimise and/or eliminate any impact during peak Carnaby's Cockatoo flight periods while ensuring minimal interruption to turbine operation.

Based upon the conditions outlined in the Shire of Dandaragan Planning Approval, the bird mortality monitoring program is to be reviewed based on the findings from two years of turbine operation. During this time, the bird abundance and mortality surveys will provide adequate data to detect any impacts on Carnaby's Cockatoo or other bird species from the turbines.

1 INTRODUCTION

1.1 PROJECT DESCRIPTION

APA is Australia's largest natural gas infrastructure business. APA own, manage and/or operate a portfolio of energy assets worth $20 billion that include gas storage facilities, gas-fired power stations and wind farms. They also own and manage 15,000 kilometres of natural gas pipelines connecting sources of supply and markets across mainland Australia. These pipelines deliver half of Australia's natural gas usage.

In 2011, APA purchased the Emu Downs Wind Farm. The purchase of this asset included the approved Development Applications for the Emu Downs Solar Farm and the Badgingarra Wind Farm Development Project along with the completed surveys. Both projects are situated in the Shire of Dandaragan.

The BWF will be capable of generating an energy output of up to 130 MW for supply to the energy market and will consist of 36 wind turbine generators located across six parcels of land (**Map 1**). The BWF will also include a new substation, a 33kV in-ground reticulation, a small grid interconnection to the existing transmission line, and associated site roads and infrastructure.

Both the BWF and Emu Downs Solar Farm are located on freehold land which is primarily used for agriculture. APA has caveats on each of the landowner's titles for the wind farm and a lease with the landowner for the solar farm. To support the grant of the wind farm development approval, the former project owners undertook various technical and environmental surveys including flora, fauna, ethnography and archaeology aspects.

1.2 MONITORING OBJECTIVES

The bird monitoring program was designed to meet the specific conditions listed under the Shire of Dandaragan Planning Approval for the Badgingarra Wind Farm. This includes bird mortality monitoring (Condition 20) and targeted monitoring of Carnaby's cockatoo (Condition 21).

Condition 20 – Bird Mortality

"The proponents shall develop and implement a bird mortality monitoring program within 12 months of commencement of Wind Farm operations. The program shall be developed in consultation with the Department of Parks and Wildlife and/or the WA Museum. Results of the program shall be forwarded to the Shire of Dandaragan."

The objective of the bird mortality study was to identify bird mortality rates from the windfarm extension near Badgingarra. This required a combination of standardised searches including:

- baseline and ongoing bird monitoring when the wind farm is operational
- carcass searches
- searcher efficiency trials
- scavenger trials.

Condition 21 – Carnaby's Cockatoo Monitoring

"The proponents shall develop and implement an annual monitoring program for Carnaby's Cockatoo (Calyptorhynchus latirostris) bird strike, foraging and roosting (including any avoidance) behaviour, with reporting to the Commonwealth Department of the Environment, Water, Heritage and the Arts. The WA Museum (Mr Ron Johnstone or his nominated appointment) is to be consulted in developing appropriate survey methodologies for Carnaby's Cockatoo. The duration of this monitoring program will be defined during the development of the program and subject to review, based on findings during the first two years' monitoring."

The objectives of the Carnaby's Cockatoo monitoring program were to determine the baseline and ongoing monitoring to determine if the site is utilised by Carnaby's Cockatoo as part of daily foraging flight patterns and/or seasonal migrations both pre and post wind farm operation.

This required:

- baseline and ongoing Carnaby's Cockatoo monitoring using the species-specific survey design with the minimum number of replicates required for statistical analysis. As there was no pilot study to determine this quantitatively, a rule of thumb is at least 6 replicates are required to generate enough degrees of freedom to allow for a test of significance to be completed.
- the use of standardised methodology and data collection techniques suited to detecting site utilisation by Carnaby's Cockatoo
- surveys to be conducted at ecologically appropriate times of the year relevant to Carnaby's Cockatoo
- using methodology that could also gather baseline data for other bird species diversity and abundance.

1.3 CARNABY'S COCKATOO

1.3.1 THREATENING PROCESSES

The loss and degradation of breeding and foraging habitat is considered one of the main threatening processes for Carnaby's Cockatoo. This includes habitat fragmentation, removal of nest hollows, competition for hollows and clearing of foraging habitat. Additionally, the mortality of individual birds through vehicle strike, shooting etc. is also a major contributor to population declines (DotEE 2017b).

Life history traits such as low reproductive rates (including low clutch size), long immature periods (four years), long generational time (ca. 15 years) and the use of tree hollows increase the susceptibility of Carnaby's Cockatoo to these threatening processes (Williams *et al.* 2017). The rapid decline of Carnaby's Cockatoo populations has been compounded by these 'slow' life histories – low reproductive rates over long lifespans (Heinsohn *et al.* 2009; Murphy *et al.* 2003; Williams *et al.* 2017).

Recent research has found, that assuming no changes in the extent or quality of breeding habitat, and current breeding or survival rates, the most important factor currently limiting population growth for Carnaby's Cockatoo is adult survival (Williams *et al.* 2017). The mortality of individual adults is a key driving factor in population declines given the slow reproductive rate of Carnaby's Cockatoo. Even a small increase in adult mortality may lead to population decline via recruitment failure. The sensitivity of population viability to adult survival is characteristic of cockatoos and other long-lived birds (Heinsohn *et al.* 2009; Stahl & Oli 2006; Williams *et al.* 2017). Density-dependent mortality is caused when the carrying capacity of an area, based on resource availability, is exceeded. This is caused through the reduction of available resources from habitat loss. Density-independent mortality is caused by a variety of factors including vehicle strike, shooting, poaching of eggs and birds, or injuries sustained through vegetation clearing. Avoiding these density-independent mortality events is extremely important to the recovery of the species (Commonwealth of Australia 2017).

1.3.2 CARNABY'S COCKATOO HABITAT IN THE BADGINGARRA REGION

Three Important Bird Areas (IBA) for Carnaby's Cockatoo that are relevant to the study area (DPaW 2013; Dutson 2009) were identified. These are:

- **Coomallo:** Located approximately 25 km to the northeast of the BWF site. This area supports at least 1% of the Carnaby's Cockatoo breeding population (minimum of 40 breeding pairs) which nest in woodland remnants and isolated paddock trees and feed in native shrublands.
- **Koobabbie:** Located near Coorow and approximately 100 km northeast of the BWF site. This large pastoral property has 254 ha of remnant Wandoo and Salmon Gum woodland vegetation. Supports at least 1% of the Carnaby's Cockatoo breeding population (up to 32 breeding pairs). Fledglings have been recorded at Coomallo Creek and Beekeepers Nature Reserve.
- **Northern Swan Coastal Plain:** Located between the Swan River and Moore River, this area supports 4,600-15,000 birds in the non-breeding season and a small number of pairs of breeding birds; this is the largest population of birds that gather in the non-breeding season.

Breeding sites around the windfarm site include Three Springs, Coomallo, Carnamah, Coorow, Badgingarra and Moora regions which are vacated by the end of February each year. Adults and fledglings fly west to coastal feeding habitat where they aggregate in flocks in Kwongan heath and pine plantations. Occasionally

a flock of 60 – 100 birds remain in the Badgingarra National Park area into March – April. From July through to September birds fly back to breeding sites (Johnstone 2008).

In the breeding season, birds have been found to forage an average of 1.4 km from Coomallo Creek. During the non-breeding season they migrate west and forage locally within 50 km (Saunders 1980). **Figure 1** shows the known patterns of seasonal migrations (Williams *et al.* 2017).

A regional habitat assessment was completed by Brett Lane & Associates (2008) who identified over 44,000 hectares of Carnaby's Cockatoo habitat within the surrounds of the proposed wind farm site. This includes:

- Badgingarra National Park: 13,108 ha
- Coomallo Nature Reserve: 8,807 ha
- Southern Beekeepers Nature Reserve: 10,808 ha
- Nambung National Park: 8,362 ha
- Hill River Nature Reserve: 882 ha
- Un-named Conservation Park: 2,369 ha.

Additionally, there are substantial areas of Carnaby's Cockatoo habitat outside of conservation estate which are also utilised for foraging and nesting (Dawson 2017).

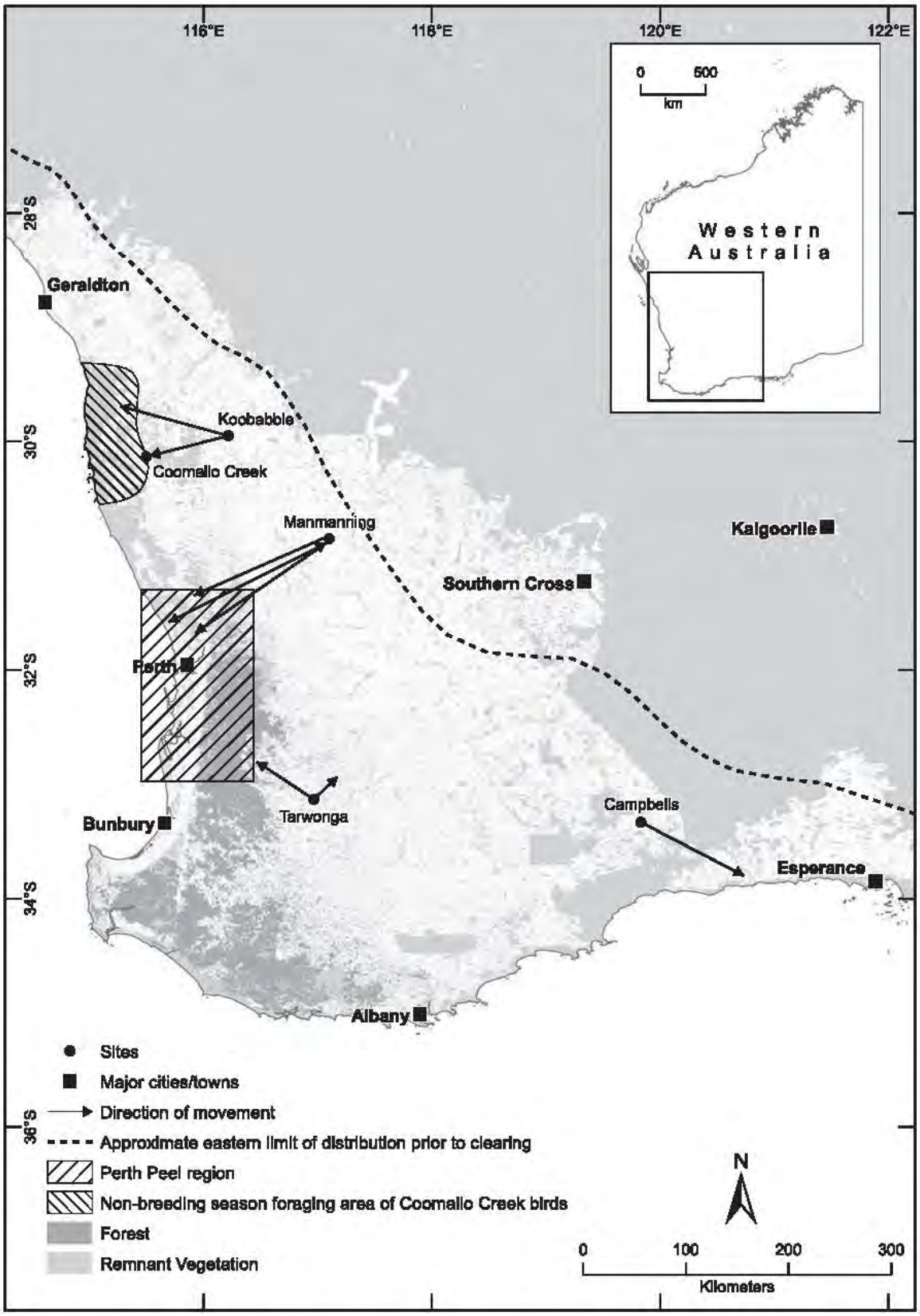

Figure 1: Known seasonal migration patterns of Carnaby's Cockatoo

2 METHODS

To prepare the monitoring methodology (Ecoscape 2017), Ecoscape sought advice from the following specialists:

- Ron Johnstone: Curator of Ornithology Western Australian Museum
- Rick Dawson: previously Acting Manager, Nature Conservation Branch DBCA
- Dr Matthew Williams: Biometrician DBCA
- Dr Denis Saunders: Research Fellow CSIRO Land & Water.

2.1 ABUNDANCE MONITORING – CARNABY'S COCKATOO & OTHER BIRDS

The abundance monitoring collates data regarding both Carnaby's Cockatoo and other bird species. Standard bird surveys/counts are unsuitable to capture data that reflects Carnaby's Cockatoo counts and site use. A species-specific methodology was used based on a modified point count method similar to that used in the Great Cocky Count (Shah 2006). This involved recording the location, count and flight pattern of Carnaby's Cockatoo from eight impact sites and eight reference sites during peak flight times (seasonally and daily).

Each year there are two peak flight periods for Carnaby's Cockatoo:

1. Adult west-east migration period for breeding (July to September)
2. Adult and fledgling east-west migration for feeding (December to April).

Each day there are two peak flight times. These are:

1. Dawn – 30 minutes before dawn until two hours after dawn
2. Dusk – 2 hours prior to dusk to 30 minutes after dusk.

The breeding and coastal feeding migrations are determined by local resource availability as driven by the onset of rainfall (Ecoscape 2017). The bi-annual migrations times are indicative only and vary depending on resource availability.

The methodology outlined above allows for the survey of other bird species to occur concurrently. For the baseline monitoring, a minimum of four surveys over the two peak Carnaby's Cockatoo flight periods was recommended by DBCA Science & Conservation Division (Ecoscape 2017).

Site selection for surveys included both impact and reference sites. Impacts sites are associated with wind turbines and based on statistical advice from DBCA, were required to be at least two kilometres apart. Reference sites were required to be at least one kilometre from a turbine site, at least two kilometres from other reference sites and linked to an impact site with similar characteristics (i.e. vegetation type, disturbance level) (Ecoscape 2017). Eight impact sites and eight reference sites were selected at random and are shown in **Map 2**.

Each site was surveyed over a 30 minute period, a minimum of five times per survey period with surveys occurring during the periods of highest Carnaby's Cockatoo activity (dawn and dusk) (Department of Sustainability Environment Water Populations & Communities 2012; Department of the Environment and Energy 2017a; Shah 2006). A survey timing matrix was developed which permitted all survey sites to be monitored during six of the eight possible monitoring periods (**Table 1**).

Table 1: Monitoring schedule for each survey at turbine (T) and reference (R) sites

Day	Observer	Morning Period				Afternoon Period			
		Survey A	Survey B	Survey C	Survey D	Survey W	Survey X	Survey Y	Survey Z
1	A	34T	15T	22T	36T	12T	-	09T	-
	B	34R	15R	22R	36R	12R	-	09R	-
2	A	15T	22T	36T	34T	12T	09T	05T	01T
	B	15R	22R	36R	34R	12R	09R	05R	01R
3	A	22T	36T	34T	15T	05T	01T	12T	09T
	B	22R	36R	34R	15R	05R	01R	12R	09R
4	A	01T	12T	09T	05T	34T	15T	22T	36T
	B	01R	12R	09R	05R	34R	15R	22R	36R
5	A	12T	09T	05T	01T	15T	22T	36T	34T
	B	12R	09R	05R	01R	15R	22R	36R	34R
6	A	05T	01T	12T	09T	22T	36T	34T	15T
	B	05R	01R	12R	09R	22R	36R	34R	15R
7	A	01T	05T	-	-	-	-	-	-
	B	01R	05T	-	-	-	-	-	-

2.1.1 DATA COLLECTION

Data was collected using standardised surveys to capture the information presented in **Table 2.** Data sheets were completed even when birds were not recorded as absence data was required for data analysis. This data was collected for both Carnaby's Cockatoo and all other bird species recorded.

Table 2: Data collected at reference and impact sites

	Data	Specifics
Collect for each survey site (turbine/reference site)	Observer name	
	Date	
	Unique point identifier	
	GPS location	UTM
	30 min search start time	24 hour time
	30 min search finish time	24 hour time
	Wind speed	m/s
	Air temperature	°C
	Estimate of cloudiness	% cover
	Habitat type and quality	
	Distance to nearest remnant veg	metres
Collect for each bird or flock	Species name	
	Number of individuals	
	Distance from turbine	0-250 m 250-500 m 500-1,000 m
	Activity	Landed or fly-over
	Flight direction (for Carnaby's Cockatoo)	Compass bearings e.g. flying west to east
	Flight height estimate*	0-20 m: below rotor height 20-150 m: at rotor height 150 m+: above rotor height

*Rotor swept area heights (RSA heights) are between 20 and 150 metres above ground for the largest turbines expected to be constructed.

Opportunistic Carnaby's Cockatoo sightings were also recorded in addition to any night roosts that were located.

2.1.2 DATA ANALYSIS AND REPORTING

As these are baseline surveys, the bird count data and flight heights is presented as a collation and summary of raw numbers. ANOVA methods similar to those outlined by Underwood (1991) will be completed once future data sets are obtained to allow for a comparison to the baseline data. This requires sampling after turbine construction using the standardised methodology.

2.2 CORRECTION FACTORS

2.2.1 CARCASS PERSISTENCE – IMPACT OF SCAVENGERS

Carcass removal trials estimate the impact of scavengers on carcass counts. Carcass counts often under-estimate the actual impact of wind farms as scavengers may remove carcasses before they can be found by humans. Carcass removal trials were used to determine a correction factor that will be used in future data analysis to accurately reflect any impacts of the wind farm. The results from these trials will also determine how often mortality surveys will need to be conducted.

Carcasses were placed around wind turbines and monitored at regular intervals until taken by a scavenger or decomposed.

Trials were undertaken at eight turbine sites where 80 carcasses of varying size classes (**Table 3**) were randomly distributed within a 250m by 250m area around the turbine base. Carcasses were tagged for identification and a GPS location taken. **Figure 2** shows the carcass search area around a turbine or reference site and transects that were walked.

Due to the unexpectedly high scavenger activity levels observed in the field, each impact site was searched every second day and to record carcass removal by scavengers. One 1-4 kg carcass at each site was also monitored using a Reconyx HC 500 motion camera to determine which scavenger species were present.

Table 3: Carcass size classes used in to determine scavenger impact

Size class	Weight (grams)	Type used
Small	10 to 100	Chicks, budgerigars, and cockatiels
Medium	100 to 1000	Pigeons and small chickens
Large	1000 to 4000	Ducks and roosters/large chickens

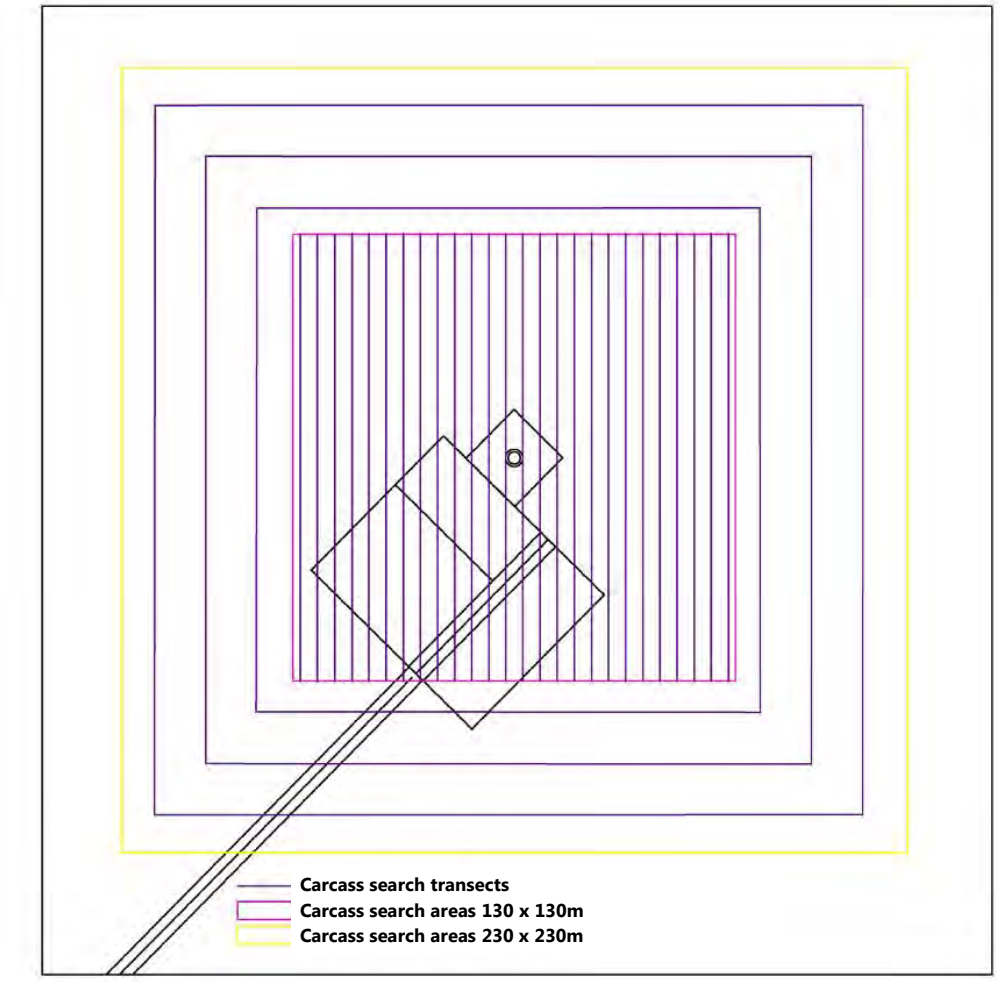

Figure 2: Carcass persistence transect walk lines for each site (turbine or reference) (Wood 2015)

Data Analysis

Kaplan-Meier survival analysis was used be used to generate a correction factor based on persistence of carcasses in the landscape (Pollock *et al.* 1989). This method determines how long a carcass will remain in the field before being taken by a scavenger which is converted to a correction factor for use on raw counts in the mortality surveys. Data was analysed using XLSTAT.

2.2.2 SEARCHER EFFICICENCY

Carcass counts at wind farm sites can be biased due to potential differences in searcher efficiency and being able to only sample a proportion of the wind farm site. Differences in searcher efficiency can arise from differing levels of survey experience and site visibility from differences in vegetation cover and terrain. Studies have shown that when detection biases are not taken into account, human searchers greatly underestimate the number of animals killed by wind turbines (Korner-Nievergelt et al. 2013).

Searcher efficiency trials were undertaken to determine a correction factor which is site-specific for the Badgingarra Wind Farm site and also personnel-specific for Ecoscape staff. Design was similar to the carcass persistence trials, however carcasses were placed out by a 'tester' without the 'searchers' knowledge. Ten carcasses from the various size classes were randomly distributed at turbine sites. The 'searcher' was then asked to retrieve as many carcasses as possible while walking transects as shown in **Figure 2**.

The searcher efficiency correction factor was calculated using the formula below (Bird Studies Canada *et al.* 2016).

$$Se = \sum_{i=0}^{n} \frac{p_i}{P_i} * s_i$$

Pi = Number of carcasses placed in trials completed by searcher i

pi = Number of carcasses found by searcher i during trials

si = Proportion of turbines that were searched by searcher i

n = Total number of searchers

(Bird Studies Canada et al. 2016)

3 RESULTS

The survey dates for the collection of the baseline Carnaby's Cockatoo and other bird data for the 2017/2018 survey season are outlined in **Table 4**.

Table 4: Baseline survey types and dates 2017/2018 season

Survey type	Survey period 1 (July to Sep) Inland breeding	Survey period 2 (Dec to Feb) Coastal feeding
Baseline Carnaby's and other birds	Survey event 1: 6 to 12 October 2017 Survey event 2: 2 to 8 December 2017	Survey event 3: 9 to 16 Feb 2018 Survey event 4: 9 to 16 April 2018
Carcass persistence	Not required	Survey event 3: 9 to 16 Feb 2018 Survey event 4: 9 to 16 April 2018
Searcher efficiency	Not required	9 to 16 Feb 2018

The results reported are from sequential survey events that form the baseline monitoring for the period October 2017 to April 2018 to coincide with peak Carnaby's Cockatoo migration and activity times.

