Crudine Ridge Wind Farm Bird and Bat Adaptive Management Plan Implementation Report Year 4

Squadron Energy

ecological AUSTRALIA
A TETRA TECH COMPANY

Document Tracking

Project Name:	Crudine Ridge Wind Farm BBAMP Implementation Year 4
Project Number:	23MUD6634
Project Manager:	Lachlan Metzler, Tom Kelly

Version	Prepared by	Reviewed by	Approved by	Status	Date
3	Kacey Tada, Lachlan Metzler	Tom Kelly	Kalya Abbey	Final	12/08/2026

This report should be cited as 'Eco Logical Australia 2025, Crudine Ridge Wind Farm Bird and Bat Adaptive Management Plan Implementation Report Year 4, Prepared for Squadron Energy.'

Acknowledgements

This document has been prepared by Eco Logical Australia Pty Ltd with support from Squadron Energy.

Contents

List of Figures

List of Tables

Abbreviations

Abbreviation	Description
AICc	Akaike Information Criterion
BBAMP	Bird and Bat Adaptive Management Plan
BC Act	*Biodiversity Conservation Act 2016*
BCS	NSW Biodiversity, Conservation and Science Group of the NSW Department of Climate Change, Energy, the Environment and Water (now CPHR)
BUS	Bird utilisation Surveys
CPHR	Conservation Programs, Heritage and Regulation
CRWF	Crudine Ridge Wind Farm
DCCEEW	Commonwealth Department of Climate Change, Energy, the Environment and Water

Abbreviation	Description
DPE	NSW Department of Planning and Environment (now DPHI)
DPHI	NSW Department of Planning, Housing and Infrastructure
ELA	Eco Logical Australia Pty Ltd
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
GLMs	Generalised Linear Models
IUCN	International Union for Conservation of Nature
MNES	Matters of National Environmental Significance
RSA	Rotor swept area
SSD	State Significant Development

1. Introduction

Eco Logical Australia (ELA) was engaged by Squadron Energy for the Year Four implementation of the Bird and Bat Adaptive Management Plan (BBAMP) for the Crudine Ridge Wind Farm (CRWF) project. This report details the results of Year Four operational phase monitoring, that was undertaken from October 2024 to July 2025.

1.1. Background

CRWF is located 45 km south of Mudgee and 45 km north of Bathurst in the central tablelands of NSW.

In May 2016, the NSW Department of Planning and Environment (DPE; now NSW Department of Planning, Housing and Infrastructure (DPHI)) issued approval for the CRWF project, approving up to 77 turbines. The Commonwealth Minister for the Department of Climate Change, Energy, the Environment and Water (DCCEEW) issued approval of up to 37 turbines on 4 April 2017, selected from 57 approved turbine locations, under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

The overall aim of the BBAMP is to provide a program for monitoring the impacts on birds and bats and a strategy for managing and mitigating any significant impacts arising from the operation of CRWF. Specific BBAMP objectives relevant to this report are outlined below (see Section 1.3, CRWF BBAMP 2025 version 3.2):

- To implement a monitoring program capable of detecting any impacts to 'at-risk' birds and bats that can reasonably be attributed to the operation of the project.
- To directly record impacts on birds and bats through a targeted carcass search sampling protocol and prompt carcass removal.
- To document an agreed decision-making framework that outlines the specific actions to be taken and possible mitigation measures implemented to understand and reduce any impacts on bird and bat populations, or in the event that an impact trigger is detected.
- To detail specific monitoring for 'at-risk' bird and bat groups, such as the *Aquila audax* (Wedge-tailed Eagle), and include seasonal carcass searches and periodic species-specific surveys.
- Minimising raptor activity in the area through controlling pests and minimising availability of raptor perches.
- Using best practice methods for bat deterrence; including managing potential lighting impacts.
- To detail specific and potential mitigation measures and related implementation strategies to mitigate any detected significant impacts on birds and bats.
- To identify matters to be addressed in periodic internal reports on the outcomes of monitoring, the application of the decision-making framework, mitigation measures adopted and their result.

1.2. Purpose of this monitoring report

Squadron Energy developed a BBAMP (CRWF BBAMP 2017) to satisfy the requirements of Condition 22, Schedule 3 of the NSW State Significant Development (SSD) 6697 Conditions of Consent. The

BBAMP was also prepared to satisfy Condition 1 (a) of the Commonwealth Approval EPBC Ref: 2011/6206. The BBAMP was subsequently updated in 2025 (CRWF BBAMP 2025 version 3.2) to reflect changes in the monitoring program (see below) and has been submitted to NSW DPHI for approval. Implementation of the BBAMP is required in accordance with Condition 22, Schedule 3 of the NSW SSD6697 and Condition 9 of Commonwealth Approval EPBC Ref: 2011/6206.

Following the completion of Year One and Year Two of BBAMP implementation monitoring, a revised monitoring program was submitted to the NSW Biodiversity, Conservation and Science Group of the NSW Department of Climate Change, Energy, the Environment and Water (BCS), now Conservation Programs, Heritage and Regulation (CHPR), as part of the Year Two annual BBAMP report. BCS provided written support of the revised monitoring program on 16 August 2023, with the ongoing monitoring comprising the following components:

- Formal seasonal carcass monitoring undertaken during the middle month of each season (i.e. January, April, July, October) across all 37 turbines, within a 60 m radius inner search zone of each turbine.
- Incidental carcass monitoring and collection carried out by CRWF operational staff.
- Targeted surveys for raptor breeding activity during winter (July) and spring (October) across the CRWF site and within 2 km of the site
- Raptor, threatened and migratory species flight path tracking during seasonal monitoring.

The Commonwealth DCCEEW also provided agreement to the revised monitoring program as part of an updated BBAMP, on 17 July 2024.

Following the completion of Year Three monitoring, additional carcass monitoring was proposed to be implemented in Year Four during both February and March 2025, to provide increased survey effort within the summer and autumn seasons.

Table 1 below outlines the specific statutory requirements of the BBAMP which underlie the operational phase monitoring program and the associated methodology and performance measures applicable to the monitoring undertaken during Year Three of the BBAMP implementation.

Table 1: Statutory requirements of the BBAMP and their relevant methods of assessment and performance measures

Statutory Requirements	Performance Measures	Assessment Methodology	How Condition is fulfilled
NSW SSD6697 Conditions of Consent, Schedule 3			
Condition 22(c): include a detailed program to monitor and report on: • the effectiveness of these measures and plans; and • bird and bat strike annually, or as otherwise directed by the Secretary.	Operational phase mortality surveys undertaken quarterly at all 37 turbines for at least two years, with a review after Year 4 to determine if a change in the methodology is required.	Carcass monitoring	Recording and notification of relevant triggers as detailed below. Threatened species: A threatened bird or bat species (or recognisable parts thereof) listed as threatened (not migratory) under the Commonwealth *Environment Protection Biodiversity Conservation Act 1999* or NSW *Threatened Species Conservation Act 1995* (now the NSW *Biodiversity Conservation Act 2016* (BC Act), is found dead or injured within 150 m of a wind turbine during any mortality search or incidentally by wind farm personnel (Section 6.1.1, CRWF BBAMP 2025 version 3.2). Non-threatened species: A total of four or more bird or bat carcasses or parts

Statutory Requirements	Performance Measures	Assessment Methodology	How Condition is fulfilled
			thereof, of the same non-threatened species are recorded at the same turbine over two successive searches (excluding ravens, magpies, sulphur-crested cockatoos, corellas, and introduced species) (Section 6.2.1, CRWF BBAMP 2025 version 3.2).
Commonwealth Approval – EPBC Ref: 2011/6206			
Condition 1 (a): implement the above NSW Conditions of Approval, where Management Plans: means the Biodiversity Management Plan, Biodiversity Offsets Management Plan, and Bird and Bat Adaptive Management Plan.	As above	As above	As above

Table 2 below outlines the specific statutory requirements of the BBAMP that were completed in Year One and Year Two of operational phase monitoring program. As, such these monitoring activities are closed and not applicable to Year Four of the BBAMP implementation, however, they do provide relevant baseline and trial data which has been utilised within this report.

Table 2: Statutory requirements of the BBAMP and their relevant methods of assessment and performance measures completed in Year One and Year Two of operational phase monitoring

Statutory Requirements	Performance Measures	Assessment Methodology	How condition is fulfilled
NSW SSD6697 Conditions of Consent, Schedule 3			
Condition 22(b): develop a Bird and Bat Adaptive Management Plan (BBAMP) that includes: • Baseline data on bird and bat populations in the locality that could potentially be affected by the development, particularly 'at risk' species and threatened species; • A detailed description of the measures that would be implemented on site for minimising bird and bat strike during operation of the development.	Baseline bird and bat surveys completed; Bird Utilisation Surveys (BUS) (operational phase) undertaken in Year One as detailed in the BBAMP; Detail mitigation measures in approved BBAMP.	Completion of baseline surveys as per the methodology specified in Section 2.1.1 of the CRWF BBAMP 2017. Documenting incidental carcass finds Documenting removal of carcasses to avoid scavenging. Pest control Lighting design	Completion of baseline surveys. Completion of operational phase surveys.
Condition 22(c): include a detailed program to monitor and report on: • the effectiveness of these measures and plans; and • bird and bat strike annually, or as otherwise directed by the Secretary.	Scavenger and detector efficiency trials undertaken in Year One (Table 12, CRWF BBAMP 2017).	Scavenger and detector efficiency (observer) trials	Scavenger and observer trials successfully undertaken

2. Methods

2.1. Formal carcass monitoring

In Year Four, quarterly (seasonal) carcass monitoring was implemented at all 37 turbines listed in Table 3 below. Carcass searches were undertaken via walked transects spaced every six metres, within a search area of 60 m radius from the base of each turbine (Figure 1), to detect bat and bird carcasses. The monitoring was conducted over two to three field days in October 2024, January, February, March, April and July 2025, by ELA ecologists trained in the carcass search methodology and experienced with regards to the bat and bird species identification. As mentioned above in Section 1.2, the February and March 2025 monitoring events were added to the Year Four monitoring program to provide additional seasonal survey effort during the summer and autumn period. This additional monitoring was implemented to increase survey effort due to the potential for increased turbine collision risk during the typical period of peak microbat and flying-fox activity and sub-adult Wedge-tailed Eagle dispersal.

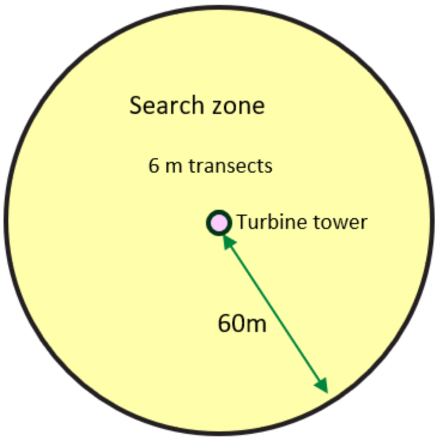

Figure 1: 60 m carcass search zones underneath the turbines

For each carcass detected, the following variables were recorded in the carcass search data sheet:

- GPS position, distance in metres and compass bearing of the carcass from the wind turbine tower
- Substrate and vegetation beneath the carcass (e.g. hard-stand, short grass, long grass)
- Species, age, number, sex (if possible), signs of injury and estimated date of strike
- Weather (including recent extreme weather events, if any), visibility, maintenance to the turbine and any other factors that may affect carcass discovery
- Where the species was not able to be immediately identified, photographs were provided to experienced ecologists within two business days of the find for identification, with the ecologist to provide a positive identification in reply within 5 business days for the possible reporting of an impact on a threatened species, within 2 business days of confirmation.

Table 3: Turbines surveyed during each carcass monitoring event

Pyramul cluster			Sallys Flat cluster
A1	A17	A34	A87
A2	A20	A35	A89
A4	A21	A38	A94

Pyramul cluster			Sallys Flat cluster
A6	A22	A43	A95
A7	A23	A44	A100
A8	A24	A47	A102
A9	A26	A52	A103
A10	A29		A104
A13	A31		A105
A14	A32		A106

2.2. Incidental carcass monitoring and collection

All bird and bat carcasses found incidentally by wind farm personnel were recorded and photographed, with all relevant carcass data collected consistent with the carcass detection protocol outlined above. Data and photographs were shared with ELA ecologists for identification, with ELA advising whether the carcass should be stored in the onsite freezer or disposed (where identification had been determined and the species was confirmed as non-threatened).

Feral pest animals were also recorded incidentally during monitoring, with the location, quantity and record type (e.g. direct observation, scats, diggings) noted and communicated to CRWF staff.

2.3. Targeted raptor breeding surveys

Roaming searches were undertaken within accessible areas of a 2 km buffer of the wind farm footprint (see Figure 2 and Figure 3) to identify raptor nests and other signs of breeding activity during the typical regional breeding season of Wedge-tailed Eagles, from July to November (Squadron Energy 2017). This corresponded to the surveys completed in October 2024 and July 2025 during the Year Four monitoring program implementation. Targeted search areas within accessible areas of the 2 km buffer were the focus of these breeding surveys based upon records of raptor activity, including the location of previously recorded Wedge-tailed Eagle carcasses, adult pairs and suitable breeding habitat. Suitable breeding habitat included mature woodland and dry sclerophyll forest containing tall, mature trees in prominent landscape positions, including ridgelines and upper hillsides. It is noted that substantial areas within the 2 km buffer were not able to be accessed as they fell outside of landholdings associated with the CRWF project, along with safety issues due to steep terrain.

Surveys within the targeted search areas were undertaken on foot and by drone (DJI Mavic 2 Pro; DJI Enterprise) to visually identify individual nests, with information regarding location, shape, dimensions and activity (presence/absence/signs of use) documented where nests were recorded. All raptor flight paths were recorded during targeted surveys, consistent with the methodology described below in Section 2.4, with the quantity, age and sex of birds also recorded, where identification was possible.

2.4. Raptor, threatened and migratory species flight path tracking

The flight paths of raptors and listed threatened and migratory species (e.g. *Hirundapus caudacutus* (White-throated Needletail)) were actively recorded during all field surveys completed during Year Four monitoring, including both seasonal and targeted raptor breeding surveys. The following information was recorded for each raptor, threatened and migratory species flight observed during field surveys:

- Date, location and duration of observation period

- Time and duration of flight
- Number, age and sex (where identifiable) of birds observed
- Flight height above ground and relative to the turbine Rotor Swept Area (RSA)
- Flight behaviour (e.g. flapping, kiting, circling, gliding or diving)
- Other occasional behaviours observed and to be recorded may include terrestrial displays, perching and habitat.

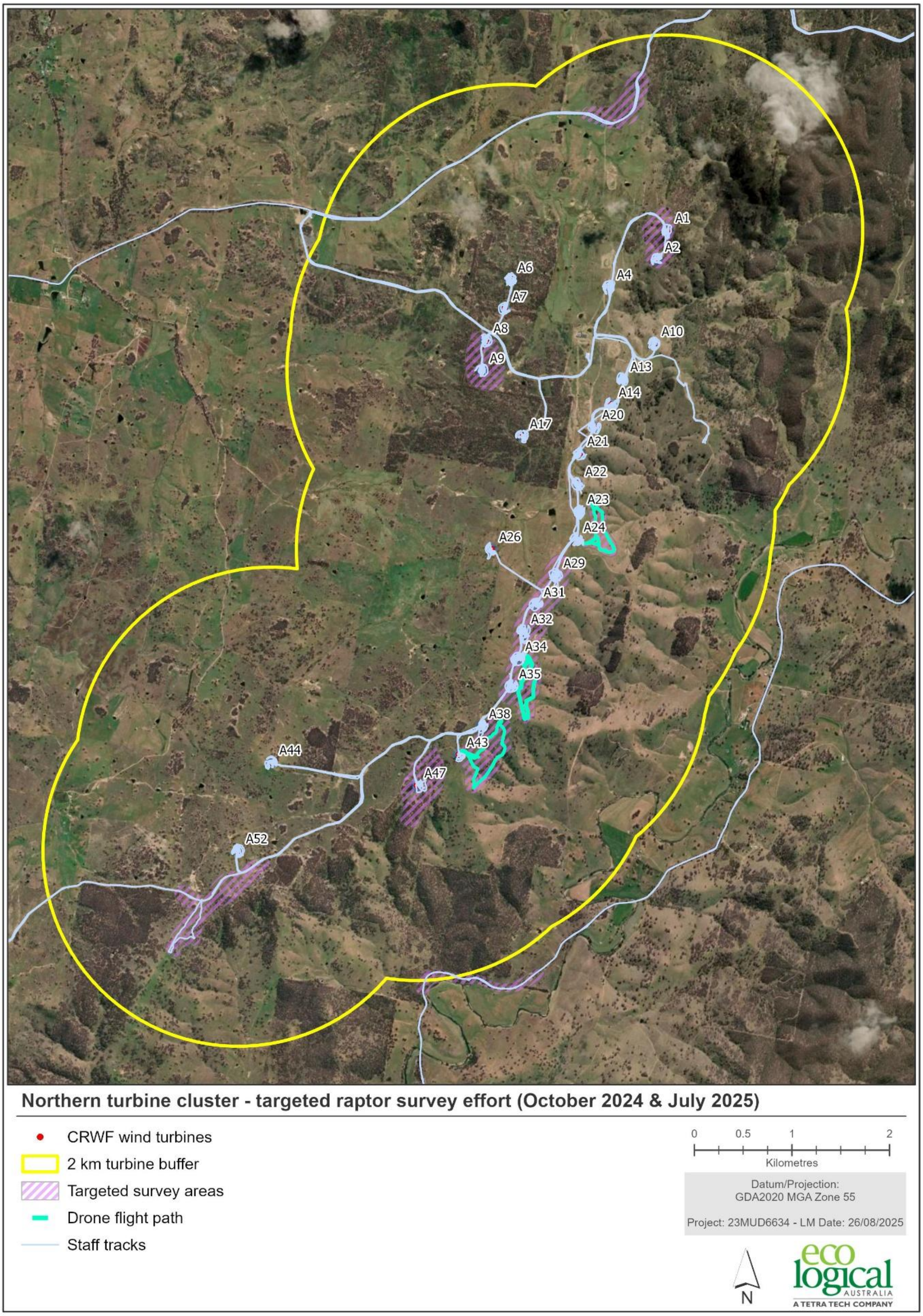

Figure 2: Survey area and effort for raptor breeding activity, including targeted searches and drone flight paths (north)

