CROOKWELL 2 & 3 WIND FARMS

BIRD AND BAT UTILISATION SURVEYS

Crookwell Development Pty Ltd

BL&A Brett Lane & Associates Pty. Ltd.
Ecological Research & Management
Suite 5 61–63 Camberwell Road, Hawthorn, VIC 3123
P.O. Box 337, Camberwell, VIC 3124
Ph. (03) 9815 2111
Fax. (03) 9815 2685

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1. INTRODUCTION

Development consent was originally granted in June 2005 for the Crookwell 2 Wind Farm with up to 46 wind turbines and associated infrastructure (DA 176-8-2004-i), and the development consent was modified in 2009 (Mod-1). The Crookwell 3 Wind Farm proposal is located to the east and south of the Crookwell 2 Wind Farm project is currently under consideration by the NSW Department of Planning and Environment (DPE).

The Crookwell 2 & 3 Wind Farms (C2&3WF) are centred approximately 14 km south-east of Crookwell and approximately 28 kilometres north-west of Goulburn in the Southern Tablelands of New South Wales. It lies on a series of higher ridges that have been used for decades for sheep and cattle grazing. The majority of the area has been either completely or mostly cleared of its original native vegetation. As a consequence of the long grazing history, the vegetation present lacks a diverse understorey and indigenous ground cover — introduced pasture grasses now dominate the ground cover.

Crookwell Development Pty Ltd engaged Brett Lane & Associates (BL&A) to implement pre-operational surveys as outlined in the Bird and Bat Adaptive Management Plan (BBAMP) for the C2&3WF. This investigation was commissioned to provide data on the utilisation by birds and bats of the wind farm site during autumn. This represents the first attempt of collecting data on birds and bats at C2&3WF and will provide a baseline measure on bird and bat utilisation at the wind farm suitable for comparison with future post-construction data.

The bird utilisation survey (BUS) was undertaken consistent with the requirements for a "Level One" bird risk assessment in accordance with 'Wind Farms and Birds - Interim Standards for Risk Assessment' issued by the Australian Wind Energy Association (AusWEA 2005). This approach has been endorsed in the Association's latest Best Practice Guidelines (Clean Energy Council 2013).

The bird and bat utilisation surveys were undertaken in February–March 2017 by Khalid Al-Dabbagh, an experienced ornithologist.

This investigation was undertaken by a team from Brett Lane & Associates Pty Ltd, comprising Khalid Al-Dabbagh (Senior Zoologist), Alan Brennan (Senior Ecologist and Project Manager) and Brett Lane (Principal Consultant).

2. BIRD UTILISATION SURVEY

2.1. Methodology

2.1.1. Fixed-point bird count method

The fixed-point bird count method used to collect bird utilisation data involved an observer stationed at a survey point for 15 minutes. The adequacy of using 15 minutes as an interval to record the presence of birds during bird utilisation surveys was investigated in an earlier study at another wind farm site (BL&A unpublished data). This showed that 82 to 100 percent (average 88 percent) of species actually seen in one hour of surveying were seen in the initial 15 minutes of observation. Based on this result, the period of 15 minutes used in the formal bird utilisation surveys was considered adequate to generate representative data on the bird species in the area during replicate surveys.

During this period, all birds observed within 200 metres were recorded. The species, the number of birds and the height of the bird when first observed were documented. For species of concern (threatened species, waterbirds and raptors), the minimum and maximum heights were recorded.

For the purpose of this report, flight height relative to the rotor swept area (RSA) height is presented as described below. These heights were based on the actual turbine heights that were constructed, and were different from those used during the pre-construction phase.

- **A =** Below RSA (< 30 metres above ground)
- **B =** At RSA (30 – 160 metres above ground)
- **C =** Above RSA (> 160 metres above ground)

In the BUS, heights were measured at 10 m intervals between 0 and 40 metres and at 20 metre intervals above 40 metres and up to 160 metres. This allowed for more precise description of bird flight heights.

During the surveys, eight counts were made at each survey point. Counts were made at different times of the day to allow for time-of-day differences in bird movements and activity. Table 1 indicates when each point was counted on each survey day. This schedule ensured that all points were visited at all times of day so that no time-of-day biases affected the pooled count data. The timing of the counts was slightly changed as day light hours differed between seasons and the prevailing weather conditions. The bird utilisation surveys were undertaken over six days.

Table 1: Times when points were counted for each fixed-point count survey day

Date	Days/ time	8:00-8:15	8:30-8:45	9:00-9:15	9:30-9:45	10:30-10:45	11:00-11:15	11:30-11:45
10/02/2017	1	1	2	3	4	5	6	7
11/02/2017	2	5	6	7	8	R1	R2	1
13/02/2017	3	R1	R2	1	2	3	4	5
14/02/2017	4	3	4	5	6	7	8	R1
15/02/2017	5	7	8	R1	R2	1	2	3
16/02/2017	6	5	6	7	8	R2	R1	2
Date	**Days/ time**	**12:00:12:15**	**13:15-13:30**	**13:30-13:45**	**14:45-15:00**	**15:15-15:30**	**15:45-16:00**	**16:15-16:30**
10/02/2017	1	8	R1	R2	1	2	3	4
11/02/2017	2	2	3	4	5	6	7	8
13/02/2017	3	6	7	8	R1	R2	1	2
14/02/2017	4	R2	1	2	3	4	5	6
15/02/2017	5	4	5	6	7	8	R1	R2
16/02/2017	6	1	4	3				

Note: See Figure 1 for survey point locations. The prefix 'R' refers to reference points.

2.1.2. Timing of the surveys

The current survey lasted six days and was undertaken during the period 10th – 16th February 2017. The timing covers a suitable period for surveying birds as their populations are probably at their maximum abundance following the summer recruitment and that most of the summer visitors to the wind farm area are probably still present.

2.1.3. Locations of survey points

Ten fixed survey points were established; eight impact and two reference points. Impact points were located near and among turbine locations and reference points were located on edge of the wind farm boundaries in areas of similar habitat or at least 500 metres away from the proposed turbines.

The survey points were distributed as evenly as possible (subject to access constraints) across the proposed wind farm site to maximise coverage in areas where wind turbines would be located (Figure 1). Impact points were positioned on elevated ground where possible, allowing a clear view in all directions.

The reference points were established on public land for ease of access and were located in areas covered by some remnant native vegetation and/or natural wetlands to provide clear picture of birds at the wind farm site.

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CROOKWELL 2 & 3 WIND FARMS
INDICATIVE SITE INFRASTRUCTURE AND TURBINE LAYOUT MAP

MAP LEGEND

- Public Roads
- Existing 330kV Transmission Line
- Land Parcels
- 330kV Switchyard / Substation
- Crookwell 2 Wind Farm Site Boundary
- Crookwell 3 Wind Farm Site Boundary
- F50 Crookwell 2 Approved Turbines to be upgraded
- A25 Crookwell 3 proposed turbines pending approval
- 80 metre Wind monitoring Mast Area
- Landowner Property #1
- Landowner Property #2
- Landowner Property #3
- Landowner Property #4
- Landowner Property #5
- Landowner Property #6

Rev: 6 March 2017 - R08

0 500m 1000m 1500m 2000m
SCALE

2.1.4. *Incidental observations*

In addition to the observations during formalised, fixed-point counts, incidental observations of birds of concern (threatened species, raptors, and waterbirds) were made whilst travelling throughout the proposed wind farm site. Notes were also made on woodland birds observed in remnant woodlands and any early morning and evening roosting movements. Emphasis was placed on observing birds that were moving through the site at RSA height.

