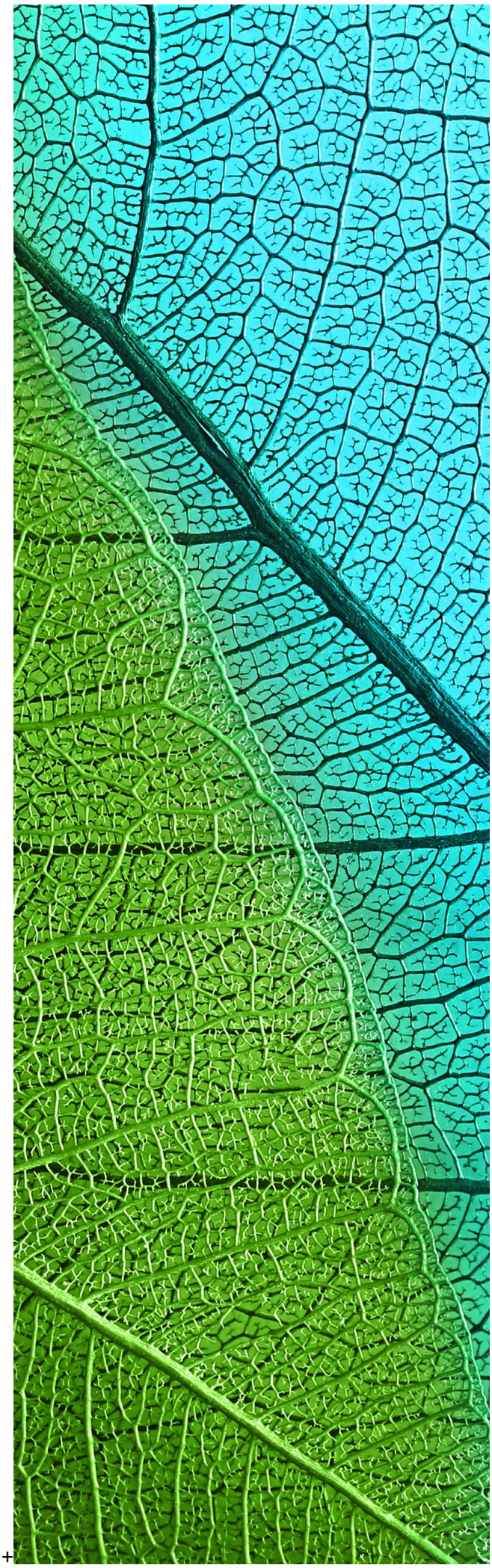

Murra Warra Wind Farm – Stage Two

Implementation of the Bird and Avifauna Management Plan – Annual Report

Prepared for RES Australia Pty. Ltd.

April 2025
Report No. 19049.3 (1.1)

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Nature Advisory acknowledges the traditional owners and sovereign custodians of the land on which we work from—the Wurundjeri people of the Woi Wurrung language group. We extend our respect to their Ancestors and all First Peoples and Elders past and present.

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1. Introduction

The Murra Warra Wind Farm (MWWF), located near Horsham in the Wimmera Bioregion of Western Victoria (VIC), received planning approval for 116 wind turbines and associated infrastructure (Horsham Permit No. PA1600127 and Yarriambiak Permit No. PA1600128). The wind farm is approximately 10 kilometres north-east of Murra Warra, 32 kilometres north of Horsham and 25 kilometres east of Dimboola.

Under the planning approval; Conditions 56, 57 and 58 for PA 1600127B and Conditions 57, 58 and 59 for PA 1600128C require the development and implementation of a 'Bat and Avifauna Management Plan' (BAM Plan) for MWWF, which was approved in August 2017 (Biosis 2017). RES Australia Ltd engaged Nature Advisory Pty Ltd to implement the BAM Plan for Stage two of the MWWF, comprising 38 turbines.

The BAM Plan will operate for the life of the MWWF. To inform mortality estimates and impacts on birds and bats at the wind farm, monthly carcass monitoring is required for the first two years of operation. As MWWF was constructed in two stages, monitoring was conducted separately for each:

- Stage one (MWWF1): Monitoring commenced in March 2020 and concluded in April 2022.
- Stage two (MWWF2): Monitoring commenced in January 2023 and concluded in December 2024.

Twenty-four months of monitoring and the associated monthly and annual reporting have already been completed for MWWF1 and detailed in a report – Murra Warra Wind Farm 2 Year Monitoring Report (Nature Advisory 2022).

This report presents the results of the 24-month MWWF2, which has included:

- Monthly carcass searches under 12 turbines,
- Carcass persistence trials and searcher efficiency trials,
- Incidental raptor monitoring.

Section 3.5 of the BAM Plan outlines that at the completion of the MWWF2, the report will include:

- *"Tabulated results of searches and incidental finds for all bird and bat collisions (carcasses & feather spots), including results for turbines fitted with aviation warning lighting and details of any operation of the lighting during the reporting period.*
- *Estimated total of annual mortalities for all listed species detected in carcasses searches.*
- *Results of all bird and bat monitoring investigations."*

This report addresses the above points in the following sections:

Section 2: the methods of MWWF2, including incidental raptor surveys and mortality monitoring program.

Section 3: Presents the results of the MWWF2.

Section 4: Provides a discussion of results and presents recommendations.

This BAM Plan implementation and reporting has been carried out by 'Banjo' (Scent Detection Dog), 'Gir' (Scent Detection Dog), 'Barkimedes' (Scent Detection Dog), 'Cruise' (Scent Detection Dog), 'Kitty' (Scent Detection Dog), Sam Plant (Zoologist and Dog Handler), Liz Browne (Zoologist and Dog Handler), Lilith Armstrong (Zoologist and Dog Handler), Lana Abdelganne (Zoologist and Dog Handler), Jesra García (Zoologist and Dog Handler), Jesca Norris (Zoologist and Dog Handler), Oriana Lucil-Milevoj (Zoologist and Dog Handler), Rebecca Cherubin (Zoologist and Dog Handler), Dr Robin Leppitt (Senior Zoologist), Kelsey Smith (Zoologist, Dog Handler and Project Manager), Jackson Clerke (Senior Ecologist and Project Manager), Bernard O'Callaghan (Director) and Brett Lane (Principal Consultant).

2. Methods

2.1. Mortality estimates

Mortality estimates during the MWWF2 were derived using the Monte Carlo simulation method. Factors such as scavenger loss, searcher efficiency and survey coverage were used to calculate an overall mortality for bats and birds between January 1, 2023, to, December 31, 2024 (Appendix 11). Collisions up to one month prior to the first survey were accounted for.

2.1.1. Carcass searches

Carcass searches followed the methodology as outlined in Section 3.2 of the MWWF BAM Plan (Biosis 2017). To ensure a valid dataset for statistical analysis, the mortality detection search was based on 33% of the 38 Stage Two turbines at MWWF2, totalling 12 turbines. The 12 turbines were selected at random. However, due to some access and Occupational Health and Safety constraints, several turbines had to be reselected. The 12 turbines that have been searched monthly during the MWWF2 are listed in Table 1 and shown in Figure 1.

Table 1: List of turbines searched

Selected Murra Warra Stage Two Turbines					
A03	A05	A09	A11	A15	A16
A18	A21	A22	A28	A31	A34

Notes: Light green cells indicate turbines with aviation safety lighting.

Mortality detection searches entail the ground beneath each of the 12 selected turbines being searched to a radius of 90 metres once per month for 24 months (referred to as 'standard searches'). Mortality detection searches were conducted by a person trained in zoology and dog handling and a professionally trained scent detection dog. Each mortality detection search was undertaken on foot, along 20-metre transects, starting down-wind and walking perpendicular to the direction of the wind across the 90 m search radius (Figure 2).

The detection dog is trained to find and indicate on any bird or bat carcasses either side of each transect, and the handler will subsequently identify and collect data on these "finds". To avoid double counting during future searches, the carcass or feather spot is removed from the search area.

Weather observations and factors influencing search coverage were recorded for each search on field data sheets (Appendix 1). Whenever a carcass or feather spot was recorded under a turbine, photographs were taken and information about the condition of the find was recorded (Appendix 1). Feather spots are a likely an indication of the carcass of a bird being scavenged before the survey effort commenced for that month (Bernardino et al. 2020). Section 3.2 in the BAM Plan defines a feather spot as:

"A collection of 10 or more wing or tail feathers found together, which are indicative of the injury or death of a bird".

On finding a carcass or feather spot, the searcher:

- Took photos of the carcass and/or feathers,
- Recorded notes on identifying features
- Removed the remains from site to avoid re-counting,

- Transferred fresh carcasses and feather spots to a freezer at the site office for storage so it could be identified, or identity verified and used later in observer efficiency and scavenger trials (see below).

An incidental record is a carcass found under a turbine outside of the formal mortality detection program (e.g., by wind farm personnel during routine inspections of infrastructure, during turbine searches under a turbine not selected for monthly searches, or outside of the 120m search radius).

To ensure that the search pattern is appropriately covered, both the handler and the dog's position in the search radius is tracked in real time via a hand-held GPS unit linked to a GPS tracking collar which is fitted to the dog. Electronic files for GPS searches under the turbines can be made available upon request. The results have also been reviewed by a statistician to ascertain the likely level of precision in the estimate of bird and bat mortality for the given survey effort.

Figure 1. Murra Warra Stage 2 turbine locations

Project No: 19049.03
Project: Murra Warra Wind Farm Stage 2
Date: 31/03/2025

Study area
Road
Stage 2 turbine
Searched turbine

N

Meters
0 260 520 780 1,040
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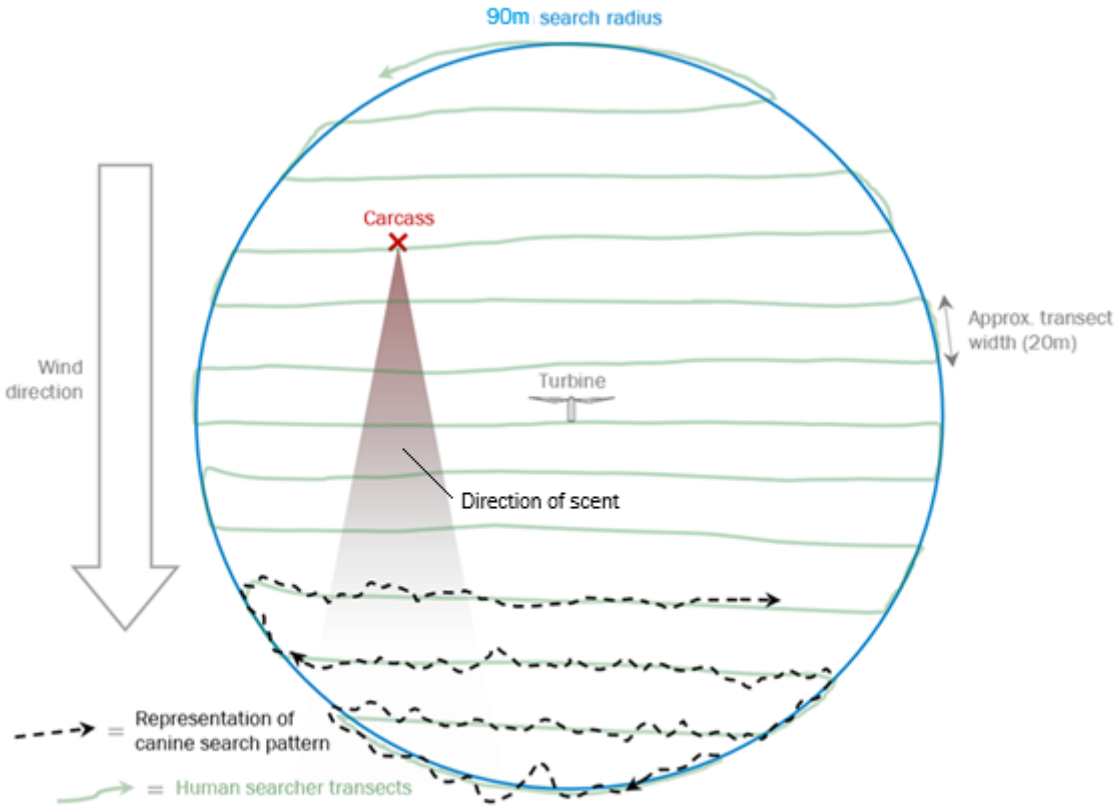

Figure 2: Diagram of search zone, transect width and search pattern at turbines

2.1.2. Searcher efficiency trials

The BAM Plan states that four searcher efficiency trials will be conducted over the two-year monitoring period, two in spring and two in autumn, or as appropriate to assess detection rates across seasonal variations.

Searcher efficiency trials (also referred to as detectability trials) are intended to determine the probability of the search team detecting a bird or bat carcasses on the ground. They involve the search team and an accessor. The search team is defined as the dog handler and scent detection dog. and the accessor is the person that without the knowledge of the scent dog or handler places carcasses in an area to be searched and records the number of carcasses found by the search team. The search team are not aware of the location, type or number of carcasses placed by the accessor.

Between 19 and 30 carcasses were randomly placed within the 90-metre search radius of at least eight turbines to be searched per trial. These carcasses were a range of birds or bats found at the Murra Warra site or a similar substitute (e.g., Common Myna). Small bat carcasses were randomly placed on the ground within 60 m of the turbine. GPS coordinates of each carcass are recorded to ensure that each placed carcass was not confused with an actual “collision carcass”. Upon completion of each trial the search team informed the accessor the location and species of each carcass found, the accessor then returned to each turbine to retrieve carcasses that were not found.

A blind trial was not considered necessary as the detection dog is unaware of the trial taking place as opposed to any other search activity.

2.1.3. Carcass persistence trials

Carcass persistence trials (also referred to as scavenger trials) ascertain the rate at which carcasses are removed by scavengers. Scavenger trials are used to develop a 'correction factor' for the estimate of the numbers of birds and bats affected by the wind farm. Scavengers can include ground-dwelling animals, such as foxes, feral cats, and rats (more likely to detect carcasses by scent), as well as aerial scavengers such as raptors, corvids, and passerines (more likely to detect carcasses visually).

Section 3.2.7 of the BAM Plan details the process for carcass persistence trials. A motion sensor camera is set up to monitor the carcass and take photos of any scavenger activity taking place This approach can provide more accurate timing of scavenging and identify scavengers. A camera is attached to a tree, fence post, or star picket approximately 1–2 metres away from each randomly placed carcass. The carcass is then left for a period of approximately 30 days, after which the camera is collected, and scavenging activity reviewed.

The field of view of cameras is limited and scavengers may simply move a carcass out of that view (frame). Records from any carcasses from persistence trials that are found by subsequent dog searches must be documented and included in the database for persistence trials. If carcasses were moved during these checks, cameras would be redeployed in a new location. If the carcass remained at day 30, it would be recorded as being scavenged at day 30 to incorporate the finding into the statistical report.

To determine the scavenging rates on birds and bats, three size categories of carcasses were used (small, medium, and large). Where carcasses of the species of concern could not be found, a similar sized substitute has been used. The aim has been to use ten carcasses of each size category during each scavenger trial, or 20 per year per size category. In practice this has not been feasible as 10 solely 'large birds' could not be sourced. Therefore, a mix of small bird and bat and medium birds was employed for each trial. On one occasion in July 2024, a small chicken was used as a substitute due to lack of available carcasses.

Each trial was located within the vicinity of operating turbines and within the search radius if possible. Turbines used were the same as those used for mortality searches.

Cameras were installed during the dates listed below and checked approximately 30 days later

- 21 – 22 August 2023,
- 18 – 19 September 2023,
- 31st October 2023,
- 27th February 2024,
- 12 – 13 March 2024,
- 23rd April 2024,
- 15 – 16 May 2024 and
- 17th July 2024

2.1.4. Incidental raptor monitoring

Although not a requirement of the MWWF BAM Plan, Nature Advisory Zoologists recommended raptor monitoring be conducted in conjunction with the carcass monitoring program due to detected raptor mortality. Incidental raptor observations were made while traversing the wind farm site and searching

under turbines, with data collected listed in Appendix 2. Raptors were observed with binoculars, on foot and from vehicles.

2.1.5. Bird risk reduction measure

To reduce the likelihood of attracting raptors to the area, Section 3.6 of the BAM Plan states that timely and regular removal of carcasses of livestock and other large animals from the wind farm is required to reduce the incidence of collision with turbines by birds that are attracted to the carcass to feed. Carcasses are to be removed from paddocks adjacent to turbines within 48 hours of their discovery.

MWWF should continue to work with landholders over the life of the project to ensure that farm management practices minimise availability of carrion in paddocks adjacent to turbines, and in turn minimise the attractiveness of the site to raptors and other species of bird.

2.1.6. Limitations

The growing of crops during spring and summer limited the ability of the search teams to search the entire search radius. This was mostly due to the growth of crops making it impossible for the search team to move through the crop and the thick crop growth reduced visibility and the potential to detect snakes. Additionally, crop stubble has the potential to cause injury to the scent dog's eyes. Hence, during months where there was significant crop growth or remaining stubble, an alternative search area of just the hardstands, accessible areas and access roads were monitored (Figure 3).

This reduced search area was accounted for in mortality estimations statistical analysis. See Appendix 11.

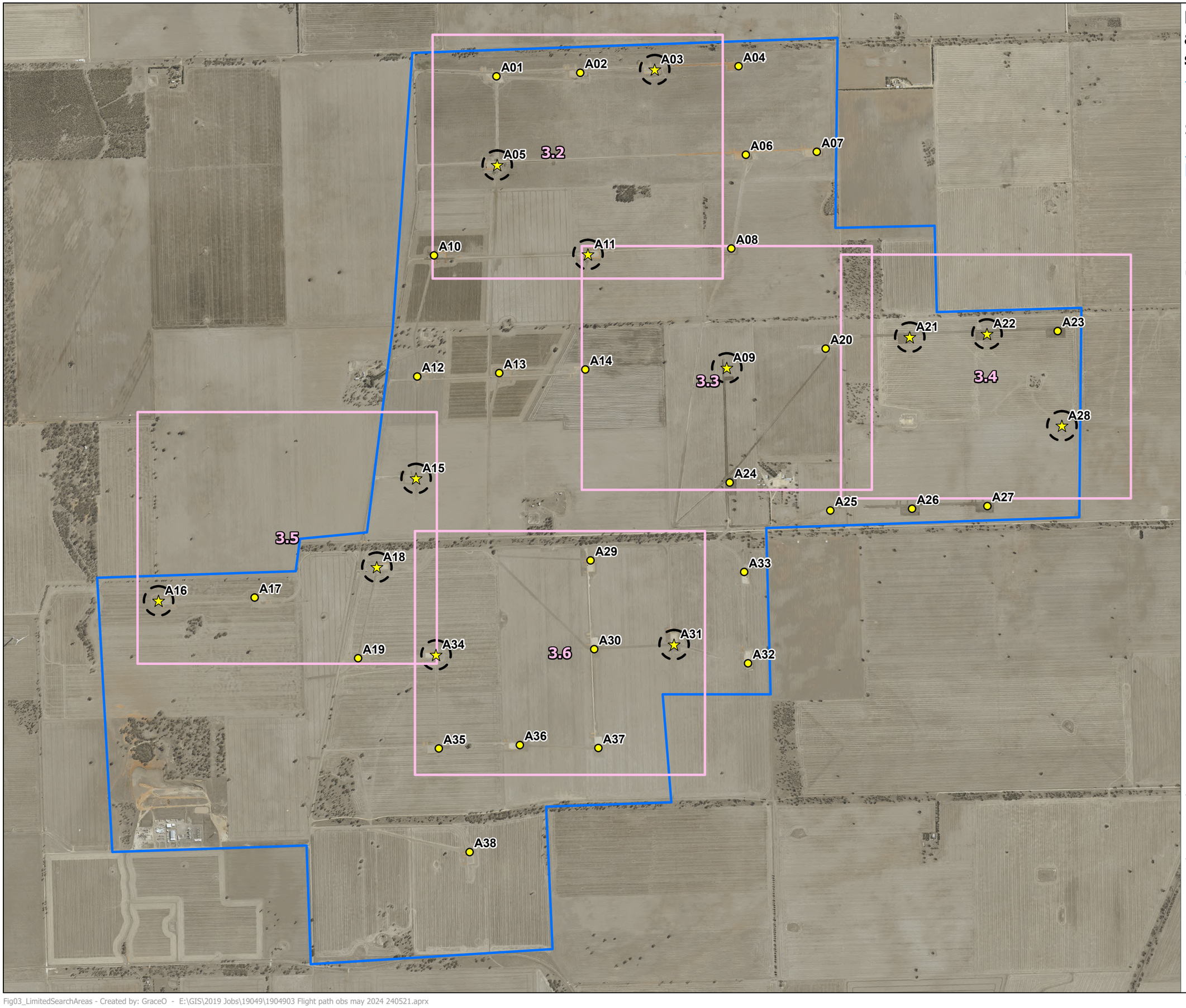

Figure 3.1: Limited search areas - 90m "standard" searches

Project No: 19049.03
Project: Murra Warra Wind Farm Stage 3
Date: 18/03/2025

- Study area
- Map pages
- Turbines
- Searched turbine
- Initial search (90 m)