3.1 BASELINE CARNABY'S COCKATOO AND OTHER BIRD DATA

Carnaby's Cockatoo was recorded from 75% of survey sites (12 out of 16) (**Map 3**). These were seven impact sites and five reference sites with records summarised in **Appendix 1**.

Carnaby's cockatoo - raw counts

Sixty-three percent of Carnaby's Cockatoo records were counted during the early morning surveys (34 surveys) and the remaining counts (37% or 20 surveys) were from the late afternoon. Abundance ranged from records of single individuals up to a large flock of 489 birds at reference site 22 in December 2017 and flying below rotor height (<20 m). In total, 3751 Carnaby's Cockatoo were counted over the 2017/2018 survey period and represented 36.1% of all birds counted. The highest counts were recorded from Turbine 1 and Reference sites 1, 9, 22 and 36 (**Table 5**).

Table 5: Carnaby's Cockatoo raw counts by survey site (October 2017 to April 2018)

	Turbine sites								Reference sites							
Site	Site 1	Site 5	Site 9	Site 12	Site 15	Site 22	Site 34	Site 36	Site 1	Site 5	Site 9	Site 12	Site 15	Site 22	Site 34	Site 36
Carnaby's cockatoo count	700	154	123	85	23	2	0	1	777	0	906	0	99	604	0	277

Table 6 outlines Carnaby's Cockatoo counts over the four survey periods.

Table 6: Carnaby's Cockatoo raw counts by survey period (October 2017 to April 2018)

Survey Period	Carnaby's cockatoo count
1 : October 2017	148
2 : December 2017	515
3 : February 2018	1815
4 : April 2018	1273
TOTAL	**3751**

Carnaby's cockatoo – flight heights

Of the 54 surveys where Carnaby's Cockatoo was present, 10 of these where heard only and hence have no count or flight height data recorded. In regards to counts, it was observed that 278 (9%) of Carnaby's Cockatoo were estimated to be flying at rotor height. These observations were from Turbines 5 and 15 and Reference site 9.

All bird species – raw counts

A total of 66 bird species (including Carnaby's Cockatoo) were recorded from the baseline surveys. Forty-five species were recorded from impact sites and 64 species were recorded from reference sites. **Table 7** provides the top 20 bird species recorded during the baseline surveys. These 20 species are 90.1% of the cumulative count data (8835 counts), with the remaining 9.9% (not shown here) consisting of an additional 46 species and 972 individuals. Future surveys will be compared back to baseline data to determine if there is any impact on Carnaby's Cockatoo and other birds from wind farm operation.

Table 7: Top 20 bird species by fractional rank and percent species composition

Rank	Species	Counts	% composition
1	Carnaby's Cockatoo	3541	36.1
2	Australian Raven	896	9.1
3	Galah	680	6.9
4	Straw-necked Ibis	560	5.7
5	White-cheeked Honeyeater	546	5.6
6	Australian Magpie	433	4.4
7	Magpie-lark	346	3.5
8	Silvereye	278	2.8
9	Little Corella	265	2.7
10	Brown Honeyeater	192	2.0
11	White-winged Fairy-wren	167	1.7
12	Yellow-rumped Thornbill	144	1.5
13	Australian Ringneck	124	1.3
14	Willie Wagtail	124	1.3
15	Tawny-crowned Honeyeater	118	1.2
16	Rufous Songlark	91	0.9

Rank	Species	Counts	% composition
17	Australian Kestrel	89	0.9
18	Red Wattlebird	86	0.9
19	Brown Songlark	78	0.8
20	White-fronted Chat	77	0.8
	TOTALS	**8835 records**	**90.1%**

3.2 CARNABY'S OPPORTUNISTIC AND ROOST DATA

From the opportunistic records, Carnaby's Cockatoo was either feeding or flying below rotor height (~<20 m). Opportunistic records were also collected during the surveys and are summarised in **Appendix 2**. For survey event three, the majority of records are primarily in association with the roost site at the intersection of Cadda Rd and Munbinea Rd during the December surveys when birds would be migrating to the coast to feed. All monitoring data can be provided upon request.

Two new roost sites were located during the field surveys. The first of these is located at the intersection of Cadda Rd and Munbinea Rd (50J 330173E, 6636191N). Approximately 100 Carnaby's Cockatoos were recorded regularly from this roost site during the December field surveys. The precise location of the second roost was not established, but is located west/south-west of Turbine 01, possibly in tall trees near a dam along Yerramullah Rd, approximately 600m NW of Reference Site 01. A flock of approximately 300 birds was noted roosting in this area during the February field surveys. In addition to the three known roosts (provided by Birdlife Australia) there are now five recorded roosts in the vicinity of the Badgingarra Wind Farm) (**Map 4**).

3.3 CORRECTION FACTORS

3.3.1 CARCASS PERSISTENCE – IMPACT OF SCAVENGERS

Analysis showed that on average, a carcass persisted for 3.5 days in the field before it was taken by a scavenger. Confidence intervals were small which indicates replication was adequate resulting in precise data.

When carcasses were first checked on day two (two days after the initial drop), 53% persisted in the field (i.e. not scavenged). On day four this reduced to 38% of carcasses persisting in the field and on day six only 27% of carcasses were left un-scavenged (**Figure 3**).

The initial correction factor to incorporate the impact of scavengers in post-construction surveys will vary dependent on which day of the survey the carcass is found. For example if carcasses are found on day one, 0.725 would be used. If carcasses are found on day six, 0.267 would be used. As surveys will not be on consecutive days, interpolation can be used based on the results of **Table 8**. The correction factor will require adjustment as additional data is acquired.

Table 8: Carcass persistence rates in the field based on Kaplan-Meier survival analysis

Survey day	Carcass persistence correction factor	Carcass persistence
1 day after carcass drop	0.725*	73%
2 days after carcass drop	0.525	53%
4 days after carcass drop	0.381	38%
6 days after carcass drop	0.267	27%

*this is an interpolated value based on field data.

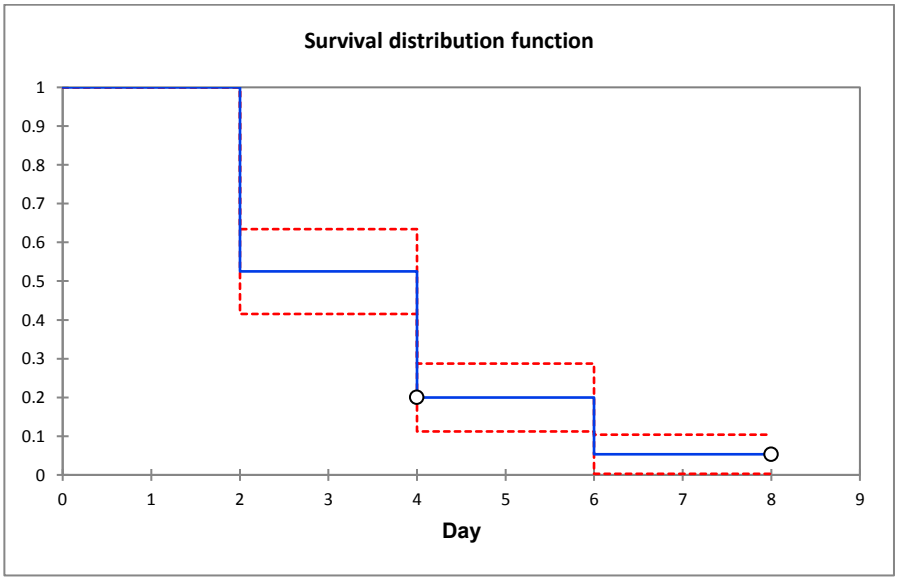

Figure 3: The impact of scavengers on carcass persistence at the Badgingarra Wind Farm site

Motion camera imagery indicated that foxes removed the majority of large carcasses, however, wedge-tailed eagles and cats were also recorded. Additional trials will be completed in association with ongoing monitoring to take into account the substantial impact of scavengers during post-construction impact surveys. This will include placing motion cameras on small and medium size carcasses.

Un-scavenged carcasses were all from the small size class (i.e. chicks and cockatiels).

3.3.2 SEARCHER EFFICIENCY

Of the 80 carcasses that were placed out, eight were scavenged prior to the trial beginning and hence were removed from analysis. Based on this survey, the searcher efficiency correction factor for Ecoscape zoologists at the Badgingarra Wind Farm site is 0.84, or out of the 72 carcasses that were placed, 84% were found by the searchers. All carcasses missed in the field were from the 'small' size class of carcases which were either chicks or cockatiels.

4 DISCUSSION

SURVEYS COMPLETED 2017/2018 SEASON

Site use and flight height

Carnaby's Cockatoos were recorded utilising the Badgingarra Wind Farm site with counts varying substantially, from individuals to flocks of up to 400+ birds. Despite frequent site use, the majority of Carnaby's cockatoos seen during surveys and opportunistically were observed to be flying below rotor height (~<20 m). Only 9% were seen to fly at rotor height during the standardised surveys. A caveat on the flight height data is that the zoologists reported that it was difficult to estimate bird flight heights due to the absence of features in the landscape to provide a point of reference. It should be noted that in these initial surveys the bottom of rotor height was thought to be 35 m, hence the height data in this table was classed from 0 to 35 m, 35 to 125 m and 125 m+. This has since been clarified that the bottom of rotor height of the proposed wind turbine model is actually 20 m. Despite this discrepancy, visually discerning between 35 and 20 metres in the field with no points of reference is considered unlikely to be reliable. In future surveys, it is anticipated that the turbines may be a useful point of reference and that further flight height data will be collected for analysis and clarification.

Anecdotally, the zoologists undertaking the surveys observed Carnaby's Cockatoo to fly at rotor height when flying from higher ground to feed. At the survey sites, it was estimated that the birds counted generally didn't fly over 20 m in elevation.

Despite the limited sample size of only one survey season, these results are optimistic regarding the potential impact of the operating windfarm on Carnaby's Cockatoo. These initial results suggest that the majority of Carnaby's Cockatoo fly below rotor height. Ongoing monitoring and the use of turbines as a point of reference will provide adequate data to estimate the flight heights of Carnaby's Cockatoo at the Badgingarra Wind Farm site.

Survey timing

Due to timing constraints some surveys were completed outside recommended times which are July to September and December to February. The surveys took place in October, December, February and April. The first survey in October yielded low counts of Carnaby's Cockatoo (148) consistent with being outside of their migration period. It is recommended that the next round of surveys begin July at the earliest and September at the latest.

In contrast, the final survey took place in April which is outside the recommended survey period but yielded counts consistent with migration to the coast for feeding. This annual variation in flight times is based upon local resource availability as driven by rainfall (Ecoscape 2017).

Carcass persistence trials - The substantial impact of scavengers

In preparation for Carnaby's Cockatoo and other bird impact surveys once the wind farm is in operation, carcass persistence surveys were undertaken to determine the impact of scavengers in the field. Raw carcass counts often under-estimate the actual impact of wind farms as scavengers may remove carcasses before they can be found by humans. Carcass removal trials were used to generate a correction factor to more accurately reflect any windfarm impacts if they exist. Scavengers were found to have a substantial effect on carcass persistence in the field. It was found that after only two days of a carcass being dropped in the field it had only a 53% chance of still being there and not taken by a scavenger. This decreased as the survey went on, when on day six a carcass had only 27% chance of still being in the field. While carcass persistence steadily declined in the field, the longer it was left out, the rate of scavenging did decrease and the only carcasses left were small birds. These may have simply been overlooked as larger more palatable carcasses were selected and taken first.

Analysis indicates the need for frequent mortality surveys when operation commences. A correction factor was also generated to be applied to the results from the future mortality surveys. On average, it was found

that a carcass would persist in the field for 3.5 days before being taken by a scavenger. Based on this and the high rates of scavenging measured in the field it is recommended that turbine sites be re-surveyed every three to four days during Carnaby's Cockatoo peak flight periods. This will be more efficient than monthly surveys as conducted on other wind farms, as it is more ecologically appropriate to coincide with peak Carnaby's Cockatoo flight times.

Additionally, the correction factor to be applied to any carcasses found during post-construction surveys would be 0.725 on day one of survey, 0.525 on day two of survey etcetera as per the results in **Table 8**. This means that on each day of survey the correction factor would change based upon the survival analysis from the baseline carcass persistence surveys. Using this correction factor in conjunction with the searcher efficiency correction factor (below) will give a corrected and more accurate indication of any impact the wind turbines may have on Carnaby's Cockatoo and other bird species.

Searcher efficiency trials

Carcass counts at wind farm sites can be biased due to potential differences in searcher efficiency and being able to only sample a proportion of the wind farm site. Differences in searcher efficiency can arise from differing levels of survey experience and site visibility from differences in vegetation cover and terrain. Studies have shown that when detection biases are not taken into account, human searchers greatly underestimate the number of animals killed by wind turbines (Korner-Nievergelt et al. 2013). Surveys found that searcher efficiency was high at 84% due to the degraded nature of the sites offering little in the way of obstruction during carcass searches.

FUTURE SURVEYS POST WIND FARM OPERATION

Table 10 & Table 11 provides a brief overview of future surveys to determine any impacts of the windfarm. More detail is provided below.

Bird surveys for comparison with baseline data

Ongoing bird surveys are required to determine if the wind farm has any impact on bird abundance. To provide comparable data, methodology and site selection should be the same as for the baseline surveys, including surveys at dusk and dawn.

Carcass persistence surveys

As the number and impact of scavengers may vary seasonally, carcass persistence surveys are recommended twice a year. One survey for each migration period would be adequate.

Mortality and searcher efficiency surveys

Bird mortality surveys are required to be conducted during peak Carnaby's Cockatoo flight times for consistency with the baseline data. Conducting mortality surveys for two years post operation will provide adequate data to determine if the turbines have any impact. This also complies with Condition 20 as listed in the Shire of Dandaragan Planning Approval.

In addition to the standardised mortality surveys, if site staff locate any dead birds, they should be collected if possible with the following basic data forwarded to Ecoscape:

- bird species;
- condition of bird in regards to decomposition (ideally photos);
- date found; and
- GPS position or distance & direction from nearest turbine and its number.

If the species is unknown please freeze for identification by an Ecoscape zoologist.

From the baseline surveys, carcass persistence surveys and searcher efficiency surveys, there were no dead Carnaby's Cockatoos found. Therefore, we can assume the background rate of Carnaby's Cockatoo deaths prior to windfarm operation is close to zero. The original 8 turbine sites require re-survey but the reference sites do not. This is because during initial surveys the background death rate of Carnaby's Cockatoo was

close to zero (i.e. no dead birds were found). These reference sites should be replaced with an additional 8 turbine sites for the mortality surveys. This would mean only three surveys of 8 days each would be required within each migration period. This is due to the sufficient amount of replication with 16 turbine sites in total. A sample mortality survey matrix is included below outlining survey requirements and timing (**Table 9**).

For consistency with baseline bird surveys it is recommended that mortality surveys occur as follows:

- within the two seasons Carnaby's Cockatoo are most active in the region. July to September and December to March/April;
- minimum of three sampling events within each migration season;
- a sampling event is approximately eight consecutive days;
- use the same 8 turbine sites as used in the baseline bird count surveys in addition to 8 randomly selected turbine sites;
- survey the 16 turbines over the eight day survey period; and
- sites to be sampled systematically every two days due to extremely high scavenger activity.

Table 9: Sample mortality survey matrix for an 8 day survey

		Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8
MORNING SHIFT e.g. 8am to 12pm	Turbine 1	survey	no survey	survey	no survey	survey	no survey	survey	no survey
	Turbine 2	survey	no survey	survey	no survey	survey	no survey	survey	no survey
	Turbine 3	survey	no survey	survey	no survey	survey	no survey	survey	no survey
	Turbine 4	survey	no survey	survey	no survey	survey	no survey	survey	no survey
AFTERNOON SHIFT e.g. 1 to 5pm	Turbine 5	survey	no survey	survey	no survey	survey	no survey	survey	no survey
	Turbine 6	survey	no survey	survey	no survey	survey	no survey	survey	no survey
	Turbine 7	survey	no survey	survey	no survey	survey	no survey	survey	no survey
	Turbine 8	survey	no survey	survey	no survey	survey	no survey	survey	no survey
MORNING SHIFT e.g. 8am to 12pm	Turbine 9	no survey	survey	no survey	survey	no survey	survey	no survey	survey
	Turbine 10	no survey	survey	no survey	survey	no survey	survey	no survey	survey
	Turbine 11	no survey	survey	no survey	survey	no survey	survey	no survey	survey
	Turbine 12	no survey	survey	no survey	survey	no survey	survey	no survey	survey
AFTERNOON SHIFT e.g. 1 to 5pm	Turbine 13	no survey	survey	no survey	survey	no survey	survey	no survey	survey
	Turbine 14	no survey	survey	no survey	survey	no survey	survey	no survey	survey
	Turbine 15	no survey	survey	no survey	survey	no survey	survey	no survey	survey
	Turbine 16	no survey	survey	no survey	survey	no survey	survey	no survey	survey

Table 10: Ongoing monitoring for Carnaby's Cockatoo and other birds

Survey type	Frequency	Survey time of day
Baseline bird data	Two surveys per migration period which is four week long surveys per year.	Dusk and dawn as for baseline surveys
Carcass persistence surveys	One survey per migration period to be conducted during ongoing baseline bird surveys	Anytime of day
Searcher efficiency	One survey per migration period to be conducted by those doing the mortality surveys	Anytime of day
Mortality surveys	Three survey events (8 days) in each migration season	Anytime of day

5 MONITORING PLAN

An overview of the surveys completed to date and future surveys are outlined below (**Table 11**).

Surveys are required at the same sites as used for the baseline data following the standardised methodology. An exception to this is the mortality surveys, as explained previously in **Section 4.**

Surveys should take place during the biannual peak flight times. These are:

- **July to September** for adult west-east migration for breeding
- **December to April** for adult and fledgling east-west migration for feeding.

Survey dates will be dependent upon when the wind farm is operational. Below is an outline of survey timing assuming the wind farm is operational by January 2019. This date may vary in which case surveys timings can be amended to suit.

The baseline bird surveys are not dependent on the wind farm being operational and are scheduled for completion later in 2018.

Table 11: Overview of monitoring program

SURVEY TYPE	SURVEY DETAILS	SITES		TIMING
		1 - 8 Turbine (impacted)	9 - 16 Reference	
Baseline and ongoing bird surveys	Pre-construction and post operation Two survey events in each survey season A survey event is approximately eight days	✓	✓	Late 2017: two survey events Early 2018: two survey events **COMPLETED** Late 2018: two survey events Early 2019: two survey events **SCHEDULED** Late 2019: two survey events Early 2020: two survey events **OPERATIONAL PHASE**
Carcass persistence surveys	One survey event in each survey season To be conducted during ongoing baseline bird surveys	✓	X	Early 2018: one survey event **COMPLETED** Early 2019: one survey event Late 2019: one survey event Early 2020: one survey event **OPERATIONAL PHASE**
Searcher efficiency surveys	One survey event in each survey season To be conducted prior to ongoing mortality surveys	✓	X	Early 2018: one survey event **COMPLETED** Early 2019: one survey event Late 2019: one survey event Early 2020: one survey event **OPERATIONAL PHASE**
Mortality surveys	Three survey events in each survey season	✓ plus 8 new turbine sites	X	Early 2019: three survey events **OPERATIONAL PHASE** Late 2019: three survey events Early 2020: three survey events **OPERATIONAL PHASE**

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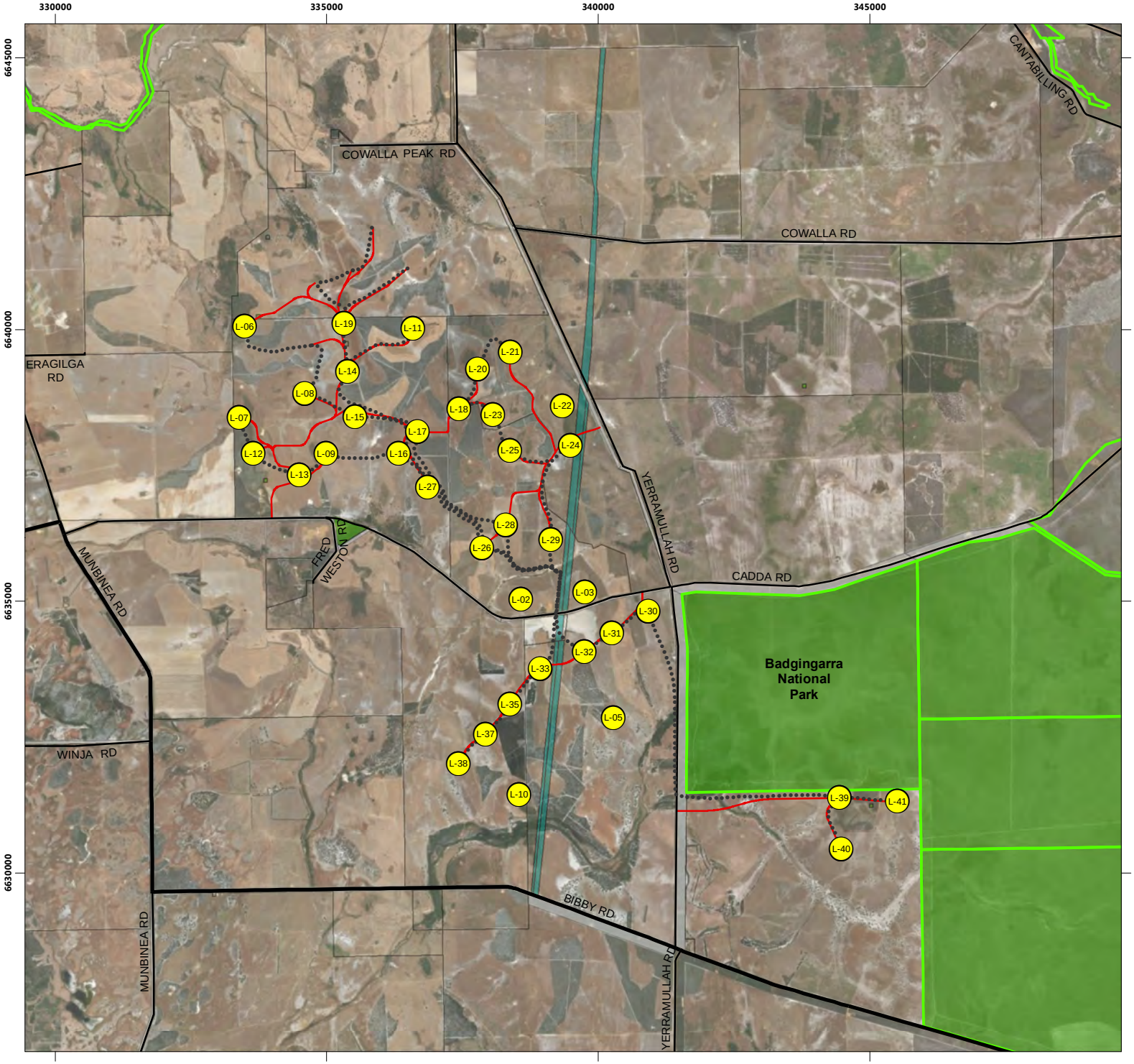
MAPS



LEGEND

- Wind Turbine Location
- Cables
- State Road
- Local Road
- Access Tracks
- DPAW Managed Lands