2.1.5. *Limitations*

The bird utilisation surveys were undertaken during late summer and therefore cover all possible types of birds including resident, summer and transient migratory species and probably early arrivals of wintering birds. The first three categories were well presented in the data; however, the transient category was less represented depending on chance use of the wind farm site while these birds were passing through the area.

The purpose of the surveys was to collect a range of data, including usage of the site by resident and migratory birds that may only occur at certain times of the year. During autumn, birds such as magpies, starlings and ravens would be in post breeding, and would collect in large feeding flocks during.

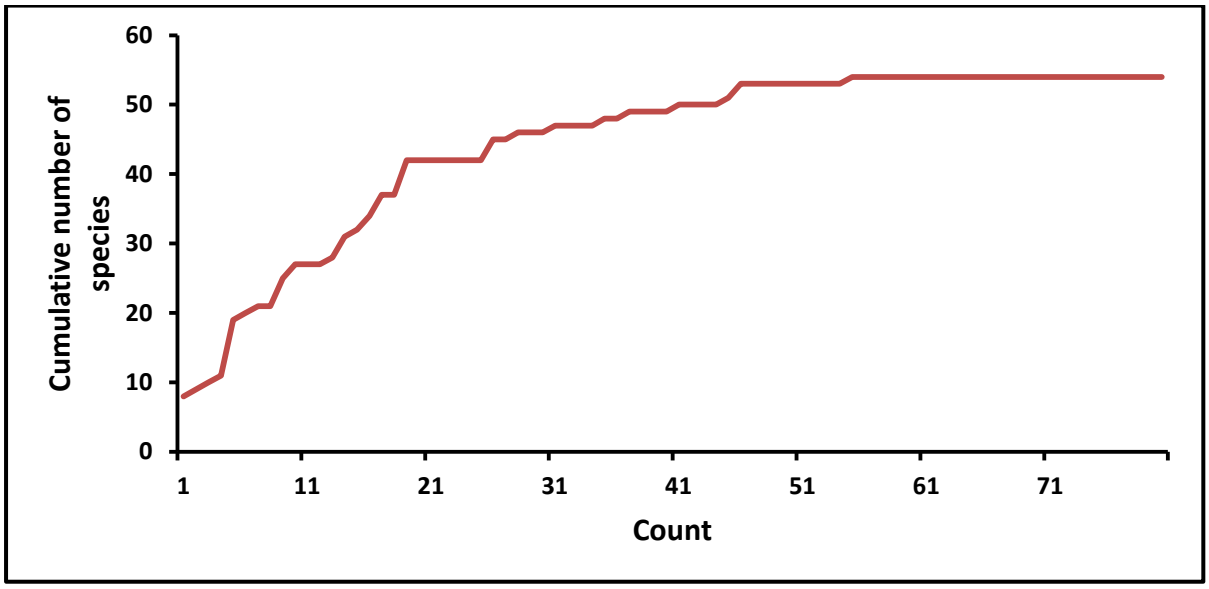
For these reasons, the utilisation rates and species relative abundances recorded during the current surveys are considered to be representative of the site year-round as they take into consideration both time-of-day and seasonal variation in bird activity and species occurrence. They are therefore considered to provide a comprehensive basis on which to assess the bird risks associated with the C2&3WF.

2.2. Results

2.2.1. *Survey Suitability*

The cumulative number of species observed from the consecutive fixed-point bird counts conducted at the observation points during the autumn survey period has been plotted (Figure 2). This indicated that during the survey, the number of species recorded levelled out after approximately 50 counts after which the line attained its asymptote and no more species of birds were added. This result suggests that the surveys collectively provide a representative picture of the diversity of bird species flying over the wind farm site during the survey periods.

Figure 2: The cumulative number of bird species recorded during consecutive counts at survey points during the autumn survey at Crookwell 2 & 3 Wind Farms.



2.2.2. *Species composition*

Some 80 bird species were recorded utilising the wind farm site during the BUS survey of autumn 2017 (Appendix 1). The number of species found on the wind farm represents approximately 50 percent of birds reported to occur in the region (species list as reported by the Bionet Atlas of NSW). The Bionet data however include many rare and threatened birds, coastal and marine birds, and many raptors that are unlikely to occur close to the wind farm site.

The number of species actually counted during the formal BUS reached 58 species, including 54 species at the impact sites and 34 species at the reference sites. The number of species counted during BUS formed over 75 percent of birds seen to utilize the wind farm site; however, many of the birds did not feature in the BUS as they were either of rare occurrence or water birds restricted to the larger water bodies or dams away from the future turbine locations (e.g. Pegar Dam and lake).

The species diversity compared well with other wind farms in the area (e.g. Gullen Range WF) and constituted mainly of a combination of birds of open grasslands and stock grazing paddocks and bush birds.

2.2.3. *Species abundance*

The species observed utilising the eight impact and two reference observation points, their abundance and height distribution are detailed in Table 2 for the impact sites and Table 3 for the reference sites. Both tables include a list of the species observed during the BUS in each of the observation points, as well as the number of individuals per species recorded at each of the three height zones (below [<30 m), at [30–160 m) and above (>160 m) RSA height).

Five species of birds were dominant and constituted most of the count; these were in order of their dominance:

- Common Starling (15.8%);
- Raven spp. (12.0%);

- Australian Magpie (12.0%);
- Yellow-rumped Thornbill (9.0%); and
- Crimson Rosella (8.1%)

The five dominant species were common farmland birds, including one introduced species (Common Starling). In general they accounted for over 56 percent of all birds recorded utilizing the impact sites.

The high count of the starling resulted from the fact that starling mostly move and feed in large flocks and when in or close to future turbine positions they inflate the count. One or two of the observed starling flocks observed in the wind farm site outside the formal count were over 500 birds per flock.

Similarly ravens were mainly either Australian Raven or Little Raven, the latter also move in large flocks at this time of the year especially in open paddocks pr cleared ridges.

The other three species are also common farmland birds, mostly found in the interface between woodlands and open grazing paddocks and usually feed in smaller flocks than the above mentioned birds in the open grazing paddocks.

At the reference points (Table 3), the five most common species counted included (in order of abundance, Noisy Miner (12.4% of all reference site birds), Crimson Rosella (10.8%), Eastern Rosella (7.3%), Australian Magpie (7.0%), and Australian Wood Duck (6.1%). The first five species recorded at the reference sites were responsible for more than 43 percent of all bird observations. The dominant species of birds on the reference sites were similar to those recorded at the impact sites with the exception of the wood ducks since both reference sites were close to small farm dams that attracted the ducks regularly; however more woodland species dominated in the reference sites as they were located closer to small woodland remnants.