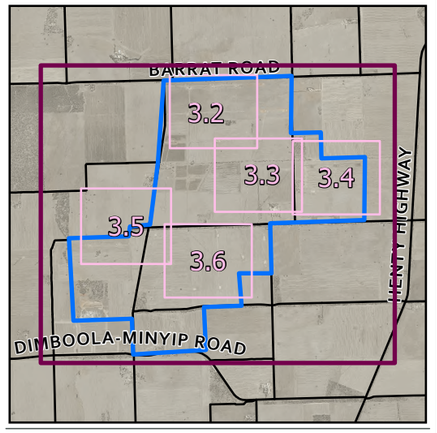

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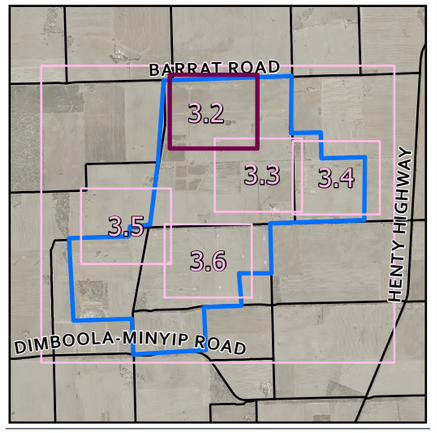
Figure 3.2: Limited search areas - 90m "standard" searches

Project No: 19049.03
Project: Murra Warra Wind Farm Stage 3
Date: 18/03/2025

Study area
Turbines
Searched turbine
Initial search (90 m)

Limited search areas

December 2023



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A11
A08
A20
A09
A14
A24

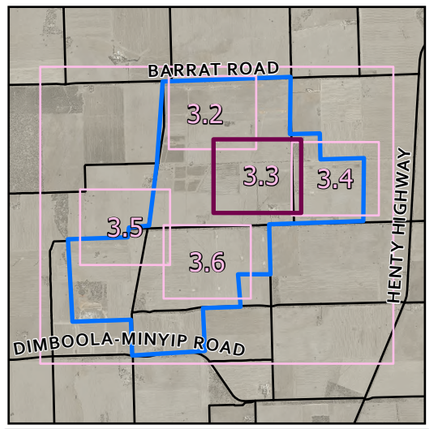
Figure 3.3: Limited search areas - 90m "standard" searches

Project No: 19049.03
Project: Murra Warra Wind Farm Stage 3
Date: 18/03/2025

- Study area
- Turbines
- Searched turbine
- Initial search (90 m)

Limited search areas

- December 2023
- July 2024



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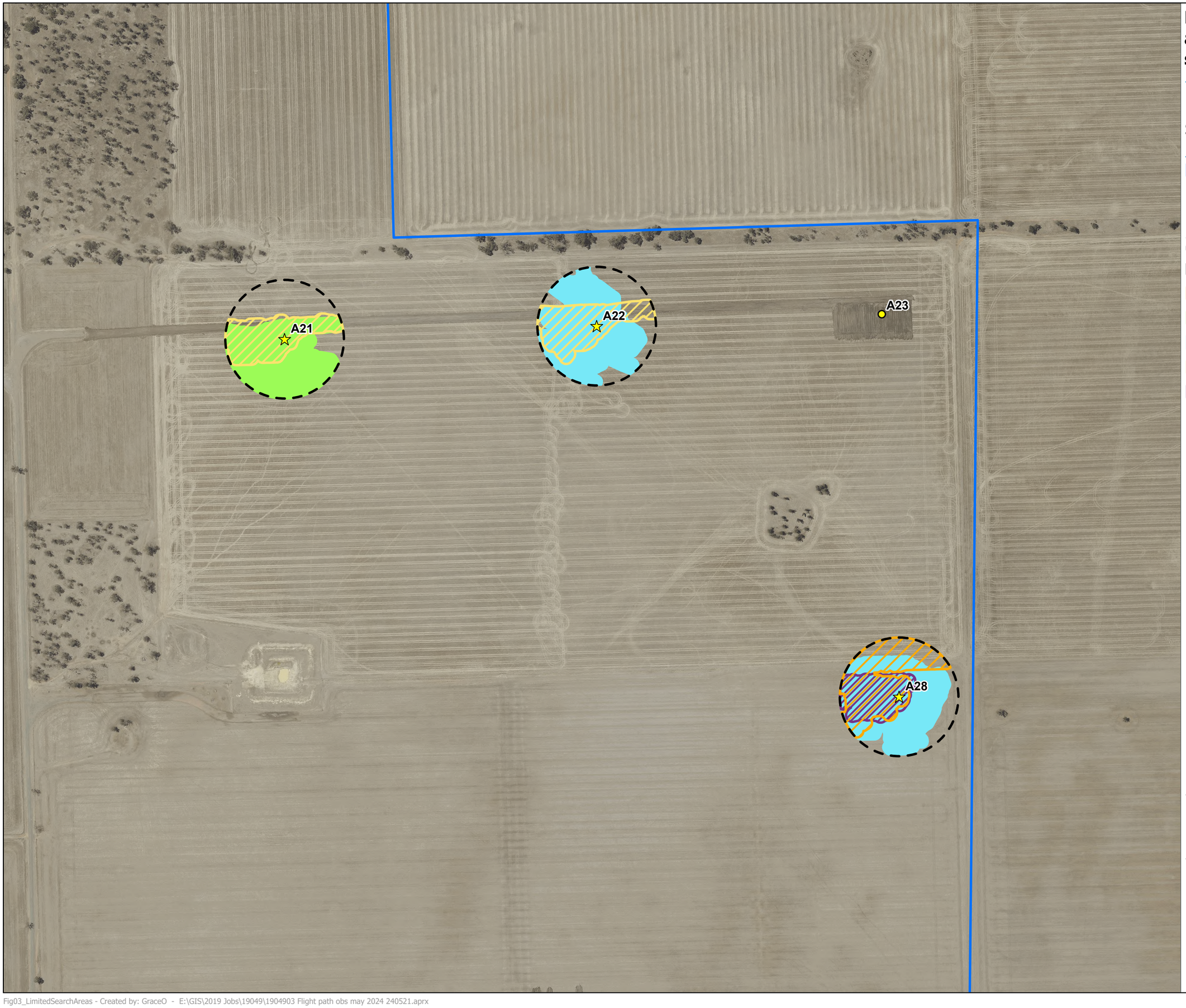

Figure 3.4: Limited search areas - 90m "standard" searches

Project No: 19049.03
Project: Murra Warra Wind Farm Stage 3
Date: 18/03/2025

- Study area
- Turbines
- Searched turbine
- Initial search (90 m)

Limited search areas

- October 2023
- May 2024
- July 2024
- October 2024
- November 2024

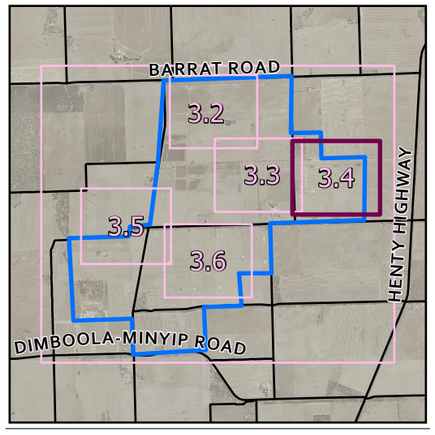

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Figure 3.5: Limited search areas - 90m "standard" searches

Project No: 19049.03
Project: Murra Warra Wind Farm Stage 3
Date: 18/03/2025

- Study area
- Turbines
- Searched turbine
- Initial search (90 m)

Limited search areas

- December 2023
- July 2024
- September 2024
- October 2024

A15
A16
A17
A18
A19
A34

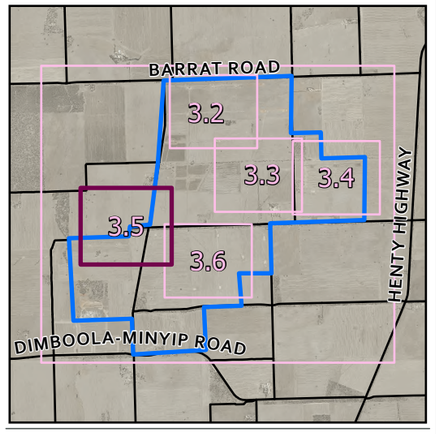

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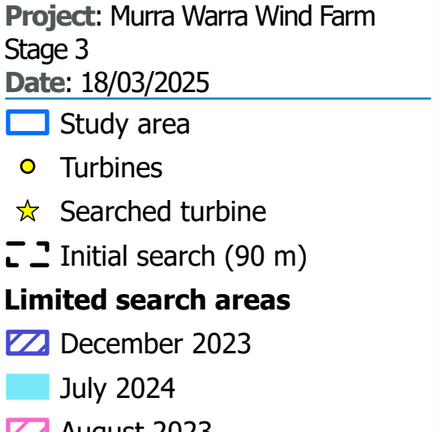
Figure 3.6: Limited search areas - 90m "standard" searches

Project No: 19049.03
Project: Murra Warra Wind Farm Stage 3
Date: 18/03/2025

- Study area
- Turbines
- Searched turbine
- Initial search (90 m)

Limited search areas

- December 2023
- July 2024
- August 2023
- September 2024
- October 2024 - Hardstand only
- October 2024



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3. Results

3.1. Carcass searches

3.1.1. Mortality results

A total of 84 carcasses were detected during 274 individual surveys over 24 monthly survey periods at MWWF2 (Appendix 3). This consisted of 13 bird carcasses, 53 bat carcasses, eight feather spots and ten incidental finds. A summary of results is shown in Table 2. Detailed results of the carcass searches are shown in Appendix 4.

Table 2: Summary of mortality detection results for bird and bats, January 2023 – December 2024

Season	Month	Bird	Bat	Feather spot	Incidental	Total Mortalities
Summer	Jan '23	3	4	0	1	8
	Feb '23	0	3	2	0	5
Autumn	Mar '23	0	4	1	1	6
	Apr '23	0	9	0	2	11
	May '23	1	7	0	0	8
Winter	Jun '23	0	1	0	0	1
	Jul '23	0	0	0	0	0
	Aug '23	1	0	0	0	1
Spring	Sep '23	0	5	0	1	6
	Oct '23	2	0	0	1	3
	Nov '23	1	1	1	0	3
Summer	Dec '23	0	1	0	0	1
	Jan '24	0	2	0	0	2
	Feb '24	0	2	1	0	3
Autumn	Mar '24	1	4	1	3	9
	Apr '24	0	2	0	0	2
	May '24	0	1	0	0	1
Winter	Jun '24	1	0	1	0	2
	Jul '24	0	0	1	0	1
	Aug '24	3	1	0	0	4
Spring	Sep '24	0	1	0	0	1
	Oct '24	0	2	0	1	3
	Nov '24	0	0	0	0	0
Summer	Dec '24	0	3	0	0	3
	Totals	**13**	**53**	**8**	**10**	**84**

Notes: Survey months with no recorded mortalities are highlighted in grey.

Across the 24-month monitoring period, Autumn saw the highest mortalities, driven primarily by bat mortality which was higher in April 2023 and May 2023. Mortality averaged 2-3 bats per month, with lower number recorded in during winter and higher numbers in Autumn, with a high of nine in April 2023. Bird mortality was less frequent and more consistent across the monitoring period averaging one bird every second month, ranging between zero and three (Figure 4).

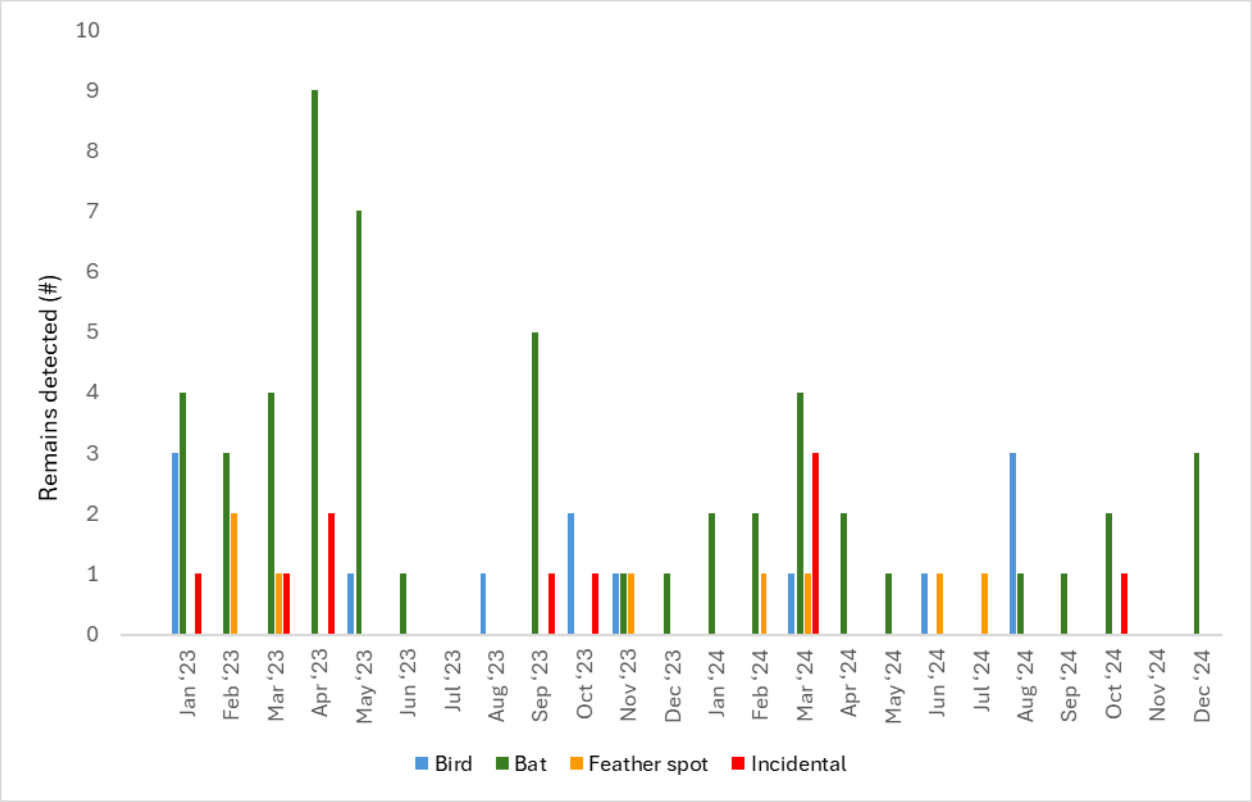

Figure 4: Number of carcasses found during searches in each month during the 24-month monitoring period.

Bird mortality

A total of 21 bird strikes were recorded within the MWWF2 site, comprising 13 partial or intact carcasses and 8 feather spots, with no pattern apparent in the timing of bird strikes (Figure 4). Five additional bird strikes were discovered incidentally by wind farm personnel. These were comprised of four partial or intact carcasses and one feather spot.

Birds made up 30.1% of all mortalities (including carcasses, feather spots and incidentals) consisting of 13 species. One individual could not be identified due to decomposition and a lack of identifying features.

Mortality detection of birds is summarised in Table 3, with species listed in ranked order of the number of remains found. Detailed information on each bird carcass, feather-spot, and incidental record during this monitoring stage can be found in Appendix 4.

The Nankeen Kestrel was recorded with the most mortalities (11), making up 42.3% of bird mortalities and 13.1% of overall mortalities. This was followed by Wedge-tail Eagle with 3 mortalities, making up 11.5% of bird mortalities.

One listed species, the Fork-tailed Swift *Apus Pacificus*, was detected during the carcass search trials. The Fork-tailed swift is Listed as Migratory under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act). There were zero Fork-tailed swift carcasses found during the formal surveys. However, two individual carcasses were found incidentally. Based on requests from the regulator, a statical median estimate of total Fork-tailed Swift mortality was generated. This was estimated though statistics as 64 over the two-year period. There is 95% confidence that fewer than 182 Fork-tailed Swits were lost based on the detected carcasses, measured detectability, scavenge rate and survey effort. It must be noted that this is an broad estimate considering the no Fork-tailed Swift were found in the regular searches.

The median estimate of total bird mortality is 1012 birds over the two-year period. Based on the detected carcasses, measured detectability, scavenge rate and survey effort, there is a 95% confidence interval that fewer than 1464 birds were killed by turbines.

Table 3: Summary of detected bird mortality at MWWF2, January 2023 – December 2024

Species	Carcass	Feather spot	Incidental	Total	% Total of bird mortalities	% Total of all mortalities
Nankeen Kestrel	5	5	1	11	42.3	13.1
Wedge-tailed Eagle	3	0	0	3	11.5	3.6
*Fork-tailed Swift	0	0	2	2	7.7	2.4
Australian Magpie	0	1	0	1	3.8	1.2
Black-shouldered Kite	1	0	0	1	3.8	1.2
Black-tailed Native hen	1	0	0	1	3.8	1.2
Common Starling	1	0	0	1	3.8	1.2
Eastern Barn Owl	0	1	0	1	3.8	1.2
Magpie-lark	0	1	0	1	3.8	1.2
Stubble Quail	1	0	0	1	3.8	1.2
Tree Martin	1	0	0	1	3.8	1.2
Unidentified Bird sp.	1	0	0	1	3.8	1.2
White-faced Heron	0	0	1	1	3.8	1.2
Totals	**15**	**7**	**4**	**26**	-	**31.0**

Notes: * = Listed as Migratory under the EPBC Act.

Bat mortality

53 bats representing at least six species made up 69.0% of the mortalities found during MWWF2. A further three species could only be identified to genus level and eight specimens were recorded as unidentified microbats due to advanced decomposition or scavenging leading to a lack of identifying features remaining. Detected bat mortality at MWWF2 is presented in Table 4. Detailed information on each bat carcass record during 2023-2024 can be found in Appendix 5.

White-striped Freetail Bat held the highest mortality rate with 14 individuals detected over 24 months, making up 24.1% of bat mortalities and 16.7% of all mortalities (birds, bats, feather spots) combined. Gould's Wattled Bat held the second highest mortality of the bats with 12 mortalities, followed by Southern Freetail Bat with 11 mortalities.

The median estimate of total bat mortality is 2036 bats over the two-year period. There is a 95% confidence interval that fewer than 2645 individuals were lost based on the detected carcasses, measured detectability, scavenge rate and survey effort.

Table 4: Summary of detected bat mortality at MWII, January 2023 to December 2024

Species	Carcass	Incidental	Total	% Total of bat mortalities	% Total of all mortalities
White-striped Freetail Bat	14	0	14	24.1	16.7
Gould's Wattled Bat	9	3	12	20.7	14.3
Southern Freetail Bat	10	1	11	19.0	13.1
Unidentified Microbat sp.	8	0	8	13.8	9.5
Freetail Bat sp. (Southern or Eastern)	4	1	5	8.6	6.0
Freetail Bat sp.	2	0	2	3.4	2.4
Large Forest Bat	2	0	2	3.4	2.4
Lesser Long-eared Bat	2	0	2	3.4	2.4
Evening Bat sp.	1	0	1	1.7	1.2
Little Forest Bat	1	0	1	1.7	1.2
Total	53	5	58	-	69.0

3.1.2. Searcher efficiency trials

Four searcher efficiency trials were undertaken during the months of August 2023, February 2024, April 2024 and September 2024. Details of these trials are listed in Table 5, with searcher efficiency results are provided in Appendix 6.

Table 5: Details of detection trials at MWWF2

Date	Search team	No. and type of Carcass	Turbines
21 - 22 August 2023	LB & Gir	9 small, 10 medium	3, 5, 9, 11, 15, 16, 18, 21, 22, 28, 31
26 - 27 February 2024	KS & Banjo	11 small 15 medium	3, 5, 9, 11, 15, 16, 18, 21, 22, 28
23rd April 2024	KS & Banjo	13 small, 10 medium	9, 15, 16, 18, 21, 22, 28, 34
10th September 2024	LXA & Gir	10 small, 10 medium, 10 large	5, 11, 15, 16, 18, 21, 22, 28, 31, 34

Notes: Lana Abdelganne (LXA), Liz Browne (LB), Kelsey Smith (KS), Sam Plant (SP).

The results of the detectability trials for Banjo and Gir are presented in Table 6. No carcasses were removed by scavengers before trials concluded. Banjo missed three White-striped Freetail Bat carcasses (small) and one Common Myna carcass (medium). Gir missed one Common Myna carcass (medium). There did not appear to be a substantial difference in the scent detection canine's ability to detect size classes of carcass. Full results of the detectability trial are presented in Appendix 6.

Table 6: Detectability trials for carcass detector dogs

Dates	Searcher	Small	Medium	Large	Total success
26/02/2024, 27/02/2024 and 23/04/2024	Banjo	20/23	24/25	N/A	91.6%
21/08/2023, 22/08/2023 and 10/09/2024	Gir	20/20	19/20	10/10	98.0%

3.1.3. Carcass persistence trials

In total 73 carcasses were deployed with the results of the trial presented in Appendix 7. Of these, 17 deployments failed due to equipment malfunction or theft of cameras.

Carcass size consisted of 40 small carcasses, 43 medium carcasses and 10 large carcasses. Red Fox was the most common scavenger recorded by the motion sensor cameras, followed by Australian Magpie and Raven sp. Where the scavenger is described as 'Scavenge Missed', this refers to the actual photograph of a scavenging event not being recorded. In this instance, it is assumed that the next photograph of the carcass not being in frame anymore was the scavenging event.