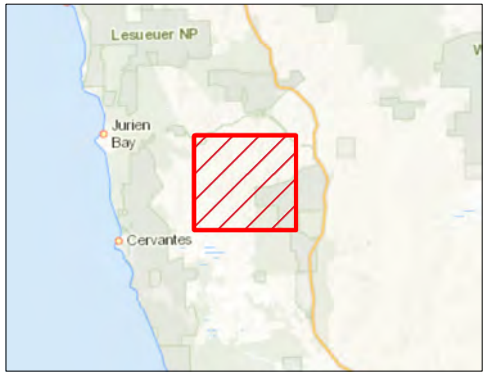
Cadastre

- Property Boundary

Usage

- Easement
- Reserve
- Road Isolation

DATA SOURCES :
SOURCE DATA: APA GROUP
SERVICE LAYERS: SOURCE: ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY



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LOCATION OF PROJECT & PROPOSED TURBINE LOCATIONS

BIRD MONITORING
BADGINGARRA WIND FARM

APA GROUP

COORDINATE SYSTEM: GDA 1994 MGA ZONE 50
PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
UNITS: METER

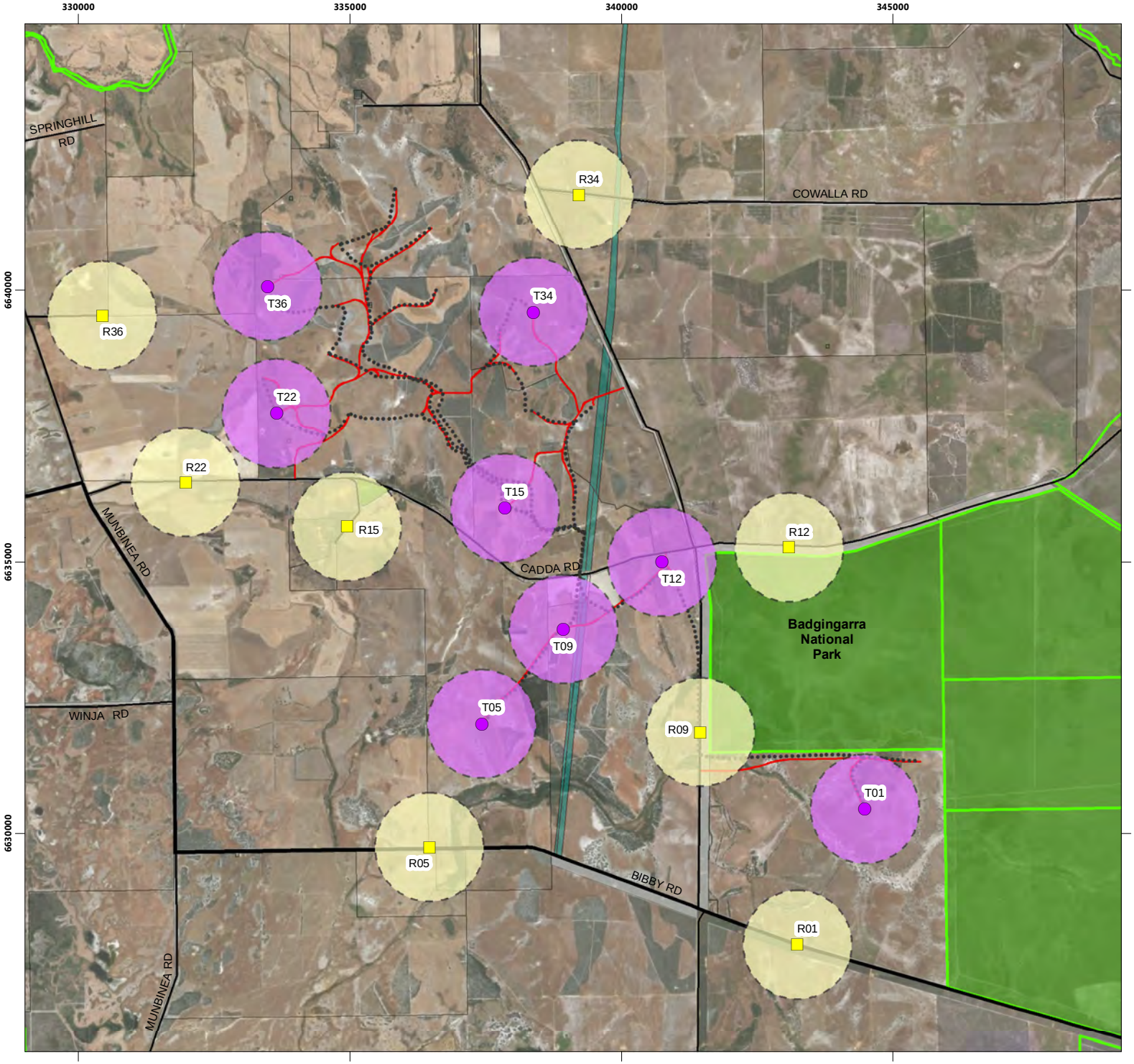
SCALE: 1:100,000 @ A4

0 1 2 3 km

PROJECT NO: 4113-17

REV	AUTHOR	APPROVED	DATE
0	CB	JN	20/6/2018

MAP 01



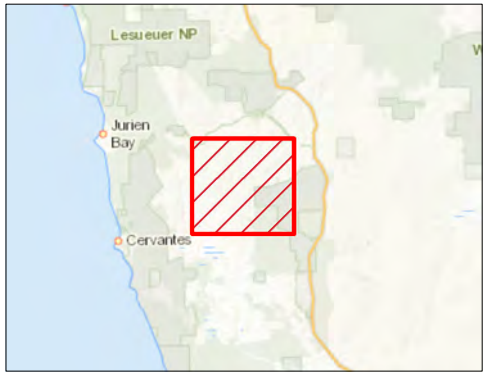
LEGEND

- Impact Site
- Reference Site
- Impact Site 1 km buffer
- Reference Site 1 km buffer
- Cables
- State Road
- Local Road
- Access Tracks
- DBCA Managed Lands

Cadastre
- Property Boundary

Usage
- Easement
- Reserve
- Road Isolation

DATA SOURCES :
SOURCE DATA: APA GROUP
SERVICE LAYERS: SOURCE: ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY



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CARNABY'S COCKATOO IMPACT AND REFERENCE SITES

BIRD MONITORING BADGINGARRA WIND FARM

APA GROUP

COORDINATE SYSTEM: GDA 1994 MGA ZONE 50
PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
UNITS: METER

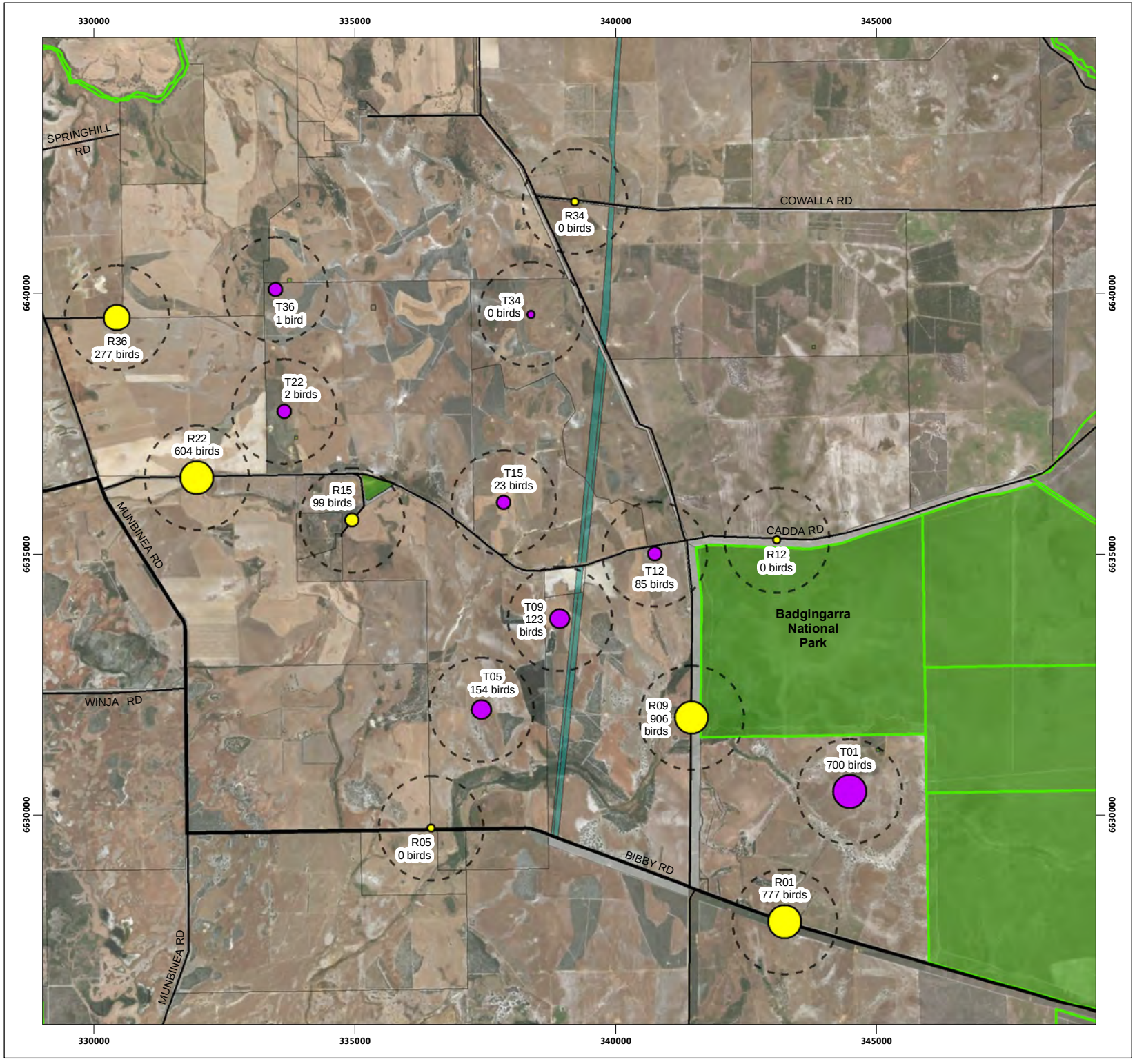
SCALE: 1:100,000 @ A4

0 1 2 3 km

PROJECT NO: 4113-17

REV	AUTHOR	APPROVED	DATE
0	CB	JN	20/6/2017

MAP 02



LEGEND

Impact sites
Bird count
- 0
- 1 - 100
- 101 - 200
- 501 - 700

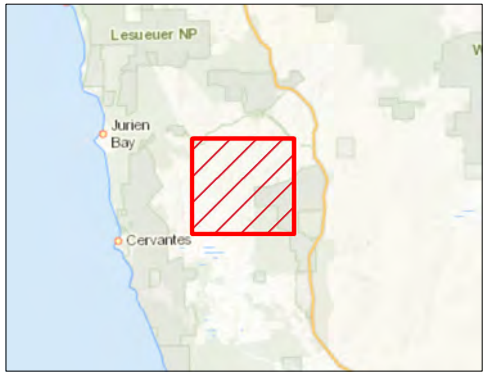
Reference sites
Bird count
- 0
- 1 - 100
- 201 - 500
- 501 - 906

Monitoring Sites 1 km buffer
DBCA Managed Lands

Cadastre
Property Boundary

Usage
Easement
Reserve
Road Isolation

DATA SOURCES:
SOURCE DATA: APA GROUP
SERVICE LAYERS: SOURCE: ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY



ecoscape

CARNABY'S COCKATOO COUNTS IMPACT AND REFERENCE SITES

BIRD MONITORING BADGINGARRA WIND FARM

APA GROUP

COORDINATE SYSTEM: GDA 1994 MGA ZONE 50
PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
UNITS: METER

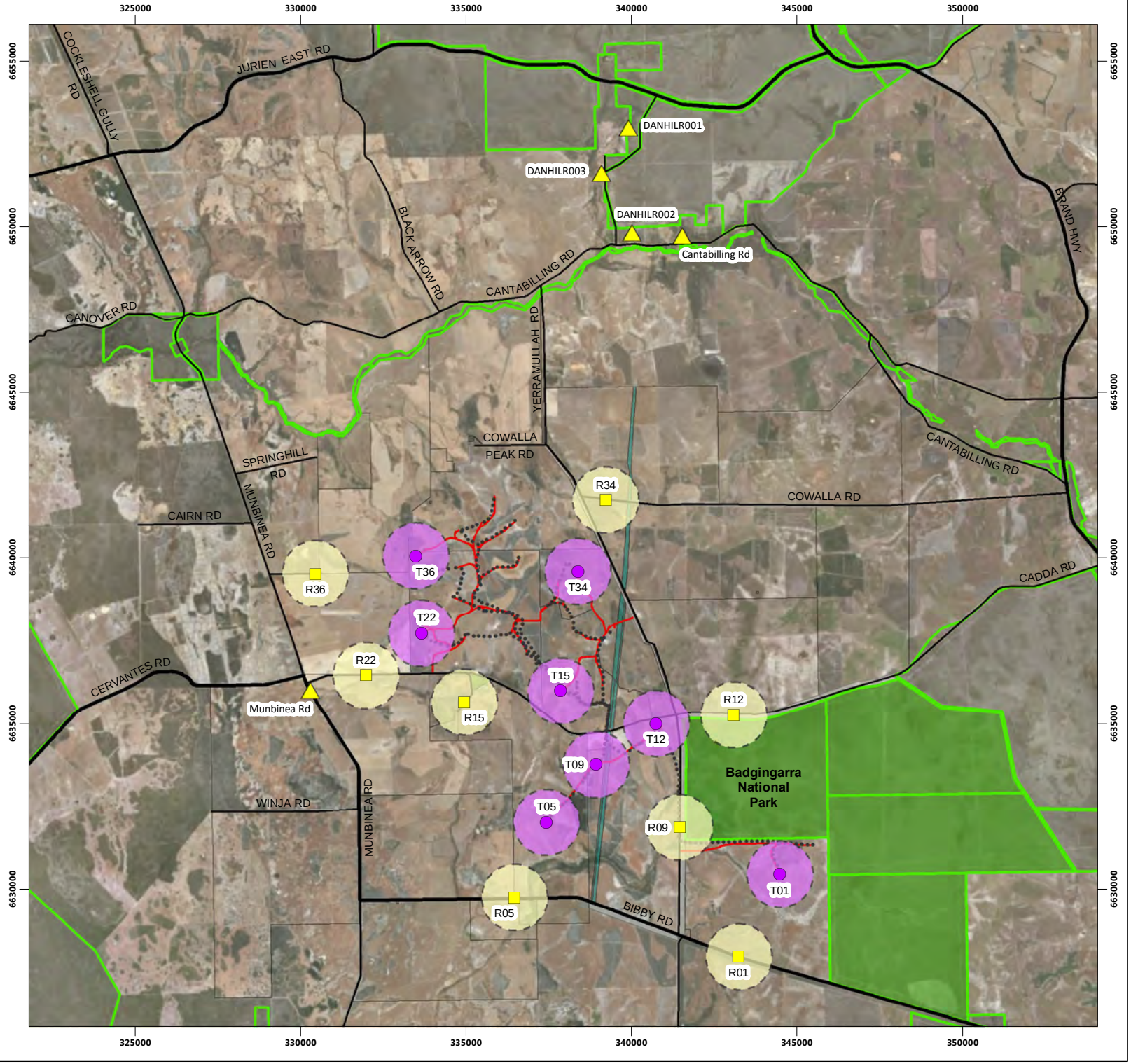
SCALE: 1:100,000 @ A4

0 1 2 3 km

PROJECT NO: 4113-17

REV	AUTHOR	APPROVED	DATE
0	CB	JN	20/6/2018

MAP 03



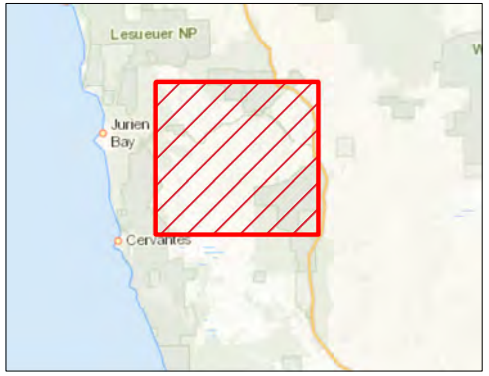
LEGEND

- Impact Site
- Reference Site
- Impact Site 1 km buffer
- Reference Site 1 km buffer
- Carnaby's Cockatoo Roost Location
- Cables
- State Road
- Local Road
- Access Tracks
- DBCA Managed Lands

Cadastre
- Property Boundary

Usage
- Easement
- Reserve
- Road Isolation

DATA SOURCES :
SOURCE DATA: APA GROUP
SERVICE LAYERS: SOURCE: ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY



ecoscape

CARNABY'S COCKATOO ROOST LOCATIONS

BIRD MONITORING BADGINGARRA WIND FARM

APA GROUP

COORDINATE SYSTEM: GDA 1994 MGA ZONE 50
PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
UNITS: METER

SCALE: 1:160,000 @ A4

0 1 2 3 4 5 km

PROJECT NO: 4113-17

REV	AUTHOR	APPROVED	DATE
0	CB	JN	20/6/2018

MAP 04

APPENDIX ONE CARNABY'S COCKATOO SURVEY RESULTS

Please note that during initial surveys the bottom of turbine rotor height was incorrectly believed to be 35 m, hence the height estimates in this table was classed from 0 to 35m, 35 to 125 m and 125 m+. This has since been clarified that the bottom of rotor height for the proposed wind turbine model is actually 20 m. Despite this discrepancy, visually discerning between 35 and 20 metres in the field with no points of reference is considered unlikely to be accurate. In future surveys, it is anticipated that the turbines may be a useful point of reference and that further flight height data will be collected for analysis and clarification.

Table 12: Carnaby's cockatoo survey results (October 2017 to April 2018)

Site	Date	Time	Abundance	Height (m)	Distance (m)	Comments
Turbine 1	11/02/2018	19:10-19:40	Unknown	-	-	Heard only, to the west of survey point – presumed to be same flock of 300 birds seen shortly before at 50J 342697S 6631491E. Heard to be travelling in a WSW direction
	12/02/2018	18:15-18:45	Unknown	-	-	Heard only, appeared to be travelling in a SSW direction
	13/02/2018	5:45-6:15	300	0-35	250-500	Seen flying SE'ly direction initially, following drainage line, then turned east towards native bushland area.
	11/04/2018	18:00-18:15	380	0-35	>1000	c. 80 flying SW along remnant vegetation along drainage line > 1 km west of survey point at 1800. c. 40 landed at water trough then followed south-west. Likely same flock seen shortly beforehand (see Appendix 2). Second flock of c. 300 followed the same track at 1815.
	13/04/2018	6:25	Unknown	-	-	Heard distantly
	14/04/2018	8:47	20	0-35	c. 1500	Flying low across paddock c. 1.5km west of point
Reference 1	2/12/2017	16:55-17:25	3	0-35	20	Flying in a westerly direction low over remnant heath along Bibby Rd
	4/12/12017	17:05-17:35	7	0-35	30, 450	Perched in remnant eucalypt grove in paddock NE of point, only seen flying between trees initially. Later flew south-west towards survey point and landed in remnant roadside heath 10m from point
	5/12/2017	4:55-5:25	9	0-35	10-400	Three seen 450m west of survey point along Bibby Rd, perched in *Eucalyptus macrocarpa* in remnant heath between Bibby and windfarm point. Single bird perched in *Adenanthos* south of survey point with three more nearby feeding in vegetation.
	12/02/2018	17:00-17:30	230	0-35	500-1000	Seen flying north following Yeeramullah Rd before veering east to land at dam approximately 600m NW of survey point. Flock then flew into large eucalypt and pines behind dam - possibly a roost location.

Site	Date	Time	Abundance	Height (m)	Distance (m)	Comments
	13/02/2018	5:30-6:00	250	0-35	500-1000	Flock appeared on large eucalypts NW of site where they were seen perched the previous afternoon. After flying around the tops of the trees, flock moved east, landing in pines and eucalypts. In combination with record previous afternoon, strongly suggests roost location.
	14/02/2018	7:25-7:55	1	0-35	0	Flew directly over survey site in ENE direction towards stand of large *Eucalyptus*
	10/04/2018	16:00-16:30	27	0-35	800	Approximately 800m north of point flying in NNE direction
	11/04/2018	17:40-18:10	63	0-35	500, 800	One flying north approximately NNW of point, 62 passed approximately 500m west of point, flying N.
	12/04/2018	17:30-18:00	147	0-35	600	Same flight path as previous day, but stopped at dam 600m NNW of point to drink.
	13/04/2018	6:00-6:30	40	0-35	500	Heard NNW of point near dam they have used as drinking source previously, roost must be close to this point. Approximately 40 then seen flying south about 500m west of point into heath
Turbine 5	5/12/2017	7:48	1	35-125	1000	Flying over pines to east of survey point, travelling NNW
	13/02/2018	7:50-8:20	70	0-35	500-1000	First seen south of site flying ENE following remnant vegetation, before turning north and landing in pine trees ENE of site
	14/02/2018	6:50-7:20	80	0-35	250-1000	Feeding on remnant vegetation ESE of survey site. Remained for duration of survey
	11/04/2018	17:05	3	0-35, 35-125	1000	Circling over pine plantation c. 1km east of site, then flew SE. Lost from view, may have landed in pines but not seen or heard further.
Reference 5	6/12/2017	6:15-6:45	Unknown	-	-	Heard to east of point
Turbine 9	6/12/2017	5:35-6:05	3	0-35	500-1000	Flying parallel to Cadda Rd, travelling west
	9/02/2018	18:25-18:55	Unknown	-	-	Heard only, to SSW of survey site
	12/02/2018	16:45-17:15	50	0-35	2000	Seen in pines approximately 2 km S of survey site
	14/02/2018	6:10-6:40	70	0-35	500-1000	Flew from SE of site in a NW direction to land in pines S of site
Reference 9	5/12/2017	6:15-6:45	1	0-35	800	Perched in large eucalypt south-east of survey point
	9/02/2018	18:15-18:45	131	0-35	500-1000	Flying south along tree line before landing in flowering *Eucalyptus todtiana* 600m E of site. Flock then moved a further 300m S before turning due W and flying across Yerramullah Rd into pasture.