Table 4 shows the distribution of bird numbers among the survey points. The total number of birds counted at the impact points varied between a minimum total of 255 birds at survey point 6 to a maximum total of 466 birds at survey point 8. The higher number at some of the survey points was mainly due to the presence of large numbers of bushbirds in the woodland remnants surrounding the observation point or the occasional large flock of starlings over the counting area during the formal fixed-point bird count.

The mix of bird species recorded at each survey point reflected the nature and type of habitat in the count area. At points with patches of native vegetation, such as remnant woodlands, more bush birds were encountered compared with points with open grazing paddocks and few or no trees.

The abundance of birds was different between the points of the survey. The highest abundance was at survey point 8 and the lowest at point 2 (Figure 3). Bird abundance (average/ha/hour) was comparatively high at points with wooded areas included in the count area (Points 4, 5, 7, 8, R1, R2), and lower at points of open grazing grassland (points 2, 3, 6). The difference between the averages of the two habitat types appear significant (no overlap of the two standard error bars) and support the hypothesis that higher numbers of birds were recorded in areas where remnant vegetation is present.

The trend in bird abundance at the reference site was similar to that of the impact points with wood area surrounding them as both reference points were located close to wooded areas (Figure 3).

Table 2: Number and height distribution of bird movements by species at the impact survey points

Species	Point 1		Point 2		Point 3		Point 4		Point 5		Point 6		Point 7		Point 8		Totals		Grand Total	% Imp.
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B		
Common Starling	4		46		27		80		69		70		4		106		406	0	406	15.8
Raven spp.	7		12		14	5	66	28	58	17	4	2	40	5	51		252	57	309	12.0
Australian Magpie	26	2	71		25	5	40		34	5	21		47		27	4	291	16	307	12.0
Yellow-rumped Thornbill	76		16		8		20		10		58		38		4		230	0	230	9.0
Crimson Rosella	27		2		17		12		28		14		45		62		207	0	207	8.1
Sulphur-crested Cockatoo			2		6		24	2			10	7	4	2	86	2	132	13	145	5.6
Galah	14				12	2	16		30	5			16		35	6	123	13	136	5.3
Magpie-lark	10		12		11		6		10		8		4		6		67	0	67	2.6
Striated Thornbill	20												40				60	0	60	2.3
Eastern Rosella	15				2		4		2				11		24		58	0	58	2.3
Red Wattlebird	8						2		12		4		32				58	0	58	2.3
Willie Wagtail	14		1		12		3		8		11		7				56	0	56	2.2
Red-rumped Parrot			2		18				12		6						38	0	38	1.5
Welcome Swallow					16	2		2	10	4			4				30	8	38	1.5
Australian Wood Duck									13						24		37	0	37	1.4
Black-faced Cuckoo-shrike	8				2					5	5		8		5		28	5	33	1.3
Pied Currawong	9		2		2		12	2					4		2		31	2	33	1.3
Buff-rumped Thornbill													30				30	0	30	1.2
House Sparrow							16		12								28	0	28	1.1
Crested Pigeon					4				6						14		24	0	24	0.9
Grey Fantail	4						2				2		12		2		22	0	22	0.9
House Sparrow									20								20	0	20	0.8
Grey Teal					2		2				2		10				16	0	16	0.6
Noisy Miner													12		2		14	0	14	0.5
Yellow-faced Honeyeater	2										4		8				14	0	14	0.5

Species	Point 1		Point 2		Point 3		Point 4		Point 5		Point 6		Point 7		Point 8		Totals		Grand Total	% Imp.
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B		
Brown Thornbill	6												6				12	0	12	0.5
White-faced Heron							3	2	4				2		1		10	2	12	0.5
Brown Falcon									2	2	3	2			2		7	4	11	0.4
Nankeen Kestrel						1		3	3			1	2		1		6	5	11	0.4
Superb Fairywren			6										5				11	0	11	0.4
Striated Pardalote											2		8				10	0	10	0.4
Varied Sittella													10				10	0	10	0.4
Australian Pipit	2						2		5								9	0	9	0.4
Red Wattlebird	2								7								9	0	9	0.4
Noisy Friarbird											5		2				7	0	7	0.3
White-necked Heron									1				6				7	0	7	0.3
European Goldfinch							6										6	0	6	0.2
Silvereye													6				6	0	6	0.2
Spotted Pardalote											4		2				6	0	6	0.2
White-eared Honeyeater											2		4				6	0	6	0.2
White-throated Treecreeper													6				6	0	6	0.2
Australian White Ibis								4									0	4	4	0.2
Common Myna											4						4	0	4	0.2
Grey Butcherbird	2								1				1				4	0	4	0.2
Grey Currawong	2												2				4	0	4	0.2
Hoary-headed Grebe	2												2				4	0	4	0.2
Laughing Kookaburra	1										2		1				4	0	4	0.2
White-plumed Honeyeater							4										4	0	4	0.2
Rufous Whistler													3				3	0	3	0.1
Stubble Quail							3										3	0	3	0.1
Wedge-tailed Eagle				2						1							0	3	3	0.1
Masked Lapwing					2												2	0	2	0.1

Species	Point 1		Point 2		Point 3		Point 4		Point 5		Point 6		Point 7		Point 8		Totals		Grand Total	% Imp.
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B		
White-throated Warbler											2						2	0	2	0.1
Australian Hobby					1												1	0	1	0.0
Grand Total	261	2	172	2	181	15	323	43	357	39	243	12	444	7	454	12	2435	132	2567	100.0

Notes: A = Below RSA height (<30 metres); B = At RSA height (30–160 metres); C = above RSA heights (160 metres); Note that no bird was recorded flying over 160 m in this survey so there is no C column in the table.

Table 3: Number and height distribution of bird movements by species at the reference survey points

Species	Reference point 1		Reference point 2		Totals		Grand total	% Imp.
	A	B	A	B	A	B		
Noisy Miner			78		78	0	78	12.4
Crimson Rosella	20		48		68	0	68	10.8
Eastern Rosella	2		44		46	0	46	7.3
Australian Magpie	20		24		44	0	44	7.0
Australian Wood Duck	24		14		38	0	38	6.1
Yellow-rumped Thornbill	36				36	0	36	5.7
Red Wattlebird	21		14		35	0	35	5.6
Grey Fantail	29				29	0	29	4.6
Common Starling	16		4		20	0	20	3.2
Yellow-faced Honeyeater	18				18	0	18	2.9
Black-faced Cuckoo-shrike	2		15		17	0	17	2.7
Magpie-lark	8		8		16	0	16	2.6
Raven spp.	12		4		16	0	16	2.6
Galah	4		10		14	0	14	2.2
Varied Sittella	14				14	0	14	2.2
White-browed Scrubwren	14				14	0	14	2.2

Species	Reference point 1		Reference point 2		Totals		Grand total	% Imp.
	A	B	A	B	A	B		
Pied Currawong	2		10		12	0	12	1.9
White-eared Honeyeater	12				12	0	12	1.9
Willie Wagtail	10		2		12	0	12	1.9
Brown Thornbill	10				10	0	10	1.6
Superb Fairywren	10				10	0	10	1.6
Striated Thornbill	9				9	0	9	1.4
Striated Pardalote	8				8	0	8	1.3
White-throated Treecreeper	8				8	0	8	1.3
Rufous Whistler	7				7	0	7	1.1
Golden Whistler	6				6	0	6	1.0
Western Warbler	6				6	0	6	1.0
White-plumed Honeyeater	6				6	0	6	1.0
Australian Pipit	4				4	0	4	0.6
Laughing Kookaburra	4				4	0	4	0.6
White-throated Warbler	4				4	0	4	0.6
Grey Currawong			2		2	0	2	0.3
Spotted Pardalote	2				2	0	2	0.3
Sulphur-crested Cockatoo		2			0	2	2	0.3
Grand Total	348	2	277		625	2	627	100.0