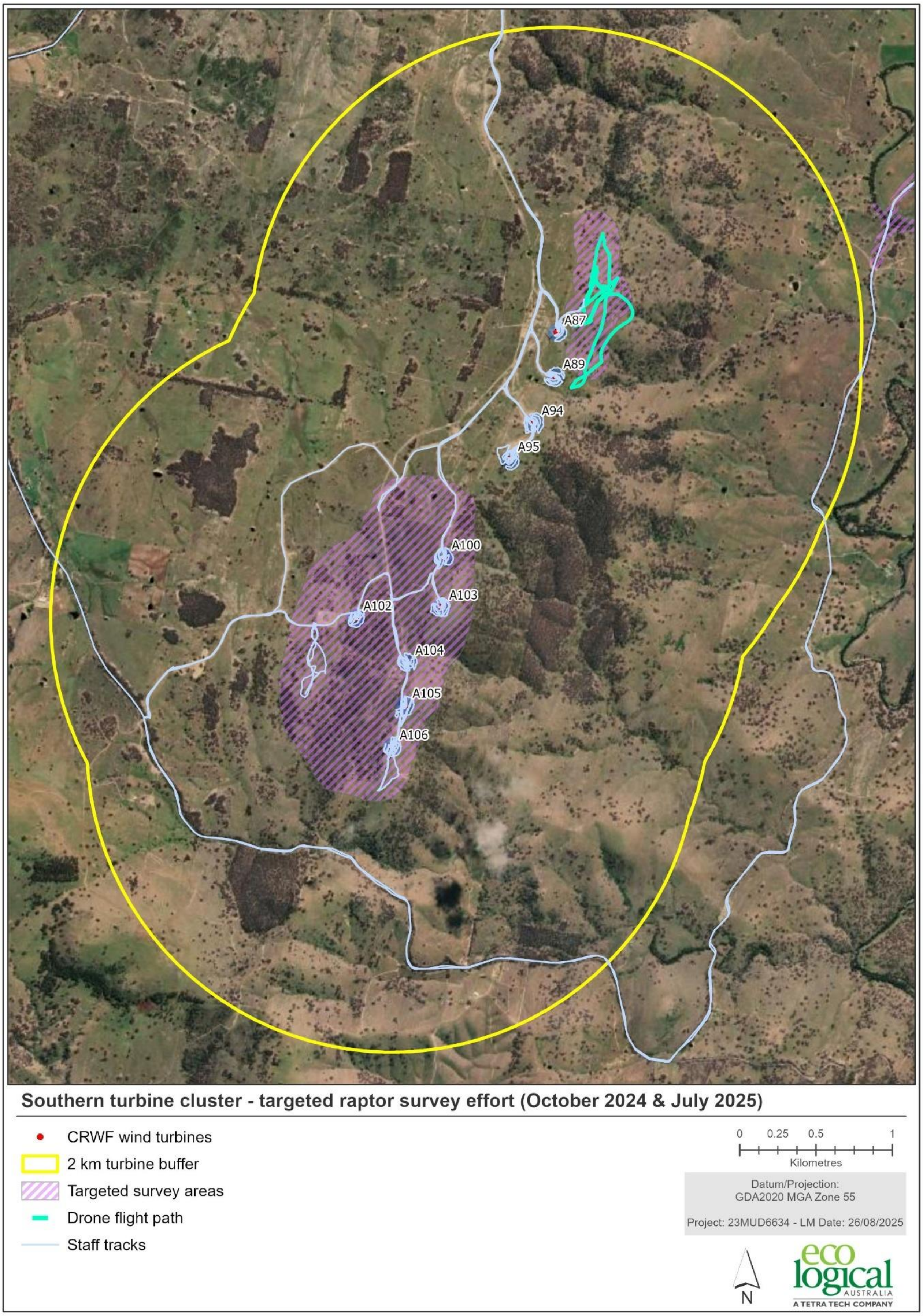

Figure 3: Survey area and effort for raptor breeding activity, including targeted searches and drone flight paths (south)

3. Results

3.1. Carcass monitoring

A total of 29 bird and 16 microbat carcasses were recorded during Year Four of the CRWF BBAMP implementation monitoring, from both formal carcass surveys and incidental finds. Locations of carcasses found during Year Four are shown in Figure 4 and Figure 5 and listed in Table 4. Bird carcasses were recorded from a total of six bird species, whilst microbat carcasses were recorded from four species. In addition to this, seven bird and seven microbat carcasses could not be identified to a species level due to advanced decomposition of the carcass or only partial remains (e.g. feathers or bones) being present.

Formal carcass monitoring conducted across four seasonal survey periods (spring, summer, autumn, and winter) identified 27 of the recorded bird carcasses and ~~all~~ 15 microbat carcasses, including the unidentified specimens. Incidental records included, two Wedge-tailed Eagle carcasses, one of which was found on a turbine pad (Turbine A32) in October 2024 and the other, which was found beneath a powerline with signs of electrocution (scorch makes on chest), approximately 400 m from the same turbine (Turbine A32) in June 2025, and one unidentified microbat carcass at Turbine A94.

The most common bird species recorded was the Wedge-tailed Eagle, with a total of 13 carcasses recorded, followed by *Cracticus tibicen* (Australian Magpie) with five carcasses recorded (Table 4). The majority of Wedge-tailed Eagle carcasses recorded were in advanced stages of decomposition or heavily scavenged and so only seven could be aged, five of which were sub-adult birds and two were adult birds. The most common bat species recorded were *Ozimops planiceps* (South-eastern Freetail Bat) and *Austronomus australis* (White-striped Freetail-bat), with three carcasses of each species recorded during Year Four (Table 4). An additional two unidentified *Ozimops* (Freetail Bat) carcasses were also recorded which may potentially represent further South-eastern Freetail Bat or one of two other locally occuring Freetail Bat species (*O. ridei* or *O. petersi*; Milne et al 2023).

No impact triggers were identified for non-threatened species, as the threshold of four or more carcasses of a single species (including consideration of unidentified species) at an individual turbine across two successive monitoring events was not exceeded. Additionally, no listed threatened species were found dead during carcass monitoring, and therefore, the threatened species impact trigger was not activated. The full carcass monitoring results for Year Four are provided in Appendix A, with a summary of all carcasses recorded from Year One to Year Four presented in Appendix B.

Table 4: Results of Year Four carcass monitoring

Common name	Scientific name	Carcass monitoring	Incidental find	Total	Turbine locations
Birds					
Australian Magpie	*Cracticus tibicen*	5		5	A14, A17, A24(2), A35
Australian Wood Duck	*Chenonetta jubata*	1		1	A87
Brown Falcon	*Falco berigora*	1		1	A26
Crimson Rosella	*Platycercus elegans*	1		1	A52
Silvereye	*Zosterops lateralis*	1		1	A35
Wedge-tailed Eagle	*Aquila audax*	11	2	13	A32, A44 (2), A47 (2), A52, A89, A100, A103, A104, A106 (2), Powerline

Common name	Scientific name	Carcass monitoring	Incidental find	Total	Turbine locations
Unidentified bird spp.	Aves (class)	7		7	A4, A14, A24, A89, A100, A104, A106
Bats					
South-eastern Freetail Bat	*Ozimops planiceps*	3		3	A2, A23, A38
Southern Forest Bat	*Vespadelus regulus*	1		1	A95
Little Forest Bat	*Vespadelus vulturnus*	1		1	A21
White-striped Freetail Bat	*Austronomus australis*	3		3	A4, A8, A47
Forest bat spp.	*Vespadelus* sp.	1		1	A43
Freetail Bat spp.	*Ozimops* sp.	2		2	A26, A106
Unidentified microbat spp.	Suborder Microchiroptera	4		5	A1, A20, A29, A94, A106
Total		42	2	5	

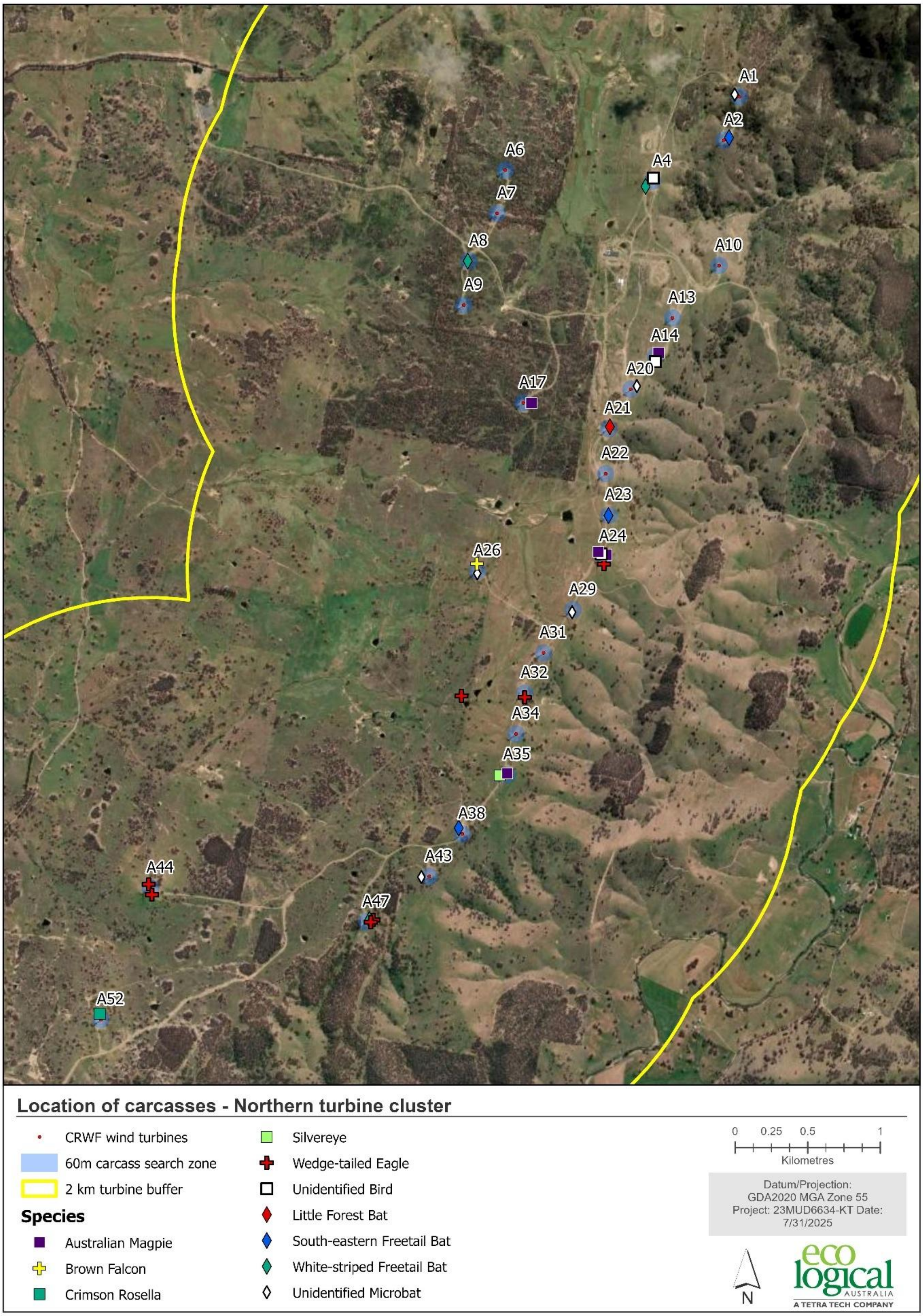

Figure 4: Location of carcasses — Northern turbine cluster

Figure 5: Location of carcasses — Southern turbine cluster

Whilst both the summer 2025 and autumn 2025 seasonal monitoring periods recorded the highest quantity of bird carcass records during Year Four monitoring with 10 bird cases in total (Figure 6), the survey effort during both of these seasons was double that of the other two seasons (spring 2024 and winter 2025). As such, allowing for survey effort, there was minimal seasonal variation in the quantity of bird carcasses recorded during Year Four monitoring. This contrasts with the results of bird carcass surveys recorded in Years One to Three of BBAMP implementation monitoring which recorded a seasonal pattern of increased bird mortality during spring and summer (see ELA 2022, 2023, 2024).

Microbat carcasses were predominantly recorded during the summer and autumn seasonal surveys in Year Four (Figure 6), continuing the seasonal pattern also recorded in Year One to Three of BBAMP implementation monitoring. As was also recorded in Year One to Three, the late-summer (February 2025) to early-autumn (March 2025) period recorded the highest quantity of microbat carcasses during Year Four. The consistency of these results across all four years of BBAMP implementation monitoring likely reflect the heightened microbat activity during these warmer months, potentially driven by greater insect availability and increased microbat abundance and mobility in the late breeding season for the majority of microbat species in south-eastern Australia (Churchill 2008; and Turbill 2008).

The implementation of additional carcass monitoring appears to have been successful in improving carcass detectability of microbats, with five carcasses recorded during February 2025 surveys and seven carcasses recorded during March 2025 (Figure 6). This represents an increase in comparison to Year 3 surveys during which only one seasonal survey was completed, in which four carcasses were recorded in summer 2024 and one carcass recorded in autumn 2024 (ELA 2024). The high persistence of Wedge-tailed Eagle carcasses means that the benefit of additional monitoring is less clear for this species and the variable carcass monitoring results further indicate this, with three Wedge-tailed Eagle carcasses recorded during the February 2025 survey and no carcasses recorded in March 2025.

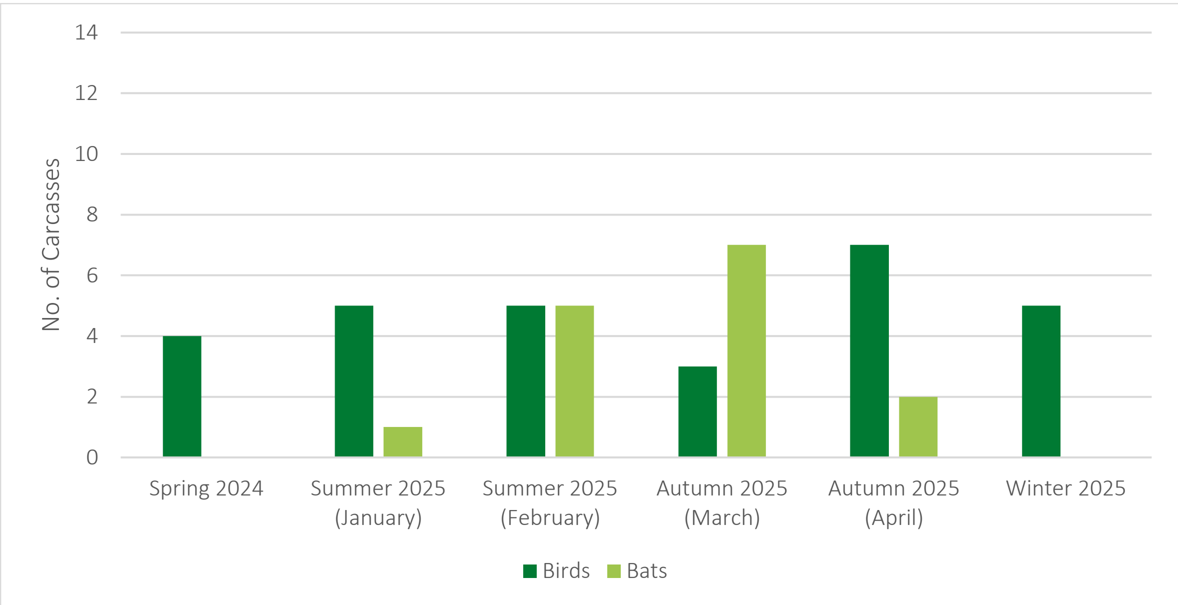

Figure 6: Bird and bat carcass seasonality from Year Four of carcass monitoring (Incidental observations were incorporated into the data for their respective seasons)

A total of five feral animal species were recorded during Year Four BBAMP implementation monitoring (Table 5). Four of the five species (excluding *Lepus capensis* (Brown Hare)) are declared as vertebrae pests in the Central Tablelands Regional Strategic Pest Animal Management Plan 2024-2028 (Local Land Service 2024).

Table 5: Feral pest species records recorded during Year Four monitoring

Feral pest species	Scientific Name	Record Type	Quantity records
Brown Hare	*Lepus capensis*	Direct observation	2 records of 2 individuals
European Rabbit*	*Oryctolagus cuniculus*	Direct observation, scats, diggings	16 records of 17 individuals
Feral Cat*	*Felis catus*	Direct observation	1 record of 1 individual
Feral Goat*	*Capra hircus*	Direct observation, scats	25 records of 183 individuals
Feral Pig*	*Sus scrofa*	Direct observation, scats, diggings	13 records of 18 individuals

*Declared vertebrate pest in the Central Tablelands Regional Strategic Pest Animal Management Plan 2024-2028 (Local Land Service 2024)

3.2. Raptor, threatened and migratory species flight path tracking

The flight paths of four raptor species were recorded during Year Four of the CRWF BBAMP implementation monitoring program (Table 6), with these flights mapped in Figure 7 and Figure 8 below. In total, 84 Wedge-tailed Eagle individuals in flight were recorded, of which the majority of flights (43) were undertaken primarily at RSA height (Table 6). Fourteen of the 84 total Wedge-tailed Eagle flights were observations of group flights involving between two and eight individual birds. Group flights included a total of nine recorded flights of adult Wedge-tailed Eagle pairs.