Site	Date	Time	Abundance	Height (m)	Distance (m)	Comments
	11/02/2018	17:55-18:25	251	0-125	500-1000	Travelled from a point SW of site in a NE direction to flowering *Eucalyptus todtiana* 600m due east of site. 76 of the 251 CBC seen were flying at 35-125m, turbine height.
	12/02/2018	17:20-18:50	100	0-35	500-1000	Seen feeding in road side vegetation approx. 700m north of site along Yerramullah Rd.
	13/02/2018	6:45-7:15	80	0-35	500-1000	Same location as previous days, 600m east of site in flowering *Eucalyptus todtiana*. Flock split with half heading north along gully/ tree line and the other half going SW across Yerramullah Rd into pasture.
	14/02/2018	6:10-6:40	79	0-35	0-250	Flew directly over site heading in a NE direction. Coming from same direction each morning from somewhere SW of site.
	15/02/2018	5:30-6:00	31	0-35	500-1000	Landed in same flowering *Eucalyptus todtiana* 600m east of site as previous mornings.
	11/04/2018	17:00-17:30	180	0-35	600	600m east of point perched in *Eucalyptus todtiana* and *Melaleuca* sp. Flock took off and flew north over heath with small groups breaking off to land in heath
	14/04/2018	6:35-7:05	3	0-35	500-1000	SE of point, flying south-east across pasture
	15/04/2018	6:00-6:30	50	0-35	600	Heard flying N somewhere to the north-east of point, too dark to see. 50 seen 600m E of point heading north. Flying along valley over *Eucalyptus todtiana* and *Melaleuca* tree line
Turbine 12	5/12/2017	6:19	Unknown	-	-	Heard distantly
	14/04/2018	6:30	80	0-35	500-600	Flying north along Yerramullah Rd, just east of road. Settled in heath near corner of Cadda Rd
	15/04/2018	8:31	5	0-35	1000	Flying north across paddocks about 1km west of survey point
Turbine 15	7/10/2017	6:10-6:40	20	0-125	800	Flying east along Cadda Rd
	14/02/2018	17:15-17:45	3	0-250	0-35	100m W of survey point, flying SE towards Cadda Rd
Reference 15	9/10/2017	7:40-8:10	10	0-35	600	Recorded N/NW of site flying in a W/SW direction
	13/02/2018	17:55-18:25	89	0-35	250-500	Seen NE of site, flying SE following a line of remnant vegetation. Settled into remnant vegetation west of site
	10/04/2018	6:55-7:25	Unknown	-	-	Heard to the south
Turbine 22	4/12/2017	5:13	2	0-35	200	Travelling in a northerly direction, landing in remnant heath c. 500m NNW of point
Reference 22	7/10/2017	7:00-7:30	15	0-35	800	Heading W/NW to dam and pine trees to forage

Site	Date	Time	Abundance	Height (m)	Distance (m)	Comments
	9/10/2017	5:15-5:45	100	0-35	-	Heard roosting W/SW of site before foraging along Cadda rd. to R22 1 hr after survey
	7/12/2017	16:45-17:15	489	0-35	0-250, 500-1000	Flock feeding in remnant heath along Cadda Rd, west of survey point. 34 birds flew east along Cadda Rd, 55 remained feeding along road, 400 flew short distance to feed in paddock and drink at dam
Turbine 36	7/10/2017	7:35-8:05	1	-	-	Heard only
	4/12/2017	5:30-6:00	Unknown	-	-	Heard distantly to the north of the survey point
Reference 36	7/10/2017	7:45-8:15	2	0-35	0	Flew over reference site heading NE
	10/04/2018	8:15	Unknown	-	-	Heard extremely distantly
	11/04/2018	7:10-7:40	15	0-35	800-1000	Small flock feeding in banksias 800-1000m east of survey point, present for duration of survey
	12/04/2018	6:35-7:05	50	0-35	750	Perched (presumed feeding) in banksias in remnant heath c. 750m north-east of survey point
	13/04/2018	1800-1830	210	0-35	1000-2000	c. 60 visited water trough just over 1km west of survey point at 1800, then flew into nearby trees close to Eragilga Rd. Flock of c. 150 joined them briefly at 1812, then all birds flew off low to the south along Munbinea Rd and settled in a line of trees c. 2km SW of point. Remained there until after conclusion of survey, suspected roost site

APPENDIX TWO CARNABY'S COCKATOO OPPORTUNISTIC RECORDS

Please note that during initial surveys the bottom of turbine rotor height was incorrectly believed to be 35 m, hence the height estimates in this table was classed from 0 to 35m, 35 to 125 m and 125 m+. This has since been clarified that the bottom of rotor height for the proposed wind turbine model is actually 20 m. Despite this discrepancy, visually discerning between 35 and 20 metres in the field with no points of reference is considered unlikely to be accurate. In future surveys, it is anticipated that the turbines may be a useful point of reference and that further flight height data will be collected for analysis and clarification.

Table 13: Carnaby's cockatoo opportunistic records (October 2017 to April 2018)

Location			Date	Time	Abundance	Height (m)	Direction of travel	Comments
Zone	Easting	Northing						
50J	330286	6636269	4/12/2017	5:20	150	0-35	-	Foraging in paddock and perched in adjacent trees
50J	330168	6636225	4/12/2017	7:24	c. 100	0-35	-	Perching in roadside eucalypts and pines on corner of Cadda and Munbinea Roads
50J	330289	6635966	4/12/2017	7:44	110	0-35	-	Perched in roadside trees
50J	330286	6636269	5/12/2017	8:10	c. 100	0-35	-	Feeding in paddock
50J	330284	6636269	5/12/2017	16:25	c. 75	0-35	-	Feeding in paddock
50J	330286	6636269	5/12/2017	18:38	100	0-35	-	Feeding in paddock and perching in roadside trees
50J	330289	6635966	6/12/2017	8:22	100	0-35	-	Perched in roadside trees along Munbinea Rd
50J	330042	6636570	6/12/2017	8:25	10	0-35	S	Flying south parallel to Munbinea Rd
50J	329936	6636894	6/12/2017	8:29	2	0-35	S	Perched in tree, flushed and flew south
50J	325320	6650065	6/12/2017	16:27	5	0-35	-	Feeding in roadside shrubs
50J	330286	6636269	6/12/2017	16:39	70	0-35	-	Feeding in paddock
50J	330286	6636269	6/12/2017	17:58	c. 100	0-35	-	Feeding in paddock and perching in roadside trees
50J	338858	6640828	8/12/2017	6:55	>1	0-35	-	One perched in roadside tree, others calling nearby but couldn't be seen
50J	342697	6631491	11/02/2018	19:00	300	0-35	S	Flew south to settle in low trees in paddock
50J	317425	6650055	13/02/2018	8:15	30	0-35	-	Feeding on Banksia
50J	337711	6635129	13/02/2018	18:30	3	0-35	E	Flying east along Cadda Rd
50J	319384	6651008	13/02/2018	8:15	5	0-35	S	Crossing Jurien Rd
50J	340470	6637467	13/02/2018	17:50	3	0-35	-	Feeding in road side vegetation
50J	339472	6629342	15/02/2018	6:00	40	0-35	-	Feeding on Banksia
50J	337846	6633656	16/02/2018	8:15	80	0-35	-	Feeding on pines and fallen pine cones on ground

Location			Date	Time	Abundance	Height (m)	Direction of travel	Comments
Zone	Easting	Northing						
50J	343552	6631475	11/04/2018	17:48	80	0-35	-	Circling low and perching in heath just north of GPS location
50J	328887	6640020	14/04/2018	9:13	2	0-35	-	Perched in banksia next to Munbinea Rd
50J	343427	6631472	15/04/2018	7:36	40	0-35	SSW	Flying low to the ground (0-35m)

Carnaby's Cockatoo and Other Birds Year One Operational Monitoring

APA

ecoscape

VERSION	AUTHOR	QA REVIEWER	APPROVED	DATE
Draft rev 0	Bruce Turner	L. Atkins Lyn Atkins Principal Ecologist	L. Atkins Lyn Atkins Principal Ecologist	10/12/2019

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SUMMARY

Ecoscape conducted operational monitoring surveys for Carnaby's Cockatoo and other birds at APA Group's Badgingarra Wind Farm Development Project from February to September 2019. Surveys were undertaken during two separate flight periods, being February to April 2019 and July to September 2019.

Bird monitoring surveys were undertaken at reference sites and selected turbines during these flight periods.

Site use and abundance surveys to record the abundance of Carnaby's Cockatoo and other bird species that occurred in the vicinity of the windfarm were undertaken. Two surveys were conducted in each of the two flight periods. Results indicated an abundance of Carnaby's Cockatoo of 400+ birds seen in flight period one (Feb-Apr 2019) as compared to an abundance of 25+ birds in flight period two (July-September 2019).

Separate statistical analysis indicated that there was a significant difference of both the bird composition in general and Carnaby's Cockatoo count data occurring between the reference and impact sites. There was no consistent difference between the impact and reference sites between years. Carnaby's Cockatoo counts were 90% higher at reference sites compared to the impact sites (3291 vs 1171, resp.). This difference could be due to seasonal differences across years and is not surprising considering the large difference between the number of Carnaby's Cockatoo counted in 2018 compared to 2019 (a 262% difference at 3541 and 923 records respectively). This difference hints towards the potential role of turbines reducing the local abundance of Carnaby's Cockatoos.

Mortality surveys were undertaken at eight selected turbines (impact sites) and eight randomly selected turbines (random sites) in three separate survey events within each of the two flight periods.

The 2019 operational monitoring resulted in the detection of eight carcasses in 600 ha giving a density of one carcass per 75 ha. No Carnaby's Cockatoo were recorded during the mortality surveys. The eight bird strike carcasses were recorded during the flight periods; two in the February to April season and six in the July to September season. Species recorded were as follows:

- Feb-Apr; one Magpie; one Kestrel
- Jul-Sep; two Kestrel; one Magpie Lark; one Little Corella; one Raven; one unidentified.

The total number of estimated bird strike events for the entire wind farm was calculated as 52.38. The calculation was a result of the application of the correction factors for searcher efficiency and carcass persistence to the raw count of detected carcasses at the 16 selected impact sites for each survey and then corrected for the 37 turbine sites within the wind farm.

1 INTRODUCTION

1.1 PROJECT DESCRIPTION

APA Group is Australia's largest natural gas infrastructure business: they own, manage and/or operate a portfolio of energy assets worth $20 billion that include gas storage facilities, gas-fired power stations and wind farms. They also own and manage 15,000 kilometres (km) of natural gas pipelines connecting sources of supply and markets across mainland Australia.

In 2011, APA Group purchased the Emu Downs Wind Farm. The purchase of this asset included the approved Development Applications for the Emu Downs Solar Farm and the Badgingarra Wind Farm (BWF) Development Project. Both projects are situated in the Shire of Dandaragan and have been operational since January 2019.

The BWF consists of 37 Siemens 3.6-megawatt wind turbine generators installed with a hub height of 85 m and a blade length of 63 m giving a total sweep diameter of 130 m (**Image 1**). Minimum tip height is 20 m above the ground and 150 m at a maximum height above the ground. The BWF is capable of generating an energy output of up to 130 MW for supply to the energy market and consists of 37 wind turbine generators. The BWF includes a substation, a 33kV in-ground reticulation, a small grid interconnection to the existing transmission line, and associated site roads and infrastructure (**Map 1**).

Image 1: Example Turbine Site

1.2 MONITORING OBJECTIVES

The bird monitoring program was designed to meet the specific conditions listed under the Shire of Dandaragan Planning Approval for the Badgingarra Wind Farm. This includes bird mortality monitoring (Condition 20) and targeted monitoring of Carnaby's cockatoo (Condition 21).

Condition 20 – Bird Mortality

"The proponents shall develop and implement a bird mortality monitoring program within 12 months of commencement of Wind Farm operations. The program shall be developed in consultation with the Department of Parks and Wildlife and/or the WA Museum. Results of the program shall be forwarded to the Shire of Dandaragan."

The objective of the bird mortality study was to identify bird mortality rates from the windfarm extension near Badgingarra. This required a combination of standardised searches including:

- site use and abundance surveys to provide information of species and abundance within and outside of the windfarm
- mortality surveys for monitoring of bird strike by turbines
- searcher efficiency trials
- scavenger trials.

Condition 21 – Carnaby's Cockatoo Monitoring

"The proponents shall develop and implement an annual monitoring program for Carnaby's Cockatoo (Calyptorhynchus latirostris) bird strike, foraging and roosting (including any avoidance) behaviour, with reporting to the Commonwealth Department of the Environment, Water, Heritage and the Arts. The WA Museum (Mr Ron Johnstone or his nominated appointment) is to be consulted in developing appropriate survey methodologies for Carnaby's Cockatoo. The duration of this monitoring program will be defined during the development of the program and subject to review, based on findings during the first two years' monitoring."

The objectives of the Carnaby's Cockatoo monitoring program were to determine use and impact, through monitoring, of the windfarm by Carnaby's Cockatoo as part of daily foraging flight patterns and/or seasonal migrations both pre and post wind farm operation.

This required:

- baseline and ongoing Carnaby's Cockatoo monitoring using the species-specific survey design with the minimum number of replicates required for statistical analysis. As there was no pilot study to determine this quantitatively, a rule of thumb is at least 6 replicates are required to generate enough degrees of freedom to allow for a test of significance to be completed.
- the use of standardised methodology and data collection techniques suited to detecting site utilisation by Carnaby's Cockatoo
- surveys to be conducted at ecologically appropriate times of the year relevant to Carnaby's Cockatoo
- using methodology that could also gather baseline data for other bird species diversity and abundance.

1.3 CARNABY'S COCKATOO

1.3.1 THREATENING PROCESSES

Carnaby's Cockatoo (*Calyptorhynchus latirostris*) is listed as a threatened species (Endangered) under both the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and the Western Australian *Biodiversity Conservation Act 2016* (BC Act). Carnaby's Cockatoo occurs in uncleared or remnant native eucalypt woodlands and shrubland or kwongan heathland dominated by *Hakea*, *Banksia* and *Grevillea* species (DPaW 2013). It is a seasonal visitor to plantations of exotic pines (*Pinus* spp.), and sometimes occurs in forests.

The loss and degradation of breeding and foraging habitat is considered one of the main threatening processes for Carnaby's Cockatoo. This includes habitat fragmentation, removal of nest hollows, competition

for hollows and clearing of foraging habitat. Additionally, the mortality of individual birds through vehicle strike, shooting etc. is also a major contributor to population decline (DotEE 2017).

Life history traits such as low reproductive rates (including low clutch size), long immature periods (four years), long generational time (ca. 15 years) and the use of tree hollows increase the susceptibility of Carnaby's Cockatoo to these threatening processes (Williams *et al.* 2017). The rapid decline of Carnaby's Cockatoo populations has been compounded by these 'slow' life histories – low reproductive rates over long lifespans (Heinsohn *et al.* 2009; Murphy *et al.* 2003; Williams *et al.* 2017).

Recent research has found that, assuming no changes in the extent or quality of breeding habitat and current breeding or survival rates, the most important factor currently limiting population growth for Carnaby's Cockatoo is adult survival (Williams *et al.* 2017). The mortality of individual adults is a key driving factor in population decline given the slow reproductive rate of Carnaby's Cockatoo. Even a small increase in adult mortality may lead to population decline via juvenile recruitment failure. The sensitivity of population viability to adult survival is characteristic of cockatoos and other long-lived birds (Heinsohn *et al.* 2009; Stahl & Oli 2006; Williams *et al.* 2017). Density-dependent mortality is caused when the carrying capacity of an area, based on resource availability, is exceeded. This is caused through the reduction of available resources from habitat loss. Density-independent mortality is caused by a variety of factors including vehicle strike, shooting, poaching of eggs and birds, or injuries sustained through vegetation clearing. Avoiding these density-independent mortality events is extremely important to the recovery of the species (Commonwealth of Australia 2017).

1.3.2 CARNABY'S COCKATOO HABITAT IN THE BADGINGARRA REGION

Three Important Bird Areas (IBA) for Carnaby's Cockatoo that are relevant to the study area (DPaW 2013; Dutson 2009) were identified. These are:

- **Coomallo:** located approximately 25 km to the northeast of the BWF site. This area supports at least 1% of the Carnaby's Cockatoo breeding population (minimum of 40 breeding pairs) which nest in woodland remnants and isolated paddock trees and feed in native shrublands.
- **Koobabbie:** located near Coorow and approximately 100 km northeast of the BWF site. This large pastoral property has 254 ha of remnant Wandoo and Salmon Gum woodland vegetation. It supports at least 1% of the Carnaby's Cockatoo breeding population (up to 32 breeding pairs). Fledglings from Koobabbie have been recorded at Coomallo Creek and Beekeepers Nature Reserve.
- **Northern Swan Coastal Plain:** located between the Swan River and Moore River, this area supports 4,600-15,000 birds in the non-breeding season and a small number of pairs of breeding birds; this is the largest population of birds that gather in the non-breeding season.

Breeding sites around the windfarm site include Three Springs, Coomallo, Carnamah, Coorow, Badgingarra and Moora regions which are vacated by Carnaby's Cockatoo by the end of February each year. Adults and fledglings fly west to coastal feeding habitat where they aggregate in flocks in Kwongan heath and pine plantations. Occasionally a flock of 60-100 birds remain in the Badgingarra National Park area into March-April. From July through to September birds fly back to breeding sites (Johnstone 2008).

In the breeding season, birds have been found to forage an average of 1.4 km from Coomallo Creek. During the non-breeding season, they migrate west and forage locally within 50 km (Saunders 1980). **Figure 1** shows the known patterns of seasonal migrations (Williams *et al.* 2017).

A regional habitat assessment was completed by Brett Lane & Associates (2008) who identified over 44,000 ha of Carnaby's Cockatoo habitat within the surrounds of the proposed wind farm site. This includes:

- Badgingarra National Park: 13,108 ha
- Coomallo Nature Reserve: 8,807 ha
- Southern Beekeepers Nature Reserve: 10,808 ha
- Nambung National Park: 8,362 ha
- Hill River Nature Reserve: 882 ha
- Un-named Conservation Park: 2,369 ha.

Additionally, there are substantial areas of Carnaby's Cockatoo habitat outside of conservation estate which are also utilised for foraging and nesting (Dawson 2017).

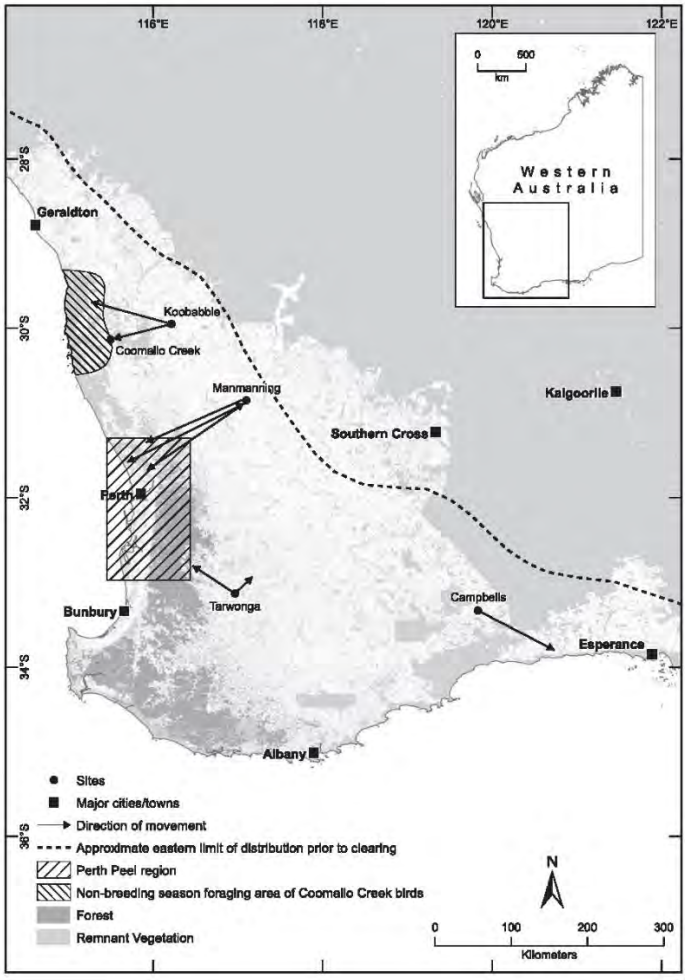

Figure 1: Known seasonal migration patterns of Carnaby's Cockatoo

1.4 PREVIOUS REPORTS

1.4.1 METHODOLOGY 2017

Ecoscape was commissioned by APA to develop an approved methodology and then undertake baseline surveys and follow-up monitoring in 2017. Ecoscape subsequently developed a methodology to address Conditions 20 and 21 as stated in the Shire of Dandaragan Planning Approval for the BWF (Ecoscape (Australia) Pty Ltd 2017). The monitoring methodology sought advice from the following specialists:

- Ron Johnstone: Curator of Ornithology Western Australian Museum
- Rick Dawson: previously Acting Manager, Nature Conservation Branch DBCA
- Dr Matthew Williams: Biometrician DBCA
- Dr Denis Saunders: Research Fellow CSIRO Land & Water.

The agreed methodology determined that the mortality of birds from wind farms required three distinct types of survey:

1. *Searcher efficiency trials:* human observers are poor at locating carcasses in the field and generally underestimate what is actually out there. This trial provides an adjustment factor to account for underestimation during carcass counts.
2. *Carcass removal trials:* scavengers have been found to have a substantial effect on the number of carcasses counted at a site. Depending on the local conditions and numbers of scavengers present, carcasses are taken from the site which underestimates of the impact of wind farms. This trial provides an adjustment factor to account for the underestimation during carcass counts.

3. *Monthly carcass counts:* these are surveys conducted monthly where observers count the number of carcasses found using standardised methodology and data collection techniques. Absence data is especially important and even if no carcasses are found, data sheets need to be completed and submitted for analysis.

In addition to the above surveys it was also required to maintain an understanding of the birds using the BWF site and the surrounding landscape, this is referred to as site use and abundance. This was achieved by monitoring and counting bird species at the selected impact turbine sites and their associated reference sites four times a year during the flight periods of Carnaby's Cockatoo.

All survey types are being used in this first year of post construction operational monitoring for the BWF project for a period of two years post construction.

1.4.2 BASELINE AND PRE-CONSTRUCTION ANNUAL REPORT 2018

The 2018 Annual Report (Ecoscape 2018) provided results of the initial surveys other than Mortality counts, as the turbines had yet to be constructed and made operational. Carcass persistence and searcher efficiency trials were undertaken to provide the baseline correction factors that are to be applied to the mortality results once operational monitoring has commenced.

Within this 2019 Annual Report, results for 2019 are compared to data from 2018 and discussed in terms of difference. Statistical analysis testing for significant difference was performed on the site use and abundance data only as there was no mortality data from 2018 due to the turbines not being operational.

2 METHODS

2.1 ADAPTATIONS TO 2018 METHODOLOGY

During the 2019 operational monitoring it became apparent that using DISTANCE methods for the detection of carcasses for the mortality surveys, carcass persistence and searcher efficiency surveys was not appropriate. DISTANCE is a method developed for live animals to determine abundance (numbers/area) whereas the carcass searches are purely to provide the number of carcasses detected/area. As carcasses are static the required data could be achieved by using a Plot Search Method which is more time and cost efficient while still providing data for persistence and efficiency. The Plot Search Method involves an observer walking around a 250 m x 250 m search area in decreasing circles and recording carcasses as they are observed. This adaptation was presented to DBCA for approval and was accepted for the second flight period surveys.

A further adaptation was made to the process of searcher efficiency and carcass persistence for cost benefit. A single event of dropping tagged carcasses was used to collect data for both searcher efficiency and carcass persistence trials at the beginning of each flight period. Forty eight carcasses were tagged and dropped at random turbine sites and immediately monitored for searcher efficiency. These same carcasses were left in the field and used for carcass persistence trials during the first surveys of each flight period.

Bird monitoring methods follow those as detailed in the agreed methodology developed by Ecoscape (Ecoscape (Australia) Pty Ltd 2017) and the adaptations mentioned above. **Table 1** indicates each survey type, the frequency of the survey and the preferred time of day that surveys are undertaken.

Table 1: Ongoing operational monitoring for Carnaby's Cockatoo and other birds

Survey type	Frequency	Survey time of day
Site use and abundance survey	Two surveys per flight period	Dusk and dawn
Mortality surveys	Three survey events in each flight period	Any time of day
Carcass persistence surveys	One survey per flight period; monitored by staff undertaking the mortality surveys	Any time of day
Searcher efficiency	One survey per flight period; undertaken by staff during the mortality surveys	Any time of day

2.1.1 TURBINE SITE NUMBERS

The 2018 surveys were conducted pre-construction and the sites used were assigned numbers based on the plans current at that time. These turbine numbers were subsequently altered by the time the turbines had been constructed and therefore monitoring site numbers were changed to reflect the alterations. **Table 2** lists the original 2018 site numbers and the 2019 site numbers subsequently assigned to them, reference sites were not affected by this alteration. The new site numbers are referred to throughout this report and on maps.

Table 2: Turbine Site Numbers

2018 Pre Construction Turbine Number	Site Type	2019 Post Construction Turbine Number
T01	Impact	T02
T02	Random	T01
T03	Random	T03
T04	Random	T34
T05	Impact	T32
T06	Random	T33
T07	Random	T06
T08	Random	T35
T09	Impact	T36
T10	Random	T07
T11	Random	T05
T12	Impact	T04
T13	Random	T37
T14	Random	T08
T15	Impact	T31
T16	Random	T16
T17	Random	T24
T18	Random	T30
T19	Random	T27
T20	Random	T28
T21	Random	T29
T22	Impact	T26
T23	Random	T13
T24	Random	T15
T25	Random	T23
T26	Random	T25
T27	Random	T21
T28	Random	T12
T29	Random	T11
T30	Random	T14
T31	Random	T22
T32	Random	T19
T33	Random	T10
T34	Impact	T09
T35	Random	T20
T36	Impact	T17
T37	Random	T18

2.2 SITE USE AND ABUNDANCE MONITORING – CARNABY'S COCKATOO & OTHER BIRDS

The abundance monitoring collates data regarding both Carnaby's Cockatoo and other bird species. Standard BirdLife Australia bird surveys/counts are unsuitable to capture data that reflects Carnaby's Cockatoo counts and site use as the standard surveys do not consider observations at long distances around a sample site. A species-specific methodology was developed based on a modified point count method similar to that used in the Great Cocky Count (Shah 2006). This involved recording the location, count and flight pattern of Carnaby's Cockatoo from eight impact sites and eight reference sites during peak flight times (annually and daily). Opportunistic sightings of Carnaby's Cockatoo were recorded by the surveyors

during both the site use and abundance surveys and the mortality surveys as the teams moved between the selected survey sites.