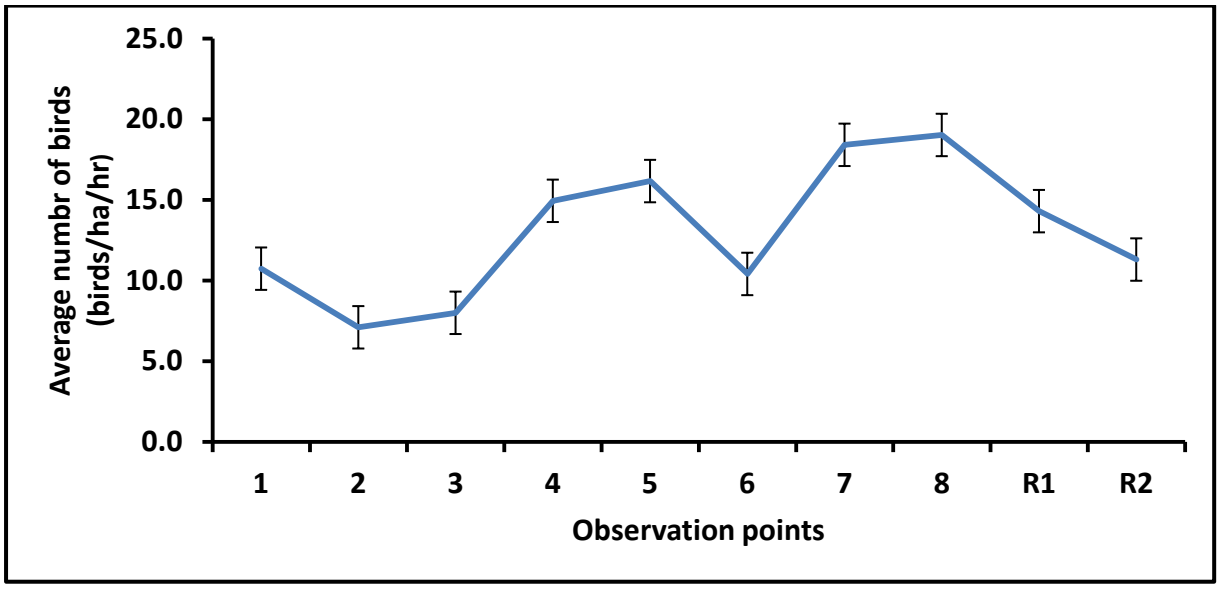
Notes: A = Below RSA height (<30 metres); B = At RSA height (30–160 metres); C = above RSA heights (160 metres); Note that no bird was recorded flying over 160 m in this survey so there is no C column in the table.

Table 4: Number of birds recorded at each survey point during BUS survey at Crookwell II & III Wind Farm

Observation Points	Impact points		Grand Total	% importance	Density No./ha/hour
	A	B			
1	261	2	263	10.2	10.7
2	172	2	174	6.8	7.1
3	181	15	196	7.6	8.0
4	323	43	366	14.3	14.9
5	357	39	396	15.4	16.2
6	243	12	255	9.9	10.4
7	444	7	451	17.6	18.4
8	454	12	466	18.2	19.0
Total	**2,435**	**132**	**2,567**	**100.0**	
Reference Points					
R1	348	2	350	55.8	14.3
R2	277	0	277	44.2	11.3
	625	2	627	100.0	25.6
Grand Total	**3,060**	**134**	**3,194**	**124.4**	

Notes: A = Below RSA height (<30 metres); B = At RSA height (30–160 metres); C = above RSA heights (160 metres); Note that no bird was recorded flying over 160 m in this survey so there is no C column in the table.

Figure 3: Average number of birds (birds/ha/hour) at the impact and reference sites (Average ± SE)



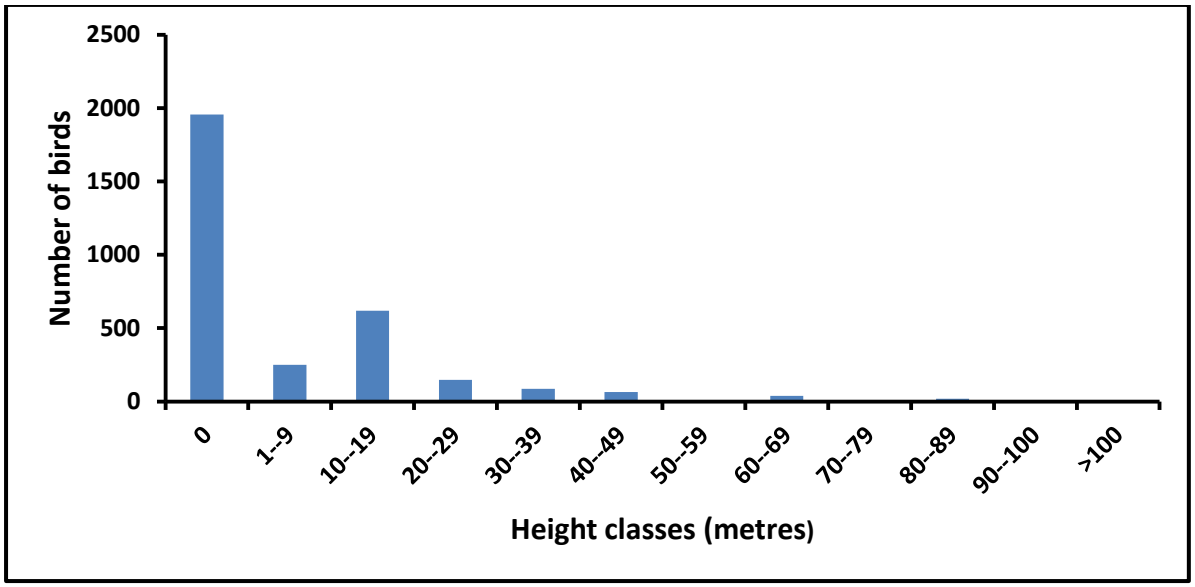
2.2.4. Flight heights

Bird heights were classified as below (< 30 metres), at (30–160 metres), and above (> 160 metres) RSA height. The number of birds recorded at the different flight heights are presented in Table 5.

The distribution of flight heights was almost similar between the surveying points with the majority of birds recorded flying below RSA heights. Overall, 94.8 percent of birds were below RSA height, 4.2 percent at RSA height and no flights above RSA height.

The detailed height distribution of birds over the wind farm site is shown in Figure 4. The height distribution confirm that most birds actually flew below RSA height therefore reducing impact and or collision risks between birds and operational wind turbines.

Figure 4: The height distribution of birds utilizing the wind farm site.