Survival analysis was used to determine the distribution of time until complete loss of carcasses from scavenge. The median time to total loss via scavenge for bats and birds is 1.5 days with a 95% confidence window of [1.2, 2] days

3.1.4. Analysis of Lit Turbines

Six of the 30 turbines across Murra Wind farm Stage 1 and 2 were fitted with aircraft lighting. Two of those turbines, A3 and A5, were included in the monthly turbines to be searched. The lights on the turbine are activated by the Warracknabeal Airport lighting system. No data on when they were lit or unlit was able to be provided.

No significant difference between mortality rates at lit vs unlit turbines was found.

3.2. Incidental raptor monitoring

There were 65 incidental observations of raptors representing seven species during incidental monitoring (Table 7, Appendix 8). 9.2% of these observations were of birds flying at rotor swept area (RSA) height.

The four most regularly seen species flying at RSA were the Nankeen Kestrel, Black-shouldered Kite, Black Kite and Wedge-tailed Eagle. The Black Facon (FFG Act: Critically Endangered) was observed once at MWWF and was the only listed species observed incidentally at MWWF. During this observation, three individuals were recorded, one adult (parent) and two recently fledged juveniles. They were observed, diving and soaring between turbines. One individual was observed 'attacking' a turbine blade that was stationary. Additional notes on this observation are presented in Appendix 9. Full results of incidental raptor observations are presented in Appendix 8.

Table 7: Incidental raptor records at MWWF2, January 2023 – December 2024

Species	A	B	C	Total	percentage at RSA (%)
Nankeen Kestrel	33	2	-	35	5.7
Black-shouldered Kite	20	1	-	21	4.8
Black Kite	2	1	-	3	33.3
Brown Falcon	2	-	-	2	0

Species	A	B	C	Total	percentage at RSA (%)
Black Falcon	-	1	-	1	100
Wedge-tailed Eagle	-	1	-	1	100
Australian Hobby	1	-	-	1	0
Total	58	6	0	65	

Notes: A = Below RSA, B = at RSA, C = above RSA, * = Species in bold are listed under the Victorian *Flora and Fauna Guarantee Act 198*Bird risk reduction measures

3.3. Limitations

The growth of dense crop – up to the hardstand in many instances – reduced the search areas beneath and surrounding all 12 turbines at MWWF2 from September to December inclusive. Searches at turbines were limited (to varying degrees) outside of September to December due to a number of additional limiting factors including:

- Dense grass/weeds
- Weed and crop spraying
- Farmers working within the search radius
- Construction works occurring
- Stored equipment
- Waterlogged soils, large ponds of water and deep mud
- Fencing

These limitations often occurred infrequently. Where fencing could not be lifted clear from the ground to allow the canines to pass through, and lifting or allowing dogs to jump over fences presents injury risks to each the handler and dog (due to electric and barbed wire). The handler therefore completed visual inspection of any areas unable to be accessed by the scent detection canine, but human's significantly lower detection efficiency means that it is possible that mortalities (especially small bats and partial remains) would have been missed in these areas. Turbines with modified searches are listed in

Table 8.

On one occasion, spraying prompted a site shutdown and the search team to cease the survey. As a result, the following turbines were not searched in November 2024: 11, 15, 16, 18, 31 and 34. Additionally, some turbines across the 24-month monitoring period could not be searched on occasion due to construction works taking place within the search area.

Table 8: Turbines with modified searches by month and year

Turbines with modified search areas		
Month	2023	2024
January	N/A	3, 5, 9, 11 16, 21, 28, 31
February	N/A	31
March	N/A	31
April	N/A	31
May	N/A	21
June	N/A	31
July	N/A	9, 15, 22, 28, 31
August	N/A	15, 21, 22, 31
September	N/A	15, 18, 21, 22, 28, 31, 34
October	3, 9, 11, 16, 28, 31	11, 15, 18, 21, 22, 31, 34
November	3, 9, 11, 16, 28, 31	9, 21, 22, 28
December	3, 5, 9, 11, 16, 28, 31	15, 31

Statistical estimation was undertaken to attempt to account for this overall reduction in total search area due to the significant OH&S risks outlined above.

4. Summary and adaptive management

4.1. Summary of detected mortalities

A total of 84 mortalities were recorded within the MWWF2 site during the two-year monitoring period. This included 26 birds and 58 bats across 24 months of carcass detection searches. No impact triggers were recorded during the reporting period. Scavenging estimates indicated an averaging scavenging rate of 1.5 days. The carcass search teams located 94 of the 99 carcasses during searcher efficiency trials for a combined carcass detection rate of 95%, indicating a high probability of carcass detection during surveys if present.

4.2. Bird Mortality detection

A total of 21 bird strikes were recorded over the 24-month period within the MWWF2 site, comprising 13 partial or intact carcasses and 8 feather spots, with no pattern apparent in the timing of bird strikes. Five additional bird strikes were discovered incidentally by wind farm personnel. Most of these bird mortalities were from species common to farmland environments across Victoria and species reported to have high numbers of collisions at windfarms across south-eastern Australia (Smales, 2015). The two most detected species were Nankeen Kestrels and Wedge-tailed Eagles.

Nankeen Kestrel

Nankeen Kestrel carcass was the mostly commonly detected at MMWF2 with 11 mortalities, making up 42.3% of bird mortalities and 13.1% of mortalities overall. Nankeen Kestrel is a common and widespread species throughout Australia and is associated with most open habitats including farmland with scattered trees (Stewart, 2021). The species forages for prey using a variety of techniques. High-quartering and hovering are particularly favoured. They also use hunting from perches or ground, soaring, contour hunting and low, slow quartering at low elevations. The foraging strategies of Nankeen Kestrel mean that it commonly flies at RSA (rotor-swept area). This, coupled with the species' propensity to hunt in open situations while searching for prey, make the species the most susceptible to collisions with wind turbines at MWWF2. The impact from MWWF2 is unlikely to be significant to these species local or regional populations do its increasing population trends due to farming, and its occurrence across most of the continent (Birdlife International 2025).

Wedge-tail Eagle

Wedge-tail Eagles were the second most detected with 3 mortalities, making up 11.5% of bird mortalities and 3.6% of total mortalities. Wedge-tailed Eagles are characterised as being both a diurnal and crepuscular hunter, preying on a wide variety of live vertebrates, from medium-sized songbirds to large mammals (especially macropods), as well as regularly exploiting carrion (Cherriman, 2022). The species tends to soar from close to the ground to many hundreds of metres aboveground while searching for foraging opportunities, (Marchant and Higgins 1993). These behaviours bring the species into RSA height and increases the risk of collision compared with other species. Additionally, the presence of carrion, particularly stock carcasses throughout lambing season may act as an attractant, favoring higher rates of foraging within proximity of turbines and increasing the risk of collision. Analysis by Symbolix (2020) show that mortalities of this species are generally not scavenged, remaining in situ until complete composition. Given this, it is likely that the actual mortality rate would not be much higher than that detected as the dogs would eventually find the persisting carcasses each month. As the species is listed as secure across its range, and the population is thought to be increasing (BirdLife International 2022, IUCN 2022), this level of mortality is not likely to be significant for the species at a population scale.

Fork-tailed Swift

There was a notable observation of two Fork-tailed Swift carcasses that were detected incidentally. Details on the finds are detailed in **Table 9**. No impact trigger was met for this species, however, MWWF2 notified DEECA of the outcome and requested a meeting to discuss potential impacts. DEECA recommended that an investigation was conducted into potential mitigation measures and that a species specific mortality estimate was provided in the Annual Report. A literature review and report was compiled and sent to DEECA (Appendix 10). DEECA acknowledged receipt of the report and would provide further advice, if required, after submission of the 24-month period Annual Report.

Table 9: Details on mortality detection of two Fork-tailed Swift in 2024 at MWWF2

Date found	Turbine	Distance from turbine (m)	Date of ID by Senior Ornithologist	Date DEECA notified
13 March 2024	18	102	20 March 2024	19 April 2024
13 March 2024	21	97	20 March 2024	19 April 2024

The Fork-tailed swift is Listed as Migratory under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act). Though no Fork-tailed Swifts were found during formal surveys, the resulting (median) estimate of total mortality is 64 Fork-tailed Swifts lost on site over the two-year period (Appendix 11). There is 95% confidence that fewer than 182 Fork-tailed Swifts were lost based on the detected carcasses, measured detectability, scavenge rate and survey effort. Whilst the two Fork-tailed Swift mortalities did not qualify for an impact trigger, it was reported to the Victorian Department of Energy, Environment and Climate Action (DEECA) on 19 April 2024, as required under the BAM Plan. A literature review and investigation of potential mitigation measures was produced by Nature Advisory (Appendix 10). It was determined that the cause of death of both Fork-tailed Swift individuals was likely to be collision with turbines. Appendix 11 shows the Symbolix mortality estimate for Fork-tailed Swift included modelling on coverage factor calculation based on a study by Hull and Muir (2010) for calculating what proportion of carcasses would fall within the turbine radius. Symbolix found that 92% of Fork-tailed Swift carcasses were expected to fall within the 90m radius, while 8% could land between 90 and 110m from the turbine., , This in conjunction with the species exhibiting risk behaviour that may lead to collisions when utilising the MWWF2 site (DCEEW 20024) provided evidence for death by collision with turbine. Section 3.1 determines that significant impact would be triggered if turbine collisions affected more than 0.01% of the population estimate of a listed migratory species during any one year of the monitoring program. The current global population estimate for Fork-tailed Swift is at least 100,000, with Australian population estimates over 20,000 (DOE 2015). For a significant impact to occur, at least 200 individuals would need to be lost within a 12-month period. Mortality estimates were for 64 individuals over a 24-month period (Appendix 11). As such, there is unlikely to be a significant impact to Fork-tailed Swift.

Black Falcon

Another notable observation was three Black Falcons (*FFG Act*: Critically Endangered) detected in a single observation flying amongst the turbines, although no mortalities of this species were detected. The species flies at RSA height often and collides with operating turbines across Victoria (Nature Advisory unpublished data). The species is known to breed in the vicinity to MWWF2 and expected to keep occurring in the area.

4.3. Bat mortality detection

Bat mortality for the 24-month period totalled 58 individuals. Mortality estimates, when factoring in searcher efficiency and scavenger rates for bats, by Symbolix (Appendix 11) produced a median estimate of 2,036 bats over the 24 months (95% confidence interval of fewer than 2,645), or if simply averaged would be around 1,018 bats / year. There was some seasonal variability in bat mortality, with higher rates typically observed in warmer months and very little recorded during winter. Bat mortality was higer in April and May 2023. The most common species of bat carcasses were White-striped Freetail Bat, Gould's Wattled Bat and Southern Freetail Bat, which made up 24.1%, 20.7% and 19.0% respectively. A number of studies (Moloney et al. 2019, Smales 2012, Symbolix 2020) have identified that these species are commonly impacted by wind farm operations and that White-striped Freetail and Gould's Wattled Bat in particular are over-represented as mortalities across many wind farms. Observations by Nature Advisory (Nature Advisory 2024) at various wind farms in other parts of these species' range are consistent with these findings. This is related to the foraging behaviour of all three microbat species which causes them to fly within RSA height in pursuit of high-flying insects (Churchill 2008). This unfortunately brings these species into collision with turbines.

4.4. Ecological feasibility of mortality estimates

The median estimate of total bird mortality was 1012 birds over 24 months (95% confidence interval of fewer than 1464) (Appendix 11). This value is an indication of the impact MWWF2 is having on birds generally. There may be some localised impact on the common species listed above but this is unlikely to cause a long-term decline in regional populations for any of the common species, given their widespread and prolific populations. It is important to view this estimated mortality value through an ecological lens.

In regard to the mortality estimates, the very low carcass persistence rate recorded (1.5 days) has substantially raised potential mortality estimates to levels that, while statistically possible based on results, are unlikely to be ecologically possible. Actual observed mortality for birds was 21 and was extrapolated to a statistically possible 1,012 over 24 months. Actual observed mortality for bats was 58 and extrapolated to a statistically possible 2,036. For example, Nankeen Kestrel made up 42.3% of bird mortality which could be expected to mean that up to an estimated 428 individuals were potentially killed over 24 months. Given that the highest number of Nankeen Kestrel's observed incidentally using the wind farm site during a single survey period was two, this seems highly unlikely.

For microbats, it is known that White-striped Freetail Bat can have up to 25 individuals per colony (although up to 300 can be found in the case of maternity colonies) and roost primarily in mature tree hollows (Churchill 2008). While it is unknown how many colonies occur within the footprint of MWWF2 or within the maximum daily foraging distance (20km (Rhodes and Catteral 2008)), it is unlikely that there is sufficient habitat around Murra Wurra and the broader region for which a significant proportion is used for agriculture to support the number of colonies that could result in the estimated mortality of 2036 for bats. Approximately 24% of mortality was of White-striped Freetail bat which could be expected to mean up to 489 of the species were killed, would require up to 20 non-maternity colonies to be within foraging range of the wind farm. While this may be plausible, it is unlikely that any colonies would be travelling 20 km in a night to MWWF2, given the uniformity of the agricultural landscape in the Murra Wurra region.

Such low carcass persistence rates may be related to the use of substitute carcasses (i.e. Common Myna) which are not necessarily reflective of species available to scavengers under turbines and may be more attractive to potential scavengers than microbats and other bird species. Another factor may be the necessary deploying of carcasses repeatedly over one season in a limited area, which may have resulted in attracting scavengers to the site due to scavenging opportunities being available for extended periods,

thus resulting in much higher scavenging activity. However, there may just be very high scavenger activity at MWWF2. As such; the mortality estimates in this case may not be appropriate to use as an assessment tool for impacts at MWWF2.

4.5. Adaptive management recommendations

Considering the discussion above, it is recommended that any further monitoring and mitigation measures focus on raptors and microbat species.

As per Section 3.6 of the BAMP; MWWF2 is primarily a crop farm, however removal of carrion from underneath turbines in paddocks used for stock grazing is recommended to continue for the life of the wind farm. Additionally, stock should not be fed grain within 200 metres of turbines (subject to land holder agreement) as this may attract parrots.

MWWF2 should continue to work with landholders over the life of the project to minimise the attractiveness of the site to raptors.

The required two-year mortality detection program at MWWF2 has now concluded. The 24 months of mortality search data provide a valuable insight into the impact of the wind farm on bird and bat species in the region. Extension of the formal carcass monitoring program is not recommended nor required at this time.

Incidental reporting of carcasses by staff at Murra Warra Wind Farm – Stage One and Two should continue. Wind Farm staff should continue to photograph and store any carcasses found by staff under turbines as per the BAM Plan. This will continue to provide some indication of ongoing impacts to birds and bats at the wind farm. MWWF should continue to work with landholders over the life of the project to minimise the attractiveness of the site to raptors, parrots, and other species of birds.

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Appendix 1: Carcass find data sheet for Murra Warra Wind Farm (Inc. MWII)

BAT AND AVIFAUNA MANAGEMENT PLAN DEAD/INJURED BIRD AND BAT DATASHEET				
Date and location:				
Date:	Observer/s:			
Time animal was found:	GPS coordinates:			
Turbine ID/location description:				
Detection:				
Survey method (circle):	*Formal*	*Incidental*		
Carcass/injured animal photographed? *Yes / No*	Photo details (e.g., photo numbers, location of saved photos):			
Weather details at the time of detection:				
Temperature:	*Cold <15 °C*	*Mild 15 - 30 °C*	*Hot >30 °C*	
Precipitation:	*Fine*	*Showers*	*Rain*	
Wind strength:	*Calm*	*Breeze*	*Moderate*	*Strong*
Wind direction:	Cloud cover (%):			
Carcass/injured animal information and condition				
Species (if unknown, classify to closest taxonomic group):				
Age (circle):	*Unknown*	*Adult*	*Juvenile*	
Sex (circle):	*Unknown*	*Male*	*Female*	
Condition (circle):	*Dead (carcass)*	*Injured but alive*	*Feather spot (10+ feathers)*	
Degree of decay (circle):	*Fresh*	*> a week old*	*Very old or highly decayed*	
Describe type of any injuries evident:				
Notes/ additional information				

Appendix 2: Data collected during incidental raptor observations

- Date
- Species
- Number of individuals (count)
- Time
    - Start and end of observation.
- Distance (m) from observer
- Height range above the ground
    - As observed initially
    - Maximum height reached during observation
    - Minimum height reached during observation
- Location (as observed initially)
    - Perched, in the air, on the ground
- Habitat flown over
    - Hardstand, cropped land, grazing paddock, etc.
- Behaviour (as observed initially)
    - Soaring, gliding, hovering, powered (flapping), displaying, resting, foraging
- Flight path
    - Spatial polyline depicting the flight path as accurate as possible, including any circling behaviour
    - Recorded on georeferenced mapping software (ArcGIS Field Maps®)
    - Where a pair of raptors are flying together for the duration of the observation, a single flight path is plotted (if they diverge, flight paths are plotted separately).

Appendix 3: Details of the timing and staff of carcass search surveys

Season	Date	Search team	Individual Surveys
Summer	30/01/2023, 31/01/2023	LB & Kitty/Gir	12
	21/02/2023, 22/02/2023	LB & Kitty/Gir	11
	11/12/2023, 12/12/2023	KS & Banjo	12
	08/01/2024, 09/01/2024	KS & Banjo	11
	26/02/2024, 27/02/2024	KS, LXA & Banjo	11
	03/12/2024, 04/12/2024	JRG & Cruise/Barkimedes	12
Autumn	20/03/2023, 21/03/2023	LB & Kitty/Gir	12
	17/04/2023, 18/04/2023	LB & Kitty	11
	22/05/2023, 23/05/2023	LB & Banjo/Gir	10
	12/03/2024, 13/03/2024	KS & Banjo	12
	22/04/2024, 23/04/2024	KS & Banjo	12
	15/05/2024, 16/05/2024	KS & Banjo	12
Winter	14/06/2023	LB & Banjo/Gir	11
	24/07/2023, 25/07/2023	LB & Banjo/Gir	12
	21/08/2023, 22/08/2023	LB, SP & Gir	12
	24/06/2024, 25/06/2024	JJ & Kitty	12
	15/07/2024, 16/07/2024	LXA & Banjo	12
	26/08/2024, 27/08/2024, 28/08/2024	OL & Kitty	12
Spring	18/09/2023, 19/09/2023, 20/09/2023	LB & Banjo/Gir	12
	30/10/2023, 31/10/2023	LB, LXA & Banjo	12
	16/11/2023, 17/11/2023	LA & Gir	12
	10/09/2024	LXA & Gir	11
	01/10/2024, 02/10/2024, 03/10/2024	JRG, MP & Gir	12
	11/11/2024, 12/11/2024	KS & Banjo	6

Notes: Sam Plant (SP), Liz Browne (LB), Kelsey Smith (KS), Lana Abdelganne (LXA), Lilith Armstrong (LA), Jesra Garcia (JRG), Oriana Lucil-Milevoj (OL), Mel Potter (MP), Jessica Johnson (JJ).