Consistent with previous monitoring years, these adult pairs were predominantly recorded in the far north (near Turbines A1-A4 and east of Turbine A14), centre (near Turbine A52) and far south (near Turbines A102 and A106) of the CRWF project site (Figure 7 and Figure 8). The consistent recording of adult pairs in these same sections of the CRWF site across the four years of BBAMP implementation monitoring indicate a persistent adult population, consisting of at least three adult pairs. Additionally, an adult pair and sub-adult individual were recorded perched and then taking flight together in the north of the site between Turbines A2 and A4 during the July 2025 monitoring period, potentially indicating successful breeding of this pair. Multiple sub-adult Wedge-tailed Eagle groups, including groups of eight birds and multiple groups of three birds, were also recorded in flight during Year Four monitoring. Along with four separate records of individual sub-adult birds, the Year Four data again indicates that substantial numbers of sub-adult Wedge-tailed Eagles utilise the CRWF site.

Both *Falco berigora* (Brown Falcon) and *Falco cenchroides* (Nankeen Kestrel) were recorded commonly during Year Four, with 10 Brown Falcon flight records and 15 Nankeen Kestrel flight records observed (Table 6). These two species were recorded as either individuals or pairs and predominantly at heights below the turbine RSA. Of the other raptor species previously recorded during Year One to Year Three of BBAMP implementation monitoring, only one individual *Accipiter fasciatus* (Brown Goshawk) was recorded (Table 6), with this individual recorded flying low through and between trees. No raptor species were recorded perching on turbines or overhead powerlines within the CRWF site during Year Four monitoring.

Overall, raptor flight activity recorded during Year Four was comparatively high and for Wedge-tailed Eagle, Brown Falcon and Nankeen Kestrel, exceeded the combined number of flight records from Years One to Three combined (Table 6). The Wedge-tailed Eagle has been by far the most common and abundant raptor recorded since the commencement of monitoring (Table 6). This species has been recorded across the full extent of CRWF throughout all years and seasons of monitoring. Flight activity of this species occurred at various altitudes above, below and within the RSA height, with visual confirmation of individuals exhibiting turbine avoidance behaviour when flying in very close proximity to the operating turbines.

The additional monitoring completed in summer and autumn of Year Four was successful in capturing high raptor activity during this period with a total of 38 Wedge-tailed Eagle flights and three flights of both Brown Falcon and Nankeen Kestrel recorded across the February 2025 and March 2025 surveys.

Table 6: Observed raptor flights Year Four vs Year One - Three

		Year 4				Year 1 - 3
Common Name	**Scientific Name**	**Above RSA**	**Within RSA**	**Below RSA**	**Total flights**	**Total flights**
Black Kite	*Milvus migrans*					1
Black-shouldered Kite	*Elanus axillaris*					2
Brown Falcon	*Falco berigora*		5	5	10	6
Brown Goshawk	*Accipiter fasciatus*			1	1	3
Collared Sparrowhawk	*Accipiter cirrocephalus*					2
Little Eagle	*Hieraaetus morphnoides*					1
Nankeen Kestrel	*Falco cenchroides*		5	10	15	14
Square-tailed Kite	*Lophoictinia isura*					1
Wedge-tailed Eagle	*Aquila audax*	23	43	18	84	84
Whistling Kite	*Haliastur sphenurus*					1

In addition to the raptor species listed above, three threatened bird species were recorded during Year Four monitoring, however, no individuals of these species were recorded flying at heights within the RSA (Table 7).

Table 7: Threatened non-raptor species identified in Year Four

Name	Scientific name	BC Act	EPBC Act	Observation date	Comment
Dusky Woodswallow	*Artamus cyanopterus cyanopterus*	Vulnerable	-	19 Feb 2025	A single bird was sighted in trees approximately 70 m from Turbine A23.
Scarlet Robin	*Petroica boodang*	Vulnerable	-	18 July 2025	Two birds were sighted on the ground and low in trees approximately 310 m southwest of Turbine A102
Southern Whiteface	*Aphelocephala leucopsis*	Vulnerable	Vulnerable	9 April 2025	Seven birds were sighted on the ground and in low shrubs approximately 50 m from Turbine A23

Additionally, a single *Phascolarctos cinereus* (Koala), listed as Endangered under both the NSW BC Act and Commonwealth EPBC Act, was opportunistically sighted during targeted raptor breeding surveys, however, its location was outside of the CRWF Project along Crudine Road, approximately 2 km south of the nearest turbine location (Turbine A47).

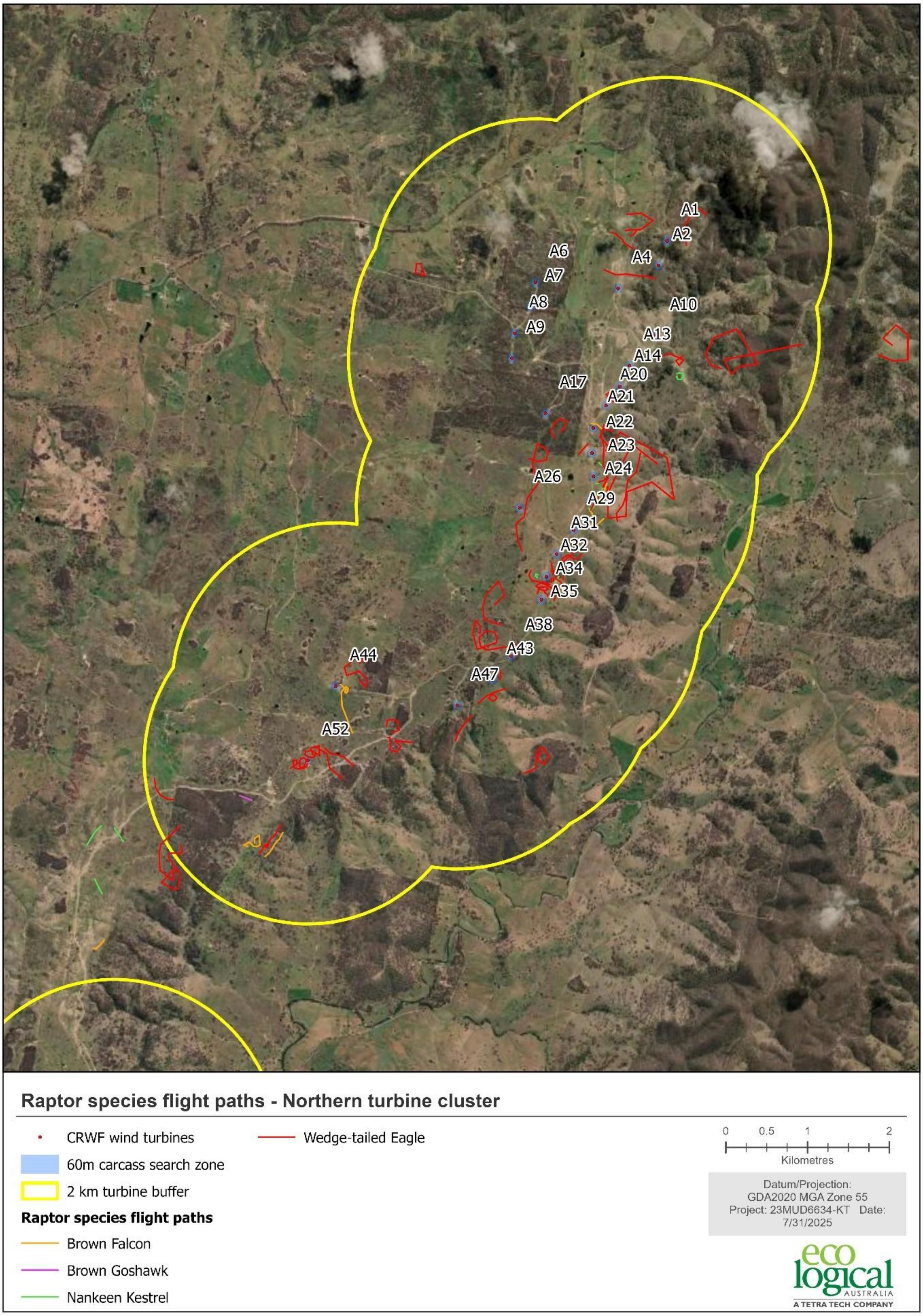

Figure 7: Raptor flight paths adjacent to northern portion of turbines. Note each line represents a single observation event and may represent flights of multiple individuals.

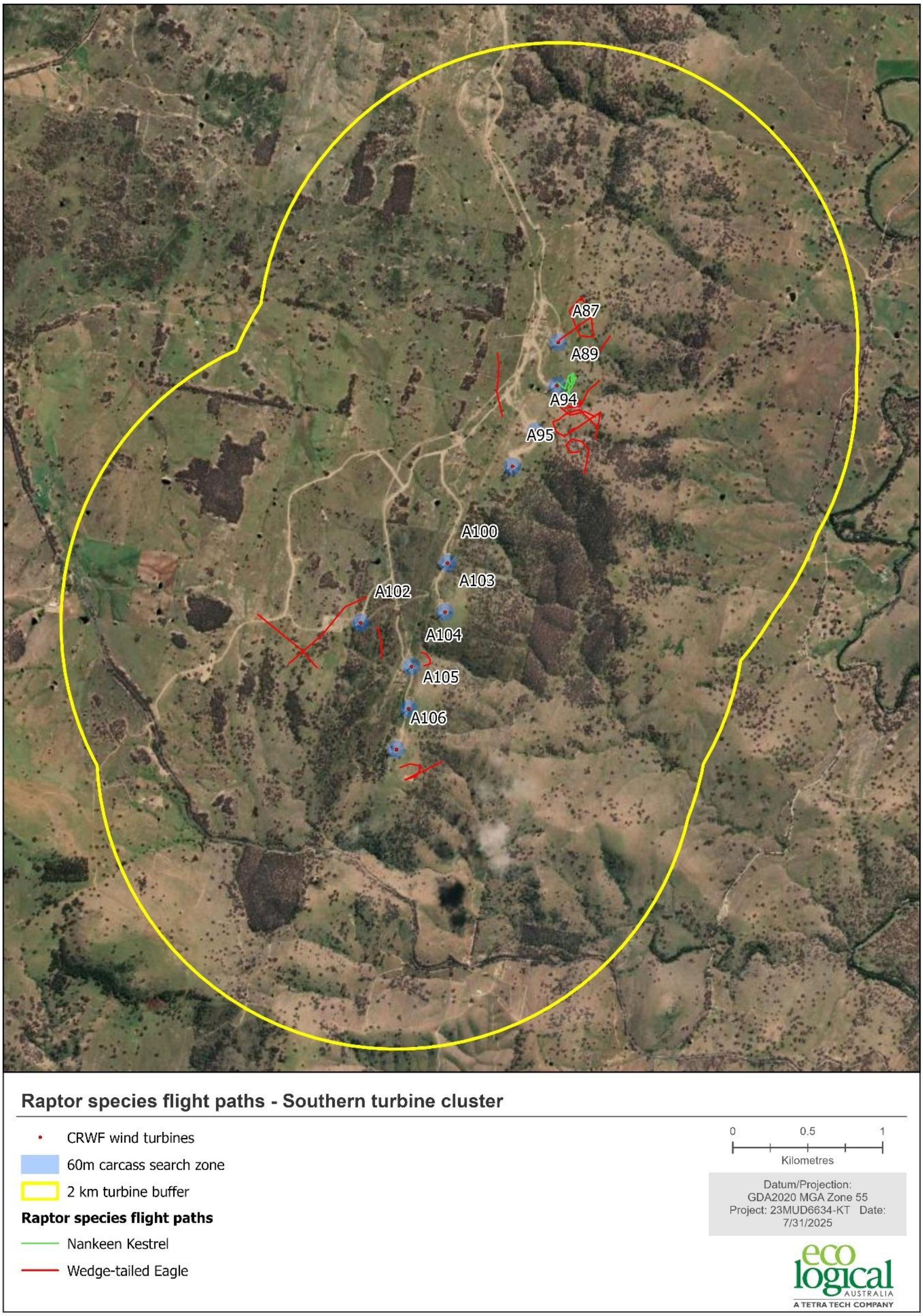

Figure 8: Raptor flight paths adjacent to southern portion of turbines

3.3. Targeted raptor breeding survey

Nest searches for Wedge-tailed Eagles and other raptor species were conducted in October 2024 and July 2025 within a 2 km buffer surrounding the CRWF. A total of 30 nests were recorded, varying in size: four nests exceeding 70 cm in diameter, nine between 50–70 cm, fifteen between 20–50 cm, and two smaller than 20 cm (Figure 9). All potential raptor nests larger than 50 cm were observed for at least ten minutes to assess any signs of activity, however, no signs of raptor breeding activity was recorded.

All previously recorded large nests, potentially suitable for Wedge-tailed Eagle were re-surveyed and confirmed as being non-active during both the October 2024 and July 2025 survey periods. The nests did not contain young birds and were not visited by adult birds whilst observed and no signs of recent whitewash or droppings were observed on the sides of the nest or beneath the nest. Additionally, drone flights completed adjacent to known nest locations and used to locate additional nests, did not elicit any defensive response from raptors providing a further indication that the recorded nests were inactive at the time of surveys. An example of a large nest, potentially suitable for use by Wedge-tailed Eagle is shown in Figure 10.

Despite no flight activity being recorded directly from raptor nests during targeted surveys, adult pairs of Brown Falcons, Nankeen Kestrels and Wedge-tailed Eagles were recorded. Adult pairs were also recorded opportunistically during Year Four carcass monitoring surveys and have also consistently been recorded during previous monitoring years. The persistent recording of adult birds indicates that breeding is likely to be occurring within the vicinity of the CRWF site. Multiple sub-adult Wedge-tailed Eagles (see Figure 11) were also recorded during both the October 2024 and July 2025 surveys and provide further indication of continued breeding activity for the species. A sub-adult bird was recorded alongside an adult pair during the July 2025 targeted surveys, however, it is noted that sub-adult birds have the capacity to disperse widely and undertake nomadic movements (Cherriman 2007) and therefore given the overall quantity of recorded sub-adults, it is unlikely that these all reflect local or even regionally bred birds.

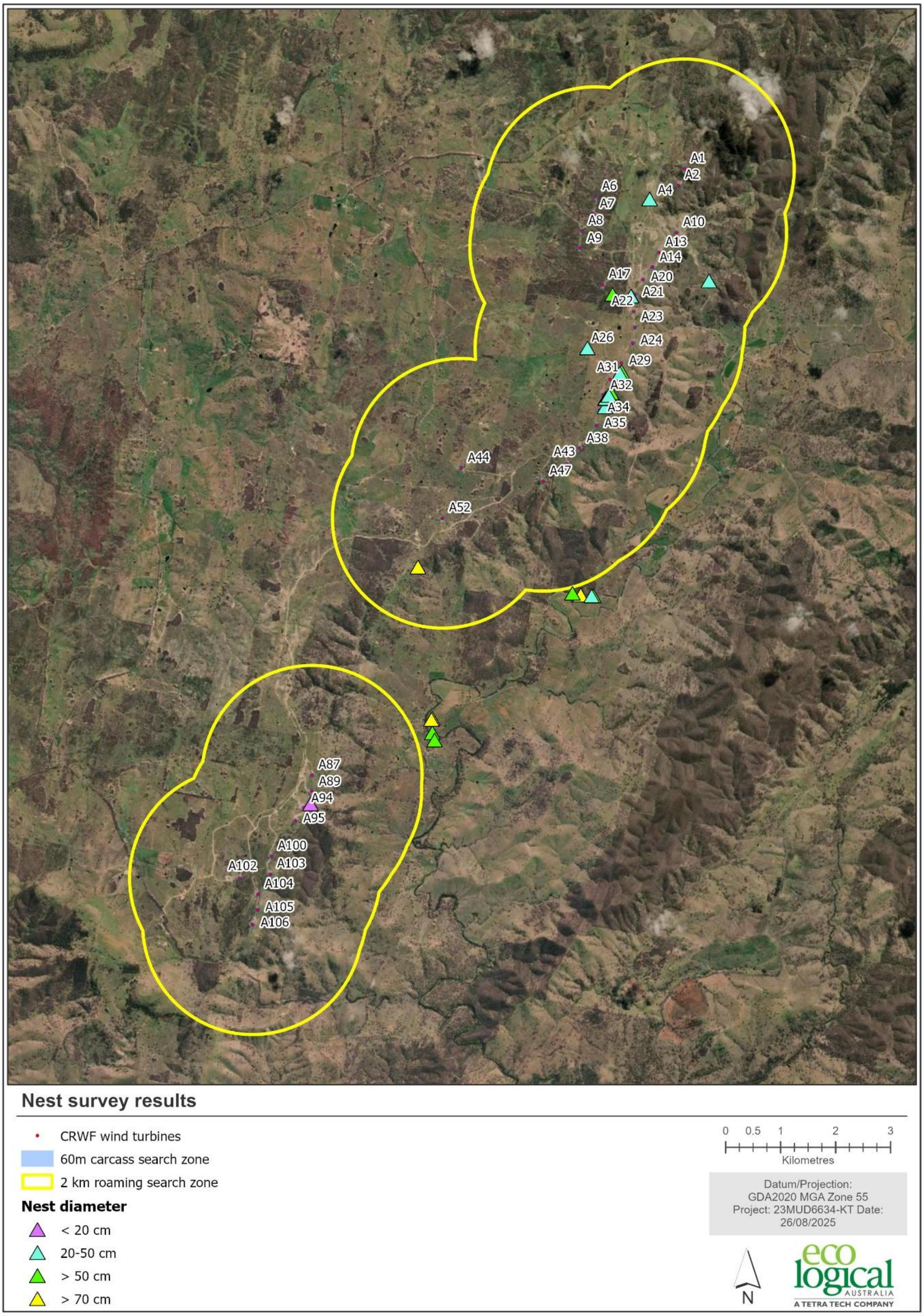

Figure 9: Location of stick nests recorded during targeted raptor breeding surveys

Figure 10: Potential Wedge-tail Eagle nest south of A52; confirmed as inactive

Figure 11: Sub-adult Wedge-tailed Eagle in flight

3.4. Raptor activity analysis

As explained in the Year Three annual report (ELA 2024), comparison of the results of Year Three and Four BBAMP implementation monitoring with Year One and Two results, must acknowledge the updates to the survey methodology undertaken between the end of Year Two and the commencement of Year Three monitoring. Methodology updates included reduced carcass monitoring frequency (quarterly carcass surveys, compared to monthly surveys) and reduced carcass search areas (100 m radius reduced to 60 m radius). Additionally, the number of turbines searched during each survey period increased from 19 turbines (50%) to all 37 turbines (100%). As detailed in Section 2.1, the carcass monitoring was further updated between Year Three and Year Four with the implementation of additional monitoring periods in summer (February 2025) and autumn (March 2025).