Each year there are two peak flight periods for Carnaby's Cockatoo:

1. Adult and fledgling east-west migration for feeding (December to April).
2. Adult west-east migration period for breeding (July to September).

Each day there are two peak flight times:

1. Dawn – 30 minutes before dawn until two hours after dawn.
2. Dusk – 2 hours prior to dusk to 30 minutes after dusk.

The breeding and coastal feeding migrations are determined by local resource availability as driven by the amount of rainfall and its effects on flowering and seed set of foraging flora species (Ecoscape (Australia) Pty Ltd 2017). The bi-annual migrations times are indicative only and vary depending on this resource availability.

The methodology allows for the survey of other bird species to occur concurrently. A minimum of four surveys over the two peak Carnaby's Cockatoo flight periods was recommended by DBCA Science & Conservation Division (Ecoscape (Australia) Pty Ltd 2017).

Site selection for surveys included both impact and reference sites (**Map 2**). Impacts sites are associated with eight selected turbines sites as constant monitoring points for the entire monitoring program and therefore do not change. An additional eight turbines were selected at random for each survey event and change during the monitoring program. The eight constant impact sites and the eight random impact sites provide a total of 16 impact sites monitored during each survey event. This approach is based on statistical advice from DBCA and were required to be at least two kilometres apart.

The eight reference sites were required to be at least one kilometre from a constant impact site and at least two kilometres from other reference sites and matched to a constant impact site with similar characteristics (i.e. vegetation type, disturbance level) (Ecoscape (Australia) Pty Ltd 2017). The constant impact sites and reference sites are shown on **Map 2**.

2.2.1 SITE SELECTION

The field surveys were conducted at constructed turbines (impact and random sites) and at matched reference sites. Criteria for selection is set out below.

Impact Sites

- eight constant sites are required where turbines are proposed to be constructed
- eight random turbine sites selected for each survey event
- a minimum of 2 km between constant sites.

Reference Sites

- eight reference sites are required that are greater than 1 km from a constant site
- a minimum of 2 km between reference sites
- the number of reference sites needs to match the number of constant impact sites being monitored for analysis
- reference sites need to have characteristics as similar as possible to a constant impact sites e.g. vegetation type, distance to water etc.

Each selected site was surveyed over a 30 minute period, a minimum of five times per survey period with surveys occurring during the periods of highest Carnaby's Cockatoo activity (dawn and dusk) (Ecoscape (Australia) Pty Ltd 2017). A survey timing matrix was developed which scheduled all survey sites to be monitored. Each constant impact site was matched to a reference site based on the criteria above and listed in **Table 3**. The colours in **Table 3** indicate matched site pairs.

Table 3: Monitoring schedule for each survey at turbine (T) and reference (R) sites

Day	Survey or	Morning Period				Afternoon Period			
		Survey A	Survey B	Survey C	Survey D	Survey W	Survey X	Survey Y	Survey Z
1	A	T09	T31	T26	T17	T04	-	T36	-
	B	R34	R15	R22	R36	R12	-	R09	-
2	A	T31	T26	T17	T09	T04	T36	T32	T02
	B	15R	R22	R36	R34	R12	R09	R05	R01
3	A	T26	T17	T09	T31	T32	T02	T04	T36
	B	R22	R36	R34	15R	R05	R01	R12	R09
4	A	T02	T04	T36	T32	T09	T31	T26	T17
	B	R01	R12	R09	R05	R34	15R	R22	R36
5	A	T04	T36	T32	T02	T31	T26	T17	T09
	B	R12	R09	R05	R01	15R	R22	R36	R34
6	A	T32	T02	T04	T36	T26	T17	T09	T31
	B	R05	R01	R12	R09	R22	R36	R34	15R
7	A	T02	T32	-	-	-	-	-	-
	B	R01	R05	-	-	-	-	-	-

2.2.2 DATA COLLECTION

Data were collected using standardised surveys to capture the information presented in **Table 4.** Data sheets were completed even when birds were not recorded as absence data was required for data analysis. This data was collected for both Carnaby's Cockatoo and all other bird species recorded.

Table 4: Data collected at reference and impact sites (*Rotor swept area heights (RSA heights) are between 20 and 150 metres above ground)

	Data	Specifics
Collect for each survey site (turbine/reference site)	Observer name	
	Date	
	Unique point identifier	
	GPS location	UTM
	30 min search start time	24 hour time
	30 min search finish time	24 hour time
	Wind speed	m/s
	Air temperature	°C
	Estimate of cloudiness	% cover
	Habitat type and quality	
	Distance to nearest remnant veg	metres
Collect for each bird or flock	Species name	
	Number of individuals	
	Distance from turbine	0-250 m 250-500 m 500-1,000 m
	Activity	Landed or fly-over
	Flight direction (for Carnaby's Cockatoo)	Compass bearings e.g. flying west to east
	Flight height estimate*	0-20 m: below rotor height 20-150 m: at rotor height 150 m+: above rotor height

Opportunistic Carnaby's Cockatoo sightings were also recorded during each survey event to add to the knowledge of Carnaby's Cockatoo behaviour and their interactions with the wind farm. Similarly, night roost locations were also recorded.

2.2.3 DATA ANALYSIS AND REPORTING

Two broad types of analyses were conducted using the bird count data. The first is multivariate (i.e. making use of multiple species and multiple sites) and searches for broad overarching patterns observed while considering all bird species (i.e. composition). The second is univariate (i.e. focusing on a single species response) and focuses on the response (between reference and impact, and between years) of Carnaby's Cockatoo counts. The two methods are described in the following section.

2.2.3.1 Statistical Method

Multivariate patterns and drivers

To search for the species compositional changes between the reference and impact sites in the monitoring data for all species collected from 2018 and 2019, nonmetric multidimensional scaling (NMDS) ordination was applied to the Relative Euclidean distance generated on the bird data (bird species × sites). In this instance, the Relative Euclidean distance was the most appropriate resemblance measure to use because of its ability to handle data containing high compositional turnover (i.e. data containing many 0s) (Legendre & Anderson M.J. 1999). A visual assessment of NMDS plots can be used to provide a qualitative assessment of the broad drivers (e.g. the presence of turbines or survey year) underpinning the compositional data; further statistical testing was performed to confirm these qualitative assessments. Specifically, a method which combines compositional data with response data (survey year and the presence of turbines was conducted (distance-based redundancy analysis (db-RDA); see Borcard *et al*. 2018). The aim for this analysis was to quantify how much (%) of the compositional variance could be explained by the presence of turbines or survey year (i.e. the constrained variance). Lastly, we applied a permutation test on this db-RDA model to determine if the compositional variance explained by the presence of turbines or survey year was statistically significant. All calculations were conducted using the Vegan package (Oksanen *et al*. 2019) in the R statistical Program (R Core Team 2019).

Univariate responses

Generalised linear models (GLMs; see Zuur *et al*. 2009) were applied to formally search for differences between count data collected for Carnaby's Cockatoo only. Specifically, we sought formal testing to address the following questions:

1. Is there a difference in bird species composition and abundance between the reference and impact sites?
2. Is there a difference in Carnaby's Cockatoo counts across years?
3. Is there a consistent difference in Carnaby's Cockatoo abundance between reference and impact sites across years?
4. Is there a difference in Carnaby's Cockatoo abundance between all sites?

Before the GLMs were conducted the data was log ($\log_{x+1}$) transformed. The dispersion of the variance structure of the GLM models was formally tested using Pearson's Chi^2 statistic and the Pearson-based dispersion statistic; where the model was found to be over dispersed we applied the quasipoisson log link function. GLM analyses were conducted using base coding from the R statistical program (R Core Team 2019); dispersion testing was conducted using the MSME R package (Hilbe & Robinson 2018).

2.3 MORTALITY SURVEYS

Mortality survey methods used for operational monitoring follow the approved methods (Ecoscape 2017) submitted to DBCA and are outlined below.

Frequency: Searches for bird mortality from potential turbine blade strikes are undertaken once a month within each flight period giving six surveys for a monitoring year.

Timing: Searches are conducted on a monthly schedule while maintaining the same time interval between consecutive surveys of the same turbine. i.e. survey turbine X in week Y of each month.

No. of turbines: Sixteen sites were surveyed monthly using the same eight constant impact turbine sites and eight randomly selected impact turbine sites for each survey. The constant impact turbine sites are excluded from the random list.

Search area definition: Search areas should incorporate the following;

- search area is based on the large bird category (**Table 5)**
- search area consists of a square plot at 250 m x 250 m (6.25 ha)
- a carcass data sheet must be completed even if no carcasses are found. This is required for data analysis to be robust.

Search area: For each turbine, the search area was set at 6.25 ha (250 m x 250 m). The size of the plots was set to ensure that large bird carcasses would be detected as the final rotor sweep height is 130 m and therefore Carnaby's Cockatoo would possibly be cast out at a greater distance than that listed in **Table 5**. GPS units were used to ensure plots were consistently searched without overlap.

Table 5: Recommended search area radii (Hull & Muir 2010)

	Small Turbine (hub height 65 m, rotor sweep height 66 m)	Medium Turbine (hub height 80 m, rotor sweep height 90 m)	Large Turbine (hub height 94 m, rotor sweep height 112 m)
Bats	55 m	65 m	74 m
Small Birds	68 m	78 m	87 m
Large Birds	103 m	112 m	122 m

Opportunistic/incidental finds: Bird carcasses may be discovered outside of scheduled surveys. These opportunistic finds were required to be processed as for scheduled searches (i.e. collected, photographed, data recorded, etc.). These finds were required to be reported separately by BWF site staff and made clear on the data sheet that it was an opportunistic/incidental find (OMNRF 2011).

2.4 CORRECTION FACTORS

2.4.1 SEARCHER EFFICIENCY

Carcass counts can be biased due to potential differences in searcher efficiency and only sampling a proportion of the sites (i.e. extrapolation of data from a subset of samples). Differences in searcher efficiency can arise from differing levels of survey experience and site visibility from differences in vegetation cover and terrain. If plots are cropped, the vegetation cover and height is likely to be more variable over time and between sites than if just grazed. Studies have shown that when detection biases are not taken into account, human searchers greatly underestimate the number of birds struck by wind turbines (Korner-Nievergelt et al. 2013).

Two Searcher Efficiency trials per searcher were undertaken to determine a correction factor which is site-specific for the BWF site and also personnel-specific for Ecoscape personnel. The same sites selected for the carcass persistence trials were used for the searcher efficiency trials and used the same carcasses deployed, as detailed in **Section 2.1**.

Commercially obtained carcasses were placed out by a 'tester' without the 'searchers' knowledge. Eight carcasses from the various size classes (two carcasses for each of the four size classes) were randomly distributed at six turbine sites. The 'searcher' was then asked to record as many carcasses as possible while walking plots in concentric lines within each plot and recorded on GPS.

The searcher efficiency correction factor was calculated using the formula below (Bird Studies Canada *et al.* 2016).

$$Se = \sum_{i=0}^{n} \frac{p_i}{P_i} * s_i$$

Carcass search areas 250 x 250 m

P_i = Number of carcasses placed in trials completed by searcher i
p_i = Number of carcasses found by searcher i during trials
s_i = Proportion of turbines that were searched by searcher i
n = Total number of searchers

The searcher efficiency correction factor (Se) is used to determine an estimated actual carcass number, this is the number of carcasses that would have been detected during the mortality surveys of the 16 selected turbine sites assuming all carcasses are detected by the searchers. The raw count of detected carcasses (n) is divided by the calculated correction factor (Se) to give an estimated actual carcass number, as illustrated below.

Estimated carcass number = n/Se.

2.4.2 CARCASS PERSISTENCE – IMPACT OF SCAVENGERS

Carcass persistence trials estimate the impact of scavengers on carcass counts. Carcass counts often under-estimate the actual impact of wind farms as scavengers may remove carcasses before they can be found by surveyors (Korner-Nievergelt *et al.* 2013). Carcass removal trials were used to determine a correction factor to accurately reflect any impacts of the wind farm and were undertaken once for each flight period on the first and fourth mortality surveys to coincide with searcher efficiency trials.

Carcasses were placed around wind turbines and monitored at regular intervals until taken by a scavenger or decomposed. Trials were undertaken at six impact sites where 48 carcasses of varying size classes (**Table 6**) were randomly distributed within a 250 m x 250 m area around each turbine. Each carcass was tagged for identification along with a GPS location record taken. Carcasses remaining were monitored by personnel undertaking the mortality surveys at the time of the trials.

Table 6: Carcass size classes used in to determine scavenger impact

Size class	Weight (grams)	Type used
Small	10 to 100	Chicks, budgerigars, and cockatiels
Medium	100 to 1000	Pigeons and small chickens
Large	1000 to 4000	Ducks and roosters/large chickens

2.4.2.1 Data Analysis

Kaplan-Meier survival analysis is used to generate a correction factor based on the persistence of carcasses in the landscape (Pollock *et al.* 1989). This method determines how long a carcass will remain in the field before being taken by a scavenger which is converted to a correction factor for use on raw counts in the mortality surveys. Data was analysed using XLSTAT®.

The carcass persistence correction factor (CP) is used with the searcher efficiency correction factor (SE) and the number of carcasses (n) detected by the mortality surveys to determine an estimated number of bird strike events (ST) for the 16 impact sites surveyed during each survey event.

ST = (n/SE)/CP

The number of estimated bird strikes is then applied to the 37 turbine sites of the wind farm to give a total estimated bird strike number for the wind farm e.g. total estimated bird strikes = ST / (16/37)

3 RESULTS

3.1 SURVEY TIMING

The survey dates for year one operational monitoring for Carnaby's Cockatoo and other birds for the 2019 survey seasons are outlined in **Table 7**.

Table 7: Operational monitoring survey type and dates 2019

Survey type	Survey period 1 (Feb to Apr) Coastal feeding	Survey period 2 (July to Sep) Inland breeding
Site use and abundance surveys	Survey 1: February 2019 Survey 2: March 2019	Survey 3: July 2019 Survey 4: September 2019
Mortality surveys	Survey 1: February 2019 Survey 2: March 2019 Survey 3: April 2019	Survey 4: July 2019 Survey 5: August 2019 Survey 6: September 2019
Carcass persistence	Trial 1: February 2019	Trial 2: July 2019
Searcher efficiency	Trial 1: February 2019	Trial 2: July 2019

The results reported are from sequential survey events that form the monitoring for the period February to September 2019 to coincide with peak Carnaby's Cockatoo migration and activity times.

3.2 SITE USE AND ABUNDANCE SURVEYS

Carnaby's Cockatoo was recorded from 44% of the 16 survey sites (7 out of 16). Abundance ranged from records of two individuals up to a large flock of 189 birds at reference site R01 in February 2019. In total, 923 Carnaby's Cockatoo were counted over the 2019 survey periods, 83 at the impact sites and 840 at the reference sites (**Table 8**). The highest counts were recorded from Reference sites R01, R15 and R34 and predominantly during the surveys of Feb-Apr 2019 (**Table 8**).

Table 8: Carnaby's Cockatoo raw counts by survey date and site (February to September 2019)

Survey period	Impact Sites								Total Count
	T02	T32	T36	T04	T31	T26	T09	T17	
1 (Feb)	0	0	0	0	0	0	0	0	0
2 (Mar)	0	3	80	0	0	0	0	0	83
3 (Jul)	0	0	0	0	0	0	0	0	0
4 (Sep)	0	0	0	0	0	0	0	0	0
Totals	**0**	**3**	**80**	**0**	**0**	**0**	**0**	**0**	**83**
Survey period	**Reference Sites**								**Total Count**
	R01	R05	R09	R12	R15	R22	R34	R36	
1 (Feb)	368	0	9	0	75	0	171	0	623
2 (Mar)	14	0	8	0	27	0	144	0	193
3 (Jul)	0	0	0	0	0	2	0	0	2
4 (Sep)	0	0	0	0	22	0	0	0	22
Totals	**382**	**0**	**17**	**0**	**124**	**2**	**315**	**0**	**840**

3.2.1 CARNABY'S COCKATOO – FLIGHT HEIGHTS

Flight heights recorded for Carnaby's Cockatoo from the site use and abundance surveys are detailed in **Table 9**. Five flocks were recorded at a flight height of between 20-150 m i.e. at rotor height, being 20% of the total number of flocks observed (25 flocks). Flocks were only recorded at impact sites T36 and T32.

Flight height is an indicator of the behaviour of the flocks whether feeding or travelling. The dominant behaviour observed was feeding, flying low over native vegetation with frequent stops to forage. Flight heights within the windfarm turbines at rotor height (20-150 m) was only observed at T36 in March 2019

where no native vegetation exists and therefore the birds were most likely travelling to another forage or roost site nearby. No Carnaby's Cockatoo carcasses were recorded during the mortality surveys.

Table 9: Recorded Flight Heights for Carnaby's Cockatoo

Site	Date	Count	Flight height (m)	Site Type	Survey
R01	3/02/2019	189	0-20	Reference	1
R01	4/02/2019	89	0-20	Reference	1
R01	5/02/2019	90	0-20	Reference	1
R09	5/02/2019	9	0-20	Reference	1
R15	3/02/2019	71	0-150	Reference	1
R15	6/02/2019	4	20-150	Reference	1
R34	3/02/2019	17	0-20	Reference	1
R34	5/02/2019	14	0-20	Reference	1
R34	6/02/2019	126	0-20	Reference	1
R34	7/02/2019	10	0-20	Reference	1
R34	8/02/2019	4	0-20	Reference	1
T32	18/03/2019	3	0-20	Impact	2
T36	19/03/2019	32	0-20, 20-150	Impact	2
T36	21/03/2019	44	0-20	Impact	2
T36	22/03/2019	4	0-20	Impact	2
R01	19/03/2019	12	20-150	Reference	2
R01	20/03/2019	2	20-150	Reference	2
R09	20/03/2019	8	0-20	Reference	2
R09	22/03/2019		0-20	Reference	2
R15	22/03/2019	16	0-20	Reference	2
R15	23/03/2019	11	0-20	Reference	2
R34	24/03/2019	144	0-20	Reference	2
R36	21/03/2019		0-20	Reference	2
R22	2/08/2019	2	0-20	Reference	3
R15	17/09/2019	22	0-20	Reference	4

3.2.2 ALL BIRD SPECIES – RAW COUNTS

Sixty four bird species (including Carnaby's Cockatoo) were recorded from the 2019 site use and abundance surveys. Thirty-two species were recorded from impact sites and 64 species from reference sites. Species data were ranked by decreasing abundance (i.e. the species with the highest recorded total count is ranked as 1). **Table** 10 provides the top 20 bird species recorded during the surveys, ranked by abundance. These 20 species are 92% of the cumulative count data (7026 counts), with the remaining 7.96% (not shown here) consisting of an additional 559 individuals.

Table 10: Top 20 bird species by fractional rank and percent species composition

Rank	Species	Reference Sites	Impact Sites	Total count	% composition of all counts recorded
1	Tree Martin	1628	0	1628	23.17
2	Carnaby's Cockatoo	83	840	923	13.14
3	Galah	423	176	599	8.53
4	Australian Raven	370	215	585	8.33
5	White-cheeked Honeyeater	533	30	563	8.01
6	Western Corella	282	170	452	6.43
7	Australian Magpie	153	90	243	3.46
8	Magpie-lark	165	61	226	3.22
9	Brown Honeyeater	163	8	171	2.43
10	Australian Ringneck	153	6	159	2.26
11	Tawny-crowned Honeyeater	127	20	147	2.09
12	Yellow-rumped Thornbill	122	24	146	2.08
13	Grey-breasted White-eye	108	0	108	1.54
14	White-winged Fairy-wren	95	12	107	1.52
15	Willie Wagtail	82	16	98	1.39
16	Australian Pipit	19	75	94	1.34
17	Welcome Swallow	82	4	86	1.22
18	Grey Butcherbird	40	8	48	0.68
19	Australian Kestrel	26	17	43	0.61
20	Singing Honeyeater	43	0	43	0.61
	Sub totals	4697	1772	6469	92.07
	Total of all counts (65 species)			7026	

3.2.1 STATISTICAL ANALYSIS

3.2.1.1 Results

Multivariate patterns and drivers

Separation in the NMDS ordination space calculated on the combined 2018 and 2019 bird abundance data indicates that there is a difference in bird species composition and abundance between the impact (black dots) and reference sites (red dots) (**Figure 2**). This qualitative assessment was confirmed by a db-RDA analysis with permutation testing. Specifically a non-significant ($P=0.064$) 3.77% of the species compositional variance was explained by the survey year and a significant ($P<0.001$) 3.92% was explained by the presence of turbines.

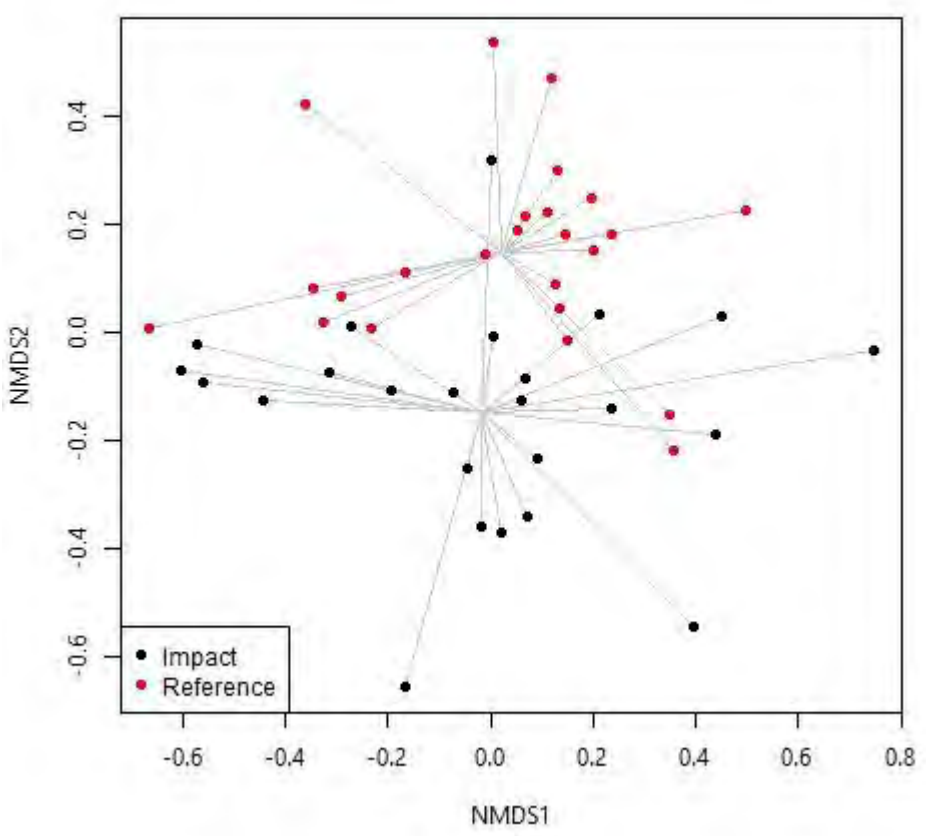

Figure 2: NMDS ordination of the 2018 and 2019 Carnaby's Cockatoo data. Stress = 0.24

Univariate responses–Carnaby's Cockatoo only GLM Tests conducted on Carnaby's Cockatoo counts suggest that there is a significant difference between the reference and impact sites; on average reference sites had 90% higher counts of Carnaby's Cockatoo compared to the impact sites (3291 vs 1171 respectively) (**Table 11**).