Appendix 4: Bird mortality data obtained during the first year of monitoring MWII, January 2023 – December 2024

Date	Common Name	Scientific Name	Carcass type	Threatened Status	Carcass (C)/ Feather spot (FS)/ Incidental (INC)	Turbine number	Distance from turbine (m)	Bearing from turbine (°)	Notes
30/01/2023	Common Starling	*Sturnus vulgaris*	Bird	None	C2301-2	18	63	145	Juvenile becoming adult. Most of body missing, just beak, some feathers and one leg, feathers are dark brown on remnant of body, lighter brown for scattered feathers and some shiny green visible, also an orange edge to some feathers.
31/01/2023	Nankeen Kestrel	*Falco cenchroides*	Bird	None	C2301-4	31	41	103	Clear a raptor, based on skull and beak, very old weeks+, barring on tail faded but visible, appropriate size and colouring for kestrel.
31/01/2023	Nankeen Kestrel	*Falco cenchroides*	Bird	None	C2301-5	9	74	145	Just the head and one tail feather, ID'd by pattern/colour of feathers and size of head, three plus days old.
21/02/2023	Nankeen Kestrel	*Falco cenchroides*	Feather Spot	None	FS2302-1	22	68	90	20+ feathers including primary flight feathers, tail feathers and small body/down feathers. Identified by distinctive barring pattern and size of feathers.
21/02/2023	Eastern Barn Owl	*Tyto alba*	Feather Spot	None	FS2302-2	31	78	300	30+ feathers, half white with a speckled brown other side with a faint barring, also lots of fluffy plain white down feathers.
20/03/2023	White-faced Heron	*Egretta novaehollandiae*	Feather Spot	None	INC2303-1	31	113	180	Found during search but outside search radius. Pile of grey feathers, 10+ and down. Feathers identified by bl - from adult bird, the moult shoes it is adult, size, shape and colour of feathers indicated species.
21/03/2023	Nankeen Kestrel	*Falco cenchroides*	Feather Spot	None	FS2303-1	28	90	14	Multiple feathers 20+, flight and tail, distinctive pattern of barring.
23/05/2023	Nankeen Kestrel	*Falco cenchroides*	Bird	None	C2305-5	9	29	197	Very fresh, brown face female, heavy streaking on chest indicates potential juvenile.
21/08/2023	Tree Martin	*Petrochelidon nigricans*	Bird	None	C2308-1	16	90	27	Small bird, <24 hours old, Tail missing, chestnut coloured spot on forehead, off-white under the chin/breast with dark streaks, dark blue/black crown/nape/back, wings dark grey on back and white underneath.
18/09/2023	Black-tailed Nativehen	*Trybonix ventralis*	Bird	None	INC2309-1	18	107	208	Brown body feathers, red legs, grey neck, faded yellow peak, black tail, approx. size of a pigeon/moorhen
31/10/2023	Wedge-tailed Eagle	*Aquila audax*	Bird	None	C2310-1	24	66	54	<24 hours old, juvenile (pale crown, nape and rump, inner wing bar, barred wing and tail feathers), query male (toe length 64mm approx.), blood around the beak, broken neck
31/10/2023	Black-shouldered Kite	*Elanus axillaris*	Bird	None	C2310-2	22	65	97	<24 hours, no visible wounds, broken neck, adult.
16/11/2023	Stubble Quail	*Coturnix pectoralis*	Bird	None	C01-231116	34	90	183	Few days old, complete carcass, visible wound in chest with maggots.
17/11/2023	Nankeen Kestrel	*Falco cenchroides*	Feather Spot	None	Fs1-231117	21	25	104	Clumps of tail feathers & down indicative of nankeen kestrel.
27/02/2024	Nankeen Kestrel	*Falco cenchroides*	Feather Spot	None	FS2402-1	11	54	190	Distinct white and black pattern on wings, rufous feathers with black tip and black barring, clumps of feathers and down.
12/03/2024	Nankeen Kestrel	*Falco cenchroides*	Feather Spot	None	FS2403-1	11	30	3	Distinct white and black pattern on wings, rufous feathers with black tip and black barring, clumps of feathers and down.
13/03/2024	Nankeen Kestrel	*Falco cenchroides*	Bird	None	C2403-3	16	14	237	Distinct white and black pattern on wings, rufous feathers with black tip and black barring, clumps of feathers and down.
13/03/2024	Fork-tailed Swift	*Apus Pacificus*	Bird	None	INC2403-2	18	102	155	White patch on throat and rump, grey feathers speckled with white, fork shape visible in tail, tapering body. Fresh+3 days old, visible head wound.
13/03/2024	Fork-tailed Swift	*Apus Pacificus*	Bird	None	INC2403-3	21	97	246	White patch on throat and rump, grey feathers speckled with white, tapering body. Fresh+3 days old, wound to abdomen, tail missing.
25/06/2024	Wedge-tailed Eagle	*Aquila audax*	Bird	None	C24.06.1	28	103	101	<72hrs old (not stiff), fully intact, broken wing, no feather spread, light brown feathers around head, barring on inner primaries.
25/06/2024	Magpie-lark	*Grallina cyanoleuca*	Feather Spot	None	FS24.06.1	28	80	192	Black & white feathers, feather spread = 1m, wing feathers avg. Length = 8-11cm.
15/07/2024	Australian Magpie	*Gymnorhina tibicen*	Feather Spot	None	C01-150724	11	35	164	Feather spot spread out over 1m, >10 feathers.
26/08/2024	Wedge-tailed Eagle	*Aquila audax*	Bird	None	C24.08.01	5	89	322	Whole intact body, not stiff, <10 med-larger feather spread.

Date	Common Name	Scientific Name	Carcass type	Threatened Status	Carcass (C)/ Feather spot (FS)/ Incidental (INC)	Turbine number	Distance from turbine (m)	Bearing from turbine (°)	Notes
26/08/2024	Nankeen Kestrel	*Falco cenchroides*	Bird	None	C24.08.03	11	9	143	One wing with >15 feathers attached, distinct white and black pattern on wing, a small piece of bone with several smaller feathers attached.
27/08/2024	Unidentified Bird sp.	*Unknown sp.*	Bird	None	C24.08.04	34	12	63	Bones of small bird wing with several small white feathers.
01/10/2024	Nankeen Kestrel	*Falco cenchroides*	Bird	None	INC241001-01	12	10	-	Whole intact body; bleeding from right nostril; found by turbine technicians at 9:30am, within a few hours of being hit as body was still warm and not yet stiff.

Appendix 5: Bat mortality data obtained during the first year of monitoring at MWII, January 2023 – December 2024

Date	Common Name	Scientific Name	Carcass type	Threatened Status	Carcass (C)/ Feather spot (FS)/ Incidental (INC)	Turbine number	Distance from turbine (m)	Bearing from turbine (°)	Notes
30/01/2023	Unidentified Microbat sp.	*Unknown sp.*	Bat	N/A	C2301-1	18	38	240	Just the wing, forearm broken and unable to be measured.
31/01/2023	Southern Freetail Bat	*Ozimops planiceps*	Bat	None	C2301-3	16	44	250	FA 32mm, prominent nostrils, freetail visible
31/01/2023	Southern Freetail Bat	*Ozimops planiceps*	Bat	None	C2301-6	22	70	247	Very old, fa 33mm, freetail, pronounced nostril, most fur gone.
31/01/2023	Southern Freetail Bat	*Ozimops planiceps*	Bat	None	INC2301-1	28	112	186	FA 34mm, freetail visible, 1-3 days old (covered in ants)
31/01/2023	Unidentified Microbat sp.	Unknown sp.	Bat	N/A	C2301-7	3	48	200	FA34mm, all identifying features destroyed by decomposition/injury. Unable to tell whether freetail or enclosed tail.
21/02/2023	Southern Freetail Bat	*Ozimops planiceps*	Bat	None	C2302-1	28	73	306	FA 32mm, prominent nostrils, freetail visible, back is darkish grey with pale base to fur, belly is pale grey, no signs of injury, less than one day old.
21/02/2023	Gould's Wattled Bat	*Chalinolobus gouldii*	Bat	None	C2302-2	9	16	180	FA 34mm, enclosed tail, dark fur on head, most of the body eaten by ants. Three plus days old
22/02/2023	Southern Freetail Bat	*Ozimops planiceps*	Bat	None	C2302-3	16	63	312	FA33mm freetail, prominent nostrils, pale grey back with paler grey belly, large wound on abdomen, approx. 1 day old.
20/03/2023	Little Forest Bat	*Vespadelus vulturnus*	Bat	None	C2303-1	16	66	8	3+ days old, FA 27mm, enclosed tail, headless, most of body missing, one wing broken
20/03/2023	Southern Freetail Bat	*Ozimops planiceps*	Bat	None	C2303-2	16	60	286	FA approx. 34mm (slightly broken), 1-3 days old, light grey belly fur, many wounds, all over body
21/03/2023	Southern Freetail Bat	*Ozimops planiceps*	Bat	None	C2303-3	22	68	235	FA 33mm, pale grey belly, darker grey back, prominent nostrils, three plus days old
21/03/2023	Freetail Bat sp.	*Ozimops sp.*	Bat	None	C2303-4	28	66	347	Just the legs and tail, probably southern freetail but unknown, three plus days old
18/04/2023	Gould's Wattled Bat	*Chalinolobus gouldii*	Bat	None	C2304-1	16	84	192	FA 44mm, dark fur on back of head, wattle visible, enclosed tail, <1 day old.
18/04/2023	Southern Freetail Bat	*Ozimops planiceps*	Bat	None	C2304-2	21	90	178	FA 34mm, freetail, prominent nostril, light grey fur which is paler on the belly. Wound on abdomen. Less than one day old. Adult.
18/04/2023	Gould's Wattled Bat	*Chalinolobus gouldii*	Bat	None	C2304-3	22	64	210	FA 44.5mm, male, dark fur on back of head, enclosed tail, less than one day old, wound on inside of neck.
18/04/2023	Unidentified Microbat sp.	*Unknown sp.*	Bat	N/A	C2304-4	11	31	50	Just a fragment of wing and broken forearm, unable to be identified - although looks large, query WSFTB
18/04/2023	Gould's Wattled Bat	*Chalinolobus gouldii*	Bat	None	INC2304-1	11	130	350	FA 44mm, dark fur on back of head, 3+ days old
18/04/2023	Gould's Wattled Bat	*Chalinolobus gouldii*	Bat	None	C2304-5	11	70	195	FA 45mm, dark fur on back of head, wattle visible, <24 hours old
18/04/2023	Unidentified Microbat sp.	*Unknown sp.*	Bat	N/A	C2304-6	3	88	274	3+ days, looked small query little forest bat - unidentified due to kitty eating carcass
18/04/2023	White-striped Freetail Bat	*Austronomus australis*	Bat	None	C2304-7	3	56	260	3 + days old, FA 60mm, freetail
18/04/2023	Gould's Wattled Bat	*Chalinolobus gouldii*	Bat	None	INC2304-2	3	100	234	< 24 hours, dark fur on head, FA 44mm
18/04/2023	Gould's Wattled Bat	*Chalinolobus gouldii*	Bat	None	C2304-8	3	66	180	<24 hours, dark fur on head, wattle visible, forearms broken but look approximate length for species
18/04/2023	White-striped Freetail Bat	*Austronomus australis*	Bat	None	C2304-9	3	56	337	3 + days old, FA 60mm, freetail
22/05/2023	Large Forest Bat	*Vespadelus Darlington*	Bat	None	C2305-1	16	82	57	1-3 days old (maggots), FA 34mm
22/05/2023	Gould's Wattled Bat	*Chalinolobus gouldii*	Bat	None	C2305-2	16	24	190	3+ days old, FA 44mm, dark fur on back of head
22/05/2023	Southern Freetail Bat	*Ozimops planiceps*	Bat	None	C2305-3	15	12	130	3+ days old, prominent nostril, FA 34mm, freetail visible. Fur largely decayed but a pale grey.
23/05/2023	White-striped Freetail Bat	*Austronomus australis*	Bat	None	C2305-4	31	57	140	Body missing, just a chunk of fur and one wing, FA60mm, 3+ days old

Date	Common Name	Scientific Name	Carcass type	Threatened Status	Carcass (C)/ Feather spot (FS)/ Incidental (INC)	Turbine number	Distance from turbine (m)	Bearing from turbine (°)	Notes
23/05/2023	White-striped Freetail Bat	*Austronomus australis*	Bat	None	C2305-6	28	80	188	3+ days old, body largely decayed, FA61mm
23/05/2023	White-striped Freetail Bat	*Austronomus australis*	Bat	None	C2305-7	22	52	291	3+ days old, freetail visible, fa61mm
23/05/2023	White-striped Freetail Bat	*Austronomus australis*	Bat	None	C2305-8	22	88	140	1-3 days old, freetail, white stripe, large fa 60mm
14/06/2023	Gould's Wattled Bat	*Chalinolobus gouldii*	Bat	None	C2306-1	31	44	60	Most hair missing, enclosed tail, FA44mm,
19/09/2023	White-striped Freetail Bat	*Austronomus australis*	Bat	None	C2309-1	31	60	250	Fresh wound on abdomen less than 24 hours, freetail, white stripe visible fa 60mm
19/09/2023	White-striped Freetail Bat	*Austronomus australis*	Bat	None	C2309-2	21	19	233	Fresh, <24 hours, male, no visible wounds, fa 60mm, freetail visible, white stripe
19/09/2023	White-striped Freetail Bat	*Austronomus australis*	Bat	None	C2309-3	21	61	220	Fresh, <24 hours, male, no visible wounds, fa 60mm, freetail visible, white stripe
19/09/2023	Freetail Bat sp. (Southern or Eastern)	Ozimops sp. (planiceps/ridei)	Bat	None	C2309-4	21	45	90	3+ days old, fa 34mm, visible freetail, fur and facial details deteriorated.
20/09/2023	Freetail Bat sp. (Southern or Eastern)	Ozimops sp. (planiceps/ridei)	Bat	None	C2309-5	15	62	73	Maggots, prominent nostrils, freetail visible, fa 33mm. Fur on head decomposed.
31/10/2023	Freetail Bat sp. (Southern or Eastern)	Ozimops sp. (planiceps/ridei)	Bat	None	INC2310-1	15	103	134	3+ days old, FA 32mm, exposed bones, all fur missing, high level decomposition, visible freetail
17/11/2023	Large Forest Bat	*Vespadelus darlington*	Bat	None	C02-231117	22	72	30	Few days old, partially scavenged, mousey coloured fur (indicating species)
12/12/2023	White-striped Freetail Bat	*Austronomus australis*	Bat	None	C23112-1	22	38	167	Desiccated, freetail visible, fa 60mm, belly fur scarce, but faint white stripe visible.
8/01/2024	Unidentified microbat sp.	*Unknown sp.*	Bat	N/A	C0124 -1	15	92	215	Very desiccated, scavenged as wings missing, most of skull exposed and facial fur/skin decayed
8/01/2024	Southern Freetail Bat	*Ozimops planiceps*	Bat	None	C0124 -2	15	80	9	Very desiccated, partly scavenged, lighter fur colouring FA 31mm, freetail clearly visible
26/02/2024	White-striped Freetail Bat	*Austronomus australis*	Bat	None	C2402-1	3	85	282	<7 days old, impacted carcass, scavenged, dark fur, FA58mm, white stripe visible
27/02/2024	Evening Bat sp.	*Vespertilionidae sp.*	Bat	None	C2402-2	16	80	320	>7 days old, complete carcass, impact wound visible, dark colouring, tail enclosed, very desiccated FA 32mm
12/03/2024	Lesser long-eared bat	*Nyctophilus geoffroyi*	Bat	None	C2403-1	15	85	204	Tail fully enclosed in membrane, ears joined above head by band of skin, light grey fur on back, fur bi-coloured dark at base, bright white on belly, FA 33.8
12/03/2024	Lesser long-eared bat	*Nyctophilus geoffroyi*	Bat	None	C2403-2	15	80	202	Tail fully enclosed in membrane, ears joined above head by band of skin, light grey fur on back, fur bi-coloured dark at base, bright white on belly, FA 34.7
13/03/2024	Freetail Bat sp. (Southern or Eastern)	Ozimops sp. (planiceps/ridei)	Bat	None	C2403-5	28	73	190	Free-tailed bat, FA 35, very desiccated and dried + 7 days, light brown colouring, genitalia not present
13/03/2024	Unidentified microbat sp.	*Unknown sp.*	Bat	N/A	C2403-4	34	85	250	Partial microbat wing, FA not present
13/03/2024	Gould's Wattled Bat	*Chalinolobus gouldii*	Bat	None	INC2403-4	3	102	187	Fur dark brown/black on head to lighter browner on rump, small wattle at base of mouth, FA 44
22/04/2024	Gould's Wattled Bat	*Chalinolobus gouldii*	Bat	None	C2404-1	5	69	72	Fur dark brown/black on head to lighter browner on rump, small wattle at base of mouth, FA 41
23/04/2024	Gould's Wattled Bat	*Chalinolobus gouldii*	Bat	None	C2404-2	15	73	53	Fur dark brown/black on head to lighter browner on rump, small wattle at base of mouth, FA 42.4

Date	Common Name	Scientific Name	Carcass type	Threatened Status	Carcass (C)/ Feather spot (FS)/ Incidental (INC)	Turbine number	Distance from turbine (m)	Bearing from turbine (°)	Notes
15/05/2024	Unidentified microbat sp.	*Unknown sp.*	Bat	N/A	C2405-1	34	90	271	Half bat wing, unable to be identified as wing was damaged
26/08/2024	White-striped Freetail Bat	*Austronomus australis*	Bat	None	C24.08.02	11	45	125	60mm FA, free tail, two white stripes on torso next to wings, very fresh, very limp
10/09/2024	White-striped Freetail Bat	*Austronomus australis*	Bat	None	C01-100924	3	32	156	Fully intact, no injury present, very fresh and limp, <24 hours old.
2/10/2024	Southern Freetail Bat	*Ozimops planiceps*	Bat	None	C241002-01	28	80	230	Forearm 33 mm Penis 9 mm, 1-2 weeks old, maggots, wing membrane eaten away, bones remain, much of face eaten away; grey fur with white stomach (coordinates: -36.24724, 142.22739)
2/10/2024	Freetail Bat sp. (Southern or Eastern)	Ozimops sp. (planiceps/ridei)	Bat	None	C241002-02	16	64	189	Forearm 34 mm; genitalia eaten away; approx. 4 weeks old, desiccated carcass, wholly intact other than genitalia and throat area decayed/eaten away; sandy brown-ish fur (coordinates: -36.25227, 142.19050)
3/12/2024	White-striped Freetail Bat	*Austronomus australis*	Bat	None	C241203-01	5	77	76	Large free-tailed bat wholly intact but with trauma to neck and chest; body limp and wet from overnight rain covered in ants
3/12/2024	Freetail Bat sp.	*Ozimops sp.*	Bat	None	C241203-02	16	47	162	Extremely desiccated but skeletally intact body; tissues of wings, abdomen, face eaten away; dark brown almost black wings and fur; tail fully enclosed within membrane; P3 and P2 similar length
3/12/2024	Unidentified Microbat sp.	*Unknown sp.*	Bat	N/A	C241203-03	16	123	203	Two extremely desiccated bat wings (forearms through to P3) with dark brown membrane desiccated and eaten away but some still attached; P3 and P2 similar length

Appendix 6: Searcher efficiency results at MWWF – August 2023, February 2024 and April 2024, September 2024.

Trial ID	Date	Search Team	Turbine	Species	Carcass Type	Size	Ground Type	Detection	Distance (m)
1	21/08/2023	Gir	16	Gould's Wattled Bat	Bat	Small	Short crop	Yes	46
2	21/08/2023	Gir	16	Common Myna	Bird	Medium	Short crop	Yes	64
3	21/08/2023	Gir	15	Gould's Wattled Bat	Bat	Small	Mud	Yes	39
4	22/08/2023	Gir	18	Gould's Wattled Bat	Bat	Small	Mud	Yes	78
5	22/08/2023	Gir	31	Common Myna	Bird	Medium	Short grass	Yes	61
6	22/08/2023	Gir	31	Common Myna	Bird	Medium	Short crop	Yes	18
7	22/08/2023	Gir	9	Gould's Wattled Bat	Bat	Small	Short crop	Yes	50
8	22/08/2023	Gir	9	Gould's Wattled Bat	Bat	Small	Short crop	Yes	40
9	22/08/2023	Gir	28	Common Myna	Bird	Medium	Short crop	Yes	25
10	22/08/2023	Gir	28	Common Myna	Bird	Medium	Hardstand	Yes	37
11	22/08/2023	Gir	28	Crimson Rosella	Bird	Medium	Short crop	Yes	73
12	22/08/2023	Gir	21	Common Myna	Bird	Medium	Hardstand	Yes	6
13	22/08/2023	Gir	22	Common Myna	Bird	Medium	Very short crop	Yes	80
14	22/08/2023	Gir	22	Common Myna	Bird	Medium	Very short crop	Yes	48
15	22/08/2023	Gir	3	White-striped Freetail Bat	Bat	Small	Short grass	Yes	15
16	22/08/2023	Gir	3	Little Forest Bat	Bat	Small	Long grass	Yes	35
17	22/08/2023	Gir	5	Gould's Wattled Bat	Bat	Small	Long grass	Yes	38
18	22/08/2023	Gir	11	Common Myna	Bird	Medium	Short grass	Yes	35
19	22/08/2023	Gir	11	Gould's Wattled Bat	Bat	Small	Hardstand	Yes	18
20	26/02/2024	Banjo	11	Gould's Wattled Bat	Bat	Small	Short crop	Yes	72
21	26/02/2024	Banjo	3	Common Myna	Bird	Medium	Tall grass	Yes	31.8
22	26/02/2024	Banjo	3	Gould's Wattled Bat	Bat	Small	Cropped	Yes	80.6
23	26/02/2024	Banjo	3	Common Myna	Bird	Medium	Hardstand	Yes	4.4
24	26/02/2024	Banjo	5	Common Myna	Bird	Medium	Hardstand	Yes	27.6
25	26/02/2024	Banjo	5	White-striped Freetail Bat	Bat	Small	Cropped	No	95.3
26	27/02/2024	Banjo	5	Common Myna	Bird	Medium	Cropped	Yes	83.6
27	27/02/2024	Banjo	11	Common Myna	Bird	Medium	Cropped	Yes	26.9