Relatively high raptor flight activity was recorded in Year Four, with Wedge-tailed Eagle flight activity peaking during summer 2025 (February) and all other raptor flight activity peaking in spring 2024 (Figure 12). Both of these periods recorded the highest number of flights for their respective species / species-groups across the full four year BBAMP implementation monitoring period, both in total flights and mean flights per monitoring event. High Wedge-tailed Eagle flight activity recorded in February 2025 corresponded with the highest recorded seasonal mortality of the species during Year Four monitoring. Three Wedge-tailed Eagle carcasses were recorded in February 2025 as well as during winter 2025, which also recorded relatively high flight activity for the species (15 total flights; see Figure 12). The exception to this trend was March 2025 (autumn), during which zero Wedge-tailed Eagle carcasses were recorded whilst flight activity remained relatively high (16 total flights).

Overall, however, the results of Year Four monitoring continue to correlate Wedge-tailed Eagle flight activity and mortality, as seen in previous monitoring years. Across each of Year One (autumn 2022), Year Two (summer 2022/23), Year Three (spring 2023) and now Year Four (summer 2025 – February) both Wedge-tailed Eagle flights and carcasses were highest during the same season. Flight activity and carcass mortality of other raptor species also showed some positive correlation during Year One to Three (Figure 12). This trend did not continue into Year Four, however, with only one Brown Falcon carcass recorded, despite ongoing raptor sightings throughout the year's seasonal monitoring periods.

The total number of Wedge-tailed Eagle carcasses recorded in Year Four (13 carcasses) decreased compared to Year Three (17 carcasses), despite an increase in survey effort. Both Year Three and Year Four recorded an increased number of carcasses compared to both Year One (5 carcasses) and Year Two (7 carcasses) monitoring. The increased carcass numbers in Year Three and Four may be reflective of the suitability of the updated methodology for monitoring Wedge-tailed Eagle carcasses, in particular by providing full turbine coverage. The effectiveness of the updated monitoring methodology can be seen in comparing Year Four results to the mortality estimate for Wedge-tailed Eagle calculated at the conclusion of Year One and Year Two monitoring (Symbolix 2023), as well as Year Four (Symbolix 2025). The annual estimate of Wedge-tailed Eagle mortality from Year One and Year Two was 13.5 Wedge-tailed Eagles and 11 Wedge-tailed Eagles for Year Four. A total of 13 Wedge-tailed Eagle carcasses were recorded during Year Four monitoring which is very close to both the Year One and Two and Year Four annual mortality estimates and much closer than the mean number of Wedge-tailed Eagles carcasses (6) recorded during Year One and Year Two monitoring.

Of the 43 total Wedge-tailed Eagle carcasses recorded across the four year's of BBAMP implementation monitoring, only three individuals have been positively identified as adult birds, whilst 29 were identified as sub-adult birds and the remaining ten birds unable to be aged. The two adult birds recorded during Year Four monitoring were recorded at adjacent turbines (A103 and A104) and during successive monitoring periods (January 2025 and February 2025). The other adult Wedge-tailed Egale recorded carcasses monitoring was recorded at turbine A23 during the July 2023 survey in Year Three (see ELA 2024).

Turbines A103 and A104 are located in the far southern section of CRWF site and the southern portion of the Sallys Flat turbine cluster where an adult pair of Wedge-tailed Eagles have been recorded flying across all four years of monitoring. On the 21 January 2025 when the adult Wedge-tailed Eagle carcass was recorded at turbine A104 (recorded at 2:45 pm and carcass age estimated at 2-3 days old) an adult pair was recorded flying between turbines A102 and A104 shortly before at 2:20 pm. Given the carcass age, these two almost simultaneous records clearly represent different adult birds. Additionally, an adult pair was also recorded in the same area, flying adjacent to turbine A104 on 11 March 2025, subsequent to the recording of both the turbine A104 adult Wedge-tailed Eagle carcass and the turbine A103 carcass on 18 February 2025. Whilst no evidence of Wedge-tailed Eagle nesting was recorded in this southern section of the CRWF site during winter 2025 targeted breeding surveys (see Figure 9), these flight records demonstrate the persistence of adult Wedge-tailed Eagle activity post-turbine collision in the same section of the CRWF. As noted in the Year Two and Year Three monitoring reports (ELA 2023; ELA 2024), this replicates the overall persistence of Wedge-tailed Eagle activity recorded across the CRWF, despite ongoing impacts to sub-adult Wedge-tailed Eagle individuals also being recorded during the first four years of the Project's operation.

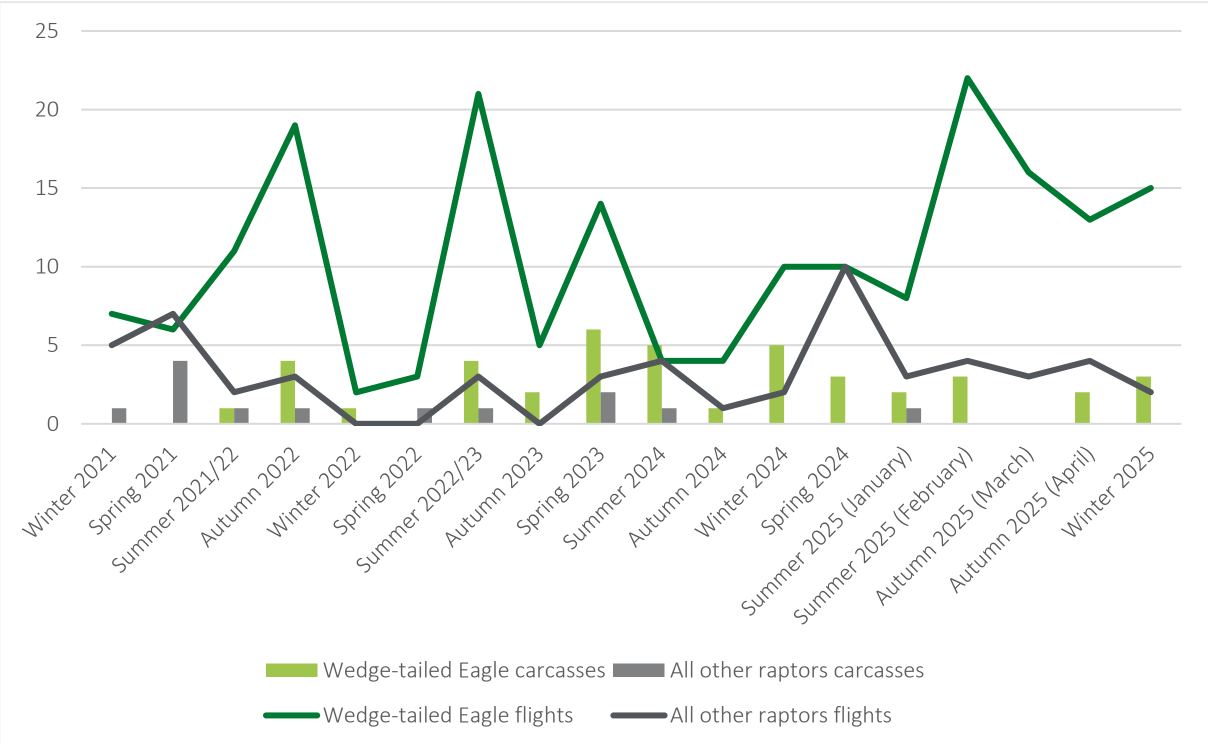

Figure 12: Wedge-tailed Eagle and all other raptor species flights and mortality (Year Four highlighted in green)

Across the first four years of BBAMP implementation monitoring, Wedge-tailed Eagle carcasses have been recorded at 21 of 37 turbines (Table 8). The number of carcasses recorded per turbine ranged from zero to five per turbine, with a mean of 1.11 and median of 1 carcass per turbine. Wedge-tailed Eagle carcass records have been recorded at 16 of 27 (59%) turbines within the northern Pyramul turbine cluster and 5 of 10 turbines (50%) within the southern Sallys Flat turbine cluster.

A heat map of Wedge-tailed Eagle carcass records for the Pyramul turbine cluster is displayed in Figure 13. Carcasses were not recorded in the northernmost portion of the Pyramul turbine cluster, comprising turbines A1 to A10 and turbine A17 (Figure 13 and Table 8). Contrastingly, the southernmost portion comprising turbines A38 to A52 recorded the highest number of carcasses across both the Pyramul turbine cluster and the Sallys Flat turbine cluster (Figure 13 and Table 8).

Interestingly, the turbines with the highest recorded Wedge-tailed Eagle mortality in the Pyramul turbine cluster present quite different environmental gradients and locations. Turbines A32 (three carcasses) and A38 (five carcasses) are located directly atop the main, predominantly cleared ridge, with a steep drop off to the east, which may limit visibility of the turbines for raptors rising up the ridgeline on thermals or flying westward through the region. Turbines A44 (three carcasses) and A52 (four carcasses), however, are located well back from the main ridge on undulating hills of scattered to open woodland and distant (0.97 – 1.5 km) from adjacent turbines (Figure 13).

Figure 14 displays the Wedge-tailed Eagle carcass heat map for the Sallys Flat cluster with the southernmost turbine A106 recording the highest number of carcasses (three). This turbine is located towards the end of the main ridge with steep slopes on three sides which may limit visibility of the turbine to approaching birds. The overall pattern of Wedge-tailed Eagle mortality across the Sallys Flat turbine cluster is variable, as seen in the case of turbine A105 which is located adjacent (0.28 km) to A106 and A104 (two carcasses), yet has not recorded any carcasses during four years of monitoring. Whilst Figure 13 and Figure 14 demonstrate some spatial patterns in Wedge-tailed Eagle carcasses recorded across the CRWF site, it is not clear whether there are any key geographical or environmental factors which uniformly determine turbine collision risk for the species.

Table 8: Turbine location and quantity of Wedge-tailed Eagle carcasses recorded during Year One to Year Four monitoring

Pyramul turbine cluster			Sallys Flat turbine cluster
A1 (0)	A17 (0)	A34 (1)	A87 (0)
A2 (0)	A20 (1)	A35 (2)	A89 (2)
A4 (0)	A21 (2)	A38 (5)	A94 (0)
A6 (0)	A22 (1)	A43 (1)	A95 (0)
A7 (0)	A23 (2)	A44 (3)	A100 (1)
A8 (0)	A24 (1)	A47 (3)	A102 (0)
A9 (0)	A26 (0)	A52 (4)	A103 (1)
A10 (0)	A29 (1)		A104 (2)
A13 (1)	A31 (0)		A105 (0)
A14 (1)	A32 (3)		A106 (3)

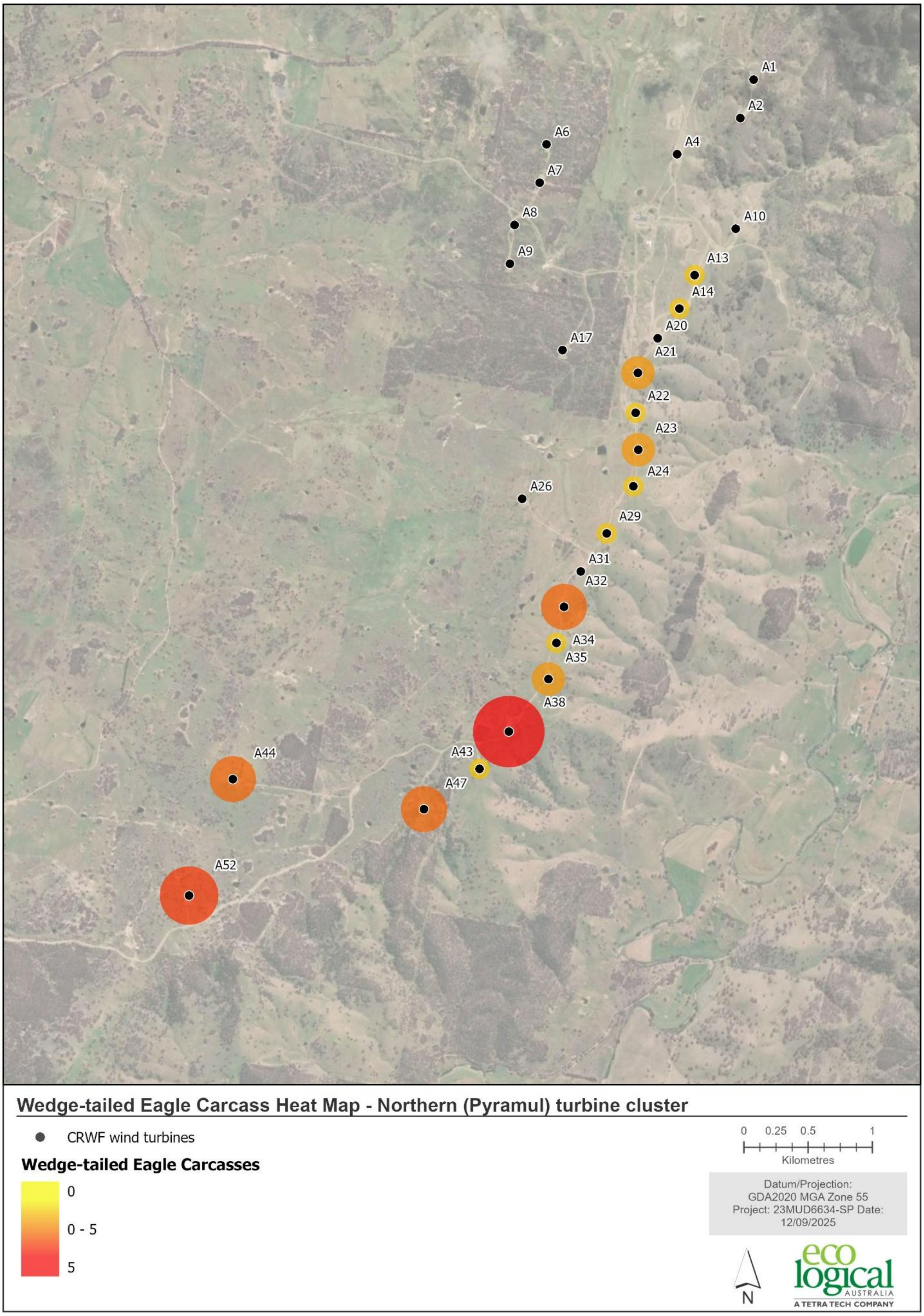

Figure 13: Heat map of Wedge-tailed Eagle carcass records across the northern Pyramul turbine cluster

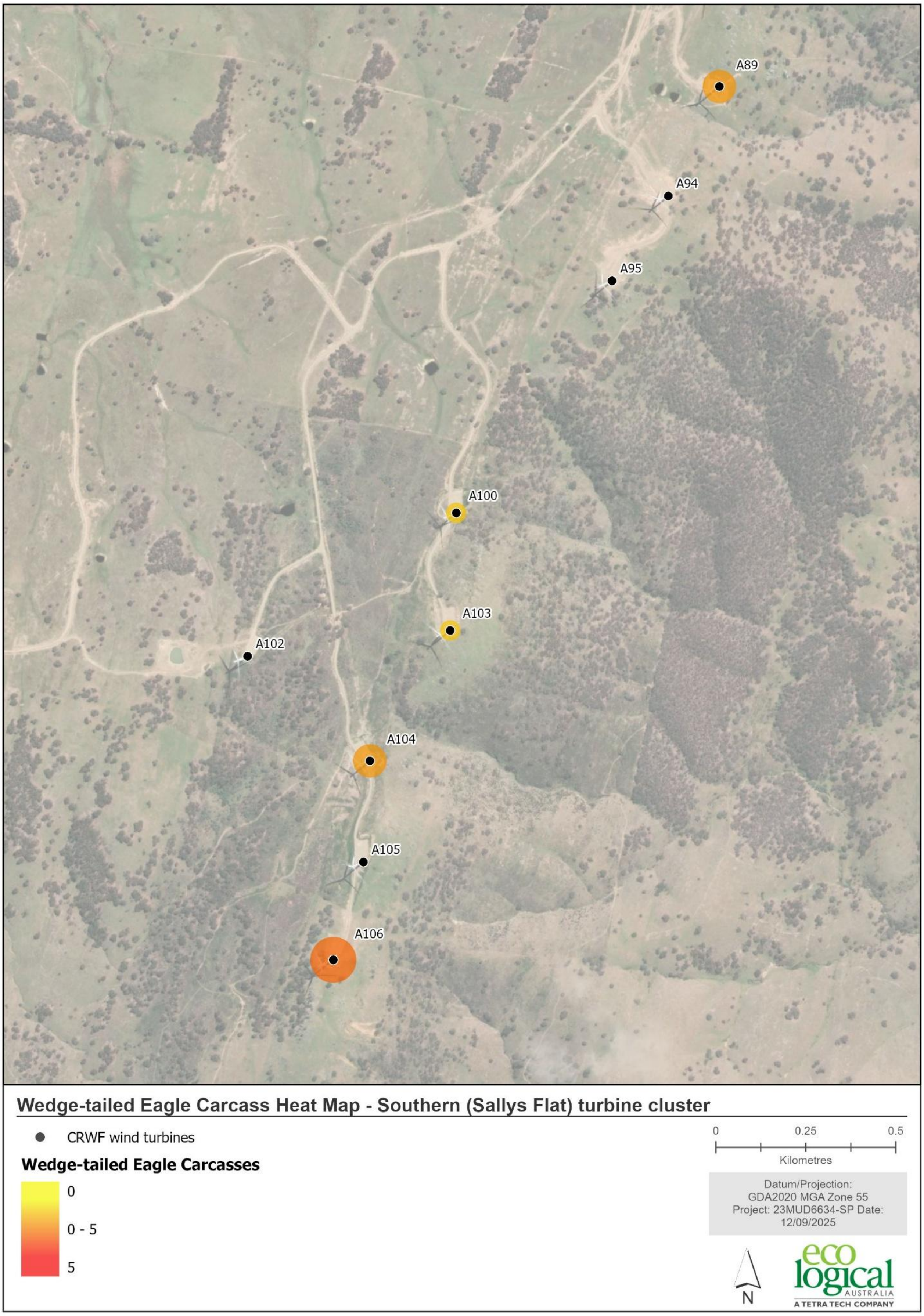

Figure 14: Heat map of Wedge-tailed Eagle carcass records across the southern Sallys Flat turbine cluster

4. Discussion

The CRWF BBAMP outlines the monitoring requirements and performance criteria to be achieved with regards to the management of potential impacts to bird and bat species. The following section provides a summary of progress against each monitoring requirement and/or performance criteria, following four years of the implementation of the BBAMP.