There was no consistent difference between Carnaby's Cockatoo abundance between the impact and reference sites between years (**Table 11**).

There was a significant difference in Carnaby's Cockatoo abundance across years; this difference could be due to seasonal differences between years and is not surprising considering the large difference between the number of Carnaby's Cockatoo counted in 2018 compared to 2019 (a 262% difference at 3,541 and 923 records respectively) (**Table 11**). This difference suggests the potential role of turbines reducing the local abundance of Carnaby's Cockatoo.

Table 11: Analysis results from GLM tests

Treatments (groups)	P (>|t|)	Interpretation
Impact v reference	0.0425*	There was an overall difference between impact and reference sites.
All sites	0.0146*	There was a difference in Carnaby's Cockatoo abundance between sites.
Reference site R12	0.0310*	Site R12 was different from all other sites
Reference site R36	0.0354*	Site R36 was different from all other sites
Years	0.0369*	There was a difference in Carnaby's Cockatoo abundance between years.
Impact v reference by year	0.7643	There were no consistent differences between the impact and reference sites between years

* denotes significant difference

3.2.2 CARNABY'S OPPORTUNISTIC AND ROOST DATA

Ten opportunistic Carnaby's Cockatoo observations were recorded during the February to April flight period; seven during survey 1 in February-March and three during survey 2 in April (**Table 12**) (**Map 3**). No observations were recorded during the July to September flight period.

The most significant record was a flock of 200 Carnaby's Cockatoo feeding on a patch of Banksia shrubs close to Turbine T11 on 17 April 2019. The flock was engaged in feeding behaviour and flying less than 3 m above the ground alighting on shrubs and then moving on at a low height. There were two other observations within the windfarm turbines: 24 birds close to T27 on 27 February 2019 and 12 birds close to T35 on 4 March 2019. The remaining observations were all along Cadda Road (**Map 3**).

No new roost sites were recorded during the 2019 monitoring. The opportunistic records observed that Carnaby's Cockatoo were either feeding or flying below rotor height (<20 m).

Table 12: Opportunistic records recorded during the 2019 operational monitoring

Record	Date	Site	Recorder	Count	Flight Height	Behaviour
1	3/02/2019	Cadda Rd near T37	JEV	5	0-20 m	foraging
2	3/02/2019	Cadda Rd	JEV	8	0-20 m	flying over
3	4/02/2019	Pines	JEV	22	0-20 m	flying over
4	31/01/2019	Cadda Rd	JEV	4	0-20 m	foraging
5	4/02/2019	Cadda Rd	JEV	5	0-20 m	flying over
6	5/02/2019	Near T33	JEV	12	0-20 m	flying over
7	27/02/2019	T27	SB	24	0-20 m	Hovering over remnant. Forage
8	4/03/2019	T35	SB	12	0-20 m	Flying from pine plantation (350m East) to the next pine plantation (500m NW). Some of the flock landed on the ground for < 30 seconds.
9	17/04/2019	T11	BT	200	0-20 m	Feeding
10	19/04/2019	Cadda Rd	BT	88	0-20 m	Foraging *Banksia prionotes*

3.3 MORTALITY SURVEYS

Three bird mortality surveys were conducted during each of the two flight periods. Mortality surveys were undertaken as follows:

- three surveys within each migration season
- used the same eight constant impact turbine sites in addition to eight random impact sites for each survey
- 16 turbines were surveyed over an 8 day period every2 days due to scavenger activity.

Eight carcasses were recorded during the 2019 survey periods (**Map 2**). Results for the mortality surveys are summarised in **Table 13.**

Table 13: Result of mortality searches for 2019

Survey event 2019	Number of carcasses	Carcass location
1 (Feb)	0	-
2 (Mar)	0	-
3 (Apr)	2	T37; T30
4 (Jul)	3	T06; T16; T20
5 (Aug)	3	T15; T15; T34
6 (Sep)	0	-

No Carnaby's Cockatoo carcasses were recorded. Five species, and one unidentified were recorded as follows:

- Australian Kestrel (*Falco cenchroides*) (T15; T30; T20)
- Australian Magpie (*Cracticus tibicen dorsalis*) (T37)
- Australian Raven (*Corvus coronoid*es) (T34)
- Magpie Lark (*Grallina cyanoleuca)* (T06)
- Little Corella (*Cacatua sanguinea*) (T15)
- Unidentified feathers (T16).

There was one incident report supplied by APA personnel of an Australian Kestrel carcass recorded at turbine T25 in November 2019 which is outside of the monitoring survey periods (**Appendix One**).

3.3.1 CARCASS DENSITY

The density of carcasses (carcasses per hectare searched) used all eight carcasses detected during the surveys and excluded the incident report data. The 16 turbines surveyed a total of 100 ha for each survey event (16 x 6.25 ha), giving a total area searched for the six surveys of 600 ha. The 2019 operational monitoring resulted in the detection of eight carcasses in 600 ha giving a density of one carcass per 75 ha.

3.3.2 SURVEY EFFORT

Survey effort for mortality searches was recorded for each flight period. This is the time taken for a searcher to complete the survey of plots around each of the selected turbines looking for bird carcasses. The search effort for the February-April flight period was 72 hours and 165 hours for the July-September flight period. The total search effort for 2019 is therefore 237 hours to search 96 turbine plots (16 turbine plots x 6 surveys/monitoring year) at an average of 2.4 hours/turbine plot.

Search effort varied due to the amount of native vegetation or crop coverage at each turbine plot. Search effort was, therefore, higher during the crop growing season which corresponded to flight period two (July-September) as it took longer for a plot to be searched when crop cover was present.

3.4 CORRECTION FACTORS

3.4.1 CARCASS PERSISTENCE

Results collected for the 2019 operational monitoring showed that on average, a carcass persisted for four days in the field before it was taken by a scavenger. Confidence intervals were small (<0.8 at 95%) which indicates replication was adequate. Carcass persistence trials were undertaken during the first and fourth mortality surveys for 2019.

The initial correction factor to incorporate the impact of scavengers in post-construction surveys varied dependent on which day of the survey the carcass was found. For example, carcasses found on day one were given a 0.725 correction factor; carcasses found on day six have a 0.267 correction factor applied. As surveys are not on consecutive days, interpolation was used based on the results of **Table 14**.

Table 14: Carcass persistence rates in the field based on Kaplan-Meier survival analysis

Survey day	Carcass persistence correction factor	Carcass persistence
1 day after carcass drop	0.725*	73%
2 days after carcass drop	0.525	53%
4 days after carcass drop	0.381	38%
6 days after carcass drop	0.267	27%

*this is an interpolated value based on field data.

Results collected for the 2019 operational monitoring returned an average of four days of carcass persistence. Therefore, a correction factor of 0.381 was applied to the mortality survey results for the 2019 operational monitoring.

3.4.2 SEARCHER EFFICIENCY

The 2019 searcher efficiency correction factor for Ecoscape zoologists at the BWF site is 0.93, or out of the 48 carcasses that were placed, 93% were found by the searchers. All carcasses missed in the field were from the 'small' size class of carcases which were either chicks or cockatiels.

3.5 ESTIMATED TOTAL BIRD STRIKES

Following the methods described above an estimated total number of bird strike events were calculated using: the mortality survey results, the searcher efficiency correction factor, the carcass persistence correction factor and the ratio of surveyed turbines to the total number of turbines within the wind farm.

The carcass persistence correction factor (CP=0.381) was used with the searcher efficiency correction factor (SE=0.93) and the number of carcasses (n=8) detected by the mortality surveys to determine an estimated number of bird strike events (ST) for the 16 impact sites surveyed during each survey event.

ST = (n/SE)/CP

ST = (8/0.93)/0.381; this gives an estimate of 22.65 estimated bird strikes at the 16 surveyed turbines for 2019.

The number of estimated bird strikes is then applied to the 37 turbine sites of the wind farm to give a total estimated bird strike number for the wind farm e.g. total estimated bird strikes = ST / (16 surveyed sites/37 total turbine sites).

Total estimated bird strikes during 2019 for the BWF is therefore 22.65 / (16/37) = 52.38.

4 DISCUSSION

4.1 CARNABY'S COCKATOO SITE USE AND ABUNDANCE

Carnaby's Cockatoo were recorded in 2019 utilising the Badgingarra Wind Farm site with counts varying substantially, from individuals to flocks of up to 200 birds. Total counts of Carnaby's Cockatoo recorded for the year one operational monitoring, at all sites combined, was 923 individual birds. When compared with the 2017-18 baseline pre-construction results of 3751 birds, the year one operational monitoring of 2019 recorded approximately 25% of the total number of birds observed before the turbines became operational.

This result may suggest that once the turbines became operational Carnaby's Cockatoo flocks avoided these sites, however, there was a general decrease of Carnaby's Cockatoo individuals recorded across all sites and the now constructed turbine sites in particular (**Table 15**, **Table 16**). A second year of monitoring will provide further data to confirm whether there is any turbine avoidance behaviour by Carnaby's Cockatoo flocks.

Table 15: Baseline (2017-18) results of Carnaby Cockatoo counts

Turbine sites								
Survey site	T02	T32	T36	T04	T31	T26	T09	T17
Carnaby's cockatoo count	700	154	123	85	23	2	0	1
Reference sites								
Survey site	R01	R05	R09	R12	R15	R22	R34	R36
Carnaby's cockatoo count	777	0	906	0	99	604	0	67

Table 16: Year one operational monitoring (2019) results of Carnaby's Cockatoo counts

Turbine sites								
Site	T02	T32	T36	T04	T31	T26	T09	T17
Carnaby's cockatoo count	0	3	80	0	0	0	0	0
Reference sites								
Site	R01	R05	R09	R12	R15	R22	R34	R36
Carnaby's cockatoo count	382	0	17	0	124	2	315	0

4.1.1 STATISTICAL ANALYSIS

A visual assessment of the NMDS ordination of bird abundance data reveals a difference in bird species composition with the composition recorded at impact sites occupying a different space (in the NMDS) compared to the reference sites (**Figure 2**). Permutation testing found that this visually observed difference was also statistically significantly different. Preliminary visual assessment of the NMDS ordination where the sites were coloured according to sampling year revealed a random pattern; permutation testing support this visual observation as survey year was found to be non- significant (i.e. explaining a small random propitiation of the species composition) .

The GLM analysis of the Carnaby's Cockatoo site use and abundance data has provided results to answer the questions of differences in Carnaby's Cockatoo abundance between impact and reference sites and Carnaby's Cockatoo counts in 2018 and 2019, as asked in **Section 2.2.3.1**.

1. *Is there a difference in bird species composition and abundance between the reference and impact sites?*

Analysis results using the 2018 and 2019 data combined indicated that there was a difference in species composition and abundance between the impact and reference sites; this relationship was statistically significant.

2. *Is there a difference in Carnaby's Cockatoo counts across years?*

GLM tests concluded that there is a significant difference in Carnaby's Cockatoo abundance between 2018 and 2019. The large difference in abundance cannot be explained by the presence of turbines alone as seasonal conditions may also explain the result; another year of monitoring could potentially assist in answering this question more definitively.

3. *Is there a consistent difference in Carnaby's Cockatoo abundance between reference and impact sites across years?*

There was no consistent difference between the reference and impact sites between years for Carnaby's Cockatoo abundance.

4. *Is there a difference in Carnaby's Cockatoo abundance between sites?*

There was significant a difference in Carnaby's Cockatoo abundance between sites.

4.1.2 CARNABY'S COCKATOO FLIGHT HEIGHTS

The majority (80%) of Carnaby's Cockatoo flocks recorded during the 2019 surveys, and opportunistically, were observed to be flying below rotor height (<20 m). The baseline results, from 2017-18, recorded that the majority (91%) of Carnaby's Cockatoo were also flying below rotor height.

Results from the 2019 year one operational monitoring are therefore comparable to the baseline results, indicating that the majority of Carnaby's Cockatoo flocks fly below rotor height at the BWF.

Zoologists reported that it was difficult to estimate bird flight heights at the reference sites due to the absence of features in the landscape to provide a point of reference; this was not the case at turbine sites as the towers proved to be useful height guides, therefore, providing reliable data.

4.1.3 OPPORTUNISTIC RECORDS

Ten opportunistic records of Carnaby's Cockatoo were observed either foraging or flying through the BWF, collected during the 2019 operational monitoring (**Table 12**). Five flocks were observed along Cadda Road and five recorded within the wind farm operational area (**Map 3**). All flocks were observed flying below rotor height (<20 m).

Flock numbers varied similar to the data collected at the reference sites with the largest flock of 200 birds foraging on Banksia shrubs near turbine T11 in April 2019 (**Table 12**).

4.2 MORTALITY SURVEY

Mortality surveys began with the commencement of the year one operational monitoring (2019) and therefore there is no "baseline" comparison as no turbines were operational in 2018.

Results from this first year (2019) of mortality surveys did not record any Carnaby's Cockatoo carcass from the 96 turbines sites surveyed. Carcasses of other bird species were recorded at the following turbine sites:

- Australian Kestrel (*Falco cenchroides*) (T15; T30; T20; T25 (incident report Nov 2019))
- Australian Magpie (*Cracticus tibicen dorsalis*) (T37)
- Australian Raven (*Corvus coronoid*es) (T34)
- Magpie Lark (*Grallina cyanoleuca)* (T06)
- Little Corella (*Cacatua sanguinea*) (T15).

Detected carcass density was recorded at one carcass per 75 hectares (600 ha/8 detected carcasses) and took on average 2.4 hours/site to survey.

4.2.1 CARCASS PERSISTENCE TRIALS

Carcass persistence trials were undertaken to determine the impact of scavengers in the field. As raw carcass counts often under-estimate the actual impact of wind farms as scavengers may remove carcasses before they can be detected (Korner-Nievergelt *et al.* 2013), carcass removal trials were used to generate a correction factor to more accurately reflect any windfarm impacts if they exist.

The trials indicated that carcass persistence steadily declined the longer they were left in place. However, the rate of scavenging also decreased, and after the trials, only small carcasses remained. These may have simply been overlooked by predators as larger more palatable carcasses were taken first.

By applying a correction factor to any carcasses found during the 2019 carcass persistence trial, the correction factor changed based on the survival analysis from the baseline surveys. The correction factors applied were 0.752 on day 1 and 0.525 on day 2, as per **Table 14**. The average length of carcass persistence was 4 days during the 2019 operational monitoring in comparison to 3.5 days recorded in 2018.

4.2.2 SEARCHER EFFICIENCY TRIALS

Carcass counts at wind farm sites can be biased due to potential differences in searcher efficiency and being able only to sample a proportion of the wind farm site. Differences in searcher efficiency can arise from differing levels of survey experience and site visibility from differences in vegetation cover and terrain. Studies have shown that when detection biases are not taken into account, human searchers greatly underestimate the number of birds struck by wind turbines (Korner-Nievergelt et al. 2013).

The 2019 operational monitoring surveys recorded a searcher efficiency correction factor of 0.93 due to the degraded nature of the sites offering little in the way of obstruction. Using 0.93 as a searcher efficiency correction factor applied to the eight detected carcasses means an additional 1.12 birds were potentially struck by turbines during the monitoring survey period that went undetected.

The 2018 monitoring recorded a searcher efficiency correction factor of 0.84 and is therefore directly comparable to the 2019 results.

4.2.3 ESTIMATED BIRD STRIKE

The total number of estimated bird strike events for the 2019 operational monitoring was calculated at 52.38 birds for the entire wind farm.

There is no comparison to be made with 2018 data as turbines were not operational.

5 MONITORING PLAN

An overview of the surveys completed to date and future surveys are outlined below (**Table 17**).

Surveys are required at the same sites as used for the year one monitoring following the standardised methodology.

Surveys should take place during the two peak flight periods:

- **December to April** for adult and fledgling east-west migration for feeding.
- **July to September** for adult west-east migration for breeding.

Below is an outline of survey timing.

Table 17: Overview of monitoring program 2019-2020

SURVEY TYPE	SURVEY DETAILS	TIMING
Site use and abundance surveys	Two seven day survey events in each flight period	Feb-Apr 2019: two survey events – **COMPLETED** Jul-Sep 2019: two survey events - **COMPLETED** Feb-Apr 2020: two survey events - Scheduled Jul-Sep 2020: two survey events - Scheduled
Mortality surveys	Three eight-day survey events in each flight period	Feb-Apr 2019: three survey events - **COMPLETED** Jul-Sep 2019: three survey events - **COMPLETED** Feb-Apr 2020: three survey events - Scheduled Jul-Sep 2020: three survey events - Scheduled
Carcass persistence surveys	One single day survey event in each flight period	Feb 2019: one survey event - **COMPLETED** Jul 2019: one survey event - **COMPLETED** Feb 2020: one survey event - Scheduled Jul 2020: one survey event - Scheduled
Searcher efficiency surveys	One single day survey event in each flight period	Feb 2019: one survey event - **COMPLETED** Jul 2019: one survey event - **COMPLETED** Feb 2020: one survey event - Scheduled Jul 2020: one survey event - Scheduled

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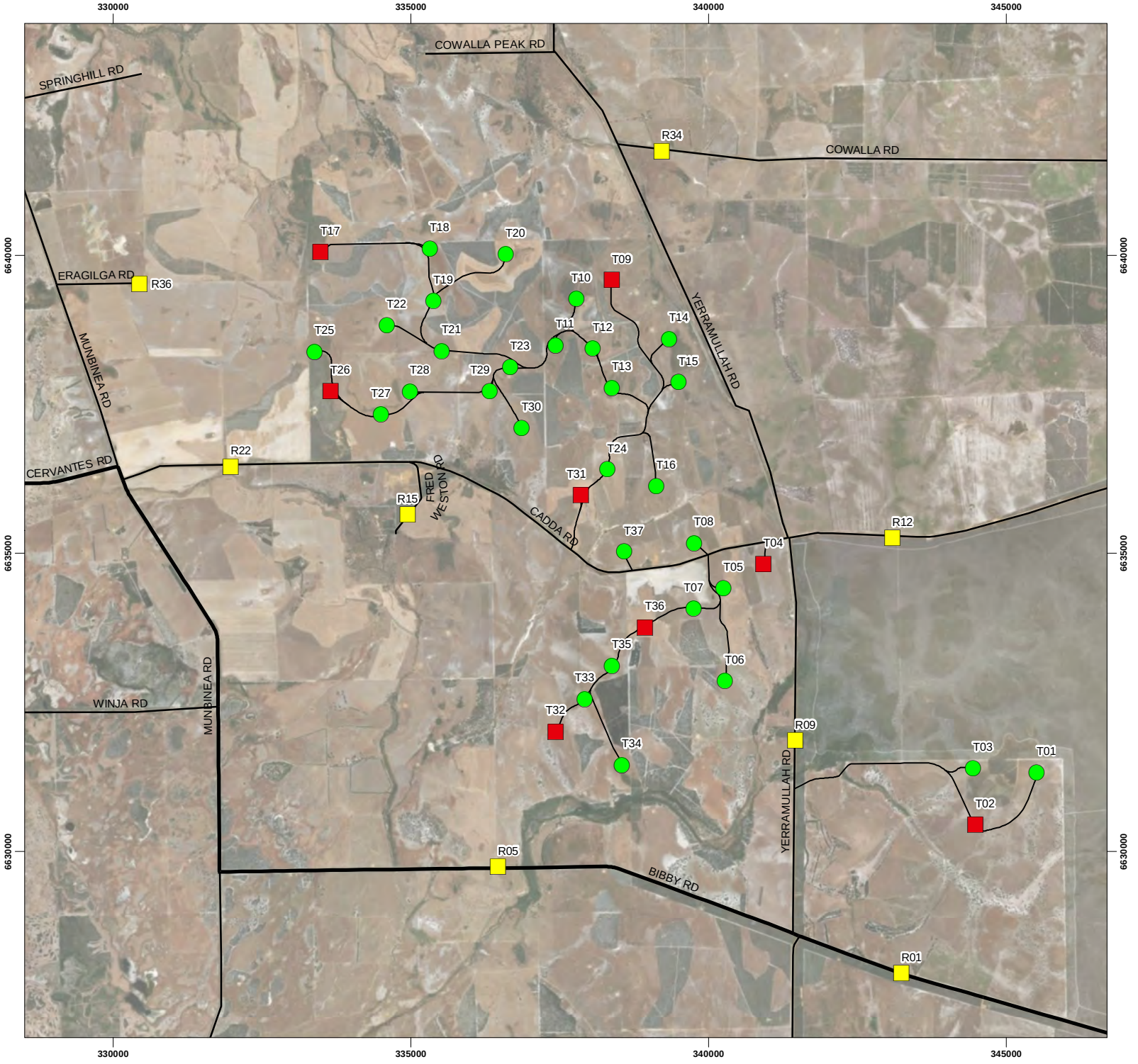
MAPS