Of the species recorded utilizing the wind farm site, 13 species were seen flying at RSA height at the impact sites (Table 5). The five most common species at this height are:

- Raven spp.:
- Australian Magpie;
- Sulphur-crested Cockatoo;
- Galah; and
- Welcome Swallow.

These five species accounted for 81.0% of the total birds observed at RSA height at impact survey sites. Overall, only 5.1 percent of all observed birds flew at RSA height at the surveyed impact sites (Table 5).

At the reference sites only one species of bird (Sulphur-crested Cockatoo) was observed flying at RSA height.

Table 5: Species flying at rotor swept height (RSA) at the impact sites during BUS surveys

Species	Total birds at			Grand total	% RSA birds	% RSA of all RSA flight birds	% RSA of flights of all birds
	A	B	C				
Raven spp.	252	57	0	309	18.4	43.2	2.2
Australian Magpie	291	16	0	307	5.2	12.1	0.6
Sulphur-crested Cockatoo	132	13	0	145	9.0	9.8	0.5
Galah	123	13	0	136	9.6	9.8	0.5
Welcome Swallow	30	8	0	38	21.1	6.1	0.3
Black-faced Cuckoo-shrike	28	5	0	33	15.2	3.8	0.2
Nankeen Kestrel	6	5	0	11	45.5	3.8	0.2
Brown Falcon	7	4	0	11	36.4	3.0	0.2
Australian White Ibis	0	4	0	4	100.0	3.0	0.2
Wedge-tailed Eagle	0	3	0	3	100.0	2.3	0.1
Pied Currawong	31	2	0	33	6.1	1.5	0.1
White-faced Heron	10	2	0	12	16.7	1.5	0.1
Grand Total	**2435**	**132**	**0**	**2567**	**5.1**	**100.0**	**5.1**

A= below RSA height (<30 m), B = at RSA height (30 -160 m), and C= above RSA height (>160 m).

2.2.5. Raptors

Four raptor species were recorded during the surveys, comprising 26 observations in total. The presence of these raptors varied between the survey points (Table 2) and generally they were recorded in low numbers compared with other species (Table 6).

Brown Falcon and Nankeen Kestrel were the most abundant raptor species at C2&3WF, with resident pairs observed flying throughout the wind farm. Both species flew often flew at RSA height, with 36.4% of Brown Falcon and 45.5% of Nankeen Kestrel flights observed at RSA height, making up 75% of all birds flying at RSA height (Table 6).

Wedge-tailed Eagles usually soar high, and often above RSA heights. Of the 3 recorded occurrences of this species over the wind farm site during formal BUS counts, all (100%)

flight were at RSA height; however, the overall importance of the eagles among other RSA raptors was 25% of all birds flying at RSA height (Table 6).

The number of raptors was low in relation to the total number of birds recorded during the BUS. Raptors formed approximately 0.5% of all birds recorded at the wind farm at all heights (Table 6). Based on the low utilisation rate by other raptor species at the impact survey points, risks to these species are considered to be low.

The Wedge-tailed Eagle is considered as birds of special interest and its numbers should be monitored closely. During the current survey only three eagles were recorded flying over the wind farm site. This number is very low and amounts to 0.02 birds per hectare per hour. This figure is very low compared to densities recorded at close by operational wind farms. Crookwell II & III wind farm is likely a part of the feeding territory of one family of eagles.

2.2.6. Waterbirds

Seven waterbird species were recorded during the BUS surveys, comprising 82 observations in total (Table 6). Of these, approximately 45% were the Australian Wood Duck.

The Australian Wood Duck is a very common farmland waterbird that usually roosts along the edges of farm dams and forages in farm dams and open paddocks next to dams during day and night. They are gregarious birds, known to move and forage in flocks. Flocks of this species were observed at several farm dams throughout the C2&3WF. This species was not regularly observed flying at RSA heights though small flocks may on occasion fly at RSA height, particularly at night time.

The remaining waterbirds recorded at impact points were common species, including White-faced and White-necked Heron, Grey Teal, Australian White Ibis, Hoary-headed Grebe and masked Lapwing (Table 6).

The C2&3WF site contained many small farm dams close to the future wind turbine locations, but these dams generally lacked aquatic vegetation and had bare edges trampled by stock.

On the other hand there were also some fair sized dams away from the future wind turbines with some aquatic vegetation, and a large lake behind the close by Pegar Dam. These water bodies attracted a good number of water birds such as Eurasian Coots, Black Swan, Silver Gulls, few cormorants, moorhen and few ducks. None of the common birds using these waterbodies were seen flying over the wind farm and were mainly restricted in their movements to the waterbodies.

Table 6: Raptor and Waterbird species recorded at the impact survey points during BUS surveys

Species	Number of birds at:			Grand total	% RSA birds	% RSA off all RSA birds	% RSA of all birds
	A	B	C				
Raptors							
Brown Falcon	7	4	0	11	36.4	33.3	0.2
Nankeen Kestrel	6	5	0	11	45.5	41.7	0.2
Wedge-tailed Eagle	0	3	0	3	100.0	25.0	0.1
Australian Hobby	1	0	0	1	0.0	0.0	0.0
Total raptors	**14**	**12**	**0**	**26**	**46.2**	**100.0**	**0.5**

Waterbirds							
Australian Wood Duck	37	0	0	37	0.0	0.0	0.0
Grey Teal	16	0	0	16	0.0	0.0	0.0
White-faced Heron	10	2	0	12	16.7	1.5	0.1
White-necked Heron	7	0	0	7	0.0	0.0	0.0
Australian White Ibis	0	4	0	4	100.0	3.0	0.2
Hoary-headed Grebe	4	0	0	4	0.0	0.0	0.0
Masked Lapwing	2	0	0	2	0.0	0.0	0.0
Total waterbirds	**76**	**6**	**0**	**82**	**7.3**	**4.5**	**0.2**
Total all birds	**2435**	**132**	**0**	**2567**	**5.1**	**100.0**	**5.1**

2.2.7. Listed species

Most birds found to utilise the wind farm site were common birds. Of the species recorded during the BUS, one species only (Varied Sittella) was listed as vulnerable under the NSW *Threatened Species Conservation Act 1995* (TSC Act).

The Varied Sittella was observed on several occasions during the survey at the impact points that included some remnant woodland within their counting area. This species has also been recorded incidentally outside the formal BUS from many other wooded localities within the wind farm site.

2.3. Conclusions

The conclusions from the BUS of the C2&3WF are presented below:

- The study area consists largely of cleared ridges and plateaux supporting an abundance of common, predominantly farmland birds.
- The study area supports very few raptors or waterbirds — groups considered vulnerable to collision with operating wind turbines. Raptors and waterbirds represented 0.5% and 0.2% respectively of all birds surveyed.
- The diversity of birds recorded within the study area was low.
- Bird abundance and diversity was higher at observation sites surrounded by remnant woodlands or scattered trees compared to sites lacking trees.
- The list of birds recorded flying at RSA heights was similar between the eight impact observation points. The five most abundant species accounted for almost 81% of the birds counted at RSA height. These were all common species that are widespread across the C2&3WF site and the wider region. Raptors were not common with only 0.5% of all records being recorded at RSA heights. Waterbirds were similar to raptors with only few recorded flying at RSA height.
- The utilisation rate of the Wedge-tailed Eagle averaged 0.02 eagles per hectare per hour during the survey. The utilisation rate of other raptors and waterbirds was found to be also very low when compared to similar rate from other wind farms in the area (BL&A; unpublished data).
- One species of threatened bird was recorded utilising the study area — Varied Sittella. The sittella is a woodland birds that rarely venture outside the woodland and was seen during the formal counts or incidentally within or close to woodland areas. The collision risk to threatened species from operating turbines is considered low.