Trial ID	Date	Search Team	Turbine	Species	Carcass Type	Size	Ground Type	Detection	Distance (m)
28	27/02/2024	Banjo	11	White-striped Freetail Bat	Bat	Small	Hardstand	Yes	4.1
29	27/02/2024	Banjo	15	White-striped Freetail Bat	Bat	Small	Cropped	Yes	70.8
30	27/02/2024	Banjo	15	White-striped Freetail Bat	Bat	Small	Cropped	Yes	7.7
31	27/02/2024	Banjo	15	Common Myna	Bird	Medium	Cropped	Yes	79.8
32	27/02/2024	Banjo	18	Common Myna	Bird	Medium	Gravel	Yes	89.5
33	27/02/2024	Banjo	18	Common Myna	Bird	Medium	Cropped	No	63.6
34	27/02/2024	Banjo	18	White-striped Freetail Bat	Bat	Small	Cropped	Yes	71.7
35	27/02/2024	Banjo	16	Common Myna	Bird	Medium	Cropped	Yes	27.8
36	27/02/2024	Banjo	16	Common Myna	Bird	Medium	Cropped	Yes	54.2
37	27/02/2024	Banjo	9	White-striped Freetail Bat	Bat	Small	Cropped	Yes	33.3
38	27/02/2024	Banjo	9	White-striped Freetail Bat	Bat	Small	Gravel	Yes	35.1
39	27/02/2024	Banjo	22	Common Myna	Bird	Medium	Dirt	Yes	37.1
40	27/02/2024	Banjo	22	Common Myna	Bird	Medium	Cropped	Yes	72
41	27/02/2024	Banjo	22	White-striped Freetail Bat	Bat	Small	Cropped	Yes	28.6
42	27/02/2024	Banjo	21	Common Myna	Bird	Medium	Cropped	Yes	74.4
43	27/02/2024	Banjo	21	Common Myna	Bird	Medium	Cropped	Yes	63.7
44	27/02/2024	Banjo	28	Common Myna	Bird	Medium	Cropped	Yes	30.7
45	27/02/2024	Banjo	28	White-striped Freetail Bat	Bat	Small	Gravel	Yes	55
46	23/04/2024	Banjo	15	White-striped Freetail Bat	Bat	Small	Dirt	No	73
47	23/04/2024	Banjo	15	Common Myna	Bird	Medium	Dirt	Yes	66
48	23/04/2024	Banjo	15	White-striped Freetail Bat	Bat	Small	Dirt	Yes	9.3
49	23/04/2024	Banjo	16	Common Myna	Bird	Medium	Cropping	Yes	78.6
50	23/04/2024	Banjo	16	White-striped Freetail Bat	Bat	Small	Hardstand	Yes	38
51	23/04/2024	Banjo	16	Common Myna	Bird	Medium	Grass	Yes	12.7
52	23/04/2024	Banjo	18	Gould's Wattled Bat	Bat	Small	Gravel	Yes	27.3
53	23/04/2024	Banjo	18	Common Myna	Bird	Medium	Dirt	Yes	41.6
54	23/04/2024	Banjo	18	White-striped Freetail Bat	Bat	Small	Grass	Yes	1
55	23/04/2024	Banjo	9	White-striped Freetail Bat	Bat	Small	Dirt	Yes	78.2

Trial ID	Date	Search Team	Turbine	Species	Carcass Type	Size	Ground Type	Detection	Distance (m)
56	23/04/2024	Banjo	9	Common Myna	Bird	Medium	Gravel	Yes	36.9
57	23/04/2024	Banjo	9	Common Myna	Bird	Medium	Grass	Yes	41.4
58	23/04/2024	Banjo	21	Common Myna	Bird	Medium	Dirt	Yes	14.8
59	23/04/2024	Banjo	21	White-striped Freetail Bat	Bat	Small	Dirt	Yes	36.2
60	23/04/2024	Banjo	21	Nankeen Kestrel	Bird	Medium	Gravel	Yes	67.5
61	23/04/2024	Banjo	22	White-striped Freetail Bat	Bat	Small	Dirt	Yes	17.8
62	23/04/2024	Banjo	22	White-striped Freetail Bat	Bat	Small	Dirt	No	22.4
63	23/04/2024	Banjo	22	Ozimops spp.	Bat	Small	Gravel	Yes	62.3
64	23/04/2024	Banjo	28	Gould's Wattled Bat	Bat	Small	Cropping	Yes	31.7
65	23/04/2024	Banjo	28	Ozimops spp.	Bat	Small	Cropping	Yes	73
66	23/04/2024	Banjo	28	Common Myna	Bird	Medium	Cropping	Yes	74.7
67	23/04/2024	Banjo	34	White-striped Freetail Bat	Bat	Small	Hardstand	Yes	1
68	23/04/2024	Banjo	34	Common Myna	Bird	Medium	Dirt	Yes	73.9
69	10/09/2024	Banjo	5	Wedge-tailed Eagle	Bird	Large	Grass	Yes	45.5
70	10/09/2024	Gir	5	Common Myna	Bird	Medium	Grass	Yes	63.3
71	10/09/2024	Gir	5	Gould's Wattled Bat	Bat	Small	Hardstand	Yes	16.3
72	10/09/2024	Gir	5	Gould's Wattled Bat	Bat	Small	Grass	Yes	88.3
73	10/09/2024	Gir	11	Common Myna	Bird	Medium	Hardstand	Yes	16.7
74	10/09/2024	Gir	11	Common Myna	Bird	Medium	Cropped	Yes	64.1
75	10/09/2024	Gir	11	Freetail Bat	Bat	Small	Dirt/Hardstand	Yes	7.9
76	10/09/2024	Gir	15	Wedge-tailed Eagle	Bird	Large	Cropped	Yes	78.2
77	10/09/2024	Gir	15	Gould's Wattled Bat	Bat	Small	Cropped	Yes	9.3
78	10/09/2024	Gir	15	Nankeen Kestrel	Bird	Medium	Cropped	Yes	7.7
79	10/09/2024	Gir	16	Common Myna	Bird	Medium	Cropped	Yes	21.2
80	10/09/2024	Gir	18	Common Myna	Bird	Medium	Dirt/Gravel/Hardstand	Yes	48.8
81	10/09/2024	Gir	18	Wedge-tailed Eagle	Bird	Large	Cropped	Yes	34.1
82	10/09/2024	Gir	31	Gould's Wattled Bat	Bat	Small	Cropped	Yes	27.3
83	10/09/2024	Gir	31	Gould's Wattled Bat	Bat	Small	Cropped/Dirt	Yes	31.4

Trial ID	Date	Search Team	Turbine	Species	Carcass Type	Size	Ground Type	Detection	Distance (m)
84	10/09/2024	Gir	31	Gould's Wattled Bat	Bat	Small	Hardstand/Grass	Yes	78.2
85	10/09/2024	Gir	21	Freetail Bat	Bat	Small	Hardstand	Yes	43.7
86	10/09/2024	Gir	21	Wedge-tailed Eagle	Bird	Large	Cropped	Yes	18.3
87	10/09/2024	Gir	21	Wedge-tailed Eagle	Bird	Large	Grass/Dirt	Yes	88.6
88	10/09/2024	Gir	22	Common Myna	Bird	Medium	Cropped	Yes	20.3
89	10/09/2024	Gir	22	Common Myna	Bird	Medium	Cropped	No	32.5
90	10/09/2024	Gir	22	Common Myna	Bird	Medium	Hardstand	Yes	38.6
91	10/09/2024	Gir	22	Nankeen Kestrel	Bird	Medium	Hardstand/Cropped	Yes	80.1
92	10/09/2024	Gir	28	Wedge-tailed Eagle	Bird	Large	Cropped	Yes	50.2
93	10/09/2024	Gir	28	Wedge-tailed Eagle	Bird	Large	Cropped	Yes	69.4
94	10/09/2024	Gir	28	Wedge-tailed Eagle	Bird	Large	Cropped	Yes	84.1
95	10/09/2024	Gir	34	Gould's Wattled Bat	Bat	Small	Hardstand	Yes	47.1
96	10/09/2024	Gir	34	Gould's Wattled Bat	Bat	Small	Hardstand	Yes	66.6
97	10/09/2024	Gir	34	Wedge-tailed Eagle	Bird	Large	Tall Grass	Yes	37.3
98	10/09/2024	Gir	34	Wedge-tailed Eagle	Bird	Large	Tall Grass	Yes	24.9

Appendix 7: Carcass persistence results

Trial start date	Trial Start time	Turbine	Species	Species used	Scavenger ID	Scavenge substrate	Date Scavenge Detected	Time Scavenge Detected	Scavenger
21/08/2023	15:50	34	Common Myna	Bird	1	Mud/Short Grass	22/08/2023	10:45	Raven sp.
21/08/2023	16:23	16	Common Myna	Bird	2	Short Grass	-	-	Scavenge Missed
22/08/2023	12:34	9	Common Myna	Bird	3	Mud/Short Grass	22/08/2023	11:08	Red Fox
22/08/2023	12:48	18	Common Myna	Bird	4	Long Grass	29/08/2023	22:07	Red Fox
22/08/2023	13:05	31	Crimson Rosella	Bird	5	Long Grass	-	-	Not Scavenged
22/08/2023	13:29	28	Common Myna	Bird	6	Long Grass	23/08/2023	11:23	Red Fox
22/08/2023	13:56	21	Australian Magpie	Bird	7	Long Grass	28/08/2023	23:58	Red Fox
22/08/2023	14:09	22	Common Myna	Bird	8	Long Grass	25/08/2023	9:06	Red Fox
22/08/2023	15:00	5	Gould's Wattled Bat	Bat	9	Hardstand	24/08/2023	1:00	Red Fox
22/08/2023	15:18	3	Gould's Wattled Bat	Bat	10	Long Grass	-	-	Scavenge Missed
18/09/2023	15:47	16	Common Myna	Bird	11	-	-	-	Scavenge Missed
18/09/2023	15:57	18	White-striped Freetail Bat	Bat	12	Long Grass	19/09/2023	21:29	Red Fox
19/09/2023	9:15	34	Nankeen Kestrel	Bird	13	Hardstand	22/09/2023	23:29	Red Fox
19/09/2023	11:13	9	White-striped Freetail Bat	Bat	14	Hardstand	-	-	Camera Fail
19/09/2023	12:00	28	Black-tailed Nativehen	Bird	15	Crops	19/09/2023	22:08	Red Fox
19/09/2023	13:22	21	White-striped Freetail Bat	Bat	16	Grass	17/10/2023	6:19	Red Fox
19/09/2023	14:20	22	Australian Magpie	Bird	17	Grass	21/09/2023	20:10	Red Fox
19/09/2023	15:25	3	White-striped Freetail Bat	Bat	18	Hardstand	19/09/2023	16:56	Raven sp.
20/09/2023	10:10	11	Common Myna	Bird	19	Crops	25/09/2023	1:16	Red Fox
31/10/2023	10:40	15	White-striped Freetail Bat	Bat	20	Hardstand	2/11/2023	14:55	Raven sp.

Trial start date	Trial Start time	Turbine	Species	Species used	Scavenger ID	Scavenge substrate	Date Scavenge Detected	Time Scavenge Detected	Scavenger
31/10/2023	11:20	31	Brown Falcon	Bird	21	Low Crops	2/11/2023	10:13	Red Fox
31/10/2023	12:05	24	Long-billed Corella	Bird	22	Hardstand	1/11/2023	19:05	Australian Magpie
31/10/2023	12:44	28	Common Myna	Bird	23	Crops	3/11/2023	21:28	Red Fox
31/10/2023	13:55	23	White-striped Freetail Bat	Bat	24	Hardstand	-	-	Camera Fail
31/10/2023	14:19	20	White-striped Freetail Bat	Bat	25	Hardstand	9/11/2023	12:44	Red Fox
31/10/2023	15:00	2	Common Myna	Bird	26	Hardstand	7/11/2023	19:59	Red Fox
31/10/2023	15:12	1	Tree Martin	Bird	27	Hardstand	6/11/2023	14:18	Scavenge Missed
31/10/2023	16:09	11	White-striped Freetail Bat	Bat	28	Crops	-	-	Scavenge Missed
31/10/2023	16:50	5	White-striped Freetail Bat	Bat	29	Hardstand	31/10/2023	20:36	Red Fox
27/02/2024	9:05	10	Common Myna	Bird	30	Grass	4/03/2024	-	Red Fox
27/02/2024	9:22	15	Common Myna	Bird	31	Grass	29/02/2024	21:29	Red Fox
27/02/2024	9:42	18	Common Myna	Bird	32	Grass	28/02/2024	20:45	Red Fox
27/02/2024	10:03	17	Common Myna	Bird	33	Grass	29/02/2024	-	Scavenge Missed
27/02/2024	12:33	24	Wedge-tailed Eagle	Bird	34	Grass	27/02/2024	21:56	Red Fox
27/02/2024	12:56	21	Black-shouldered Kite	Bird	35	Grass	29/02/2024	10:06	Red Fox
27/02/2024	13:19	22	White-striped Freetail Bat	Bat	36	Hardstand	27/02/2024	16:23	Australian Magpie
27/02/2024	13:45	28	Nankeen Kestrel	Bird	37	Grass	28/02/2024	-	Scavenge Missed
27/02/2024	14:37	25	White-striped Freetail Bat	Bat	38	Grass	-	-	Scavenge Missed
27/02/2024	14:56	34	White-striped Freetail Bat	Bat	39	Grass	29/02/2024	2:37	Red Fox
12/03/2024	16:45	10	Common Myna	Bird	40	Grass	14/03/2024	-	Scavenge Missed
12/03/2024	17:55	15	Common Myna	Bird	41	Grass	12/03/2024	10:26	Red Fox

Trial start date	Trial Start time	Turbine	Species	Species used	Scavenger ID	Scavenge substrate	Date Scavenge Detected	Time Scavenge Detected	Scavenger
13/03/2024	8:21	24	Wedge-tailed Eagle	Bird	42	Grass	13-14/03/2024	-	Scavenge Missed
13/03/2024	9:05	17	Common Myna	Bird	43	Grass	21/03/2024	18:59	Red Fox
13/03/2024	11:59	21	Common Starling	Bird	44	Grass	14/03/2024	0:23	Red Fox
13/03/2024	13:14	28	Common Myna	Bird	45	Grass	20/03/2024	3:43	Red Fox
13/03/2024	13:43	25	Common Myna	Bird	46	Grass	-	-	Scavenge Missed
13/03/2024	13:53	18	Common Myna	Bird	47	Grass	-	-	Camera Fail
13/03/2024	14:44	34	Grey Fantail	Bird	48	Grass	19/03/2024	0:58	Red Fox
13/03/2024	16:47	22	Gould's Wattled Bat	Bat	49	Hardstand	13/03/2024	19:12	Red Fox
23/04/2024	8:52	17	White-striped Freetail Bat	Bat	50	Grass	-	-	Camera Stolen
23/04/2024	10:01	15	White-striped Freetail Bat	Bat	51	Grass	-	-	Scavenge Missed
23/04/2024	10:13	18	White-striped Freetail Bat	Bat	52	Grass	24/04/2024	18:19	Red Fox
23/04/2024	10:25	10	White-striped Freetail Bat	Bat	53	Grass	-	-	Camera Fail
23/04/2024	11:57	21	Common Myna	Bird	54	Grass	25/04/2024	0:08	Red Fox
23/04/2024	13:38	24	Common Myna	Bird	55	Grass	-	-	Camera Fail
23/04/2024	14:28	28	Common Myna	Bird	56	Grass	24/04/2024	19:45	Red Fox
23/04/2024	14:44	22	Common Myna	Bird	57	Hardstand	23/04/2024	-	Australian Magpie
23/04/2024	15:33	34	Nankeen Kestrel	Bird	58	Grass	26/04/2024	0:31	Red Fox
15/05/2024	15:03	34	Common Myna	Bird	59	Hardstand	16/05/2024	-	Australian Magpie or Red Fox
16/05/2024	7:53	18	Common Myna	Bird	60	Grass	20/05/2024	18:17	Red Fox
16/05/2024	9:41	28	Common Myna	Bird	61	-	-	-	Camera Fail
16/05/2024	10:00	26	Gould's Wattled Bat	Bat	62	-	-	-	Camera Fail
16/05/2024	10:53	16	Gould's Wattled Bat	Bat	63	Grass	27/05/2024	20:08	Red Fox

Trial start date	Trial Start time	Turbine	Species	Species used	Scavenger ID	Scavenge substrate	Date Scavenge Detected	Time Scavenge Detected	Scavenger
16/05/2024	11:50	12	Ozimops sp.	Bat	64	-	29/05/2024	1:32	Red Fox
16/05/2024	12:35	11	White-striped Freetail Bat	Bat	65	-	-	-	Scavenge Missed
17/07/2024	8:35	11	Nankeen Kestrel	Bird	66	Hardstand	17/07/2024	12:17	Red Fox
17/07/2024	8:49	12	Nankeen Kestrel	Bird	67	Grass	17/07/2024	17:33	Raven sp.
17/07/2024	8:59	18	Nankeen Kestrel	Bird	68	Grass	17/07/2024	18:57	Red Fox
17/07/2024	9:14	26	Nankeen Kestrel	Bird	69	Grass	-	-	Camera Fail
17/07/2024	9:27	28	Nankeen Kestrel	Bird	70	Hardstand	-	-	Camera Fail
17/07/2024	9:38	22	Small Chicken	Bird	71	Hardstand	19/07/2024	18:33	Red Fox
17/07/2024	9:53	16	White-striped Freetail Bat	Bat	72	Grass	18/07/2024	7:00	Red Fox
17/07/2024	10:05	34	Nankeen Kestrel	Bird	73	Hardstand	17/07/2024	13:01	Australian Magpie

Appendix 8: Incidental raptor observations during the 24-month monitoring period at MWII, January 2023 – December 2024.

Date	Species	Species count	Time	Height range of bird (m)	Distance (m)	Behaviour	Habitat flown over	Comments (describe location on site for mapping)	Observer
31/01/2023	Black-shouldered Kite	1	9:09	N/A	100	Perched/Resting	-	Perched on tree NW of turbine A22.	LB
21/02/2023	Nankeen Kestrel	2	6:57	10-35	50	Hovering	Road and crops	Both hovering near turbine A19 then flew south-east.	LB
21/02/2023	Nankeen Kestrel	1	7:43	10-20	20	Flapping	Paddocks	Flying along road and then northeast.	LB
21/02/2023	Black-shouldered Kite	2	8:18	5-10	10	Flapping	Crops	Took off from tree and flew over paddocks and back towards road.	LB
21/02/2023	Nankeen Kestrel	1	10:14	5-10	5	Flapping	Crops	Flew across road in a north to south direction, near turbine A22.	LB
21/02/2023	Nankeen Kestrel	1	11:22	0-20	10	Hovering	Crops	Took off from fence and then flew west, then east and hovered.	LB
22/02/2023	Black-shouldered Kite	1	9:12	10-15	0	Flapping	Road and crops	Flew across the road in a north-west direction.	LB
20/03/2023	Black Kite	1	14:15	20-30	0	Gliding	Crops	Flew over observer at turbine A18.	LB
21/03/2023	Nankeen Kestrel	3	10:45	5-20	50	Foraging (Hunting)	Crops	Flew around turbine A22 then went and harassed galahs and magpies in nearby trees.	LB
21/03/2023	Black-shouldered Kite	2	11:41	10-20	30	Powered flight (Flapping)	Crops and scattered trees	Adults, flew past observer.	LB
17/04/2023	Nankeen Kestrel	1	16:31	N/A	N/A	Perched	-	Perched on telegraph pole on Ailsa Wheat Road.	LB
18/04/2023	Nankeen Kestrel	1	9:18	5-20	20	Powered flight (Flapping)	Crops	Adult individual flew in a NE direction near turbine A15.	LB
23/05/2023	Black-shouldered Kite	1	10:28	10-20	20	Powered flight (Flapping)	Crops	Flew past the hardstand of turbine A28.	LB
23/05/2023	Black-shouldered Kite	2	12:00	5-15	60	Powered flight (Flapping)	Crops	N/A	LB
23/05/2023	Nankeen Kestrel	1	13:34	10-20	40	Hovering	Grassland	N/A	LB
23/05/2023	Nankeen Kestrel	1	14:22	N/A	20	Perched	Crops	Adult female.	LB
14/06/2023	Nankeen Kestrel	1	10:46	120-140	0	Soaring	Hardstand	Seen flying directly around hub of turbine A11, 139m high.	LB
14/06/2023	Nankeen Kestrel	2	13:27	15-30	30	Powered flight (Flapping)	Crops		LB
14/06/2023	Nankeen Kestrel	1	13:43	10-20	100	Hovering	Pasture		LB
14/06/2023	Black-shouldered Kite	1	14:01	5-10	10	Gliding	Pasture		LB
14/06/2023	Black-shouldered Kite	1	14:18	15-30	50	Powered flight (Flapping)	Pasture		LB
14/06/2023	Nankeen Kestrel	1	14:26	10-25	40	Powered flight (Flapping)	Pasture		LB
14/06/2023	Nankeen Kestrel	1	15:32	0-20	50	Hovering	Crops		LB
14/06/2023	Nankeen Kestrel	1	16:00	10-20	30	Powered flight (Flapping)	Crops		LB
24/07/2023	Nankeen Kestrel	1	14:07	0-10	10	Resting	Fence	Perched.	LB
24/07/2023	Black-shouldered Kite	1	16:18	20-30	20	Powered flight (Flapping)	Crops		LB
24/07/2023	Nankeen Kestrel	1	16:43	0-10	30	Powered flight (Flapping)	Road		LB
25/07/2023	Nankeen Kestrel	2	10:44	80-140	0	Gliding	Hardstand	Circling round the turbine hub.	LB
25/07/2023	Nankeen Kestrel	1	12:48	0-10	15	Powered flight (Flapping)	Pasture	Perched on road bollard, and then flew away.	LB
25/07/2023	Nankeen Kestrel	2	13:22	20-30	20	Soaring	Crops		LB
21/08/2023	Black-shouldered Kite	1	16:16	10-15	20	Powered flight (Flapping)	Crops	Harassing perched Brown Falcon.	LB
21/08/2023	Brown Falcon	1	16:17	10	15	Resting	-	Perched on powerline.	LB
22/08/2023	Nankeen Kestrel	1	11:32	20-30	30	Powered flight (Flapping)	Crops		LB
22/08/2023	Nankeen Kestrel	1	13:08	5-25	20	Hovering	Pasture		LB
22/08/2023	Nankeen Kestrel	1	13:09	20-30	300	Powered flight (Flapping)	Pasture		LB
22/08/2023	Nankeen Kestrel	1	13:13	20-30	30	Hovering	Pasture		LB
22/08/2023	Nankeen Kestrel	1	14:25	20-30	20	Hovering	Pasture		LB
22/08/2023	Nankeen Kestrel	1	10:56	20-30	30	Hovering	Pasture		SP