LEGEND

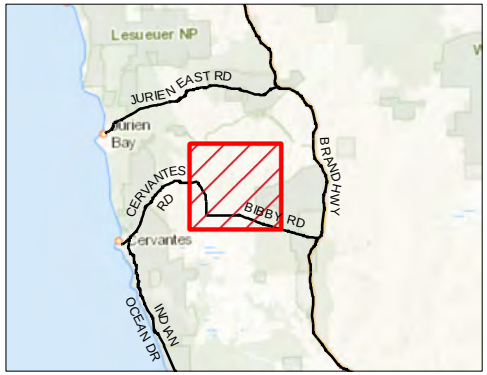
Reference Sites

Turbines

Impact sites

Random sites

DATA SOURCES:
SOURCE DATA: APA GROUP
SERVICE LAYERS: SOURCE: ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY



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MONITORING SITES

BIRD MONITORING
BADGINGARRA WIND FARM

APA GROUP

COORDINATE SYSTEM: GDA 1994 MGA ZONE 50
PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
UNITS: METER

N

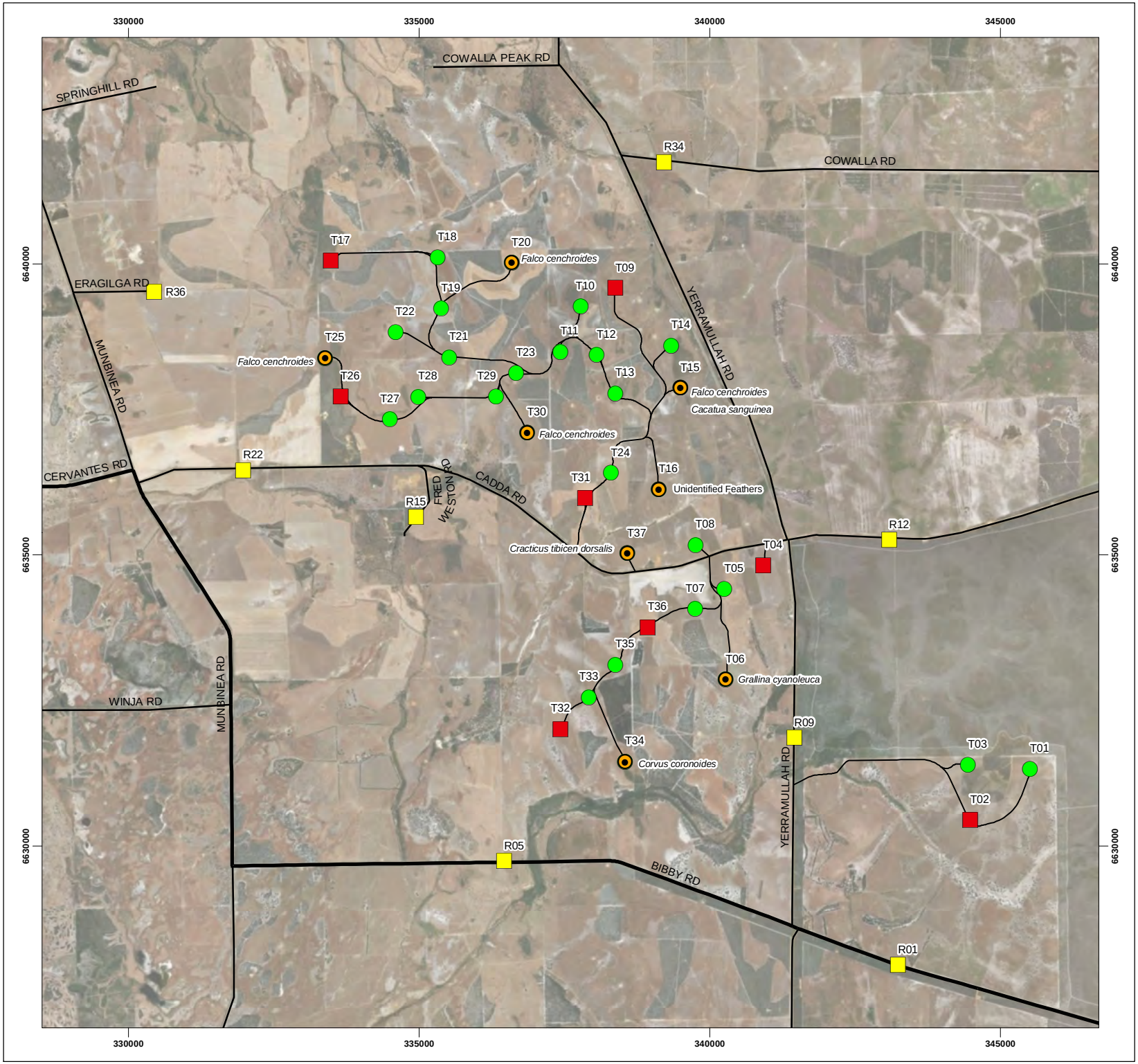
SCALE: 1:90,000 @ A4

0 1 2 km

PROJECT NO: 4309-19

REV	AUTHOR	APPROVED	DATE
0	SB	BT	11/11/2019

MAP 01



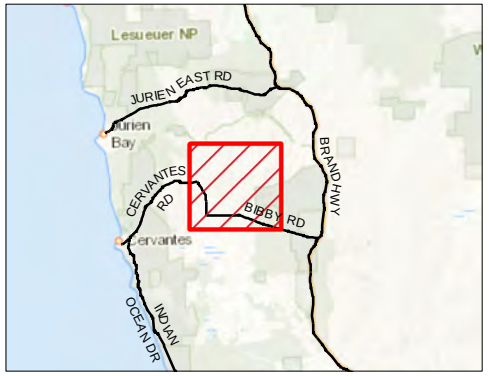
LEGEND

- 2019 Carcass records
- Reference Sites

Turbines

- Impact sites
- Random sites

DATA SOURCES:
SOURCE DATA: APA GROUP
SERVICE LAYERS: SOURCE: ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY



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2019 CARCASS RECORDS

BIRD MONITORING
BADGINGARRA WIND FARM

APA GROUP

COORDINATE SYSTEM: GDA 1994 MGA ZONE 50
PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
UNITS: METER

N

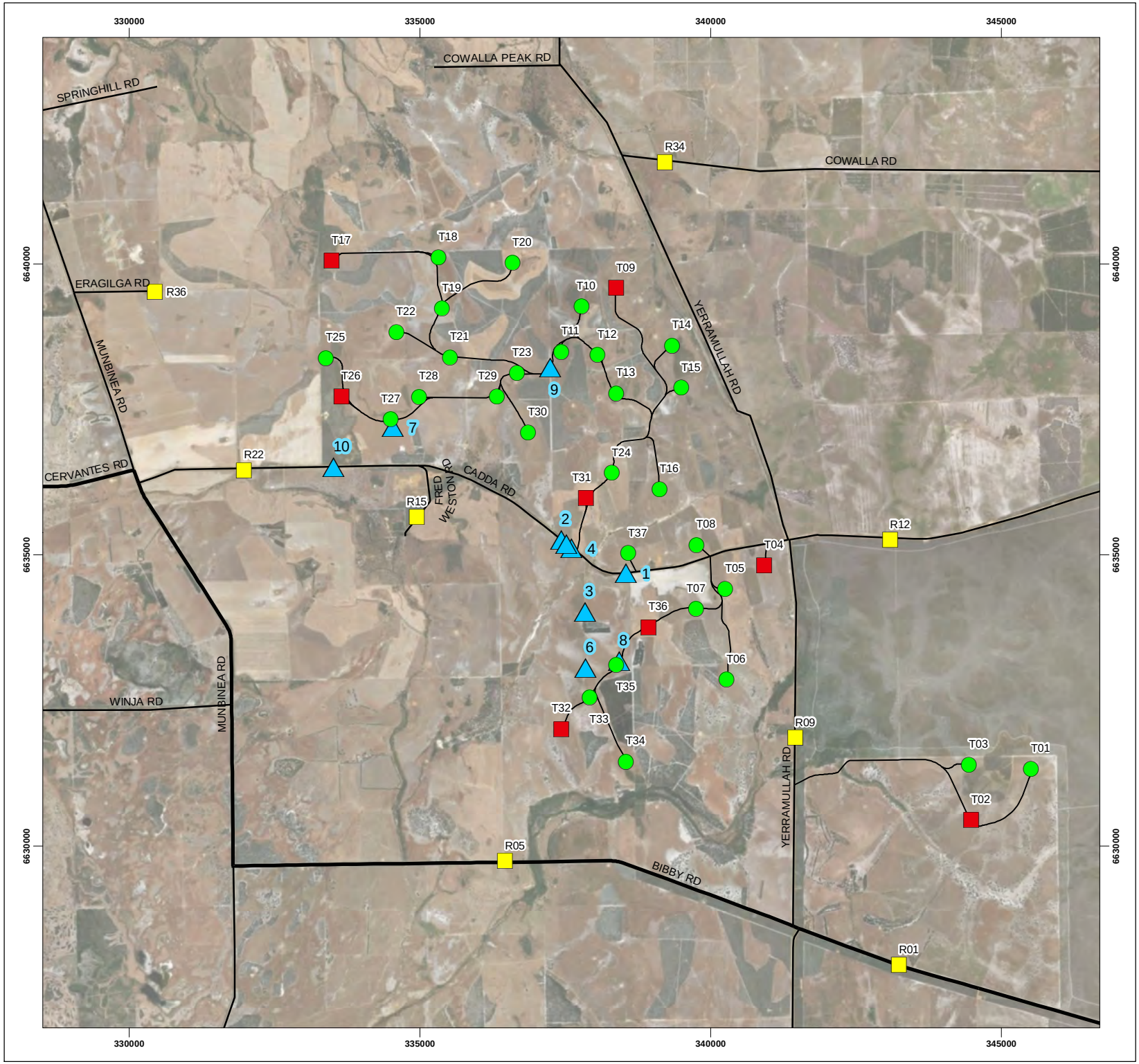
SCALE: 1:90,000 @ A4

0 1 2 km

PROJECT NO: 4309-19

REV	AUTHOR	APPROVED	DATE
0	SB	BT	11/11/2019

MAP 02



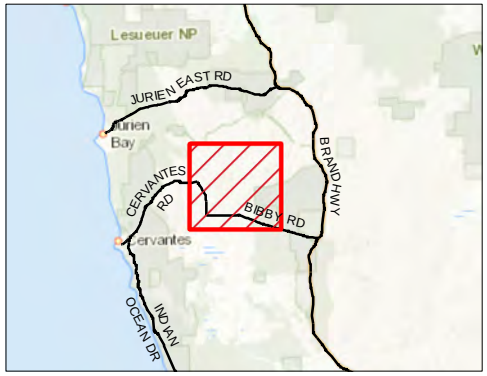
LEGEND

- Reference Sites

Turbines

- Impact sites
- Random sites
- Carnaby's Black-Cockatoo Opportunistic Record

DATA SOURCES :
SOURCE DATA: APA GROUP
SERVICE LAYERS: SOURCE: ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY



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CARNABY'S BLACK COCKATOO 2019 OPPORTUNISTIC RECORDS

BIRD MONITORING BADGINGARRA WIND FARM

APA GROUP

COORDINATE SYSTEM: GDA 1994 MGA ZONE 50
PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
UNITS: METER

N

SCALE: 1:90,000 @ A4

0 1 2 km

PROJECT NO: 4309-19

REV	AUTHOR	APPROVED	DATE
0	SB	BT	11/11/2019

MAP 03

APPENDIX ONE BIRD STRIKE INCIDENT REPORT

SIEMENS Gamesa RENEWABLE ENERGY

Bird Strike Form - BWF

Reporting Person

First Name: Matthew

Last Name: MARX

Email: matthew.marx@siemensgamesa.com

Bird Found

Type: FALCON?

Location: T25

Time and date: 0900 09/10/19

Wind Direction/Weather: SW 2M/S SUNNY

Photo:

Field Summary Report - Spring 2019

APA Group

ecoscape

VERSION	AUTHOR	QA REVIEWER	APPROVED	DATE
draft rev0	Bruce Turner	L. atkins Lyn Atkins Principal Ecologist	L. atkins Lyn Atkins Principal Ecologist	11/11/2019

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ACKNOWLEDGEMENTS

Ecoscape acknowledges the assistance and support provided by APA and their contractors while undertaking the field surveys, in particular Darryl Fraser and Madonna Burns.

1 INTRODUCTION

1.1 BACKGROUND

On 29 November 2016 the Shire of Dandaragan granted an extension of the Planning Approval for the Badgingarra Wind Farm to 12 December 2019. The Shire set out specific conditions as part of the Planning Approval. Conditions 20 and 21 specifically refer to bird mortality and Carnaby's Cockatoo (*Calyptorhynchus latirostris*) monitoring:

> Condition 20: *The proponents shall develop and implement a bird mortality monitoring program within 12 months of commencement of Wind Farm operations. The program shall be developed in consultation with the Department of Parks and Wildlife and/or the WA Museum. Results of the program shall be forwarded to the Shire of Dandaragan*.
>
> Condition 21: *The proponents shall develop and implement an annual monitoring program for Carnaby's Cockatoo (Calyptorhynchus latirostris) bird strike, foraging and roosting (including any avoidance) behaviour, with reporting to the Commonwealth Department of the Environment, Water, Heritage and the Arts. The WA Museum (Mr Ron Johnstone or his nominated appointment) is to be consulted in developing appropriate survey methodologies for Carnaby's Cockatoo. The duration of this monitoring program will be defined during the development of the program and subject to review, based on findings during the first two years' monitoring*.

Based upon the conditions outlined in the Planning Approval, the bird mortality monitoring program is to be reviewed based on the findings from two years from commencement of turbine operation. During this time, the bird abundance and mortality surveys will provide adequate data to detect any impacts on Carnaby's Cockatoo or other bird species from the turbines.

Ecoscape conducted the pre-operational baseline monitoring surveys for Carnaby's Cockatoos and other birds at APA Group's Badgingarra Wind Farm Development Project from October 2017 to August 2018.

The next phase of the monitoring program requires the collection of comparative data to determine if the operational wind farm has any detectable impacts on Carnaby's Cockatoo or other bird species in the spring migration season of 2019.

This memo documents the results of the second mortality and abundance monitoring surveys which were undertaken from July to September 2019. **Map 1** shows the location of reference sites, random sites and impact turbines sites, **Map 2** shows the location of recorded carcasses and opportunistic observations.

2 METHODS

2.1 BIRD MORTALITY

2.1.1 CARCASS REMOVAL (SCAVENGER IMPACT) TRIALS

A carcass removal trial was undertaken prior to the carcass searches commencing in July 2019. The results allow for a correction factor to be calculated for use in data analysis to more accurately reflect the impact of the wind farm.

Carcasses were placed across the search areas of selected turbine sites. Carcass removal trials allow detection of the background level of carcass removal. Carcasses were left in the field until they completely decomposed or were taken by scavengers and were checked every 2-3 days.

2.1.2 SEARCHER EFFICIENCY

Carcass counts at wind farm sites can be biased due to potential differences in searcher efficiency and being able to only sample a small proportion of the wind farm site due to budgetary and time constraints. By completing searcher efficiency trials, a correction factor can be calculated to allow for differences in searcher's ability to detect carcasses.

A searcher efficiency trial was undertaken prior to carcass searches commencing in July 2019; three field personnel undertook the trial. Three to five discretely marked carcasses were placed at each impact site. A 'tester' controlled the trials, placing the carcasses into the search areas and collecting them after the trial, noting if any were scavenged or removed. Searchers recorded carcasses at each of the test sites; data collected was used to determine each field member's correction factor.

2.1.3 CARCASS SEARCHES

Bird mortality metrics were collected by completing active carcass searches. Three carcass searches were undertaken during the July-September 2019 flight season at each of the eight previously selected turbines (Impact Sites) and eight randomly selected turbines (Random Sites) (

Table 1). The impact sites remained constant for each of the three carcass searches, while the random sites varied.

Table 1: Carcass Search Sites - Flight Season Jul-Sep 2019

Turbine No.	July	August	September
Impact Sites			
02	•	•	•
04	•	•	•
09	•	•	•
17	•	•	•
26	•	•	•
31	•	•	•
32	•	•	•
36	•	•	•
Random Sites			
01	•		
03	•		•
05		•	
06	•		
07			
08			•
10		•	
11	•		
12		•	
13			•
14			•
15			
16			
18			
19		•	
20	•		•
21	•		
22			•
23			•
24			•
25	•		
27		•	
28		•	
29		•	
30			
33			
34			
35	•		
37		•	

2.2 CARNABY'S COCKATOO SURVEYS

2.2.1 SITE USE AND BIRD ABUNDANCE SURVEYS

Carnaby's Cockatoo site use and abundance surveys aim to provide information of site use by Carnaby's Cockatoo and other bird species and record their abundance. The monitoring program is based on a modified point count method recording the location and abundance of Carnaby's Cockatoo from the impact and reference sites and includes any opportunistic sightings recorded when travelling between sites.

Two site use and abundance surveys were undertaken during the adult and fledgling east-west migration season (July to September) (**Table 2**). Reference and impact sites are indicated on **Map 1**.

3 RESULTS

3.1 CARCASS SEARCHES

Six carcasses of struck birds were recorded during the spring flight period (**Map 2**). Three carcasses were recorded during the July survey period and a further three were recorded in August. No carcasses were recorded during the September survey.

On 29 July three carcasses were recorded; a Magpie Lark (*Grallina cyanoleuca)* was recorded at T06, an Australian Kestrel (*Falco cenchroides)* was recorded at T20 and an unidentifiable species recorded at T16. All that remained of these carcasses were a small number of flight and tail feathers.

On 23 August an Australian Raven (*Corvus coronoide*s) was recorded T34 and an Australian Kestrel (*Falco cenchroides)* at T15. In both instances all that remained of carcasses were wing feathers. The Kestrel wing was fully intact while the Raven feathers were torn apart and spread across a couple of metres. On 27 August the carcass of a Corella (*Cacatua sanguinea*) was recorded at T15, again all that remained was a scattering of breast feathers.

Due to the lack of remains the probability is high that the birds were struck by the turbine blades and subsequently predated on, or removed, by either a Fox (*Vulpes vulpes*) or Feral Cat (*Felis catus*).

The carcass removal by scavenger's evidence reinforces the need to maintain a monitoring regime of every second day in order to detect bird strikes during the survey period. It would appear that a longer interval between surveys for any given site is likely not to detect a bird strike as carcasses are removed within the two day interval.

3.1.1 BIRD STRIKE INCIDENT

On the morning of the 9 November the carcass of an Australian Kestrel was discovered by Matthew Marx from Siemens Gamesa at approximately 9 am at T25. The image recorded provides evidence of an intact, freshly struck carcass. The original incident form is included in **Appendix One**.

Image 1: Australian Kestrel carcass from T25

3.1.2 SURVEY EFFORT

Data from the carcass surveys recorded a total search effort of 55-56 hours for an eight day survey period. The total search effort for the flight period is approximately 165 hours over the three surveys now completed.

3.2 SITE USE AND ABUNDANCE SURVEYS

The two site use and abundance surveys provided information on the species and number of birds moving across the windfarm site (**Table 2**). Observations and abundance for Carnaby's Cockatoo (*Calyptorhynchus latirostris*) is the only data presented as this species is the focus of the monitoring. Reference and Impact site locations are provided on **Map 1**. Survey 1 was undertaken during 30 July-5 August 2019 and survey 2 during 16-22 September 2019.

Table 2: Site use and abundance results for Carnaby's Cockatoo only.

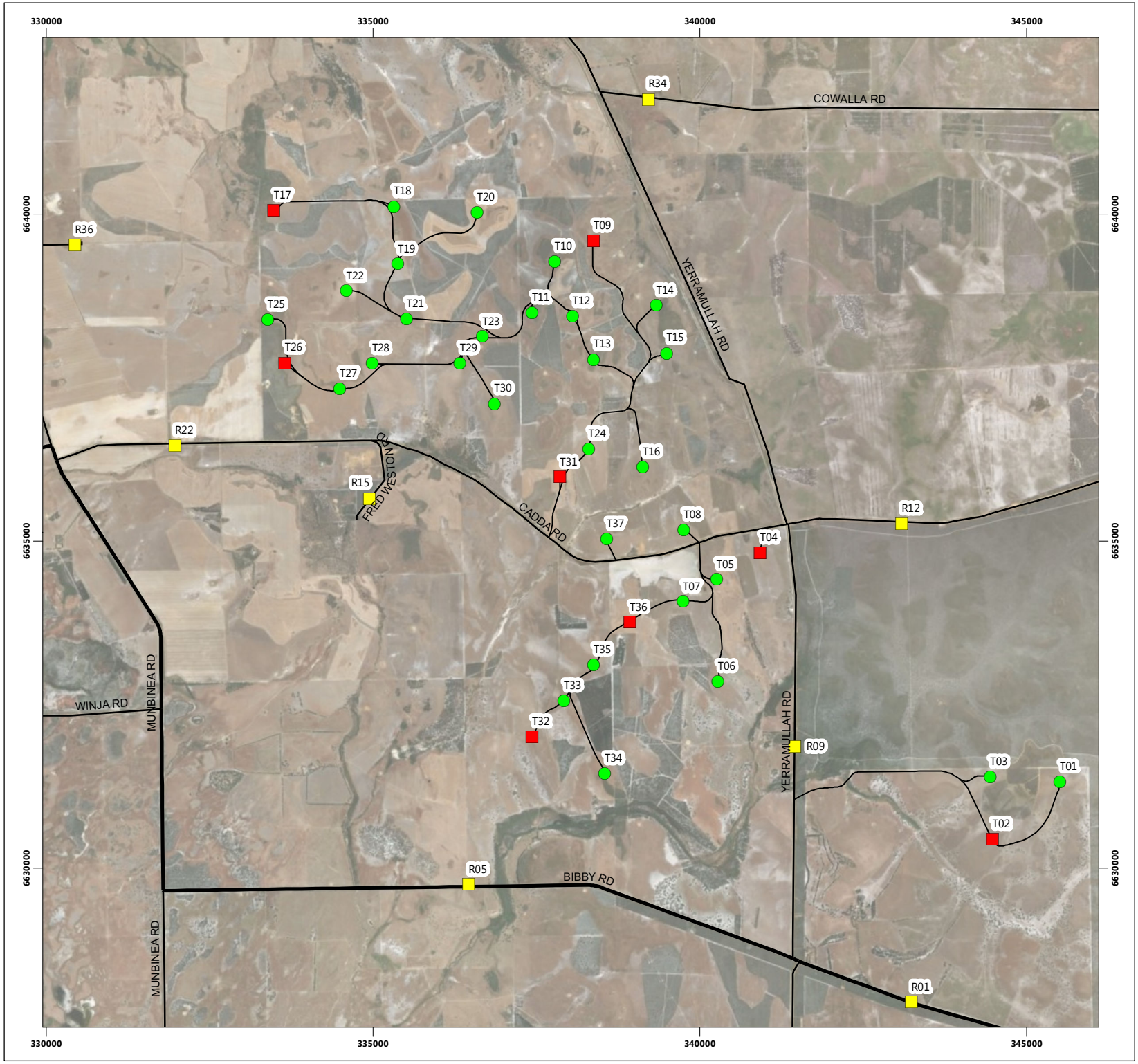
Sites	Survey 1 Jul	Abundance	Survey 2 Sept	Abundance
Reference Sites				
R01				
R05				
R09				
R12				
R15			1 flock	22
R22	1 flock	2		
R34				
R36				
Impact sites				
T02				
T04				
T09				
T17				
T26				
T31				
T32				
T36				
Opportunistic Observations				
01	1 flock	2		
02	1 flock	3		

The results indicate flocks of Carnaby's Cockatoo are greatly reduced since the Feb-Apr 2019 survey. Only two flocks were observed at Reference sites with 24 birds recorded in total. No Carnaby's Cockatoo were observed at Impact turbines. Two opportunistic observations were recorded with 2-3 birds in each flock. (**Map 2**). The number of flocks observed have declined as has the number of individuals within each flock.

CONCLUSION

Carnaby's Cockatoo is persisting in the landscape in diminished numbers with no recorded impact from turbine strikes.