The pre-operational fixed point bird utilisation surveys have satisfied the requirement for obtaining pre-operational baseline bird utilisation data.

3. BAT SURVEY

3.1. Methodology of 2017 survey

3.1.1. Timing

The current survey was undertaken from 8th March to 2nd April to coincide with the autumn migration period of the threatened Eastern Bentwing Bat (EBB). This timing was determined in consultation with Dr Doug Mills of the Office of Environment and Heritage (OEH), Queanbeyan. Dr Mills has been closely monitoring EBB migration and breeding at the Wee Jasper and Drum caves in NSW (the nearest known maternity caves to the wind farm site).

The survey recorded over 188 detector-nights, totalling 2,256 recording hours. The survey comprised a significant effort during the migration time of the EBB, when this species is most likely to be present on the site.

Site selection

The layout of the C2&3WF was reviewed and sites were selected based on habitat. The site selection sought to:

- Provide coverage of a diversity of habitats, ranging from open pasture to wooded areas; and
- Provide even coverage of the wind farm site.

Eight ground sites were selected representing the dominant habitats. In addition, two sub-sites were established at the wind mast for simultaneous recordings of bats: one at 50 metres height and one at ground level. 10 bat detectors (eight SongMeters and two Anabats) at the nine sites were used during this survey.

The location and characteristics of the recording sites are described below and shown in Figures 1.

Site1: Located on top of small hill surrounded by large pines and native acacia and overlooking a wide open grazing paddock.

Site 2: Located on top of a small hill within large open grazing paddocks lacking trees.

Site 3: Located on top of a ridge (medium height hill) within a large open grazing paddock; nearest trees approximately 200 metres away.

Site 4: Located within a small valley on side of a small creek with little water and some introduced none-native trees. The remaining surrounding area was cleared hill.

Site 5: Located on edge of creek within a hilly area with few introduced trees and shrubs. This position is surrounded by cleared hills mainly for stock grazing with a small remnant woodland approximately 200 metres away.

Site 6: Located within a large grazing paddock lacking in trees or any form of shelter for roosting bats.

Site 7: Include two sub sites at the wind mast location; **A**: at 50 metres above ground tied to the wind mast, and **B**: on ground underneath the wind mast. The whole area is on top of a ridge for stock grazing lacking in native trees. A line of planted old pines were approximately 100 metres from the wind mast.

Site 8: Located on a small hill within large grazing paddocks. The site was also close to small remnant of woodland with large native eucalypts and also close to a small farm dam.

Site 9: Located on side of a small hill in cleared grazing area with few scattered large eucalypts.

Three models of bat detectors were used for recording: the SongMeter SM2$^+$ 2 with external microphone, the SongMeter SMZC with internal microphone and the Anabat SD2.

3.1.2. Recording protocol

The recording protocol for the survey is summarised below:

- Ten bat detectors were installed by a qualified zoologist experienced in the operation of this equipment;
- SongMeters and Anabats were set to begin recording 30 minutes before dusk and stop recording 30 minutes after sunrise; and
- After eight days, the batteries and the SD cards in the bat detectors were changed.

After the bat detectors were removed, the SD cards holding the recorded data were removed and data transferred onto computers for later analysis.

3.1.3. Call analysis

Recorded bat calls were identified by Dr Greg Richards (Greg Richards & Associates; Gungahlin, ACT). Call identification was undertaken using the standard practice for identifying bat calls, where the characteristics of site-recorded bat calls were compared with reference calls from known species recorded across Australia. Identification is largely based on the sonogram generated by the bat detector software that shows changes to the sound frequency of calls over time. For most species, a call sequence of at least one second in duration (approximately 20 pulses in the sequence) is required before confident identification can be made.

The following process was used in the call analysis:

- All files were screened visually to identify any call that could belong to a threatened bat species (EPBC listed or TSC Act listed); and
- As a precautionary measure all calls were allocated to species *or* species complexes when species could not be confidently identified.

Call analysis comprised identifying bat species present and the total numbers of calls attributed to threatened species and the common White-striped Freetail Bat (*Austronomus australis*) (WSFB), at each survey site. The White-striped Freetail Bat was targeted in the analysis because it was a species most likely to be found flying at heights above 50 m where it is exposed to a risk of collision with operating turbines.

3.1.4. Limitations

The identification of echolocation calls from microbats in south-eastern Australia is facilitated by the fact that many calls are species-specific. Calls that could not be identified definitively were allocated to species complexes.

A further limitation in the use of this technique is that it is not possible to census bat numbers. For example, 10 calls of a particular species may be recorded but it is not

known if this represents 10 individuals of that species or one individual of that species flying past the bat recorder 10 times. Therefore, it is not possible to determine utilisation rates, only activity levels.

Occasionally recording devices such as those used in the survey experience technical difficulties, which are not uncommon. As a result short periods of time may not be recorded and total hours of recordings vary between the different recorders. Weather conditions including severe storms during the recording period may at time interfere with the recording process.

The bat detectors used during this survey sample a limited airspace to a distance of approximately 20-30 metres.

Finally, bat activity levels may vary in response to weather variables such as air temperature, relative humidity, barometric pressure, wind speed, direction & gusts, rain and moonlight. Typically, bats are found to be less active during the following circumstances (G. Richards; pers. comm.):

- During periods of full moon, and when the moon is high in the sky;
- At higher wind speeds a decrease in activity may be observed at wind speeds over 10 metres per second (recognising recordings at higher wind speed may be attenuated); and
- During moderate to heavy rainfall.

3.2. Results

3.2.1. Species composition and distribution

Ten bat species and one species complex were identified utilizing C2&3WF (Table 7). The vast majority of calls identified were from common species of bats that are not of conservation concern (i.e. are not listed as rare or threatened under any federal or state legislation).

Six of the ten species were of regular occurrence, found in almost all sites and not limited to any particular section of the wind farm, though some species were more common than others (Table 7). Three other species, although common and widespread, were restricted to only few of the nine recording sites. One species was listed as vulnerable in NSW (TSC Act 1995).

Of note were the following:

- The Eastern Bentwing Bat (EBB) listed as vulnerable in NSW (TSC Act 1995). The Eastern Bentwing Bat was a focus of this survey, as it was designed to reveal whether this species travel over the wind farm site during its autumn journey from its breeding colony at Wee Jasper Caves, near Yass towards its wintering grounds. The EBB was not positively recorded. however, some calls were identified as part of a species complex with Forest Bats which may be attributable to any of the species in the complex (see below);
- The Yellow-bellied Sheathtail Bat (YSB) is listed as vulnerable in NSW (TSC Act 1995). This was recorded at one site. This was identified from one weak call at site 2. This bat is a summer visitor to the southern states and usually not common at this part of its range.
- One species complex was also recorded: Eastern Bentwing Bat/Forest Bat Complex (EBB/FB). This category recognises that calls are sometimes indistinguishable

between these species and could be either. They have been conservatively recorded as possible involving EBB for this report.