4.1. Bird, Wedge-tailed Eagle and bat mortality estimates

No impact triggers were identified through the results of carcass monitoring for non-threatened or threatened bird and bat species (see Section 3.1) and therefore, the decision making framework and mitigation response detailed in the CRWF BBAMP (Section 6.1 and 6.2; Squadron Energy 2025) was not required to be implemented. Carcass monitoring is designed to record direct bird and bat mortality, however, carcass monitoring data from Year Three and Year Four is utilised to provide estimates of total bird and bat, and Wedge-tailed Eagle mortality across the CRWF. Mortality estimates also utilise site specific searcher efficiency and scavenger efficiency trial data, with the analysis completed by Symbolix (2025) and detailed in full in Appendix C. The following sub-sections below present a summary of the mortality estimation methodology and results.

4.1.1. Searcher efficiency trials

Symbolix undertook analysis of the searcher efficiency trials undertaken in Year One of monitoring (see ELA 2022) in order to calculate overall detectability proportions of bird and bat carcasses for the CRWF. Symbolix advised that the use of Year One trial data for determining detectability in calculating Year Three and Year Four mortality estimates, remains valid as the detectability rate isn't affected by the monitoring frequency or search area. The key component of the monitoring methodology, being carcass searches conducted by humans, remains unchanged across the four years of monitoring, with carcass detection dogs not used for surveys at the CRWF site.

Bird, bird proxy (domestic rats), bat and bat proxy (domestic mice) carcasses were utilised across searcher efficiency trials. Searcher efficiency was estimated by fitting binomial generalised linear models (GLMs). The optimal model was determined, guided by the small-sample corrected Akaike Information Criterion (AICc) (Anderson and Burnham 2004), which is a method for selecting the best approximating and parsimonious model. The most parsimonious model of searcher efficiency was the "intercept-only" model (i.e. all carcasses have the same expected searcher efficiency) according to AICc. Therefore, bat and bird detection efficiencies are aggregated in the mortality estimate model, as presented in Table 9 below.

Mean detectability for bats and birds was calculated to be 76%, with a lower and upper 95% confidence interval of 64% and 85%.

Table 9: Detection efficiencies for bats and birds

Variable	Bats and Birds
Number of carcasses placed	70
Number of carcasses found	53
Mean detectability proportion	0.76
Detectability lower bound (95% confidence interval)	0.64

Variable	Bats and Birds
Detectability upper bound (95% confidence interval)	0.85

4.1.2. Scavenger efficiency trials

Symbolix also undertook analysis of the scavenger efficiency trials undertaken in Year One of monitoring (see ELA 2022) in order to calculate median time to total carcass removal (loss) by scavenger, for birds and bats. As was the case with the searcher efficiency modelling, AICc analysis of the survival regression models, showed the most parsimonious model was the model that combined bats, birds and bat and bird proxies.

The median time to total loss (carcass removal) via scavenge for bats and birds was calculated at 2.9 days, with a lower and upper 95% confidence window of 1.0 and 6.2 days.

4.1.3. Coverage factor

Two other key components of the mortality estimations are the coverage factor and proportion of turbines searched. The coverage factor estimates the probability that a carcass falling at a searched turbine will fall within the 60 m and 100 m radius search areas. In order to calculate this, Symbolix generated carcass fall-zone distributions for each species class (bat, small – medium bird and large bird i.e. Wedge-tailed Eagle) based on the dimensions of turbines at CRWF.

On average, it was calculated that 85% of bat, 64% of small – medium birds and 57% of Wedge-tailed Eagles would fall within the inner 60 m radius search zone. For the outer 100 m radius search zone, it was calculated that 100% of bats, 96% of small – medium birds and 89% of Wedge-tailed Eagles would fall within the outer search zone.

The proportion of turbines searched is required as an input to calculate the overall mortality estimation, which for Year Three and Year Four carcass monitoring, involved all 37 turbines (100%), whilst for Year One and Year Two monitoring, involved 19 turbines (51.35%).

4.1.4. Bird mortality estimate

Accounting for the total bird carcasses recorded during formal surveys across the four years (Year One to Year Four) of the CRWF carcass monitoring program, the median resulting estimate of total mortality is 459 birds lost at CRWF over the four year period, with a 95% confidence interval of equal to or fewer than 619 birds. Using the median estimate, this corresponds to an estimated mortality rate of 3.1 birds per turbine per year. Year Three monitoring recorded a substantially higher median estimated bird mortality compared to Year Four, with 337 birds estimated for Year Three and 119 birds estimated for Year Four.

4.1.5. Wedge-tailed Eagle mortality estimate

Whilst Wedge-tailed Eagle carcasses are also included in the total bird mortality estimate above, a separate model was run for this species given its unique characteristics with reference to the model inputs described above and its heightened turbine collision risk (Stark and Muir 2020). A total of 35 Wedge-tailed Eagle carcasses were recorded during formal surveys across the four years of the CRWF carcass monitoring program. The resulting median estimate of total mortality is 57 Wedge-tailed Eagles lost at CRWF over the four year period, with a 95% confidence interval of equal to or fewer than 77 individuals lost over the same time period. Using the median estimate, this corresponds to an estimated mortality rate of 0.39 Wedge-tailed Eagles per turbine per year. Year Three monitoring recorded a substantially higher median estimated bird mortality than Year Four, with 33 birds estimated for Year Three and 11 birds estimated for Year Four.

Wedge-tailed Eagle mortality estimates do not apply an upper limit on the number of birds which could be on site, assuming that Wedge-tailed Eagle presence and activity is constant all year round and that there is an unlimited supply of potential carcasses to be found. Components of the monitoring results presented in Section 3.2 and Section 3.4 above are contrary to these assumptions. Whilst monitoring across the four year's of CRWF operations indicates the presence of a large local and regional Wedge-tailed Egale population, it has been demonstrated that Wedge-tailed Eagle activity fluctuates (see Figure 12) and the consistent recording of adult pairs within established territories, would likely limit the total number of individuals present across the CRWF site at any given time.

4.1.6. Bat mortality estimate

A total of 50 bat carcasses were recorded during formal surveys across the four years of the CRWF carcass monitoring program. The median resulting estimate of total mortality is 437 bats lost at CRWF over the four year period, with a 95% confidence interval of equal to or fewer than 650 bats lost over the same time period. Using the median estimate, this corresponds to an estimated mortality rate of 2.95 bats per turbine per year. Year Three monitoring recorded a substantially higher median estimated bat mortality than Year Four, with 165 bats calculated for Year Three and 44 bats for Year Four.

Bat mortality estimates do not apply an upper limit on the number of bats which could be on site, assume that bat presence and activity is constant all year round and that there is an unlimited supply of potential bat carcasses to be found. As detailed in Section 3.1, however, seasonal peaks in bat presence and activity have been observed at CRWF, as evidenced by the increased bat mortality during summer and autumn (see Figure 6), coinciding with known migratory and breeding events for locally common species including Little Forest Bat and White-striped Freetail Bat (Churchill 2008). Given these discrepancies between the mortality estimate model and the monitoring data, the model may overestimate bat mortality during periods of low activity and presence (i.e. late autumn to early spring) but equally may underestimate bat mortality during periods of high activity and presence.

4.1.7. Comparison of Year One and Two and Year Three and Four mortality estimates

A comparison of mortality estimates across the four years of CRWF BBAMP implementation is provided in Table 10. Year Three mortality estimates are substantially higher than the other three monitoring years. This result reflects the relatively high quantity of carcasses recorded during that year and the reduced monitoring frequency which is likely to have resulted in the relatively high bat estimate in particular, given the known scavenger rate for this species group.

Increased monitoring frequency during the peak microbat activity seasons of summer and autumn in Year Four, is likely to have contributed to the lower mortality estimate for bats during Year Four. Similarly, increased monitoring frequency during this period of Wedge-tailed Eagle juvenile dispersal may also have contributed to the lower Year Four estimate, which is consistent to estimates also recorded during Year One and Year Two monitoring (Table 10). Both results demonstrate the adaptive approach taken in implementing the BBAMP and the capacity of the monitoring program to record impacts to 'at-risk' birds and bats throughout the operation of the CRWF.

Table 10: Mortality estimates (median 50% estimates) for birds, Wedge-tailed Eagle and bats across the four years of CRWF BBAMP implementation and combined cumulative estimate

Monitoring Year	Birds	Wedge-tailed Eagle	Bats
Year 1	126	9	100
Year 2	125	9	68
Year 3	337	33	165
Year 4	119	11	44
Cumulative (Year 1-4)	459	57	437

4.2. Progress of management objectives and completion criteria

Table 11 below details the specific management objectives and performance criteria relevant to the BBAMP monitoring program, along with a comment regarding relevant results and adherence based on Year Four monitoring. CRWF management objectives and performance criteria are currently partially being achieved.

Table 11: Management objectives and performance criteria and relevant results from Year Four monitoring

Management objectives	Management activities	Performance criteria	Comments
Mortality monitoring	All 37 turbines to be searched seasonally (every three months) to 60 m in accordance with the carcass search protocol. Survey methodology was revised from Year Two. Additionally, all 37 turbines to be searched in February and March to 60 m in accordance with the search protocol. Survey methodology was revised at the completion of Year Three based on feedback from BCS.	Operational phase mortality surveys undertaken quarterly at all 37 turbines for at least two years, with a review after Year Four to determine if a change in the methodology is required	Year Four of carcass mortality monitoring successfully completed across all 37 turbines. In no instances were four or more carcasses from the same non-threatened bird species recorded at the same turbine during successive searches and as such, the impact trigger for non-threatened species was not exceeded in Year Four monitoring. Additionally, no threatened bird species carcasses were recorded and as a result, the impact trigger for threatened species was also not exceeded. Year Four carcass monitoring data supports the current carcass search methodology of seasonal surveys with increased survey effort in summer and autumn to record required mortality data on raptor and microbat 'at risk' species groups.
Annual report	Preparation of annual reports to be submitted to relevant State departments after the completion of yearly monitoring activities.	Annual reports to be delivered within three months of completion of yearly monitoring. Annual reports to include results of yearly	This annual report (to be provided to relevant State department) details all relevant results from Year Four implementation monitoring.

Management objectives	Management activities	Performance criteria	Comments
		monitoring, any impact triggers or unacceptable impacts identified, mitigation measures implemented, application of the decision-making framework and recommendations for the following year.	
Mitigation measures to reduce risk	Carrion removal program – stock and kangaroo carcasses will be removed from within 200 m of wind turbines on a monthly basis and disposed of. Restrict lambing and grain stock feeding within 200 m of turbines. Pest control program – implement rabbit control if the carrion removal program suggests rabbit carcasses are an issue, subject to landowner agreement. Minimise external and internal lighting. Where required - use of visual deterrents (e.g. marker balls and/or flags) on overhead powerlines where they cross waterways.	Carcasses removed and activity recorded in management log book; No increase in raptor mortality during lambing season or due to grain feeding; Monitor effectiveness of rabbit control and where bird mortality is clearly related to rabbit numbers, increase effectiveness of rabbit control. Mortality at turbines near light sources does not significantly exceed that at unlit turbines. No incidental records of bird mortality from powerline collision around waterways.	Dead carcasses of birds, bats and sheep were removed and properly disposed of. Lambing does not occur in paddocks within 200 m of the CRWF operational turbines. European Rabbits, along with Brown Hare, were recorded consistently during Year Four monitoring, though active rabbit burrows were not recorded within 200 m of a turbine location. European Rabbits were recorded at turbines A38, A44, A52 and A106, with these turbines recording amongst the highest number of Wedge-tailed Eagle carcasses and may therefore indicate some relationship between rabbit abundance and raptor mortality. It is noted however, that Wedge-tailed Eagle mortality was higher in Year Three when only one European Rabbit was recorded and so this relationship is not clear. Additionally, whilst turbine A38 has recorded a total of five Wedge-tailed Eagle carcasses, none of these were recorded during Year Four and therefore do not coincide with the timing of European Rabbit records. Regardless, increased rabbit control measures are recommended, specifically targeting the above turbine locations. All turbines within the CRWF site are located away from major light sources. One incidental record of Wedge-tailed Eagle mortality

Management objectives	Management activities	Performance criteria	Comments
			was recorded underneath powerlines and adjacent to a series of farm dams during Year Four monitoring. Given the location of this powerline proximal to bird habitat and the potential for further impacts, it is recommended that the installation of powerline markers be investigated for this section of above ground powerlines.

5. Conclusion and Recommendations

5.1. General conclusions

Year Four operational phase monitoring of the CRWF BBAMP was successfully implemented from October 2024 to July 2025. The purpose of the monitoring program is to monitor the impacts from the operation of the CRWF on birds and bats through a range of methodologies and where any significant risks or impacts arise, assess the mitigation and management of these.

Formal quarterly carcass monitoring and additional monitoring were undertaken across all 37 turbines within a 60 m search zone. A total of 27 bird carcasses and identifiable remains from at least six species were recorded during formal monitoring, with an additional two bird carcass recorded incidentally. Wedge-tailed Eagle recorded the highest mortality during Year Four, with a total of 13 carcasses recorded. In no instances were four or more carcasses from the same non-threatened bird species recorded at the same turbine during successive searches and as such, the impact trigger for non-threatened species was not exceeded in Year Four monitoring. Additionally, no threatened bird species carcasses were recorded and as a result, the impact trigger for threatened species was also not exceeded. The decision making framework and mitigation response detailed in Section 6.1 and 6.2 of the CRWF BBAMP (Squadron Energy 2025) was therefore not required to be implemented.

All six recorded bird species are considered locally common and along with being non-threatened under State and Commonwealth legislation, are also listed as Least Concern under the International Union for Conservation of Nature (IUCN) Red List of threatened species (IUCN 2025). As a result, the risk rating for bird species recorded during Year Four carcass monitoring is proposed to remain unchanged.

A total of 15 bat carcasses and identifiable remains from at least four microbat species were recorded during formal monitoring. South-eastern Freetail Bat and White-striped Freetail bat recorded the highest mortality during Year Four, with a total of three carcasses each, with no species recording four or more carcasses in total or at the same turbine during successive searches. As such, the impact trigger for non-threatened bat species was not exceeded in Year Four of monitoring. Additionally, no threatened bat species carcasses were recorded and the impact trigger for threatened species was therefore, not exceeded. Accordingly, the decision making framework and mitigation response detailed in Section 6.1 and 6.2 of the CRWF BBAMP (Squadron Energy 2025) was not required to be implemented for threatened and non-threatened bats.

All four recorded bat species are considered locally common and along with being non-threatened under State and Commonwealth legislation, are also listed as Least Concern under the IUCN Red List of threatened species (IUCN 2025). As a result, the risk rating for bat species recorded during Year Four carcass monitoring is proposed to remain unchanged.

With no threatened bird or bat species listed as Matters of National Environmental Significance (MNES) under the EPBC Act recorded during Year Four monitoring, the risk rating for relevant MNES species is also proposed to remain unchanged.

A total of four raptor species' flight activities were monitored and tracked within the 2 km buffer zone in Year Four of CRWF operational monitoring. Across the four years of monitoring, increased flight activity appears to be positively correlated with increased raptor mortality for both Wedge-tailed Eagle and to a lesser extent, for other raptor species combined (see Figure 12). The overall number of Wedge-tailed Eagle carcasses recorded in Year Four has decreased compared to Year Three, however, increased in comparison with Year One and Year Two monitoring. This increase may be the result of the updated carcass monitoring methodology which has been re-designed to maximise detectability of the species under a reduced monitoring frequency since Year Three. Adult Wedge-tailed Eagle pairs along with sub-adult birds, have been consistently recorded flying within and in close proximity to the CRWF across all four years of operational monitoring and indicate the species' continued presence, including potential breeding activity within the vicinity of the CRWF, despite no active nests being recorded.

The implementation of additional monitoring was particularly effective in detecting microbat mortalities, with a total of 12 carcasses recorded in the additional February and March 2025 monitoring periods. The additional monitoring period also recorded additional raptor carcass records, along with a large quantity of raptor flight activity, with a total of 38 flights recorded across the two monitoring periods. The data collected during Year Three and Year Four BBAMP implementation monitoring supports the current methodology to provide the required mortality data for 'at risk' raptor and microbat species groups.