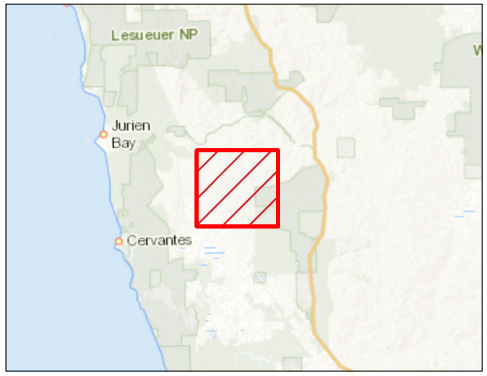
MAPS



LEGEND

- Impact Sites
- Random Sites
- Reference Sites

DATA SOURCES:
SOURCE DATA: APA GROUP
SERVICE LAYERS: SOURCE: ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEX, GETMAPPING, AEROGRID, IGN, IGP, SWISSTOPO, AND THE GIS USER COMMUNITY



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MONITORING SITES

BIRD MONITORING
BADGINGARRA WIND FARM

APA GROUP

COORDINATE SYSTEM: GDA 1994 MGA ZONE 50
PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
UNITS: METER

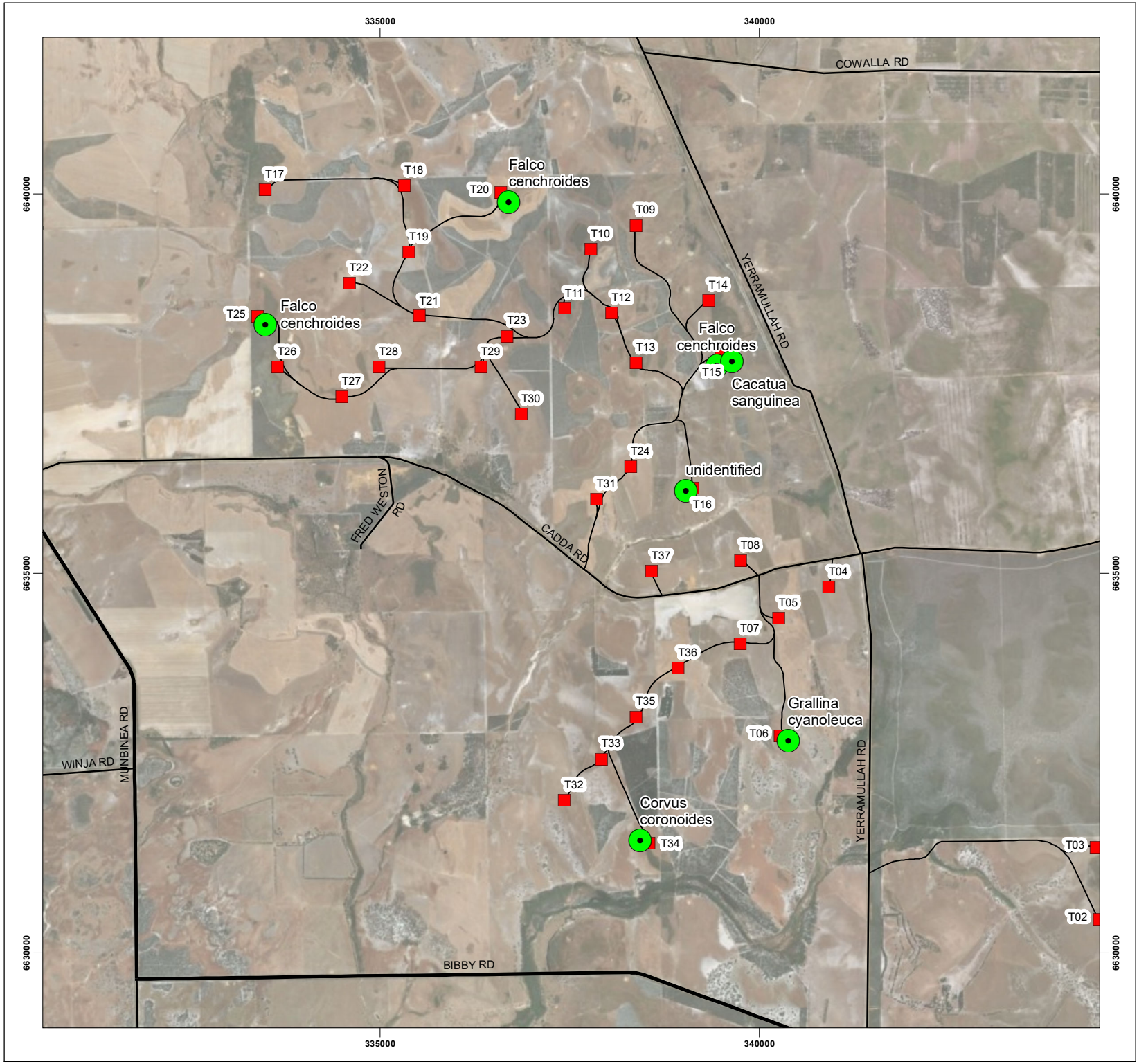
SCALE: 1:80,000 @ A4

0 0.8 1.6 2.4 km

PROJECT NO: 4113-17

REV	AUTHOR	APPROVED	DATE
0	BGT	SB	16/05/2019

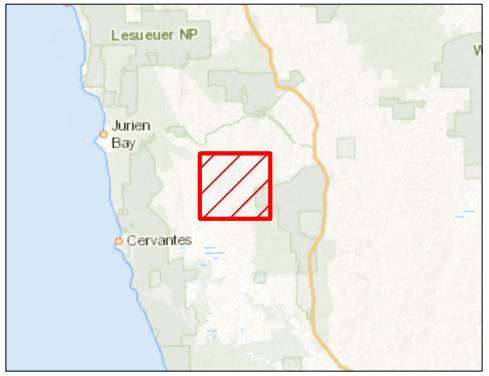
MAP 01



LEGEND

- Carcasses Jul-Sep 2019
- Turbines

DATA SOURCES:
SOURCE DATA: APA GROUP
SERVICE LAYERS: SOURCE: ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY



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CARCASS AND OPPORTUNISTIC RECORDS

BIRD MONITORING BADGINGARRA WIND FARM

APA GROUP

COORDINATE SYSTEM: GDA 1994 MGA ZONE 50
PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
UNITS: METER

N

SCALE: 1:69,015 @ A4

0 0.7 1.4 2.1 km

PROJECT NO: 4113-17

REV	AUTHOR	APPROVED	DATE
0	BGT	SB	16/05/2019

MAP 02

APPENDIX ONE BIRD STRIKE FORM

Insert Bird strike form.

SIEMENS Gamesa RENEWABLE ENERGY

Bird Strike Form - BWF

Reporting Person

First Name: Matthew

Last Name: MARX

Email: matthew.marx@siemensgamesa.com

Bird Found

Type: FALCON?

Location: T25

Time and date: 0900 09/10/19

Wind Direction/Weather: SW 2M/S SUNNY

Photo:

Field Summary Report - Summer 2020

APA

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VERSION	AUTHOR	QA REVIEWER	APPROVED	DATE
draft rev0	Hugh Osborn	 Bruce Turner Senior Zoologist	 Bruce Turner Senior Zoologist	15/05/2020

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ACKNOWLEDGEMENTS

Ecoscape acknowledges the assistance and support provided by APA and their contractors while undertaking the field surveys, in particular Madonna Burns and Darryl Fraser.

1 INTRODUCTION

1.1 BACKGROUND

On 29 November 2016 the Shire of Dandaragan granted an extension of the Planning Approval for the Badgingarra Wind Farm to 12 December 2019. The Shire set out specific conditions as part of the Planning Approval. Conditions 20 and 21 specifically refer to bird mortality and Carnaby's Cockatoo (*Calyptorhynchus latirostris*) monitoring:

> Condition 20: *The proponents shall develop and implement a bird mortality monitoring program within 12 months of commencement of Wind Farm operations. The program shall be developed in consultation with the Department of Parks and Wildlife and/or the WA Museum. Results of the program shall be forwarded to the Shire of Dandaragan*.
>
> Condition 21: *The proponents shall develop and implement an annual monitoring program for Carnaby's Cockatoo (Calyptorhynchus latirostris) bird strike, foraging and roosting (including any avoidance) behaviour, with reporting to the Commonwealth Department of the Environment, Water, Heritage and the Arts. The WA Museum (Mr Ron Johnstone or his nominated appointment) is to be consulted in developing appropriate survey methodologies for Carnaby's Cockatoo. The duration of this monitoring program will be defined during the development of the program and subject to review, based on findings during the first two years' monitoring*.

Based upon the conditions outlined in the Planning Approval, the bird mortality monitoring program is to be reviewed based on the findings from two years from commencement of turbine operation. During this time, the bird abundance and mortality surveys will provide adequate data to detect any impacts on Carnaby's Cockatoo or other bird species from the turbines.

Ecoscape conducted the pre-operational baseline monitoring surveys for Carnaby's Cockatoos and other birds at APA Group's Badgingarra Wind Farm Development Project from October 2017 to August 2018. Ecoscape completed the Year One monitoring during 2019 after the project became operational.

The Year Two monitoring program requires the collection of comparative data to determine if the operational wind farm has any detectable impacts on Carnaby's Cockatoo or other bird species in the two 2020 flight seasons.

This memo documents the results of the first mortality and abundance monitoring surveys which were undertaken from February to April 2020. **Map 1** shows the location of reference sites, random sites, and impact turbines sites, **Map 2** shows the location of recorded carcasses and opportunistic observations.

2 METHOD

2.1 BIRD MORTALITY

2.1.1 CARCASS REMOVAL (SCAVENGER IMPACT) TRIALS

A carcass removal trial was undertaken prior to the carcass searches commencing in March 2020. The results allow for a correction factor to be calculated for use in data analysis to more accurately reflect the impact of the wind farm.

Carcasses were placed across the search areas of selected turbine sites. Carcass removal trials allow detection of the background level of carcass removal. Carcasses were left in the field until they completely decomposed or were taken by scavengers and were checked every 2-3 days.

2.1.2 SEARCHER EFFICIENCY

Mortality counts at wind farm sites can be biased due to potential differences in searcher efficiency and being able to only sample a small proportion of the wind farm site due to budgetary and time constraints. By completing searcher efficiency trials, a correction factor can be calculated to allow for differences in searcher's ability to detect carcasses.

A searcher efficiency trial was undertaken prior to mortality surveys commencing in March 2020; two field personnel undertook the trial. Six to eight discretely marked carcasses were placed at two impact sites. A 'tester' controlled the trials, placing the carcasses into the search areas and collecting them after the trial, noting if any were scavenged or removed. Searchers recorded carcasses at each of the test sites; data collected was used to determine each field member's correction factor.

2.1.3 MORTALITY SURVEYS

Bird mortality metrics were collected by completing active carcass searches. Three mortality surveys were undertaken during the December 2019-April 2020 flight season at each of the eight previously selected turbines (Impact Sites) and eight randomly selected turbines (Random Sites) (**Table 1**). The impact sites remained constant for each of the three mortality surveys, while the random sites varied.

Table 1: Carcass Search Sites - Flight Season Dec 2019-Apr 2020

Turbine No.	February	March	April
Impact Sites			
02	•	•	•
04	•	•	•
09	•	•	•
17	•	•	•
26	•	•	•
31	•	•	•
32	•	•	•
36	•	•	•
Random Sites			
01			
03			
05		•	
06		•	
07		•	
08			•
10			•
11		•	
12	•		•
Random Sites			
13		•	
14	•		
15			
16			
18	•		

Turbine No.	February	March	April
19		•	
20			
21			
22			•
23			•
24			•
25	•		
27	•		•
28	•		
29			
30		•	
33	•		•
34		•	
35	•		
37			

2.2 CARNABY'S COCKATOO SURVEYS

2.2.1 SITE USE AND BIRD ABUNDANCE SURVEYS

Carnaby's Cockatoo site use and abundance surveys aim to provide information of site use by Carnaby's Cockatoo and other bird species, and record their abundance. The monitoring program is based on a modified point count method recording the location and abundance of Carnaby's Cockatoo and all other bird species observed from the impact and reference sites and includes any opportunistic sightings recorded when travelling between sites.

Two site use and abundance surveys were undertaken during the adult and fledgling east-west migration season (December to April) (**Table 2**). Reference and impact sites are indicated on **Map 1**.

3 RESULTS

3.1 CARCASS SEARCHES

Five bird carcasses were recorded during the mortality surveys (**Map 2**). Turbine T5 recorded the remains (**Plate 1**) of an Australian Raven (*Corvus coronoides)* on the 6 March 2020. Only a number of flight feathers remained at the site.

Turbine T31 recorded the carcass of an Australian Kestrel (*Falco cenchroides*) on 14 April 2020; the carcass (**Plate** 2**2**) was found on day 1 of the survey indicating that it is from the inter-survey period (between Mortality Surveys 2 and 3, 2020). As the site is bare ground within a stocked paddock the probability is high that the bird was struck by the turbine blades.

Turbine T12 recorded the flight feather remains (**Plate 3)** of an Australian Kestrel (*Falco cenchroides)* on 15 April 2020; the flight feathers were found scattered at the site, but no carcass was found; potentially predated on, or removed, by either a Fox (*Vulpes vulpes*) or Feral Cat (*Felis catus*). These remains were found on the first survey day for the random sites also indicating they are from the inter-survey period (between Mortality Surveys 2 and 3, 2020).

Turbine 23 Australian Magpie (*Cracticus tibicen*) on 15 April (**Plate** 3**4**). The carcass was fresh and found with a visibly broken wing and is presumed struck within a day or two of being found. The carcass remained in place for a number of days and had been completely removed by either a Fox or Feral Cat on or just prior to the final day of survey at this site on 21 April. No flight feathers or other traces remained. This highlights the need for regular mortality surveys to identify frequency of bird strike and locate fresh carcasses.

Turbine T32 recorded a carcass of an Australian Kestrel (*Falco cenchroides*) on 20 April 2020; the carcass condition (**Plate 2**) indicates that it is most likely from the inter-survey period (Mortality Surveys 2 and 3, 2020).

Plate 1: Flight feather remains of Australian Raven at T5.

Plate 2: Carcass of Australian Kestrel at T31

Plate 3: Flight feather remains of Australian Kestrel at T12

Plate 4: Carcass of Australian Magpie at T23

Plate 5: Carcass of Australian Kestrel at T32

The carcass removal by scavengers' evidence reinforces the need to maintain regular monitoring trips over multiple days. Although old carcasses were discovered in situ, the removal of the relatively fresh carcass of an Australian Magpie without leaving remnants of flight feathers indicates it is possible for bird strike to be missed if a predation event removes traces of a bird completely.

3.1.1 SURVEY EFFORT

Data from the mortality surveys recorded a total search effort of 16-17 hours for an eight day survey period. The total search effort for the flight period is approximately 51 hours over the three surveys now completed.

3.2 SITE USE AND ABUNDANCE SURVEYS

The two site use and abundance surveys provided information on the species and number of birds moving across the windfarm site. Observations and abundance for Carnaby's Cockatoo (*Calyptorhynchus latirostris*) is the only data presented as this species is the focus of the monitoring. Reference and Impact site locations are provided on **Map 1**. Survey 1 was undertaken during 7-14 February 2020 and survey 2 during 14-21 April 2020.

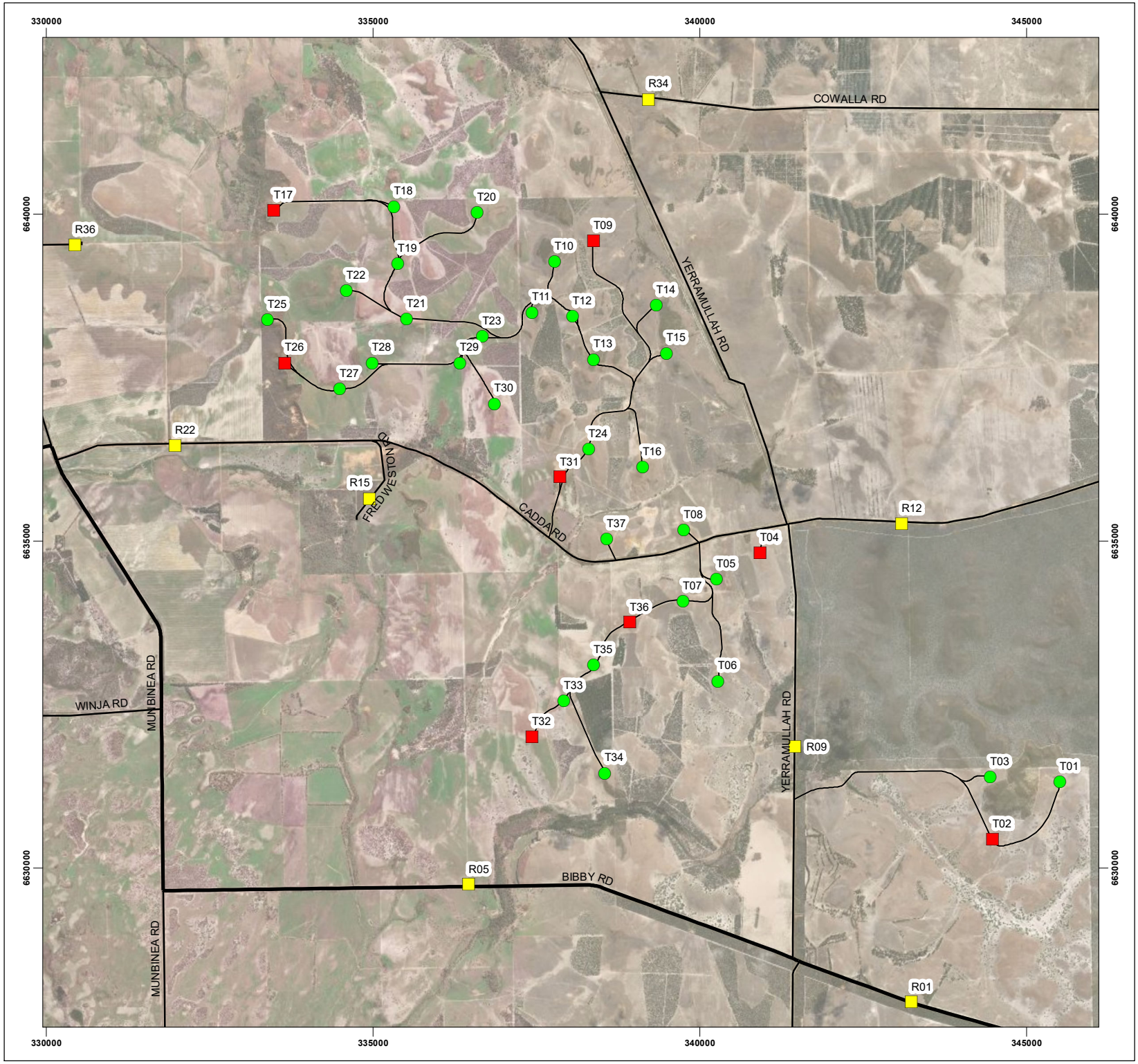
Table 2: Site use and abundance results for Carnaby's Cockatoo only

Sites	Survey 1 Feb	Abundance	Opportunistic Mar	Abundance	Survey 2 Apr	Abundance
Reference Sites						
R01	2 flocks	90 - 166	-	-	2 flocks	1 - 3
R05	-	-	-	-	-	-
R09	3 flocks	25 - 100	-	-	-	-
R12	-	-	-	-	1 flock	1
R15	-	-	-	-	1 flock	1
R22	1 flock	6	-	-	2 flocks	20 - 40
R34	1 flock	50	-	-	-	-
R36	-	-	-	-	5 flocks	8 - 90
Impact sites						
T02	-	-	-	-	-	-
T04	-	-	-	-	-	-
T09	-	-	-	-	-	-
T17	-	-	-	-	-	-
T26	-	-	-	-	-	-
T31	2 flocks	29	-	-	-	-
T32	2 flocks	82	-	-	-	-
T36	1 flock	3	-	-	-	-
Opportunistic Observations						
01	1 flock	50	-	-	-	-
02	1 flock	20	-	-	-	-
03	1 flock	40	-	-	-	-
04	-	-	1 flock	60	-	-
05	-	-	1 flock	20	-	-
06	-	-	1 flock	16	-	-
07	-	-	1 flock	160	-	-
08	-	-	-	-	1 flock	40
09	-	-	-	-	1 flock	100
10	-	-	-	-	1 flock	40
11	-	-	-	-	1 flock	10
12	-	-	-	-	1 flock	100-150

The results indicate flocks of Carnaby's Cockatoo were consistently recorded from the reference sites. Only three of the impact sites recorded flocks. Twelve opportunistic flock sightings were also recorded (**Map 2**).

Carnaby's Cockatoo is persisting in the landscape in consistent flock numbers with no impact from turbine strike being recorded.

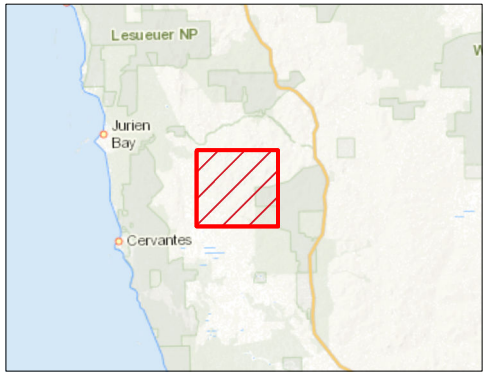
MAPS



LEGEND

- Impact Sites
- Random Sites
- Reference Sites

DATA SOURCES:
SOURCE DATA: APA GROUP
SERVICE LAYERS: SOURCE: ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY



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MONITORING SITES

BIRD MONITORING
BADGINGARRA WIND FARM

APA GROUP

COORDINATE SYSTEM: GDA 1994 MGA ZONE 50
PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
UNITS: METER

SCALE: 1:80,000 @ A4

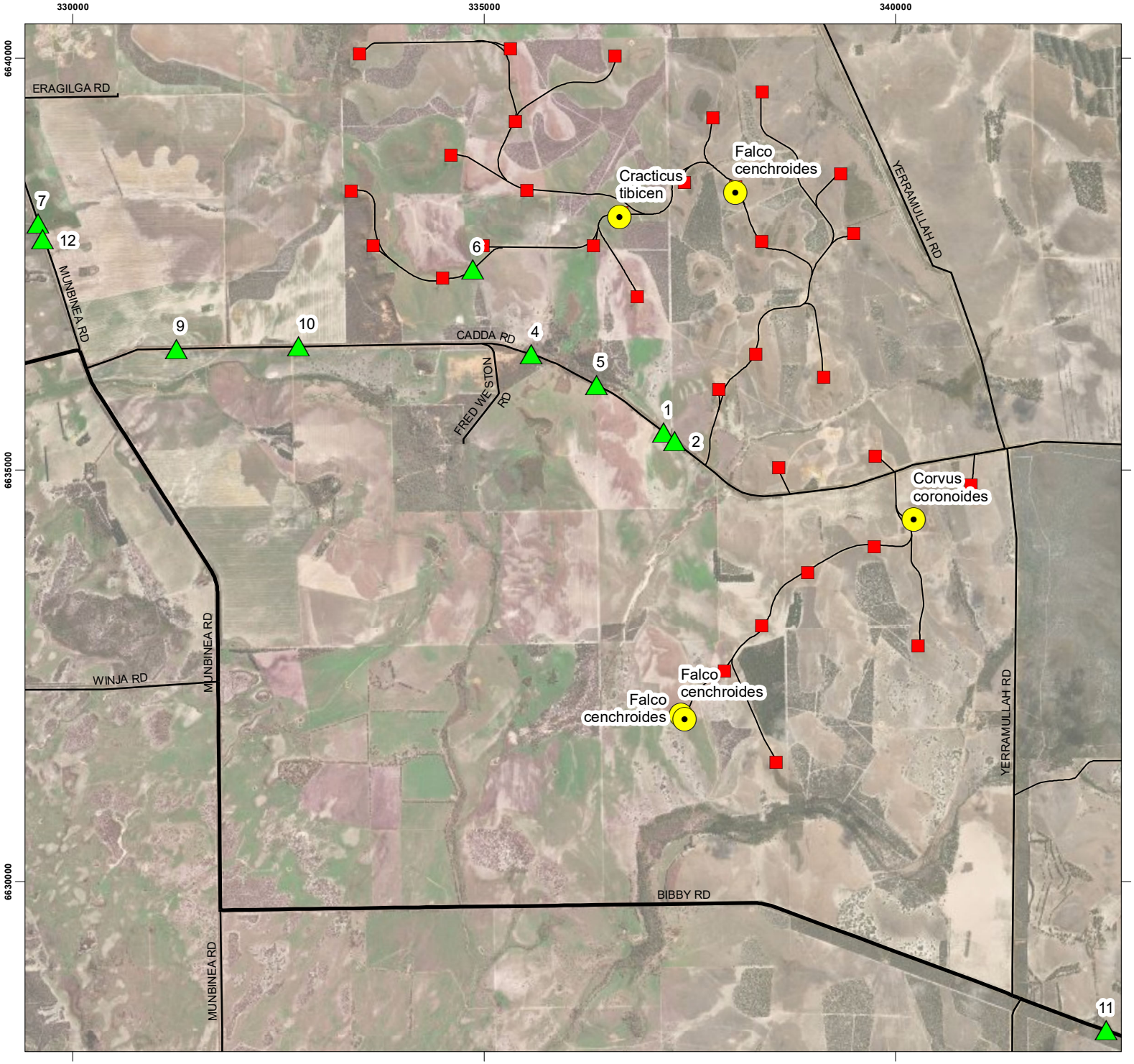
N

0 0.8 1.6 2.4 km

PROJECT NO: 4506-20

REV	AUTHOR	APPROVED	DATE
0	HCO	BGT	13/05/2020

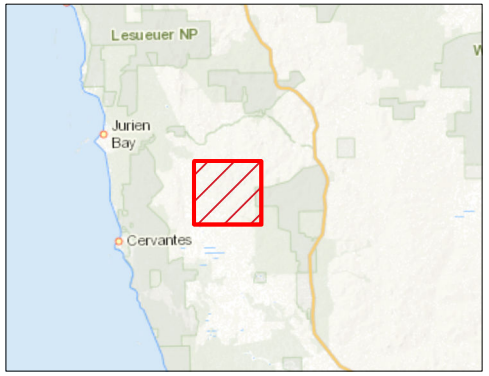
MAP 01



LEGEND

- Carcasses Feb-Apr 2020
- Carnaby's Opportunistic Records
- Turbines

DATA SOURCES:
SOURCE DATA: APA GROUP
SERVICE LAYERS: SOURCE: ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY



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CARCASS AND OPPORTUNISTIC RECORDS

BIRD MONITORING
BADGINGARRA WIND FARM

APA GROUP

COORDINATE SYSTEM: GDA 1994 MGA ZONE 50
PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
UNITS: METER

SCALE: 1:66,000 @ A4

0 0.7 1.4 2.1 km

PROJECT NO: 4506-20

REV	AUTHOR	APPROVED	DATE
0	HCO	BT	13/05/2020

MAP 02