Date	Species	Species count	Time	Height range of bird (m)	Distance (m)	Behaviour	Habitat flown over	Comments (describe location on site for mapping)	Observer
22/08/2023	Black-shouldered Kite	1	11:13	20-30	50	Hovering	Pasture		SP
22/08/2023	Black-shouldered Kite	1	11:30	10-20	20	Powered flight (Flapping)	Pasture		SP
22/08/2023	Nankeen Kestrel	1	13:17	2-10	50	Hovering	Pasture		SP
22/08/2023	Nankeen Kestrel	1	14:46	1-8	10	Powered flight (Flapping)	Pasture		SP
19/09/2023	Nankeen Kestrel	1	13:43	0-5	15	Powered flight (Flapping)	Crops	Flew across access road in a northerly direction.	LB
20/09/2023	Nankeen Kestrel	1	9:01	15-20	100	Hovering	Pasture	Over pasture.	LB
31/10/2023	Black-shouldered Kite	1	15:47	5-15	10	Powered flight (Flapping)	Crops	Flew over cropped habitat.	LB
31/10/2023	Black-shouldered Kite	1	15:59	10-20	30	Foraging (Hunting)	Crops	Flew over cropped habitat.	LB
16/11/2023	Black-shouldered Kite	1	17:37	5	-	Resting	-	Bird perched on fence post.	LA
17/11/2023	***Black Falcon**	3	9:07	40-200	-	Displaying/Playing	-	Parents with recently fledged young. Flying between turbines playing, diving, soaring etc. One adult was observed 'attacking' a turbine blade that was switched off.	LA
17/11/2023	Nankeen Kestrel	1	10:08	5	-	Resting	-	Bird perched in tree.	LA
17/11/2023	Nankeen Kestrel	1	10:15	20-60	-	Hovering	-	Hovering over crop close to switched off turbine.	LA
12/12/2023	Nankeen Kestrel	1	9:34	20-40	-	Resting/Powered flight (Flapping)	Crops	Bird perched on fence, then flew from observer, flew over crop field and out of sight.	KS
26/02/2024	Australian Hobby	1	17:33	20-29	-	Hovering	Crops	Hunting.	LXA
13/03/2024	Black-shouldered Kite	1	7:58	10-19	40	Powered flight (Flapping)	Small area of bush, crops	Sitting on powerline, flew away when observer approached.	KS
13/03/2024	Black-shouldered Kite	1	8:03	10-19	100	Foraging (Hunting)	Crops (Wheat)	Bird actively hunting/hovering over crop.	KS
22/04/2024	Wedge-tailed Eagle	2	17:24	200	500	Gliding	Flattened crop	Birds continually circling, continued to circle above same area for a long time.	KS
22/04/2024	Black-shouldered Kite	2	17:58	100	40	Foraging (Hunting)	Hardstand, flattened grass	Birds circling, calling for each other, then birds actively hunting/hovering over crop.	KS
23/04/2024	Black-shouldered Kite	1	18:36	50	-	Powered flight (Flapping)	Crops	Sitting on powerline, flew away from observer then hid in vegetation patch.	LXA
16/05/2024	Black-shouldered Kite	1	9:06	20	20	Perched	Crops	Bird perched on fence, flew away from observer as car approached.	KS
16/05/2024	Black-shouldered Kite	2	14:00	60	100	Perched	Crops	Birds perched, then flew away.	KS
25/06/2024	Nankeen Kestrel	1	9:59	1-7	30	Powered flight (Flapping)	Short crops and hardstand	Bird flying up and down, really low to the ground and close to the turbine, heading east.	JJ
16/07/2024	Black-shouldered Kite	1	8:42	0-9	-	Powered flight (Flapping)	Crops	Bird in air, flapping over plains, hunting in the grass below.	LXA
27/08/2024	Nankeen Kestrel	1	16:22	50	-	Powered flight (Flapping)	-	Bird was flapping then dived down behind a small hill.	OL
10/09/2024	Nankeen Kestrel	1	12:11	10-19	-	Powered flight (Flapping)	Crops	Bird foraging for food close to grass/cropping.	LXA
10/09/2024	Nankeen Kestrel	1	12:43	10-19	-	Powered flight (Flapping)	Crops	Bird foraging for food, circling and flapping close to grass/cropping.	LXA
10/09/2024	Nankeen Kestrel	1	14:03		-	Soaring/Gliding	Crops	One individual soaring/gliding in circles above cropping. Circles increasing in distance from observer.	JN
01/10/2024	Black Kite	1	16:04	20-600	60	Powered flight (Flapping)	Pasture	Pursued by two ravens; ascended and soared up hundreds of metres to escape them.	JRG
02/10/2024	Black-shouldered Kite	1	9:40	10-14	100	Powered flight (Flapping)	Crops	Flying over canola field.	JRG
11/11/2024	Brown Falcon	1	16:26	10-30	-	Powered flight (Flapping)	Crops	Bird was sitting on fence, perched, when observer approached. The bird took flight and flew away from the observer.	KS

**** Listed species under the Victorian Flora and Fauna Guarantee Act 1988.***

Appendix 9: Black Falcon observation notes

Date	17/11/2023
Species	Black Falcon (*Falco subniger)*
Species count	3
Start time (am/pm)	9:07 am
End time	
Duration (mins)	
Direction	
Location	
Height (m)	
Heigh range of bird (m)	40-200
Distance from observer (m)	
Distance flown (m)	
Habitat flown over	
Turbine number	
Comments	• Parents with recently fledged young. Flying between turbines playing, diving, soaring etc. • One adult was observed 'attacking' a turbine blade that was switched off.
Bird behaviour	Displaying; Playing
Actions at time of observation	• sighting recorded in Nature Advisory FieldMaps and mortality search master spreadsheet • PM and Zoology team contacted
Observer	Lilith Armstrong (LA)

Appendix 10: Fork-tailed Swift Literature Review & Mitigation Report

18th October 2024

Murra Warra Project Co II PTY LTD
C/- Murra Warra Project Co II PTY LTD
Level 61 Governor Phillip Tower, 1 Farrer Place
Sydney NSW 2000

Attention: James Cooper
By email — james.cooper@res-group.com

Dear James,

RE: MURRA WURRA 2 WIND FARM
FORK-TAILED SWIFT INCIDENTAL CARCASS FINDS
NATURE ADVISORY REF NO. 19049.04

On the 12th March 2024, two suspected Fork-tailed Swift carcasses were found incidentally at Murra Wurra 2 Wind Farm (MW2WF), just outside the search radius around turbines. One was found 102 metres from Turbine 18, and one was found 97 metres from Turbine 21. Therefore, they are currently assumed to have collided with the turbines. The carcasses were identified by a Nature Advisory zoologist, Kelsey Smith, and were confirmed by a Nature Advisory ornithologist, Guille Mayor, on 20th March 2024. When found, the carcasses were relatively fresh, estimated to be roughly 3 days old, and largely intact—one had a visible head wound, and the other was missing its tail.

A literature review and assessment (Appendix 1) undertaken by Nature Advisory zoologist Michael Sebastian, has identified that the cause of death of both Fork-tailed Swift individuals was likely to be collision with turbines, and that the species generally exhibits risk behaviour that may lead to collisions within wind farms, as they generally fly at Rotor Swept Area (RSA). However, collisions appear unlikely to occur, even at times of increased risk, based on the results of mortality monitoring to-date at both Murra Warra Stage 1 and Stage 2.

Recommendations for incidental monitoring include recording any sighting of a Fork-tailed Swift during monthly searches conducted by Zoologists.Continuation of implementing an incidental raptor monitoring protocol during carcass searches is recommended and should be sufficient to monitor Fork-tailed Swift occurrence near turbines and while traversing site monthly.

During carcass searches Nature Advisory will monitor species of raptor and Fork-tailed Swift occurring and record: species, numbers, times, dates, location, flight paths and flight heights. DEECA will be notified on further mortalities of Fork-tailed Swift on or near MW2WF by Nature Advisory to advise of increases in the risk of collision and activity patterns over time. Existing planned carcass monitoring around turbines should be sufficient to capture any further fatalities of this species should they occur, which will trigger further investigation of mitigation options, as per the bird and avifauna management (BAM) Plan.

Suggested mitigation and recovery options for wind farm operations and landholders to implement, but not limited to, are listed below:

- Notify DEECA of further mortalities, which may indicate an increase in the likelihood of collision (Section 4.1);

- Establish and maintain an internal management log where all sightings of FTS are recorded for the lifetime of the wind farm, and provide the relevant training for wind farm staff to identify FTS in flight, and any incidental mortalities;
- MW2WF to discuss with landholders about being informed before ploughing and burning regimes are expected to occur as these practices can indicate a greater chance of seeing FTS in the area
- It is recommended that MW2WF also begins to consult with CFA regarding controlled/wild burns in the area, particularly focussing on planned intentional burns given that non-agricultural burns near the site may also attract the species and lead to collision with turbines;
- Where burning is still implemented, and where unplanned burns may occur, record in a management log the locations of burning activity, dates and wind speeds should continue to be recorded in the event further mortalities occur for analysis; and
- MW2WF to discuss with landholders to consider using alternative methods of managing stubble without burning, including stubble retention, given the risk that burning may pose to Fork-tailed Swift and the potential agricultural benefits of stubble retention (including reduced erosion and increased soil moisture and organic matter retention) (Agriculture Victoria 2023).

Assessment of the effectiveness of the above measures at MW2WF is not possible as there is no published data or trials available concerning Fork-tailed Swift that Nature Advisory is aware of. Any consideration or implementation of these or other mitigation measures must be subject to a clear understanding of the cause of the impact. The recommendation of incidental monitoring, subject to discussion with DEECA, may provide further insight into the requirement and or/implementation methods for mitigation. It may also be constructive to directly discuss the existing and potential mitigation measures above with DEECA to determine preferred avenues of mitigation.

Yours sincerely,

Kelsey Smith

Zoologist & Project Manager
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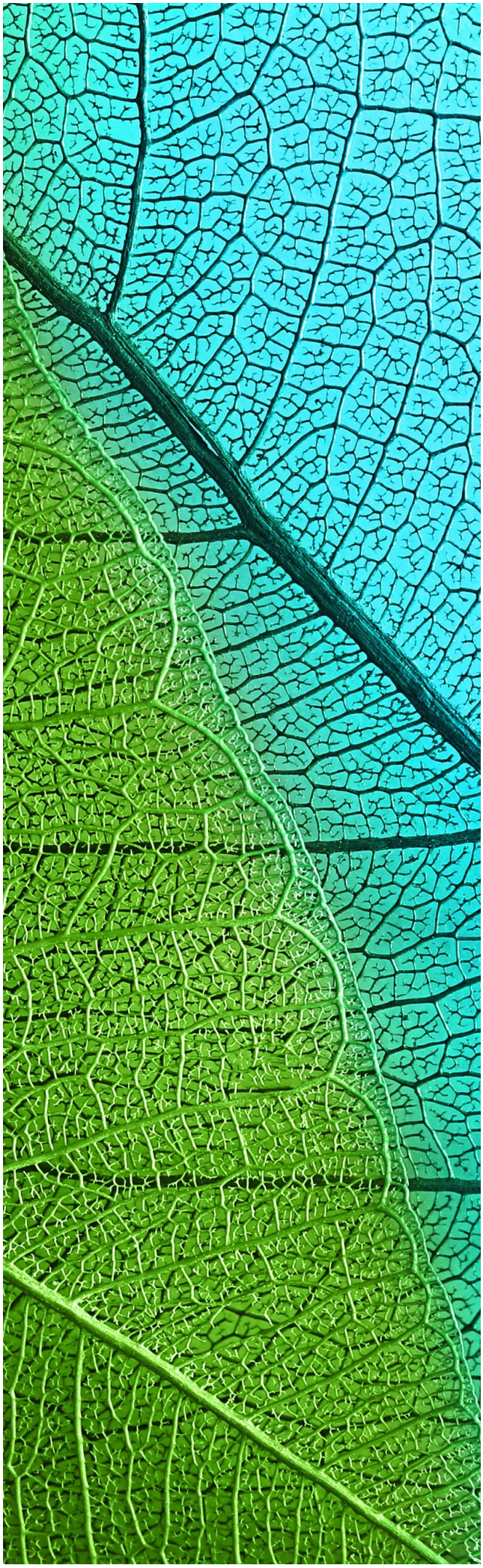

Murra Warra 2 Wind Farm

Fork-tailed Swift (*Apus pacificus*) Literature Review and Mitigation Measures

Prepared for RES Australia

July 2024
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Nature Advisory acknowledges the traditional owners and sovereign custodians of the land on which we work from – the Wurundjeri people of the Woi Wurrung language group. We extend our respect to their Ancestors and all First Peoples and Elders past, present, and future.

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1. Introduction

Murra Warra 2 Wind Farm (MW2WF) is situated about 30 km north-northeast of Horsham, straddling both the Horsham and Yarrambiack Shires. The Bat and Avifauna Management Plan (BAM plan) for MW2WF (Biosis 2017) sets a framework for identifying and managing the impacts of the wind farm on birds and bats. Section 5 of the BAM plan outlines the decision-making framework and mitigation responses in the event of an impact trigger. The BAM plan defines a significant impact trigger for a listed threatened or migratory species as follows:

> *...a significant impact would be triggered if turbine collisions at Murra Warra Wind Farm affect any more than 0.01% of the population estimate of listed threatened or migratory species during any one year of the monitoring program. For any such species, the level of impact will be calculated from the following:*
>
> • *the number of carcasses detected during monitoring searches and incidental finds;*
>
> • *factors to account for searcher efficiency and mean carcass persistence times; and*
>
> • *extrapolation from the subset of turbines searched to the total number of turbines in the wind farm.*

On 13 March 2024, two suspected Fork-tailed Swift (*Apus pacificus)* carcasses were found at MW2WF; one 102 metres from Turbine 18, and one 97 metres from Turbine 21. The carcasses were identified by a zoologist from Nature Advisory Pty Ltd during monthly monitoring as part of the implementation of the MW2WF BAM plan. When found, the carcasses were estimated to be less than 3 days old, and largely intact, with a visible wound to the head of one and to the abdomen of the other. The carcasses were inspected by ornithologists at Nature Advisory offices upon the completion of the monthly searches and confirmed as Fork-tailed Swifts on 20 March.

The Fork-tailed Swift is listed as 'Migratory' under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The number of dead individuals found was not confirmed to reach the level of an impact trigger but was reported to the Victorian Department of Energy, Environment and Climate Action (DEECA) on 19 April 2024. Following the report, DEECA provided a letter dated 6 May, 2024 (Ref: 00004510), recommending further investigation of potential mitigation measures to reduce the risk of further impacts to the species during the summer period. This report comprises this literature review and investigation of potential mitigation measures.

This report includes the following sections:

Section 2 presents a desktop investigation of the species;

Section 3 presents an evaluation of findings and risk assessment; and

Section 4 presents recommendations & conclusions.

This investigation has been carried out by a team from Native Advisory including; Michael Sebastian (Zoologist), Kelsey Smith (Zoologist and Project Manager), and Jackson Clerke (Ecologist and Project Manager).

2. Literature Review

The following section provides a review of species ecology and occurrence within the Murra Warra 2 Wind Farm vicinity.

2.1. Species Biology

The Fork-tailed Swift (*Apus pacificus)* is a highly aerial bird species, capable of spending most of the year on the wing and typically landing only for nesting and breeding. However, occasional instances of roosting have been documented in Australia. It is a highly migratory species, arriving in Australia in October. Within Victoria, it is most common from December-April, after which the species departs for its breeding grounds in the northern hemisphere.

Fork-tailed Swifts are similar in shape to the White-throated Needletail, but are significantly smaller, with a length of 18-21 cm, wingspan of 40-42 cm, and weighing 30-40 g (DCCEEW 2024). Additionally, they are much slimmer than White-throated Needletail, have narrower wings, and a longer, deeply forked tail (DCCEEW 2024). Both sexes, as well as adults and juveniles, all look similar and are indistinguishable in the field. Their diet has not been studied in detail but appears to consist entirely of flying insects (DCCEEW 2024).

Figure 1: Photos of Fork-tailed Swift

Images from Stuart Price (left) used under license CC BY-SA 2.0 (link to license: https://creativecommons.org/licenses/by-sa/2.0/) and snowmanradio (right) under license CC BY 2.0 (https://creativecommons.org/licenses/by/2.0/)

The Fork-tailed Swift occurs as a flyover over virtually all terrestrial habitats in Australia, but is most common over inland plains, and usually over dry or open habitats (DCCEEW 2024). It also often occurs around areas of updraughts, particularly around cliffs, and is said to forage along the edge of low-pressure systems and ahead of storm fronts to assist in its flight (DCCEEW 2024). When it forages in open forest, it sometimes feeds at canopy height among the tree-tops (Higgins 1999).

The Fork-tailed Swift typically feeds in flocks of 10-1000 individuals. The species is known to forage at heights of 1-300 m above ground, and likely forages at still-greater heights (DCCEEW 2024).

2.1.1. Population and Regional Occurrence

The Australian population of Fork-tailed Swift is estimated to be approx. 100,000 mature individuals (Biosis 2017). The largest flocks recorded in Victoria (and indeed, Australia) were estimated to hold 90,000 individuals in Mildura in 1961 (Simpson 1961), and 50,000 individuals in Portland in 1960 (DCCEEW 2024).

There has been 1 recorded *VBA* (DEECA 2024) observation within the last ten years within a 50-kilometre radius of the MW2WF (DEECA 2024). This observation was made at Horsham in 2020, which is well within the range of the Fork-tailed Swift but relatively distant (>30 km) from the MW2WF. However, considering the extremely mobile nature of this species, such a distance could easily be traversed in a very short timeframe (<1 day).

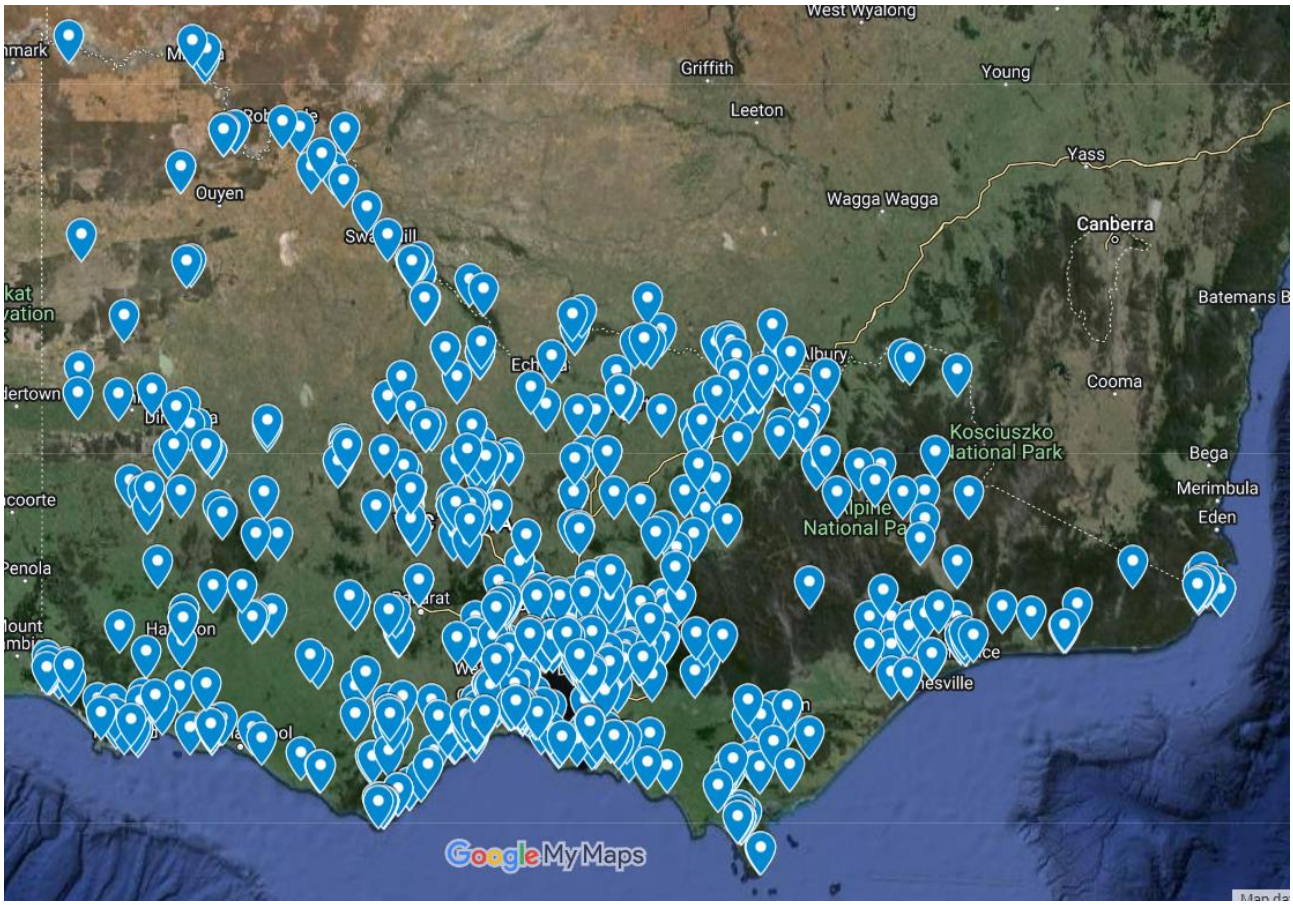

Figure 2. Distribution of Fork-tailed Swift in Victoria from all known historical VBA records (DEECA 2024)