Mortality estimates across the first four years of CRWF BBAMP implementation were calculated for birds, Wedge-tailed Eagle and bats (Symbolix 2025). The resulting median (50%) estimate of total mortality for birds is 459 birds, 57 Wedge-tailed Eagles and 437 bats, over the four year period.

In response to the CRWF Year Three annual BBAMP implementation report (ELA 2024), NSW CPHR recommended that Squadron Energy investigate the potential to trial the deployment of bird detection and identification technology and initiate informed curtailment, if required for bird species of interest at high-risk turbines. Squadron Energy has investigated a range of automated detection systems that utilise acoustic, radar, and photographic technologies, either individually or in combination. Some of these systems are designed specifically to monitor bats, while others are capable of monitoring both birds and bats. These technologies fall into several categories: data and software infrastructure (e.g. data integration platforms and automated call identification software), survey and design tools (such as detailed survey planning frameworks), detection technologies (including wildlife microphones, cameras, and radar systems), curtailment systems (acoustic and imaging-triggered turbine curtailment solutions), and behavioural mitigation tools (like UV light and chirp-boards to redirect bat activity).

As part of this investigation, Squadron Energy have engaged with several manufacturers and technology developers to explore potential trial opportunities, including indicative timing and costs. Squadron Energy have also considered the feasibility, practicality, and operational cost implications of implementing such systems at their projects. This research has also included a review of how similar systems have been deployed at wind farms in Australia—such as the use of Identiflight (Boulder Imaging) in Tasmania—as well as various acoustic and radar detection systems trialled across the northern hemisphere. Based on these investigations and in the absence of any impact triggers recorded for the Project, Squadron Energy are considered to have appropriately explored the available technologies and their potential application and will continue to monitor developments in this field to determine whether future trials or deployment are practicable.

An increased abundance in feral pest animals was recorded during Year Four monitoring, particularly of European Rabbit and Brown Hare, which are both known prey items of Wedge-tailed Eagle. Multiple records of European Rabbits were recorded at turbines A38, A52 and A106 where Wedge-tailed Eagle mortality has been recorded, however, active burrows have not been recorded within 200 m of these or other turbines. Recommendations for increased feral animal control are provided in Section 5.2 below.

A Wedge-tailed Eagle carcass was recorded underneath a section of above-ground powerline in the CWRF site, with burn marks indicating collision with the powerline and electrocution. This is the first recorded bird collision with powerlines during the first four years of BBAMP implementation monitoring. However, given previous turbine collisions and the location of the powerline adjacent to a series of farm dams, there is the potential for further impacts from waterbird, raptor and large parrot collision and hence, recommendations for additional mitigation measures in this section of powerline are provided below in Section 5.2.

5.2. Recommendations

Given the successful implementation of Year Four of the CRWF BBAMP monitoring program, Squadron Energy are considered compliant with the relevant approval conditions with regard to birds and bats, as detailed in the BBAMP. The following measures are recommended to support the adaptive management and minimisation of the Project's impacts on bird and bats:

- Expanded targeted raptor breeding surveys to be undertaken, to increase understanding of the status, location and key breeding periods for raptor species recorded within the CRWF site, in particular, the Wedge-tailed Eagle. Targeted surveys are to employ additional and increased duration focal-follow searches of adult birds during the winter to spring typical breeding season, along with ground and drone-based transects, with the aim of locating active nests.
- Investigate the installation of powerline markers on the section of powerline where bird collision has been recorded. A range of powerline markers are available to provide a visual mitigation for powerline collision such as ball markers, disks, coils and flags. Opportunistic monitoring of bird and bat carcasses should continue to be conducted as part of the Project's daily operations at above-ground powerlines located within the CRWF site.
- Increased feral animal control is recommended, specifically at turbines with multiple records of European Rabbit and Brown Hare turbines A38, A44, A52 and A106. European Rabbit is a listed vertebrate pest on the Central Tablelands Regional Strategic Pest Animal Management Plan 2024-2028 (Local Land Service 2024) with fumigation and viral control during the non-breeding season (mid-late summer) considered the most effective control method, alongside destruction of any recorded rabbit burrows (DPI 2025), where permitted by the landowner.

5.3. Commitments

Following consultation with NSW CPHR on this Year Four CRWF BBAMP monitoring report, Squadron Energy have resolved to the following commitments:

- Monitor the performance of the current Wedge-tailed Eagle impact trigger and review its performance following two years of implementation, being the conclusion of Year Six of CRWF BBAMP monitoring.
- Prepare a standalone Wedge-tailed Eagle investigation report at the conclusion of Year Five of CRWF BBAMP monitoring.

6. References

Anderson, D, and K Burnham. 2004. "Model Selection and Multi-Model Inference." Second. NY: *Springer-Verlag* 63 (2020): 10.

BirdLife Australia. 2023. Wedge-tailed Eagle. Marchant, S. et al (eds) 1990-2006 Handbook of Australian, New Zealand and Antarctic Birds. Volume 1 to 7. BirdLife Australia. Last modified 2023-11-20 06:46. Available online: https://hanzab.birdlife.org.au/species/wedge-tailed-eagle/. Accessed: October 2024.

Cherriman, S.C. 2007. *Territory size and diet throughout the year of the Wedge-tailed Eagle (Aquila audax) in the Perth region, Western Australia*. BSc Hons thesis, Curtin University, Western Australia.

Churchill, S. 2008. Australian Bats. Second Edition. Allen & Unwin, Sydney.

Department of Primary Industries (DPI) NSW. 2025. Rabbit Control. Available online: https://www.dpi.nsw.gov.au/biosecurity/vertebrate-pests/pest-animals-in-nsw/rabbits/rabbit-control. Accessed: September 2025.

Eco Logical Australia (ELA) 2022. Crudine Ridge Wind Farm Bird and Bat Adaptive Management Plan Implementation Report – Year One. Prepared for CWP Renewables Pty Ltd.

Eco Logical Australia (ELA) 2023. Crudine Ridge Wind Farm Bird and Bat Adaptive Management Plan Implementation Report – Year Two. Prepared for CWP Renewables Pty Ltd.

Eco Logical Australia (ELA) 2024. Crudine Ridge Wind Farm Bird and Bat Adaptive Management Plan Implementation Report – Year Three. Prepared for CWP Renewables Pty Ltd.

International Union for Conservation of Nature (IUCN). 2025. Species profiles database. Available online: https://www.iucnredlist.org/search?searchType=species. Accessed: August 2025.

Local Land Service. 2024. *Central Tablelands Regional Strategic Pest Animal Management Plan 2024-2028*. Local Land Service, NSW Government.

Milne D.J., Reardon T.B., Ford G. 2023. BatMap – authoritative distribution maps for Australian bats. *Australian Mammalogy*. https://doi.org/10.1071/AM23005

Squadron Energy. 2017. Crudine Ridge Wind Farm Bird and Bat Adaptive Management Plan version 2.6. Prepared by Brett Lane & Associates.

Squadron Energy. 2025. Crudine Ridge Wind Farm Bird and Bat Adaptive Management Plan version 3.2. Prepared by Brett Lane & Associates and Eco Logical Australia.

Symbolix. 2023. Crudine Ridge Wind Farm Mortality Estimate – Year 1 to 2. Prepared for Squadron Energy, 21 July 2023, Ver. 1.0.

Symbolix. 2025. Crudine Ridge Wind Farm Mortality Estimate – Years 1 to 4. Report prepared for Squadron Energy.

Turbill, C. 2008. Winter activity of Australian tree-roosting bats: Influence of temperature and climatic patterns. Journal of Zoology, 276(3), 285-290.

Appendix A Carcass monitoring data

Date	Common Name	Species Group	Turbine No.	Distance from Turbine (m)	Direction from Turbine	Ground-cover	Monitoring method
15/10/2024	Wedge-tailed Eagle	Bird	A52	44	SW	Grass	Formal
15/10/2024	Silvereye	Bird	A35	62	E	Grass	Formal
16/10/2024	Wedge-tailed Eagle	Bird	A89	62	NW	Grass	Formal
24/10/2024	Wedge-tailed Eagle	Bird	Powerline – near A34	~400m	W	Grass	Incidental
20/01/2025	Australian Magpie	Bird	A24	25	NE	Pad	Formal
21/1/2025	Australian Magpie	Bird	A17	60	E	Pad	Formal
21/1/2025	Brown Falcon	Bird	A26	45	N	Grass	Formal
21/1/2025	Wedge-tailed Eagle	Bird	A44	25	N	Grass	Formal
21/1/2025	Wedge-tailed Eagle	Bird	A104	30	E	Grass	Formal
21/1/2025	Unknown microbat	Bat	A106	50	N	Pad	Formal
17/02/2025	Southeastern Free-tailed Bat	Bat	A2	41	NE	Pad	Additional
17/02/2025	Australian Magpie	Bird	A14	30	NE	Pad	Additional
18/02/2025	Wedge-tailed Eagle	Bird	A103	60	N	Bare ground	Additional
18/02/2025	Wedge-tailed Eagle	Bird	A106	20	E	Bare ground	Additional
19/02/2025	Southeastern Free-tailed Bat	Bat	A23	6	S	Bare ground	Additional
19/02/2025	Unknown bird	Bird	A24	30	N	Grass	Additional
19/02/2025	Unknown microbat	Bat	A29	12	S	Pad	Additional
19/02/2025	Unknown microbat: Freetail bat species	Bat	A26	15	S	Grass	Additional
19/02/2025	Wedge-tailed Eagle	Bird	A47	57	E	Grass	Additional
19/02/2025	White-striped Freetail Bat	Bat	A47	30	E	Grass	Additional
10/03/2025	Unknown microbat	Bat	A1	35	W	Shrub	Additional
10/03/2025	White-striped Freetail Bat	Bat	A4	60	SW	Grass	Additional
10/03/2025	Unknown bird	Bird	A14	44	S	Grass	Additional
10/03/2025	Unknown microbat	Bat	A20	50	NE	Bare ground	Additional
11/03/2025	Unknown bird	Bird	A89	72	N	Grass	Additional
11/03/2025	Unknown microbat: Freetail bat species	Bat	A106	26	E	Bare ground	Additional
12/03/2025	Australian Magpie	Bird	A24	50	NW	Bare ground	Additional
12/03/2025	Southeastern Free-tailed Bat	Bat	A38	50	N	Grass	Additional
12/03/2025	Unknown microbat: Forest bat species	Bat	A43	58	W	Grass	Additional
12/03/2025	White-striped Freetail Bat	Bat	A8	20	W	Pad	Additional

Date	Common Name	Species Group	Turbine No.	Distance from Turbine (m)	Direction from Turbine	Ground-cover	Monitoring method
8/04/25	Little Forest Bat	Bat	A21	12	N	Grass	Formal
9/04/25	Crimson Rosella	Bird	A52	35	N	Grass	Formal
9/04/25	Australian Wood Duck	Bird	A87	40	N	Grass	Formal
9/04/25	Southern Forest Bat	Bat	A95	20	W	Grass	Formal
9/04/25	Wedge-tailed Eagle	Bird	A100	35	S	Track	Formal
9/04/25	Unknown bird	Bird	A106	50	E	Grass	Formal
9/04/25	Unknown bird	Bird	A104	31	E	Grass	Formal
10/04/25	Australian Magpie	Bird	A35	4	N	Pad	Formal
10/04/25	Wedge-tailed Eagle	Bird	A47	35	E	Grass	Formal
30/06/2025	Wedge-tailed Eagle	Bird	A32	30	S	Track	Incidental
16/07/2025	Unknown bird	Bird	A4	20	NE	Bare ground	Formal
16/07/2025	Wedge-tailed Eagle	Bird	A44	52	S	Grass	Formal
17/07/2025	Wedge-tailed Eagle	Bird	A106	15	NW	Grass	Formal
17/07/2025	Unknown bird	Bird	A100	28	SE	Grass	Formal
29/07/2025	Unknown microbat	Bat	A94	2	NW	Pad	Incidental

Appendix B Bird and bat carcass summary data

Common Name	Scientific Name	Year One	Year Two	Year Three	Year Four	Total
Birds						
Australian Magpie	*Cracticus tibicen*	9	7	4	5	25
Australian Raven	*Corvus coronoides*	1	-	-	-	1
Australian Wood Duck	*Chenonetta jubata*	1	3	-	1	5
Brown Falcon	*Falco berigora*	2	-	3	1	6
Crimson Rosella	*Platycercus elegans*	-	-	-	1	1
Collared Sparrowhawk	*Accipiter cirrocephalus*	-	2	-	-	2
Crested Pigeon	*Ocyphaps lophotes*	-	1	-	-	1
Eastern Rosella	*Platycercus eximius*	-	1	-	-	1
Galah	*Eolophus roseicapilla*	1	-	-	-	1
Magpie-lark	*Grallina cyanoleuca*	-	1	1	-	2
Nankeen Kestrel	*Falco cenchroides*	5	-	-	-	5
Pacific Black Duck	*Anas superciliosa*	1	-	-	-	1
Silvereye	*Zosterops lateralis*	-	-	2	1	3
Wedge-tailed Eagle	*Aquila audax*	5	7	18	13	43
Unknown bird	Aves (class)	-	1	3	7	11
Bats – Microchiroptera						
Gould's Wattled Bat	*Chalinolobus gouldii*	-	2	2	-	4
Large Forest Bat	*Vespadelus darlingtoni*	1	-	-	-	1
Little Broad-nosed Bat	*Scotorepens greyii*	-	1	-	-	1
Little Forest Bat	*Vespadelus vulturnus*	5	4	2	1	12
Southern Forest Bat	*Vespadelus regulus*	-	1	-	1	2
Southern Free-tailed Bat/South-eastern Freetail Bat	*Mormopterus planiceps/*	1	1	-	3	5
White-striped Freetail-bat	*Austronomus australis*	9	4	3	3	19
Unknown microbat	Microchiroptera (suborder)	3	2	1	8	14
Bats – Megachiroptera						
Little Red Flying-fox	*Pteropus scapulatus*	1	-	-		1

Appendix C Crudine Ridge Wind Farm Mortality Estimate – Years 1 to 4 (Symbolix 2025)

Crudine Ridge Wind Farm Mortality Estimate - Years 1 to 4

Prepared for Squadron, 02 October 2025, Ver. 1.0

This report outlines an analysis of mortality at Crudine Ridge Wind Farm (CRWF) from 2021-05-01 to 2025-07-17. The analysis is broken into the three related components below:

- Searcher efficiency / detectability – estimated from trials from August 2021 to April 2022.
- Scavenger loss rates – estimated from trials from August 2021 to April 2022
- Mortality estimates - based on surveys at 37 turbines, from 2021-06-01 to 2025-07-17

1 Available data

Survey data was collected and provided by Eco Logical Australia on behalf of Squadron Energy. A brief summary of the data is provided below, and the ultimate focus of this report is a discussion of the potential mortality.

Turbine parameter data (rotor diameter and height) was provided by Eco Logical Australia.

Species archetype data was taken from Hull and Muir (2010).

1.1 Data cleaning

Survey data:

- Removed rows for Turbine A09 from November 22 2024 to June 21st 2025 because it was out of service.

Carcass finds data:

- Capitalisation and hyphenation were made consistent.
- Unknown Bat sp. were recoded as Bat sp.
- Unknown Bird sp. were recoded as Bird sp.

2 Statistical methodology overview

Mortality through collision is an ongoing environmental management issue for wind facilities. Different sites present different risk levels; consequently different sites have different monitoring requirements. In order to estimate the mortality loss at a given site (in a way that is comparable with other facilities) we must account for differences in survey effort, searcher and scavenger efficiency. We used a Monte Carlo method to achieve this.

Best practice estimators project the number of found carcasses (C) up to the number of actual mortalities (M), by accounting for:

- The probability a carcass will be detected by the searcher (p)
- The probability a carcass is not lost to scavenging or decay prior to the search (r)
- The probability a carcass falls within the searched area (a) - also known as the "coverage factor"
- The fraction of turbines searched (f)

Most mortality estimators, e.g. (M. M. Huso 2011), can be conceptualised as a ratio estimator:

$$\hat{M} = \frac{C}{\hat{p} \cdot \hat{r} \cdot \hat{a} \cdot f} \tag{1}$$

The terms in the denominator provide a "boost factor" to the number of carcasses found, C.

However, a limitation of analytical methods, is estimating r, when the time between surveys is not constant. In Australia, it is common for the time between searches to vary due to seasonal changes in effort, designs targeting specific species, logistical reasons, or the use of a pulsed design in which the turbine is searched monthly with a return visit a few days later. Additionally, ratio estimators cannot handle the cases when zero carcasses are found, as zero multiplied by any number still gives zero. This limits their ability to provide an estimate for very rare species that may collide infrequently.

To address this, Symbolix have developed a Monte Carlo algorithm. We have used this method for mortality estimates at over forty wind farms in Australia to date.

Monte Carlo methods (Sawilowsky (2003), Ripley (1987)) simulate a large set of possible survey results, by simulating the actual survey protocol, and sampling from empirical distributions for scavenge loss and searcher efficiency. This method allows us to directly sample the probability a carcass was lost before each survey, negating the need to calculate r analytically for each survey round.

We then estimate how many carcasses were truly generated, given the range of searcher and scavenger efficiencies, the survey frequency and coverage, and the true "found" details. After many simulations, we can estimate the likely range of mortalities that could have resulted in the recorded survey outcome (number of carcasses found).

This method has been benchmarked against analytical approaches (M. M. Huso (2011), Korner-Nievergelt et al. (2011))]. Its outputs are equivalent but it is able to robustly model more complex survey designs (e.g. pulsed surveys, rotating survey list).

Figure 1 provides an overview of the methodology. A detailed explanation can be found in Stark and Muir (2020).