Almost all bat calls recorded were of common and widespread species regularly found at farms in this part of NSW.

Table 7: Bat species frequenting C2&3WF

Common name	Scientific name	sites of records	Ecological significance
Eastern Bentwing Bat	*Miniopterus orianae oceanensis*	not recorded	Vulnerable, migratory
White-striped Freetail Bat	*Austronomus australis*	1,3,4,5,6,7a,7b,8,9	Common, widespread
Gould's Wattled Bat	*Chalinolobus gouldii*	1,6,9	Common, widespread
Chocolate Wattled Bat	*Chalinolobus morio*	1,2,3,4,5,6,8,9	Common, widespread
Eastern Freetail Bat	*Ozimops ridei*	all sites	Common, widespread
Long-eared Bat	*Nyctophilus* spp.	all sites	Common, widespread
Inland Broad-nosed Bat	*Scotorepens balstoni*	1,2,3,7a	Common, widespread
Large Forest Bat	*Vespadelus darlingtoni*	all sites	Common, widespread
Southern Forest Bat	*Vespadelus regulus*	all sites, except 7a	Common, widespread
Little Forest Bat	*Vespadelus vulturnus*	1,2	Common, widespread
Yellow-bellied Sheathtail Bat	*Saccolaimus flaviventris*	2	Vulnerable, migratory
Species Complexes			
Eastern Bentwing/Forest Bat complex	*Miniopterus - Vespadelus*	1,3,7a,7b	Vulnerable, migratory#

= Based on potential presence of Eastern Bentwing Bat; Grey shading = threatened species recorded

3.2.2. Bat relative abundance

The number of bat calls cannot be directly used as a measure of bat density (see limitation section above); therefore other measures of relative abundance can be used to analyse importance of the various species.

For the current survey, the presence absence of the common species was recorded at each site and used to express some measure of relative abundance of bats within the wind farm site. The actual number of bat calls was recorded only for threatened species and those of special concern.

Relative abundance of the common bat species expressed as frequency of occurrence (number of nights out of total nights of recording) is summarised in Table 8. The table showed that the three most common species on the wind farm in order of activity levels were: Eastern Freetail Bat (55.9%), Southern Forest Bat (54.8%), and Long-eared Bats (44.7). The remaining species were of less common and their frequencies of occurrence varied between 8.5–32.4%. The White-striped Freetail Bat, a species of special interest as it is known to frequently collide with operating turbines, was recorded at eight of the nine sites in low frequency compared to the other common species.

Table 8: The number of nights at which bats were recorded at the nine recording sites at C2&3WF

Species	No nights bats recorded at sites										Total nights	% Occp. *
	1	2	3	4	5	6	WM 7a	WM 7b	8	9		
Eastern Bentwing Bat	0	0	0	0	0	0	0	0	0	0	0	0.0
White-striped Freetail Bat	1	0	11	0	1	1	1	21	5	1	42	22.3
Gould's Wattled Bat	21	0	0	10	0	1	0	0	0	0	32	17.0
Chocolate Wattled Bat	20	1	12	0	13	5	0	1	4	2	58	30.9
Eastern Freetail Bat	23	2	15	5	13	6	4	22	9	6	105	55.9
Long-eared Bat	12	9	9	19	14	5	5	4	5	2	84	44.7
Inland Broad-nosed Bat	7	1	1	5	0	0	0	2	0	0	16	8.5
Large Forest Bat	20	3	8	0	14	4	0	1	7	4	61	32.4
Southern Forest Bat	23	3	21	12	13	7	0	13	7	4	103	54.8
Little Forest Bat	3	1	0	18	0	0	0	0	0	0	22	11.7
Yellow-bellied Sheathtail Bat	0	1	0	0	0	0	0	0	0	0	1	0.5
Species Complexes												
Eastern Bentwing/Forest Bat complex	7	0	2	0	0	0		3	0	0	12	6.4
Total nights of recording	23	23	25	25	14	15	21	24	9	9	188	100.0

* Percentage occupancy or Percentage of all nights of records for each species

3.2.3. Threatened Bats

Threatened bat species were not recorded in any capacity at the C2&3WF. However, one possible call of the threatened Yellow-bellied Sheathtail Bat was recorded at site 2 (Table 9).

On the other hand, the threatened EEB may have been recorded as part of the species complex with Forest Bat, however the average number of calls (4 calls per site) was comparatively low, further supporting the possible lack of this species from the wind farm site during its autumn migration.

The EBB is listed as Vulnerable under the NSW TSC Act 1995. It breeds communally in certain maternity caves and undertakes two migrations each year: an autumn migration (usually March) from the maternity caves to its wintering grounds and a spring migration, back to its maternity caves for summer breeding (usually November). The two journeys take them across many habitats and occasionally over operating wind farms where they may be at risk of collision with operating wind turbines. The nearest maternity cave to Crookwell II & III Wind Farm is the Wee Jasper cave, near the township of Yass. Over 40,000 bats were counted in these caves during the 2014–2016 summers (D. Mills, OEH; pers. comm.). EBB uses a broad range of habitats, including tall forests, dry or wet

sclerophyll forests or grasslands. In forested areas it flies high over the canopy; in more open areas, such as grasslands, it usually flies within 6 metres of the ground (Churchill 2008).

The EBB was a recorded threatened species during migration times at close by wind farms, such as Gullen Range, Coleraine, and the proposed Collector Wind Farms. The number of calls varied between years which might indicate that the bats may follow different routes during each migration (G. Richards, pers. comm.).

Calls identified from the EBB/FB complex could belong to any of the two species/groups. It is likely, however, that most of the calls in this group belong to the Forest Bat group as they are far more abundant species at Crookwell II & III Wind Farm.

Table 9: Distribution of calls of the threatened bats and species of concern at C2&3WF

Threatened species	No. bat calls at sites										Total calls	Aver. per site
	site 1	site 2	site 3	site 4	site 5	site 6	site 7a	site 7b	site 8	site 9		
Eastern Bentwing Bat	0	0	0	0	0	0	0	0	0	0	0	0
Yellow-bellied Sheathtail Bat	0	1	0	0	0	0	0	0	0	0	1	0.1
Species Complexes												
Eastern Bentwing/Forest Bat complex	35	0	2	0	0	0	0	3	0	0	40	4
Bat species of special concern												
White-striped Freetail Bat	1	0	23	17	1	1	1	87	24	4	159	16

3.2.4. Flight heights

Understanding bat flight heights has been helpful in appreciating the extent to which they may collide with operating wind turbines. Concurrent recordings of bat calls were made at the wind mast site (site 7); at 50 metres above ground (7a) and on ground (7b). Data collected from this exercise is summarized in Table 10 and depicted graphically in Figure 5.

It is evident from the data that bats forage at different heights with most of the common species flew close to the ground below RSA (rotor swept area heights). Some species; however, were found to fly at RSA height and therefore exposed to collision with rotating blades of the operating turbines.