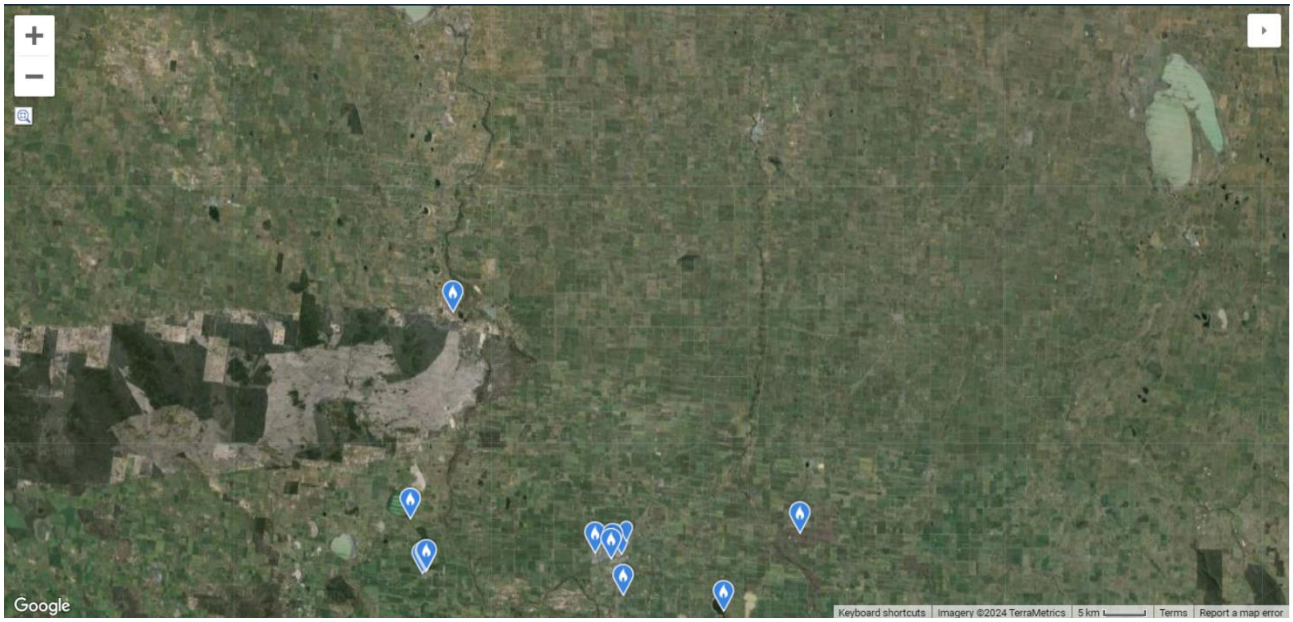

Figure 3: Fork-tailed Swift eBird records over the last 10 years (eBird 2024)

On *eBird* (eBird 2024), there have been 20 observations of the species <50 km from MW2WF in the last 10 years. Of these, the most recent are from Horsham, where 2 individuals were recorded on 12 March 2024. The highest number of individuals observed in this region in the last 10 years was a flock of 60 individuals, which were recorded from Horsham on 12 November 2018. Horsham also represents the nearest area to MW2WF where the species has been observed within the last 10 years. All records of >12 individuals (and indeed, of 40 or more individuals) in the region occurred in Horsham from February 2018 to November 2019.

It is unclear whether the above patterns in records are attributable to Horsham being a relatively high centre of activity for the species in the region, or whether it is simply an effect of a greater birdwatching presence in Horsham compared to the rest of the region.

2.1.2. Threats

The are no significant threats to the Fork-tailed Swift in Australia (DCCEEW 2024). Potential threats are listed below, but they are thought to be negligible given the wide range of the species (DCCEEW 2024):

- Habitat destruction;
- Predation by feral animals; and
- Collisions with wind farm turbines (Moloney et al. 2019).

2.1.3. Conservation Status & Legislative Protection

This species is listed as "Migratory" under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). It is not listed as threatened at a Commonwealth level, or in any Australian state or territory.

2.2. Habitat Availability

The MW2WF site is characterised by an abundance of cropland, with some remnant mallee vegetation and Black Box trees along certain roadsides and a minor proportion of paddocks used for grazing instead of cropping. As the site is on a relatively dry and open inland plain, it constitutes suitable habitat for Fork-tailed Swift, which may occur anywhere across the site.

3. Evaluation

The movement patterns of Fork-tailed Swift are poorly understood, making it difficult to predict occurrence in any particular area. There have been numerous observations of Fork-tailed Swift over recent years in the wider area as documented in the *VBA* and *eBird* platforms (Figure 2 & Figure 3). The species occurs in a widespread but scattered way across Victoria and is most common in Victoria from December-April, particularly in years when late summer sub-tropical cyclones move much further south than usual (DCCEEW 2024). Due to this, it is difficult to define core habitat for the species within Victoria. However, as previous records show some of the largest numbers of the species within Victoria (Simpson 1961, DCCEEW 2024), it can be assumed to be part of the species' range.

3.1. Cause of death

On 12 March 2024, two suspected Fork-tailed Swift carcasses were found incidentally at MW2WF, just outside the search radius around turbines. One was found 102 metres from Turbine 18, and one was found 97 metres from Turbine 21. Therefore, they are currently assumed to have collided with the turbines. The carcasses were identified by a Nature Advisory zoologist, Kelsey Smith, and were confirmed to be Fork-tailed Swift by a Nature Advisory ornithologist, Guille Mayor, on 20 March 2024. When found, the carcasses were relatively fresh, estimated to be roughly 3 days old, and largely intact—one had a visible head wound, and the other was missing its tail.

Collisions with man-made structures is a known threat to the Fork-tailed Swift (Nature Advisory 2024) but is not considered a significant threat to the species (DCCEEW 2024). With specific reference to wind farm turbines, there are several reasons why Fork-tailed Swift could collide with them: the altitude they mostly fly at, the proportion of time spent flying, and flying behaviour. The Fork-tailed Swift is a fast flyer with relatively poor manoeuvrability, making it harder to avoid turbine blades. Additionally, the species often flies in a circular manner when foraging (DCCEEW 2024). If foraging around a wind turbine, this could increase the risk of collisions by repeatedly placing individuals in positions vulnerable to the turbine blades.

3.2. Analysis of records, mortality information and ecological context

Temporal patterns of Fork-tailed Swift occurrence in the region

Temporal patterns of occurrence of the species in the Yarriambiack Shire on *eBird* indicate an increased presence in autumn, particularly April (Figure 4). *eBird* records from the Horsham Shire are more evenly distributed across the year from roughly November-March, with a weaker peak in March (Figure 5).

Figure 4: Seasonal trends in Fork-tailed Swift records across the Yarriambiack Shire

Source: eBird (www.ebird.org)

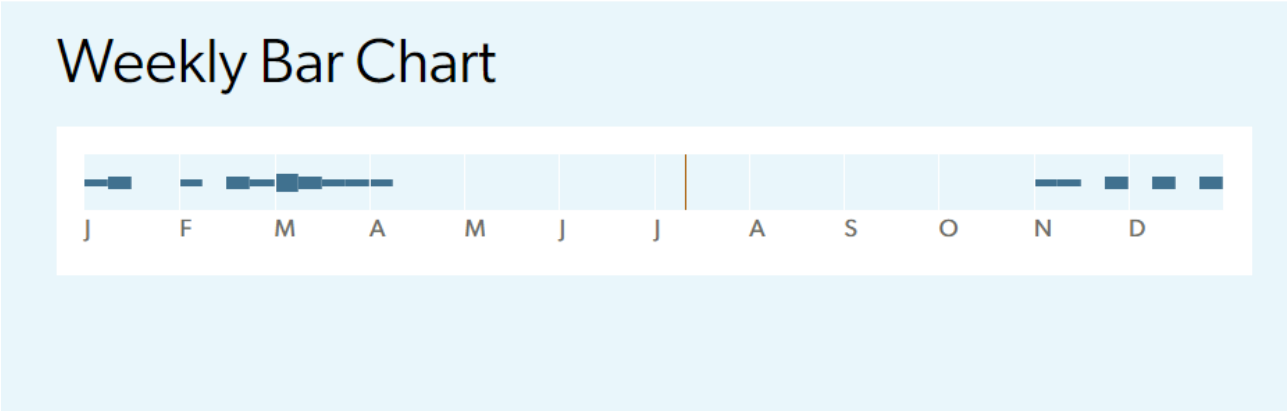

Figure 5: Seasonal trends in Fork-tailed Swift records across the Horsham Shire

Source: eBird (www.ebird.org)

Records of Fork-tailed Swift from the Atlas of Living Australia (ALA 2024) across the broader region approximately bounded by Horsham in the southwest, Birchip in the northeast, Rainbow in the northeast, and Wallaloo in the southeast (Figure 6) show most Fork-tailed Swift records in the region occur from November-March (aligning with the seasonal presence of the species in Australia). In contrast to *eBird*, the *ALA* records peak in January.

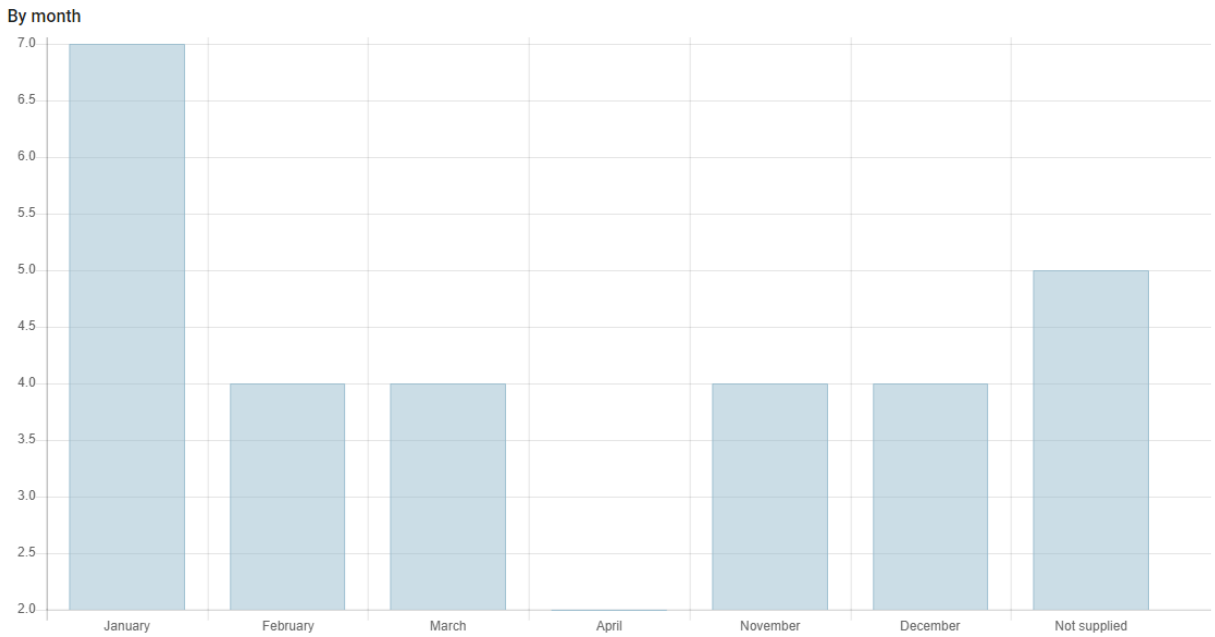

Figure 6: Seasonal trends in Fork-tailed Swift records across the semi-arid region of northwest Victoria approximately bounded by Horsham in the southwest, Birchip in the northeast, Rainbow in the northeast, and Wallaloo in the southeast.

Source: Atlas of Living Australia (www.ala.org.au)

Influence of seasonal Fork-tailed Swift activity

Fork-tailed Swift may potentially face an increased risk of collision when fledging, as they are still learning how to fly and either may not avoid turbines easily or not understand the need to avoid them. However, this species does not breed or fledge in Australia, so neither phenomenon explains why the mortalities occurred.

Fork-tailed Swifts appear to make relatively erratic and weather-dependent movements in Australia across large scales. As such, it is difficult to assign any particular movements within Australia as seasonal, and it is unlikely the collisions at MW2WF occurred due to any sort of seasonal movement.

Influence of seasonal activity of prey species

Fork-tailed Swifts prey entirely on flying insects, including small bees, wasps, termites and moths (DCCEEW 2024). Of these, termites and moths exhibit swarming behaviour that could result in high concentrations of flying insect biomass, creating an attractive foraging resource for Fork-tailed Swift. Other insect groups that could do this, and that Fork-tailed Swift are known to feed on, include flying ants, flies, bugs, and beetles (Higgins 1999).

A search for *ALA* (2024) records of potential prey species (insects from the orders Hymenoptera, Blattodea, Lepidoptera, Diptera, Hemiptera and Coleoptera—henceforth, collectively termed "flying insects") within 20 km of the Murra Warra Substation by Alisa Wheat Road returned results consisting mainly of the families Noctuidae (Owlet Moths), Lycaenidae (Gossamer-winged Butterflies), Halictidae (Sweat Bees) and Geometridae (Geometer Moths). Together, these 4 families constituted approx. 40% of the records of potential prey species in the search region. Numbers of records of flying insects appear to peak twice a year on a seasonal basis—the first, weaker peak occurs from February-April, and a second, stronger peak occurs from September-November, periods which generally align with autumn and spring respectively.

Records of flying insects from March (when the Fork-tailed Swift mortalities occurred) are neither very high nor low in number, but intermediate. In contrast to records from across the year (where the largest numbers of records—40% of the total—are from butterfly/moth and sweat bee families), at a minimum nearly 50% of records at this time of year are generally from wasp families (Vespidae, Pompiidae, Crabronidae), almost 20% from fly families (Therevidae, Bombyliidae), and approx. 10% are from butterfly/moth families (Hepialidae). This could suggest that Fork-tailed Swift is particularly foraging for wasps and flies in the region, and that the species is therefore occurring at MW2WF at this time of year as these taxa become more common in the region, but it is difficult to determine if this is the case.

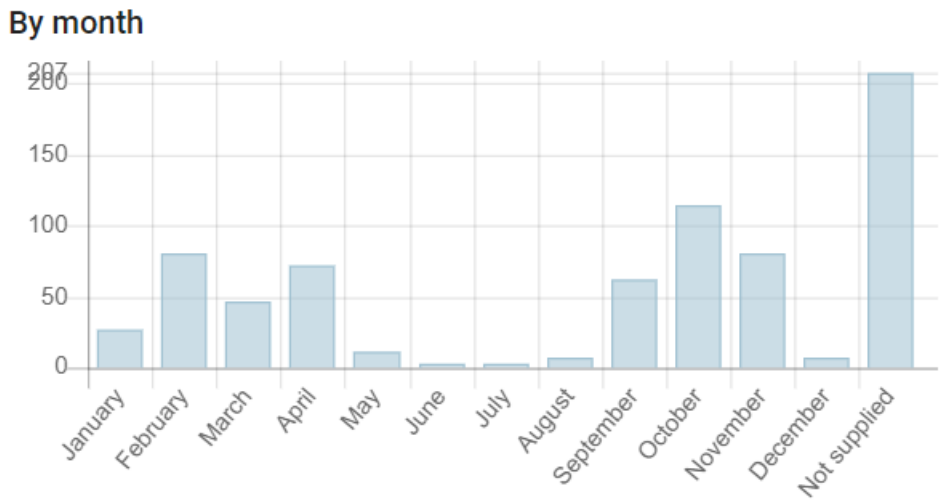

Figure 7: Seasonal trends in potential Fork-tailed Swift prey taxa (Hymenoptera, Blattodea, Lepidoptera, Diptera, Hemiptera and Coleoptera) within 20km of Murra Warra Substation.

Source: Atlas of Living Australia (www.ala.org.au)

Influence of Weather

The Fork-tailed Swift is currently thought to be more common in Victoria during years when summer sub-tropical cyclones extend much further south than usual. However, the timing of the mortalities does not align with this, as the mortalities occurred in autumn.

The Fork-tailed Swift is also thought to exploit storm fronts to aid their flying and foraging, and as such, has been thought to be indicative of the approach of inclement weather. However, based on BOM (2024) data from the Warracknabeal Airport from 9-12 March 2024, wind speeds were moderately high but not exceptional (gusts of 44-46 km/h), winds came from a northerly direction, unlikely to bring precipitation, and no precipitation was recorded. Hence, it is unlikely the dead individuals were tracking a storm front. They may instead have been tracking a warm, dry front, and it is noteworthy that the highest minimum (23.5°C) and maximum (40.7°C) temperatures of the month were recorded during this period.

In summary, conditions at the time of collision are likely to have consisted of moderately strong, very hot, northerly winds, and the individuals may have been exploiting this warm front prior to collision.

Influence of Harvesting

Zoologists performing carcass searches at the MW2WF have estimated 90% of its area to be covered by cropland. The crops grown on-site are mainly wheat. It was generally harvested in late December within the study area.

Harvesting of crops generally involves the use of heavy machinery to clear and collect crops on a large scale, and this can flush flying insects sheltering in the crops. The Fork-tailed Swift has been observed following around machinery disturbing ground vegetation, such as slashers, and it is thought that the likely reason for this is to exploit the disturbance by feeding on insects flushed out by it (Higgins 1999). In turn, this may have attracted Fork-tailed Swift to the study area and increased the likelihood of collision with turbines.

However, the timing of harvesting is misaligned with the timing of the mortalities. Harvesting generally occurs around late December, whereas the mortalities were recorded in mid-March. Therefore, whilst it is a plausible mechanism that could attract Fork-tailed Swift to the study area and increase the likelihood of collision with turbines, it does not account for the timing of the mortalities.

Influence of Burning

The Fork-tailed Swift has been previously documented being attracted by smoke and fire, presumably to feed upon the flying insects that get flushed out by the fire (Higgins 1999). Hence, it is possible the species was attracted to the MW2WF site by crop stubble burning. This is compounded by the fact that crop stubble burning is done in February-March on-site, which roughly aligns with the timing of the Fork-tailed Swift mortalities.

However, BOM (2024) data from the time period when the collision likely occurred, 9-12 March 2024, show that a moderately strong, and very hot, northerly wind was likely affecting the study area during the likely time of collision. It is unlikely that burning would have been attempted under such conditions as any fire would have proven very difficult to control. Therefore, it appears unlikely that the March 2024 mortalities of Fork-tailed Swift were driven by the species being attracted to the study area by fires, but fire in the study area, such as the stubble burning practiced from February-March annually, could attract the species in future.

3.3. Risk Assessment

Lumsden et al. (2019) recorded one Fork-tailed Swift mortality across 15 different wind farms monitored for bird and bat mortalities in Victoria over a period of 15 years. Symbolix (2020) did not record any

mortalities of this species from 10 different wind farms monitored for bird and bat mortalities over a period of 5 years. Additionally, Nature Advisory has never previously recorded collisions of this species with wind turbines, despite having completed mortality monitoring for more than 10 wind farms over the last decade. Therefore, whilst Fork-tailed Swift is a widely distributed, fast- and high-flying aerial species whose behaviour puts it at risk of collision with wind turbines, it appears that collisions are unlikely to occur.

Table 1. Likelihood of occurrence metric

Likelihood	Description
Certain	It is very probable that the risk event could occur in any year (>95%)
Almost certain	It is more probable than not that the risk event could occur in any year (>50%)
Likely	It is equally probable that the risk event could or could not occur in any year (50%)
Unlikely	It is less probable that not that the risk event could occur in any year (<50%)
Rare	It is improbable that the risk event could occur in any year (5%)

Given that:

- There is a very low number of Fork-tailed Swift mortalities detected at various wind farms monitored for bird and bat mortalities over >10 years of collective monitoring (Moloney et al. 2019, Symbolix 2020, Nature Advisory unpub. data); and
- The species has not been previously documented colliding with turbines during 2 previous years of mortality monitoring at the Murra Warra 1 Wind Farm (MW1WF) site; but
- The species may potentially be attracted to the MW2WF site annually by stubble burning, even though this is unlikely to have driven the occurrence of the current mortalities;
- The likelihood of reoccurrence of collision of Fork-tailed Swift with wind turbines at the MW2WF site is therefore considered to be "Unlikely" overall (see Table 1 above), with the current mortalities are being considered a one-off event. The multiple mortalities could have occurred due to the flocking behaviour of the species and are not a clear indication that reoccurrence is likely.
- Additionally, although the period of stubble burning from February-March could represent a time of increased risk for this species, the current mortalities are the first mortalities of the species to be detected in 2-3 years of mortality monitoring. Therefore, in accordance with Table 1 above, the likelihood of reoccurrence at this time of year is still considered to be "Unlikely".

In the event further mortalities are detected at the MW2WF site, or the species is observed flying around on-site, this likelihood of reoccurrence can be revisited.

4. Recommendations & Conclusions

The assessment has identified that, the cause of death of both Fork-tailed Swift individuals was likely to be collision with turbines, and that the species generally exhibits risk behaviour that may lead to collisions when utilising the MW2WF site. Collisions appear unlikely to occur, even at times of increased risk like February-March when stubble burning is occurring, based on the results of mortality monitoring to-date.