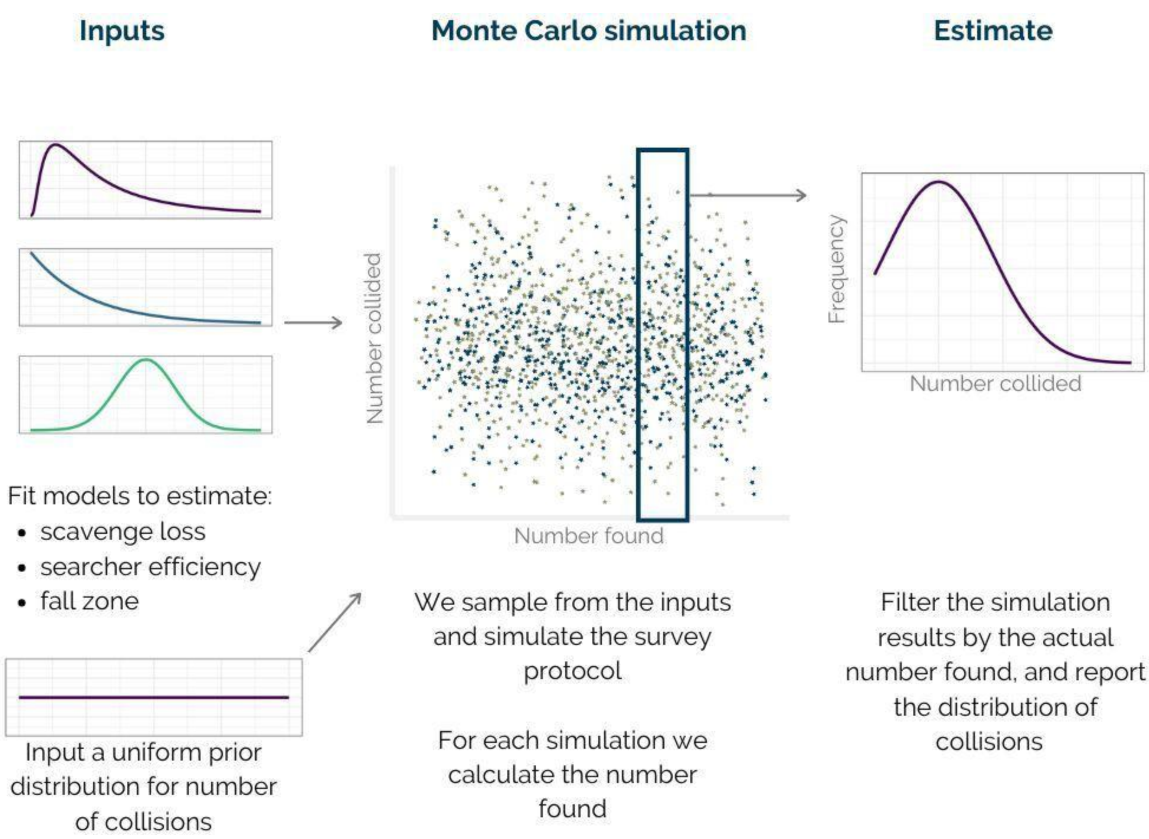

Figure 1: Overview of how the mortality estimation works.

The following sections outline how we estimate p, r and a. C is given by the field observation data for this site, and f is defined by the survey design.

3 Analysis and modelling

The survey program consisted of carcass searches, and adjunct scavenger and detection trials. We summarise the methods, field data and analysis results for each below.

3.1 Carcass search data

The carcass searches provide the C and f terms in Section 2.

3.1.1 Survey effort

Carcass searches were undertaken in accordance with the Bird and Bat Management Plan (BBMP)[1].

From June 2021 to May 2023:

- Survey type: standard and pulse surveys.
- Monitoring turbine coverage: 19 turbines were surveyed.
- Monitoring search zone: Standard surveys were surveyed out to 100 metres and pulse surveys were survey out to 60 metres.
- Monitoring frequency: Surveys would occur monthly with pulse surveys undertaken as follow-up surveys within several days of the standard survey to detect additional mortality of birds and bats (Table 1).

From October 2023 onward:

- Survey type: standard surveys only.
- Monitoring frequency: reduced from monthly (100 m full search, followed by 60 m pulse search) to quarterly (January, April, July, October).
- Monitoring search zone: reduced from 100 m full search to 60 m full search, with no follow-up pulse surveys.
- Monitoring turbine coverage: increased from 19 turbines (51.35%) to all 37 turbines (100%). Note: From January 2025 onward, only 36 turbines were surveyed due to turbine A09 being non-operational.

The mortality estimate was based on a dated list of turbine surveys. The survey frequency is summarised in Table 1.

In total, 100% of turbines were searched once a month at CRWF to 100 metres. In the Monte Carlo algorithm, we explicitly simulate the survey design. The proportion of turbines sampled (f) is therefore accounted for in the simulation.

[1] Nature Advisory (2017)

Table 1: Number of surveys per month.

Date	Standard	Pulse
2021 Jun	19	19
2021 Jul	19	19
2021 Aug	19	19
2021 Sep	19	19
2021 Oct	19	19
2021 Nov	19	19
2021 Dec	19	19
2022 Jan	19	19
2022 Feb	19	19
2022 Mar	19	19
2022 Apr	19	19
2022 May	19	19
2022 Jun	19	19
2022 Jul	19	19
2022 Aug	19	19
2022 Sep	19	19
2022 Oct	19	19
2022 Nov	19	19
2022 Dec	19	19
2023 Jan	19	19
2023 Feb	19	19
2023 Mar	19	19
2023 Apr	19	19
2023 May	19	19
2023 Oct	37	
2024 Jan	37	
2024 Apr	37	
2024 Jul	37	
2024 Oct	37	
2025 Jan	36	
2025 Feb	36	
2025 Mar	36	
2025 Apr	36	
2025 Jul	36	

3.1.2 Carcass finds

The breakdown of found carcasses per species are summarised in Table 2.

Table 2: Carcasses found during formal surveys.

Species	Bat	Bird
Australian Magpie	0	24
Australian Raven	0	1
Australian Wood Duck	0	5
Bat sp.	8	0
Bird sp.	0	11
Brown Falcon	0	6
Collared Sparrowhawk	0	2
Crested Pigeon	0	1
Crimson Rosella	0	1
Eastern Rosella	0	1
Evening Bat sp.	1	0
Forest Bat sp.	1	0
Freetail Bat sp.	2	0
Galah	0	1
Gould's Wattled Bat	4	0
Little Broad-nosed Bat	1	0
Little Forest Bat	11	0
Little Red Flying-fox	1	0
Magpie-lark	0	2
Nankeen Kestrel	0	3
Pacific Black Duck	0	1
Silvereye	0	3
South-eastern Free-tailed Bat	5	0
Southern Forest Bat	2	0
Wedge-tailed Eagle	0	35
White-striped Freetail-bat	14	0

A number of carcasses were also found incidentally. These carcasses are not included in the data that produces the mortality estimate; however we report them here for completeness (Table 3).

Table 3: Incidental carcass finds.

Species	Number found
Australian Magpie	1
Bat sp.	2
Large Forest Bat	1
Little Forest Bat	1
Nankeen Kestrel	2
Wedge-tailed Eagle	8
White-striped Freetail-bat	5

3.2 Searcher efficiency

The aim of searcher efficiency trials is the quantify the effectiveness of observers, at finding carcasses. They provide the p term in Equation 2.

3.2.1 Field methods

The searcher efficiency data was collected in accordance to the specification in Section 4.4.4 of the BBMP.

The searcher efficiency data is sourced from trials conducted from August 2021 to April 2022. Carcasses were laid out, searches for the carcasses undertaken using the same protocol as the main mortality survey (i.e. using a human observer). If the carcass was found, “success” was recorded, else “failure” was the human missing the carcass.

The carcasses deployed for searcher efficiency trials included birds (36 replicates), bird proxies (rats; 9 replicates), bats (14 replicates), and bat proxies (mice; 11 replicates).

The number of carcasses for each group are summarised in Table 4.

Table 4: Count by common name and species class used during the detection trials.

Species	Species type	Count
House Mouse	Bat proxy	11
Domestic Rat	Bird proxy	9
Chicken	Bird	2
Eastern Rosella	Bird	1
Australian Boobook	Bird	2
Australian Wood Duck	Bird	4
Little Forest Bat	Bat	5
Striated Thornbill	Bird	1
Galah	Bird	6
Nankeen Kestrel	Bird	2
Australian Magpie	Bird	4
Little Red Flying-fox	Bat	1
South-eastern Free-tailed Bat	Bat	2
Sulphur-crested Cockatoo	Bird	2
Pied Currawong	Bird	1
White-striped Freetail-bat	Bat	5
Little Lorikeet	Bird	1
Tree Martin	Bird	1
Wedge-tailed Eagle	Bird	3
Masked Lapwing	Bird	1
Grey-headed Flying-fox	Bat	1
Musk Lorikeet	Bird	1
Rainbow Lorikeet	Bird	1
Little Corella	Bird	2
White-throated Nightjar	Bird	1

3.2.2 Statistical methods

We estimated searcher efficiency by fitting binomial generalised linear models (GLMs). The optimal model was determined, guided by the small-sample corrected Akaike Information Criterion (AICc) (Anderson and Burnham 2004).

The theory of AICc is complex, the details of which are beyond the scope of this report. However, fundamentally AICc is a method for choosing the best approximating (i.e. best model fit) and parsimonious (a simpler model is preferable to a more complex model) model. For each model we fit to the data, we calculate the AICc. We compare the differences in AICc between models, which in turn informs us of the weight of evidence for that particular model.

We also consider the reliability and applicability of parameters in the model. For example, cloud cover may affect detection rates, but the ability of observers to accurately and consistently record cloud cover is likely to be poor and it is not feasible to incorporate cloud cover into a mortality estimate.

AICc is not the same as significance testing. We do not aim to state anything is significant at the 5% level, instead we aim to find a good model fit for the data.

3.2.3 Results

The most parsimonious model of searcher efficiency was the "intercept-only" model (i.e. all carcasses have the same expected searcher efficiency) according to AICc. Therefore, bat and bird detection efficiencies are aggregated in the following mortality estimate - see Table 5.

Table 5: Detection efficiencies for bats and birds by humans.

Variable	Bats and Birds
Number found	53
Number placed	70
Mean detectability proportion	0.76
Detectability lower bound (95% CI)	0.64
Detectability upper bound (95% CI)	0.85

Overall detectability of bats and birds is 76%, with a 95% confidence interval of [64%, 85%].

3.3 Scavenger efficiency

In order to accurately estimate mortality, we must account for carcass loss to scavengers. Scavenger trials are performed to quantify the time until a carcass is completely lost as a result of scavenger activity.

This section estimates the *r* term in Section 2.

3.3.1 Field methods

The scavenger efficiency data was collected in accordance to the specification in 4.4.3 of the BBMP.

Scavenger efficiency trials were conducted from August 2021 to April 2022. In total, 70 carcasses were used including a mixture of bats (14 replicates), bat proxies (mice; 11 replicates), birds of various sizes (36 replicates), and bird proxies (rats; nine replicates).

Table 6 summarises the species used in the trials.

Table 6: Count by species class used in the carcass persistence trials.

Species type	Species	Count
Bat	Little Forest Bat	5
Bat	Little Red Flying-fox	1
Bat	South-eastern Free-tailed Bat	2
Bat	White-striped Freetail-bat	5
Bat	Grey-headed Flying-fox	1
Bat proxy	House Mouse	11
Bird	Chicken	2
Bird	Eastern Rosella	1
Bird	Australian Boobook	2
Bird	Australian Wood Duck	4
Bird	Striated Thornbill	1
Bird	Galah	6
Bird	Nankeen Kestrel	2
Bird	Australian Magpie	4
Bird	Sulphur-crested Cockatoo	2
Bird	Pied Currawong	1
Bird	Little Lorikeet	1
Bird	Tree Martin	1
Bird	Wedge-tailed Eagle	3
Bird	Masked Lapwing	1
Bird	Musk Lorikeet	1
Bird	Rainbow Lorikeet	1
Bird	Little Corella	2
Bird	White-throated Nightjar	1
Bird proxy	Domestic Rat	9

3.3.2 Statistical methods

Survival analysis (Kaplan and Meier (1958), Kalbfleisch and Prentice (2011)) was used to determine the distribution of time until complete loss from scavenge (or decay). Survival analysis was required to account for the fact that we do not necessarily know the exact time of scavenge loss, only an interval in which the scavenge event happened. For example, any carcass which is unscavenged at the end of the trial, has its scavenge event in the interval $[x, \infty]$ (where x is the length of the trial).

By performing survival analysis we can estimate the time until carcass loss after a given length of time, despite these unknowns.

We fit parameterised models to analyse significant factors influencing time to scavenge (carcass species type etc.), and to find the most appropriate distribution to fit the time-to-loss curve (e.g. log-normal, exponential).

Time to carcass loss is influenced by the parameters discussed above and the distribution of the loss curve we fit to the data (M. M. P. Huso, Dalthorp, and Korner-Nievergelt 2015). The choice of loss function is important because it should capture the behaviours and relative time dependence of the various scavengers. Generally, the best distribution is the log-normal distribution (Stark and Muir 2020).

3.3.3 Results

AICc analysis of the survival regression models, showed the most parsimonious model was the model that combined bats, birds and proxies.

Figure 2 shows the survival curve fitted to the carcasses. The survival curve (smooth solid line for fitted regression curve, jagged step function for empirical removal rate) shows the estimated proportion of the set remaining at any given time. The shaded portions are the 95% confidence intervals on the estimate.

Under these assumptions, the median time to carcass removal via scavenge is 2.9 days, with a 95% confidence interval of [1, 6.2] days.

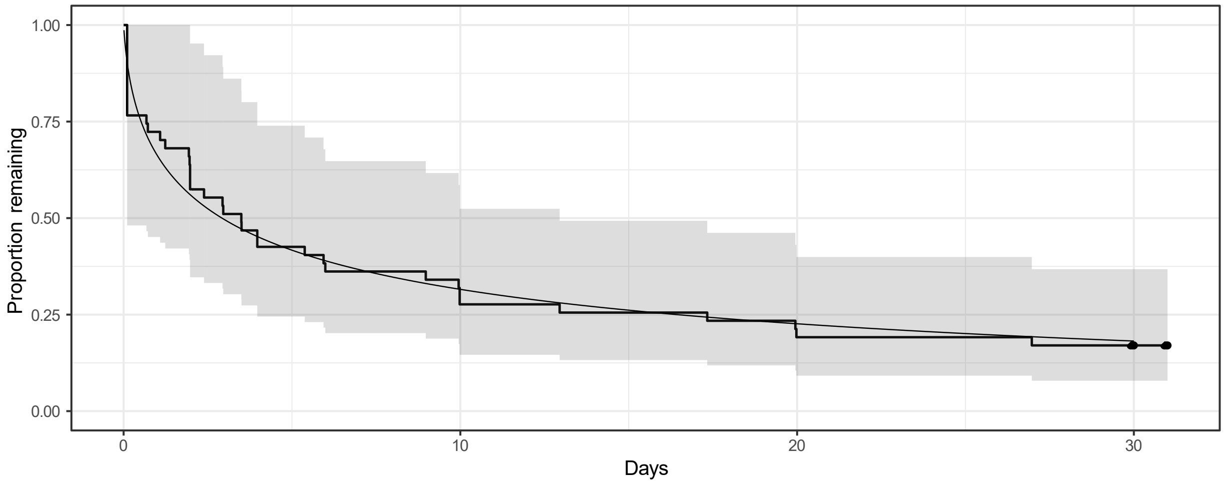

Figure 2: Empirical survival curve (the step function), with 95% confidence intervals shaded. The smooth curve presents the fitted model.

3.4 Coverage factor

The probability a carcass falls within the searched area (i.e. the “coverage factor”) is calculated to provide the a term (Section 2).

3.4.1 Statistical methods

3.4.1.1 Fall zone simulation We generated a carcass fall-zone distribution for for each species class given the turbine size at the wind farm.

The fall-zone distribution is the end result of the simulation method detailed in Hull and Muir (2010). The simulation method is a ballistics model describing bird and bat strikes by turbine blades.

3.4.1.2 Coverage factor calculation The percentage of the fall zone not covered by the survey area, provides a correction factor in the mortality estimate. Because carcasses that fall outside the searched area have a zero probability of being detected by a survey, the likelihood of landing in this region is essential to understanding the relationship between detections and actual losses.

3.4.2 Simulation inputs

The fall zone simulation requires a set of turbine and bird specifications.

Table 7 displays the dimensions and RPM of the turbines at CRWF Wind Farm. Table 8 shows the bird and bat physical parameters used. These archetypes were used as they represent a medium sized species for each species type and produce an estimate of the average fall zone.

Table 7: Turbine specifications for Crudine Ridge Wind Farm

Rotor Diameter (m)	Tower Height (m)	RPM
137	92	11.4

Table 8: Species parameters used per group.

Species type	Archetype	Mass (kg)	Min. area (sq m)	Max. area (sq m)
Bat	Gould's Wattled Bat	0.014	0.0028	0.014
Bird	Forest Raven	0.680	0.0450	0.100
WTE	Wedge-tailed Eagle	4.200	0.0700	0.800

3.4.3 Results

Figure 3 displays the simulation results, given the factors specified above. We display the cumulative density function (CDF) on the y axis versus the distance from turbine on the x axis for each species type. The CDF describes the expected proportion of carcass which fall less than or equal to a certain distance from the turbine.