The two species recorded at RSA heights were the Eastern Freetail and Long-eared Bats. Both of these species are not known to regularly fly at such heights. The White-striped Freetail, on the other hand, was not found at RSA heights during the current survey. The latter bat was almost exclusively the species flying at rotor swept area heights in surveys undertaken at other wind farms in southeaster Australia (BL&A; unpubl. data).

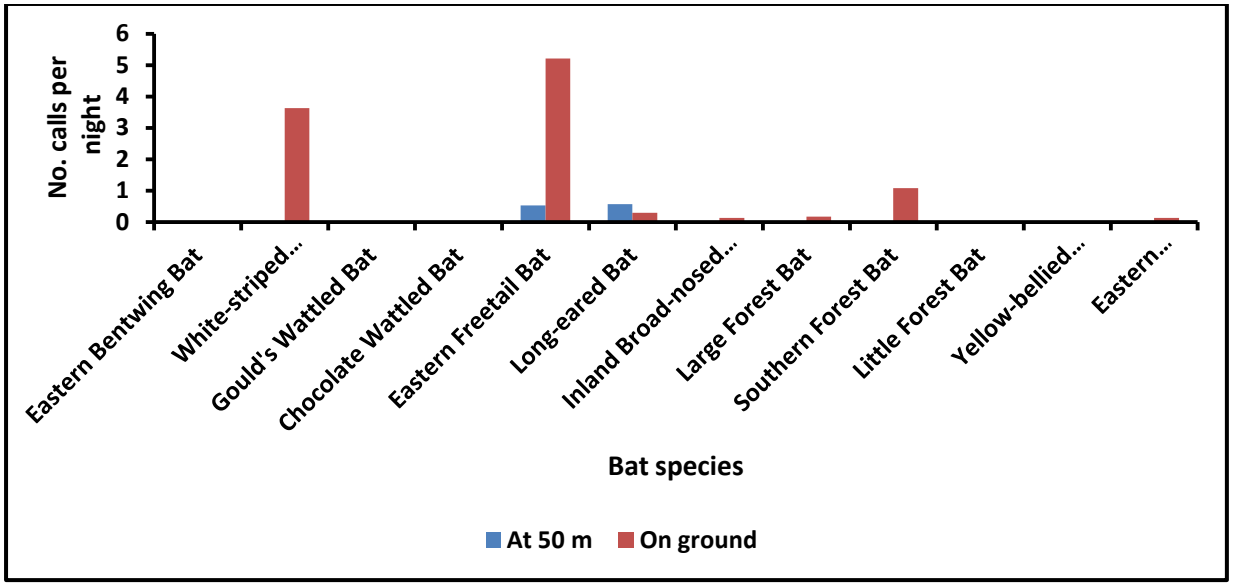
None of the threatened bats or the EBB/Forest Bat complex was recorded at RSA height.

Table 10: Concurrent recording of bat calls from 80 metres above ground and ground level

Bat species	Calls at 50 m high		Calls on ground	
	No. calls	Av. Per night*	No. calls	Av. Per night
Eastern Bentwing Bat				
White-striped Freetail Bat	1	0.05	87	3.6
Gould's Wattled Bat				
Chocolate Wattled Bat			1	0.05
Eastern Freetail Bat	11	0.5	125	5.2
Long-eared Bat	12	0.6	7	0.3
Inland Broad-nosed Bat			3	0.1
Large Forest Bat			4	0.2
Southern Forest Bat			26	1.1
Little Forest Bat				
Yellow-bellied Sheathtail Bat				
Species Complexes				
Eastern Bentwing/Forest Bat complex			3	0.1
Total nights of recording		21		24

* Number of nights of recording; 21 nights at 50 m above ground; 24 nights on ground

Figure 5: Comparison of bat calls recorded concurrently from ground level and at 50 m above ground at Crookwell II & III Wind Farm



3.3. Conclusions

Conclusions from bat survey work undertaken during the migratory season of the EBB in autumn 2017 are summarised as follows:

- Ten bat species and one species complex were identified during the survey utilising the C2&3WF;
- Species utilizing the site were common and widespread farm species in south-eastern Australia.
- Two species listed as vulnerable on the NSW TSC Act 1995: the Eastern Bentwing Bat (EBB) and Yellow-bellied Sheathtail Bat were possibly part of the bat fauna at the wind farm site. The EBB was not actually positively identified on its own, but was recorded as part of a species complex with Forest Bats. The second species was listed based on a single call only.
- Bats differed in flight height: the Eastern Freetail and Long-eared bats were the two species recorded at RSA height (over 30 m above ground), while the White-striped Freetail Bat commonly known as the species flying at this height, was recorded but from one call only.
- No threatened bat species were recorded at RSA height.
- Most of the bat species were recorded at heights below RSA (below 30 m) and are therefore considered to be exposed to a lower level of risk of collision with operating wind turbines.

4. REFERENCES

AusWEA (Australian Wind Energy Association) 2005. Wind Farms and Birds: Interim Standards for Risk Assessment. Report prepared by Brett Lane and Associates and AIRA Professional Services; Report No. 2003.35 (2.2), July 2005.

Churchill, S. 2008, Australian Bats (2nd. Ed.), Allen & Unwin, Crow's Nest, NSW.

Clean Energy Council 2013. Best Practice Guidelines for Implementation of Wind Energy Projects in Australia. Clean Energy Council, Australia.

Appendix 2: List of birds recorded in or close to C2&3WF

Australian Grebe
Australian Hobby
Australian Magpie
Australian Pelican
Australian Pipit
Australian Reed warbler
Australian Shelduck
Australian White Ibis
Australian Wood Duck
Black Swan
Black-faced Cuckoo-shrike
Black-shouldered Kite
Brown Falcon
Brown Goshawk
Brown Thornbill
Buff-rumped Thornbill
Chestnut teal Eurasian Coot
Common Bronzewing
Common Myna
Common Starling
Crested Pigeon
Crimson Rosella
Dusky Moorhen
Eastern Rosella
European Goldfinch
Galah
Golden Whistler
Great Egret
Grey Butcherbird
Grey Currawong
Grey Fantail
Grey Teal
Hardhead
Hoary-headed Grebe
House Sparrow
Laughing Kookaburra
Little Corella
Little Egret
Little Grassbird
Little Pied Cormorant
Magpie-lark
Masked Lapwing
Nankeen Kestrel
Noisy Friarbird
Noisy Miner
Pacific Black Duck
Peregrine Falcon
Pied Currawong
Purple Moorhen
Raven spp.
Red Wattlebird
Red Wattlebird
Red-rumped Parrot
Rufous Whistler
Sacred Kingfisher
Silver Gull
Silvereye
Spotted Pardalote
Striated Pardalote
Striated Thornbill
Stubble Quail
Sulphur-crested Cockatoo
Superb Fairywren
Varied Sittella
Wedge-tailed Eagle
Welcome Swallow
Western Warbler
White-browed Scrubwren
White-eared Honeyeater
White-faced Heron
White-necked Heron
White-plumed Honeyeater
White-throated Treecreeper
White-throated Warbler
Willie Wagtail
Yellow-faced Honeyeater
Yellow-rumped Thornbill
Yellow-tailed Black Cockatoo