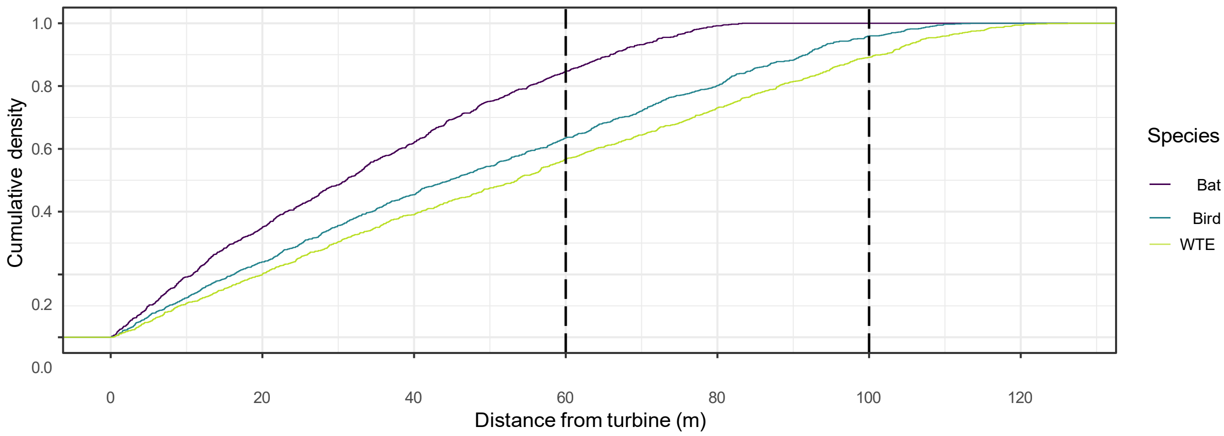

Figure 3: Cumulative distribution function of the fall zone simulation output for birds, bats and WTE. Vertical lines indicate the Pulse and Standard survey radii.

Once the fall zone distribution is calculated, we generate a "coverage factor". The coverage factor represents the expected proportion of carcasses which fall within the searched area, given the search protocol.

On average, we expect about 85% of bats, 64% of birds, and 57% of WTE to fall within 60m of the turbine, and 100% bats, 96% of birds, and 89% WTE to fall within 100m.

4 Mortality estimate

With estimates for scavenge loss, searcher efficiency, and survey coverage for CRWF, we then converted the number of bat and bird carcasses detected into an estimate of overall mortality from 2021-05-01 to 2025-07-17 (we allow for collisions to occur up to a month prior to the first survey).

The mortality estimation is done via a Monte Carlo algorithm. We used 15000 simulations, with the survey design simulated each time. Random numbers of virtual mortalities were simulated, along with the scavenge time and searcher efficiency (based on the measured confidence intervals). The proportion of virtual carcasses that were "found" was recorded for each simulation. Finally, those trials that had the same outcome as the reported survey detections were collated, and the initial conditions (i.e. how many true losses there were) reported on.

The model assumptions are listed below:

- There were 37 turbines on site available to strike bats and birds.
- Of the 37 turbines, 19 were searched at a 100 m radius during standard surveys and at a 60 m radius during pulse surveys until May 2023. From October 2023, all 37 turbines were included in standard surveys conducted out to 60 m. From January 2025 onward, only 36 turbines continued to be surveyed (Section 3.1.1).
- Search frequency for each turbine was taken from a list of actual survey dates (see Table 1 for a summary).
- Mortalities were allowed to occur from 2021-05-01 (approximately one month from the first survey), until the final surveyed date (2025-07-17).
- Bats and birds are on-site at all times during this period.
- Bats and birds that are struck are immediately replaced (i.e. strikes one day do not affect the chance of strikes the next).
- We assume that all carcasses and all feather spots (regardless of size or composition) are attributable to the wind turbines.
- Finds are random and independent, and not clustered with other finds.
- There was equal chance of any turbine being involved in a collision / mortality.
- Scavenger loss and searcher efficiency rates are calculated as outlined above.
- We assumed a log-normal scavenge shape.
- We assumed coverage factors as outlined above.

4.1 Bats

During the four years of surveys, 50 bats were found during formal surveys. The resulting (median) estimate of total mortality is 437 bats lost on site over the four year period. The (median) estimates of mortality in Year 3 and 4 are 165 and 44 bats, respectively.

Table 9 and Figure 4 display the percentiles of the distributions, to show the confidence on the mortality estimate.

Based on the detected carcasses, measured detectability, scavenge rate, and survey effort, we expect that there was a total site loss of around 437 bats, and are 95% confident that fewer than 650 individuals were lost, in the four year period.

Table 9: Percentiles of estimated total bat losses in the four years of surveys, year 3 only, and year 4 only.

Estimate	0%	50% (median)	90%	95%	99%
Cumulative	231	437	577	650	891
Year 3	87	165	233	262	325
Year 4	20	44	64	66	68

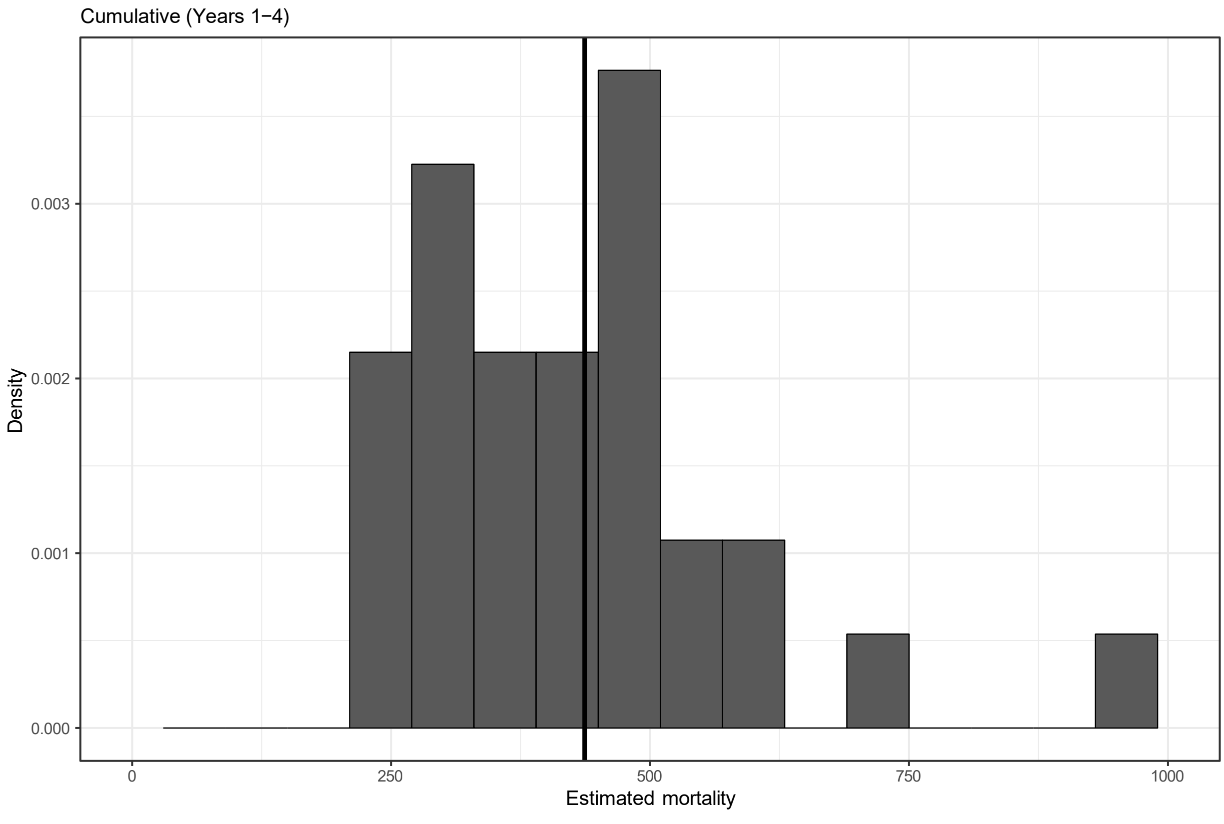

Figure 4: Histogram of the total losses distribution (bats). The black solid line shows the median.

4.2 Birds

During the four years of surveys, 62 birds were found during formal surveys. The resulting (median) estimate of total mortality is 459 birds lost on site over the four year period. The (median) estimates of mortality in Year 3 and 4 are 337 and 119 birds, respectively.

Table 10 and Figure 5 display the percentiles of the distributions, to show the confidence on the mortality estimate.

Based on the detected carcasses, measured detectability, scavenge rate, and survey effort, we expect that there was a total site loss of around 459 birds, and are 95% confident that fewer than 619 individuals were lost, in the four year period.

Table 10: Percentiles of estimated total bird losses in the four years of surveys, year 3 only, and year 4 only.

Estimate	0%	50% (median)	90%	95%	99%
Cumulative	234	459	575	619	833
Year 3	254	337	682	1049	1421
Year 4	68	119	189	370	458

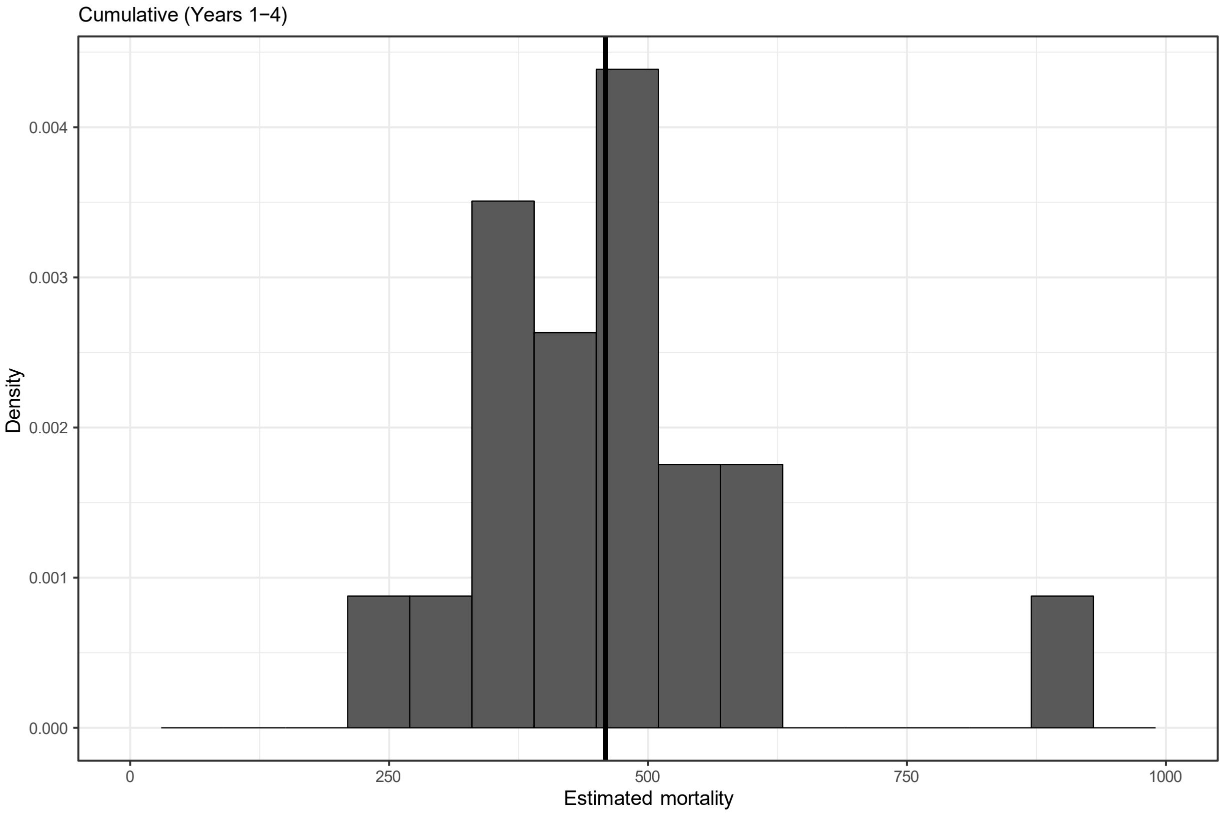

Figure 5: Histogram of the total losses distribution (birds). The black solid line shows the median.

4.3 WTE

During the four years of surveys, 35 WTE were found during formal surveys. The resulting (median) estimate of total mortality is 57 WTE lost on site over the four year period. The (median) estimates of mortality in Year 3 and 4 are 33 and 11 WTE, respectively.

Table 11 and Figure 6 display the percentiles of the distributions, to show the confidence on the mortality estimate.

Based on the detected carcasses, measured detectability, scavenge rate, and survey effort, we expect that there was a total site loss of around 57 WTE, and are 95% confident that fewer than 77 individuals were lost, in the four year period.

Table 11: Percentiles of estimated total WTE losses in the four years of surveys, year 3 only, and year 4 only.

Estimate	0%	50% (median)	90%	95%	99%
Cumulative	39	57	67	77	89
Year 3	24	33	42	47	61
Year 4	4	11	18	20	27

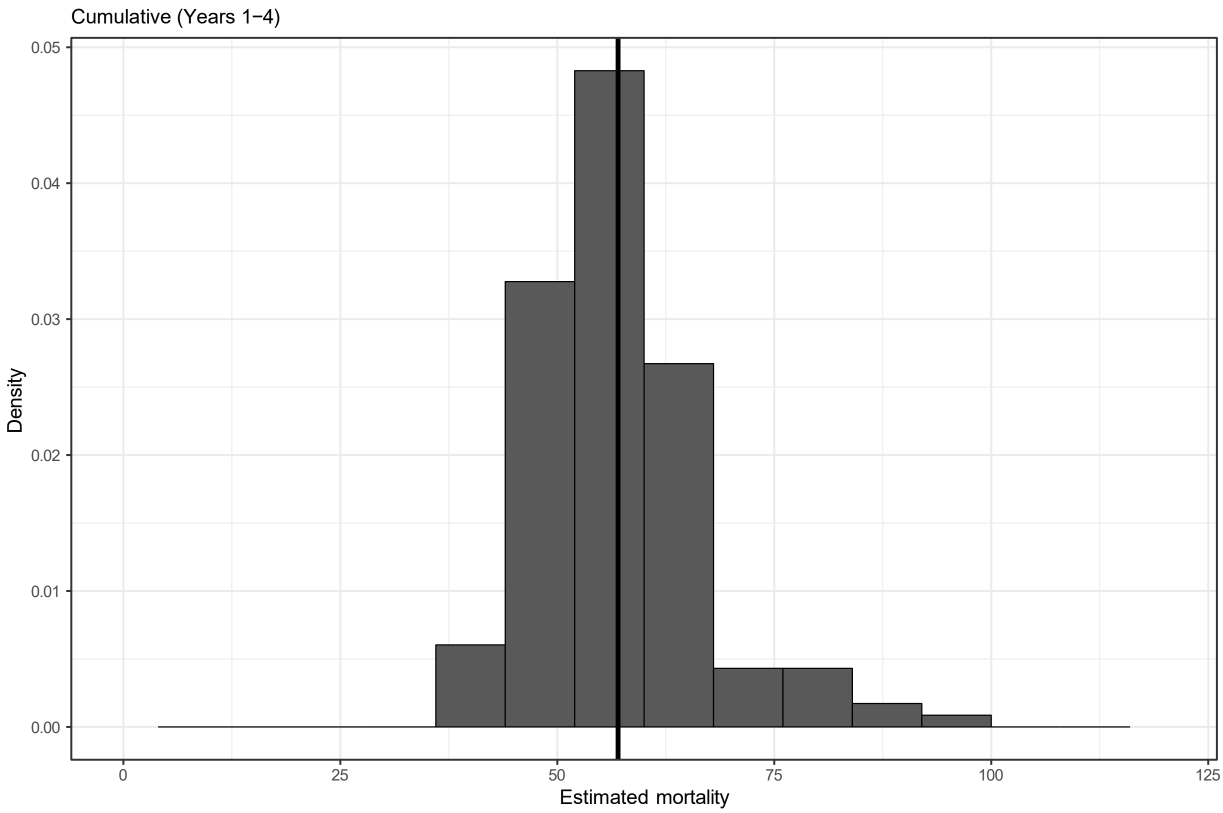

Figure 6: Histogram of the total losses distribution (WTE). The black solid line shows the median.

References

Anderson, D, and K Burnham. 2004. “Model Selection and Multi-Model Inference.” Second. NY: Springer-Verlag 63 (2020): 10.

Hull, CL, and Stuart Muir. 2010. “Search Areas for Monitoring Bird and Bat Carcasses at Wind Farms Using a Monte-Carlo Model.” Australasian Journal of Environmental Management 17 (2): 77–87.

Huso, Manuela M. P., Dan Dalthorp, and Fränzi Korner-Nievergelt. 2015. “Statistical principles of post-construction fatality monitoring.” In Wildlife and Wind Farms - Conflicts and Solutions, Volume 2, 227–37. Pelagic Publishing.

Huso, Manuela MP. 2011. “An Estimator of Wildlife Fatality from Observed Carcasses.” Environmetrics 22 (3): 318–29.

Kalbfleisch, John D, and Ross L Prentice. 2011. The Statistical Analysis of Failure Time Data. John Wiley & Sons.

Kaplan, Edward L, and Paul Meier. 1958. “Nonparametric Estimation from Incomplete Observations.” Journal of the American Statistical Association 53 (282): 457–81.

Korner-Nievergelt, Fränzi, Pius Korner-Nievergelt, Oliver Behr, Ivo Niermann, Robert Brinkmann, and Barbara Hellriegel. 2011. “A New Method to Determine Bird and Bat Fatality at Wind Energy Turbines from Carcass Searches.” Wildlife Biology 17 (4): 350–63.

Nature Advisory. 2017. “Crudine Ridge Wind Farm Bird and Bat Adaptive Management Plan.”

Ripley, Brian D. 1987. Stochastic Simulation. USA: John Wiley & Sons, Inc.

Sawilowsky, Shlomo S. 2003. “You Think You’ve Got Trivials?” Journal of Modern Applied Statistical Methods 2 (1): 218–25. https://doi.org/10.22237/jmasm/1051748460.

Stark, E, and S Muir. 2020. “Post Construction Bird and Bat Monitoring at Wind Farms in Victoria.”