The species travels and forages widely and extensively across the continent during the period it is present in Australia (October-April, often December-April in Victoria – Higgins 1999). Some localised factors like stubble burning and crop harvest may attract this species to the MW2WF site, with the former likeliest to attract them in February-March and the latter likeliest to attract them in late December-early January. However, it is likely that most of the species' movements are driven by large-scale stochastic phenomena like storm fronts that are outside the capacity of MW2WF to control, and as such, the movements and likelihood of occurrence of the species cannot be predicted with reasonable accuracy or certainty.

4.1. Recommendations

4.1.1. Incidental monitoring

During carcass searches Nature Advisory will monitor species of raptor and Fork-tailed Swift occurring and record: species, numbers, times, dates, location, flight paths and flight heights. Wind Farm staff will be notified on further sightings of Fork-tailed Swift on or near MW2WF by Nature Advisory. It is the proponents responsibility to notify DEECA of mortalities to advise of increases in the risk of collision and activity patterns over time.

Existing planned carcass monitoring around turbines should be sufficient to capture any further fatalities of this species should they occur, which will trigger further investigation of mitigation options, as per the BAM Plan.

4.2. Mitigation measures

The requirement for mitigation measures and their appropriateness must be discussed between a qualified ecologist, RSE and DEECA.

Suggested mitigation and recovery actions that are within the scope of the wind farm operations and landholders to implement, but not limited to, are listed below:

- Notify DEECA of further mortalities, which may indicate an increase in the likelihood of collision (Section 4.1);
- Establish and maintain an internal management log where all sightings of FTS are recorded for the lifetime of the wind farm, and provide the relevant training for wind farm staff to identify FTS in flight, and any incidental mortalities
- MW2WF to discuss with landholders about being informed before ploughing and burning regimes are expected to occur as these practices can indicate a greater chance of seeing FTS in the area
- It is recommended that MW2WF also begins to consult with CFA regarding controlled/wild burns in the area, particularly focussing on planned intentional burns given that non-agricultural burns near the site may also attract the species and lead to collision with turbines;
- Where burning is still implemented, and where unplanned burns may occur, record in a management log the locations of burning activity, dates and wind speeds should continue to be recorded in the event further mortalities occur for analysis.

- MW2WF to discuss with landholders to consider using alternative methods of managing stubble without burning, including stubble retention, given the risk that burning may pose to Fork-tailed Swift and the potential agricultural benefits of stubble retention (including reduced erosion and increased soil moisture and organic matter retention) (Agriculture Victoria 2023); and

Assessment of the effectiveness of the above measures at MW2WF is not possible as there is no published data or trials available concerning Fork-tailed Swift that Nature Advisory is aware of. Any consideration or implementation of these or other mitigation measures must be subject to a clear understanding of the cause of the impact. The recommendation of incidental monitoring, subject to discussion with DEECA, may provide further insight into the requirement and or/implementation methods for mitigation. It may also be constructive to directly discuss the existing and potential mitigation measures above with DEECA to determine preferred avenues of mitigation.

4.3. Offsite Offsetting

As the number of mortalities for Fork-tailed Swift has not yet hit the threshold of a significant impact (100 or more mortalities as shown by statistical modelling and/or direct detection) (Biosis 2017), no offsetting is necessary at this point in time. Any discussion of offsetting will occur after a significant impact has been detected, at which point an offset may be necessary to address the impact.

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Appendix 11: Symbolix Report – Murra Warra Wind Farm Mortality Estimate – Year 2

symbolix

Murra Warra II Wind Farm Mortality Estimate - Year 2

Prepared for Nature Advisory, 21 February 2025, Ver. 0.9

This report outlines an analysis of mortality at Murra Warra Wind Farm Stage 2 (MWWF-II) from 2023-01-01 to 2024-12-31. The analysis is broken into the three related components below:

- Searcher efficiency / detectability – estimated from trials at Murra Warra Wind Farm Stage 1 and 2 from May 2020 to September 2024.
- Scavenger loss rates – estimated from trials at Murra Warra Wind Farm Stage 1 and 2 from January 2022 to July 2024
- Mortality estimates - based on surveys at 12 turbines, from 2023-01-30 to 2024-12-04

1 Available data

Survey data was collected and provided by Nature Advisory 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 Nature Advisory.

Species archetype data was taken from Hull and Muir (2010) for birds and bats. Fork-tailed Swift species archetype data was provided by Nature Advisory.

1.1 Data cleaning

Carcass finds (formal), incidental finds, searcher efficiency, scavenger efficiency data:

- Unidentifiable/unknown birds were recoded to “Unidentified Bird”
- Unidentifiable/unknown bats were recoded to “Unidentified Bat”
- Capitalisation and hyphenation made consistent

Survey data:

- 13 surveys with `percentage_surveyed` = 0 and comments saying that no search was conducted were removed.

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 to targeting specific species, 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).

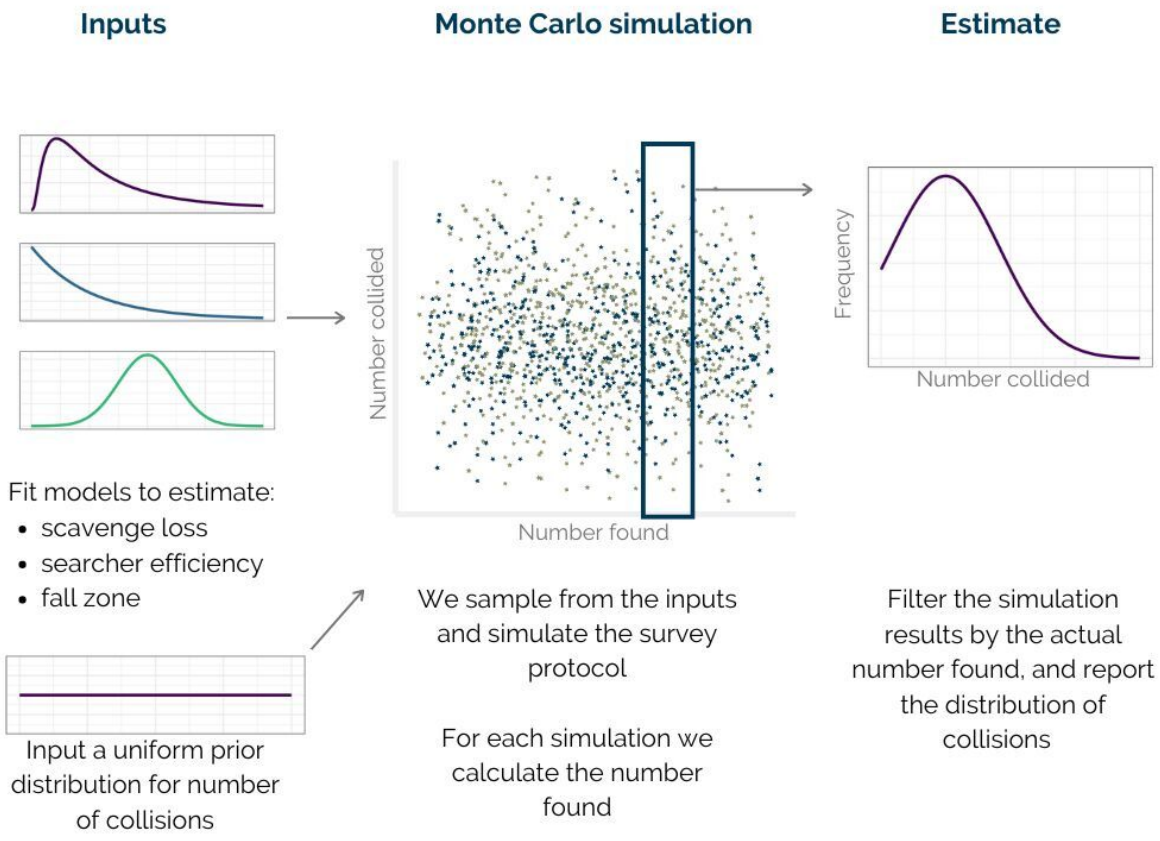

Figure 1: Overview of how the mortality estimation works.

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]. This included monthly searches by trained detection dogs at 12 turbines.

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

In total, 32% of turbines were searched monthly at MWWF-II to 90 m. 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] MW BAM plan endorsed.pdf

Table 1: Number of surveys per month.

Date	Standard	Reduced
2023 Jan	12	
2023 Feb	11	
2023 Mar	12	
2023 Apr	11	
2023 May	10	
2023 Jun	11	
2023 Jul	12	
2023 Aug	12	
2023 Sep	12	
2023 Oct	6	6
2023 Nov	6	6
2023 Dec	4	8
2024 Jan	3	8
2024 Feb	10	1
2024 Mar	11	1
2024 Apr	11	1
2024 May	11	1
2024 Jun	11	1
2024 Jul	7	5
2024 Aug	8	4
2024 Sep	4	7
2024 Oct	5	7
2024 Nov	2	4
2024 Dec	10	2

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	Feather Spot
Australian Magpie			1
Black-shouldered Kite		1	
Common Barn Owl			1
Common Starling		1	
Magpie-lark			1
Nankeen Kestrel		5	5
Stubble Quail		1	
Tree Martin		1	
Unidentified Bird		1	

Table 2: Carcasses found during formal surveys. *(continued)*

Species	Bat	Bird	Feather Spot
Wedge-tailed Eagle		3	
Evening Bat sp.	1		
Freetail Bat sp.	6		
Gould's Wattled Bat	9		
Large Forest Bat	2		
Lesser Long-eared Bat	2		
Little Forest Bat	1		
Southern Freetail Bat	10		
Unidentified Bat	8		
White-striped Freetail Bat	14		

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. Fork-tailed Swifts highlighted.

Species	Number found
Black-tailed Native-hen	1
Fork-tailed Swift	**2**
Freetail Bat sp.	1
Gould's Wattled Bat	3
Nankeen Kestrel	1
Southern Freetail Bat	1
White-faced Heron	1

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 3.2.8 of the BBMP. This included two trials each year of the carcass search program.

The searcher efficiency data is sourced from trials conducted at Murra Warra Wind Farm Stage 1 and 2 from May 2020 to September 2024. Both Stage 1 and Stage 2 trials were conducted by Nature Advisory using trained detection dogs in the same area, so by combining the data we

will obtain a more precise estimate of the detectability. Carcasses were laid out and searches for the carcasses undertaken using the same protocol as the main mortality survey (i.e. using a trained detection dog (with a human handler). If the carcass was found, "success" was recorded, else "failure" was the dog missing the carcass.

The carcasses deployed for searcher efficiency trials included birds (103 replicates), and bats (75 replicates).

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

Table 4: Count by species class and species used during the detection trials at each WF stage.

Species type	Species	Stage I	Stage II
Bat	Chocolate Wattled Bat	1	
Bat	Freetail Bat sp.		4
Bat	Gould's Wattled Bat	4	19
Bat	Little Forest Bat		1
Bat	Southern Freetail Bat	2	
Bat	Unidentified Bat	4	
Bat	White-striped Freetail Bat	21	19
Bird	Australasian Pipit	2	
Bird	Australian Magpie	3	
Bird	Brown Falcon	8	
Bird	Common Myna	18	41
Bird	Common Quail	1	
Bird	Crimson Rosella		1
Bird	House Sparrow	1	
Bird	Long-billed Corella	1	
Bird	Nankeen Kestrel	13	3
Bird	Unidentified Quail	1	
Bird	Wedge-tailed Eagle		10

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 best model for searcher efficiency was the "intercept-only model" (i.e. all carcasses have the same expected searcher efficiency).

The outputs of this model is presented in Table 5.

Table 5: Detection efficiencies for bats and birds by detection dogs.

Variable	Birds and Bats
Number found	167
Number placed	178
Mean detectability proportion	0.94
Detectability lower bound (95% CI)	0.89
Detectability upper bound (95% CI)	0.97

Overall detectability of bats and birds is 94%, with a 95% confidence interval of [89%, 97%].

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 section 3.2.7 of the BBMP. This included multiple trials at 10 randomly selected turbines each time.

Scavenger efficiency trials were conducted at Murra Warra Wind Farm Stage 1 and 2 from January 2022 to July 2024. The trials ran over approximately HOW MANY days. In total,

126 carcasses were used (including 83 birds, 18 bat proxies (mice) and 25 bats). Trials used cameras in order to record exact times of scavenge events.

Table 6 summarises the species used in the trials.

Table 6: Count by species class used in the carcass persistence trials at each WF stage.

Species type	Stage I	Stage II
Bat	1	24
Bat Proxy	18	
Bird	34	49

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, ∞] (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

The best model for scavenger efficiency combined birds, bats and bat 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 1.5 days, with a 95% confidence interval of [1.2, 2] days.

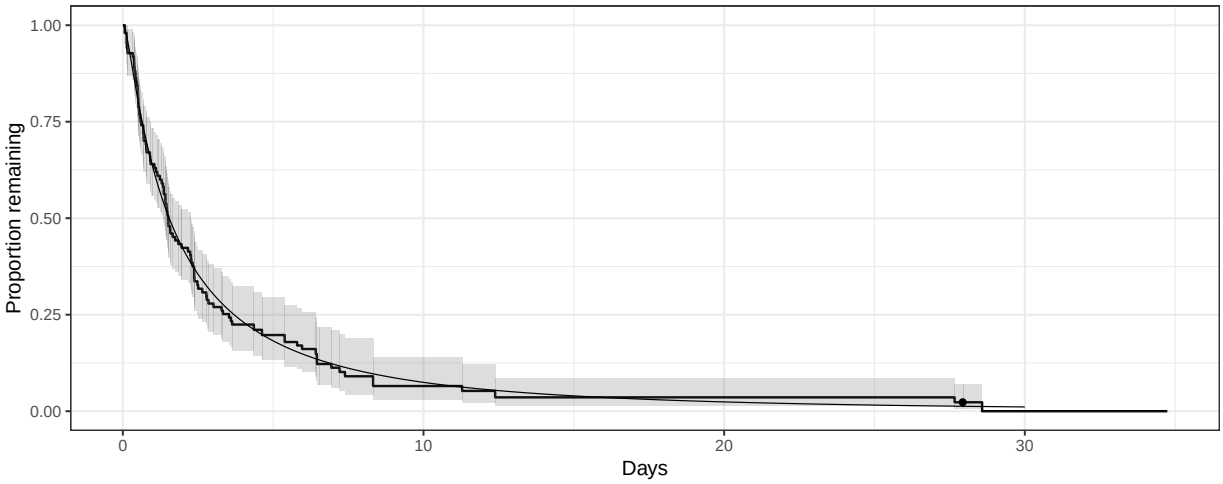

Figure 2: Empirical survival curve (the step function) for birds and bats combined, with 95% confidence intervals shaded. The smooth curve presents the fitted model.

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 MWWF-II. 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 Murra Warra Wind Farm Stage 2

Rotor Diameter (m)	Tower Height (m)	RPM
158	141	10

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	0.0028000	0.014000
Bird	Forest Raven	0.680	0.0450000	0.100000
Fork-tailed Swift	Fork-tailed Swift	0.035	0.0008553	0.020475

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.

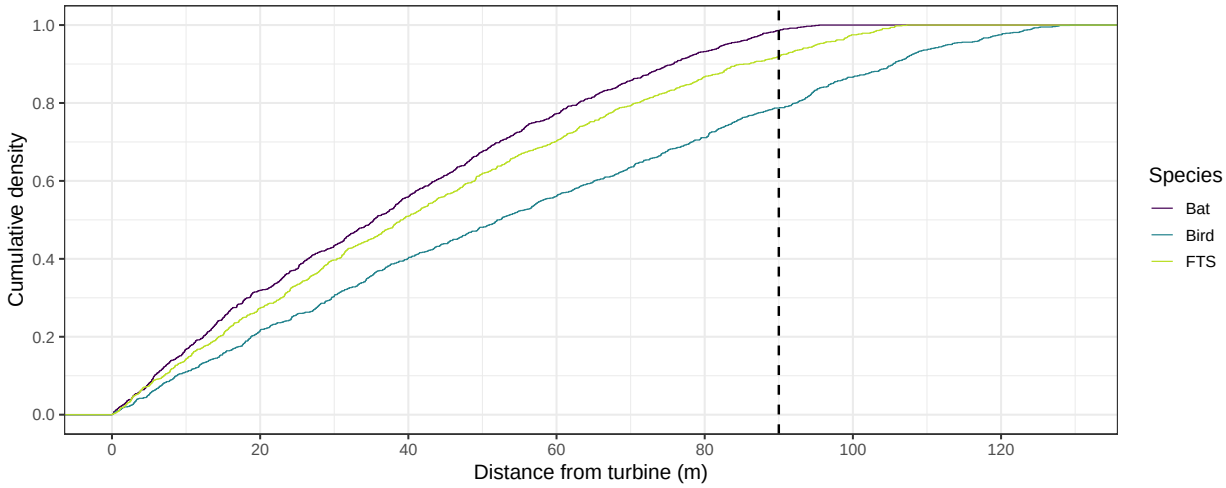

Figure 3: Cumulative distribution function of the fall zone simulation output for birds, bats and Fork-tailed Swifts. Vertical lines indicate the Standard survey radius.

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 99% of bats, 79% of birds, and 92% of Fork-tailed Swifts to fall within 90m of the turbine.

4 Mortality estimate

With estimates for scavenge loss, searcher efficiency, and survey coverage for MWWF-II, we then converted the number of bat and bird carcasses detected into an estimate of overall mortality from 2023-01-01 to 2024-12-31 (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 38 turbines on site available to strike bats and birds.
- Of these, 12 were searched monthly out to 90m.
- 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 2023-01-01 (approximately one month from the first survey), until the final surveyed date (2024-12-04).
- 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 two years of surveys, 53 bats were found during formal surveys. The resulting (median) estimate of total mortality is 2036 Bats lost on site over the two year period.

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 2036 Bats, and are 95%

confident that fewer than 2645 individuals were lost, in the two year period.

Table 9: Percentiles of estimated total bat losses in the two years of surveys.

0%	50% (median)	90%	95%	99%
1214	2036	2514	2645	3057

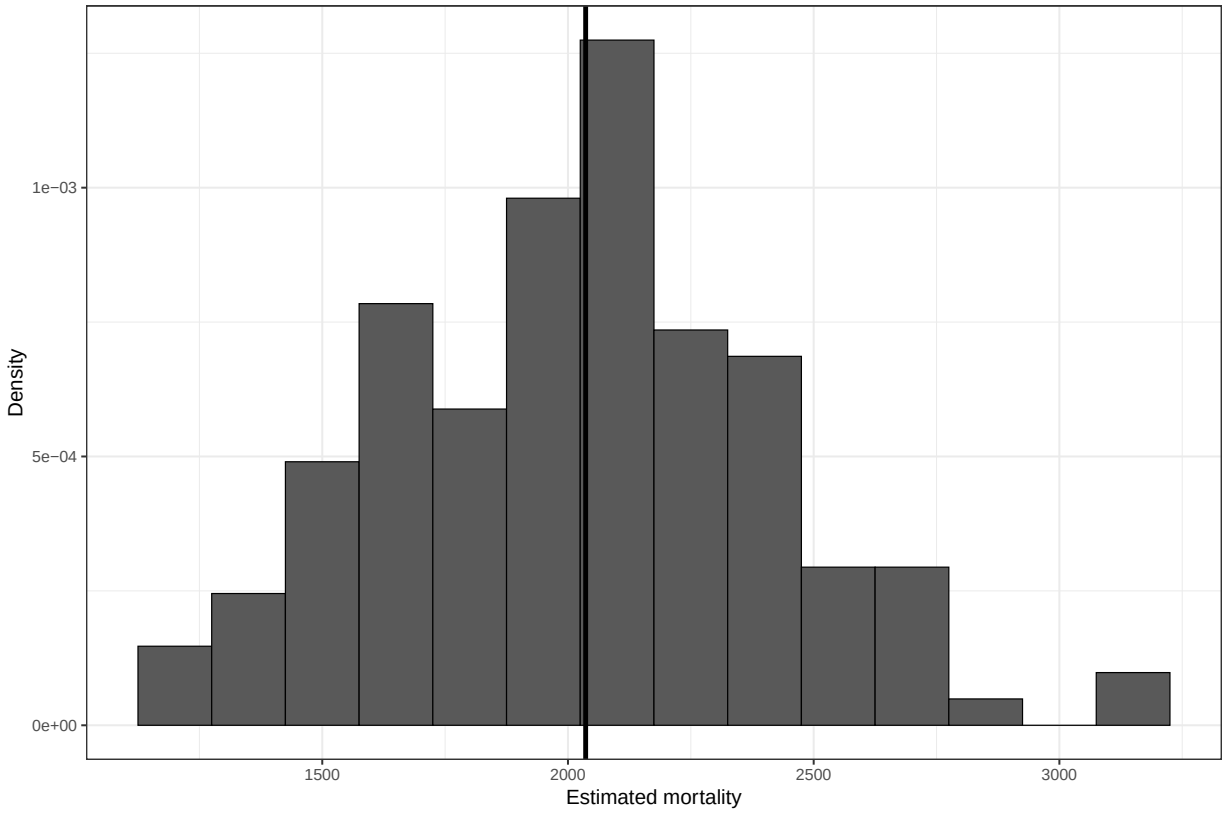

Figure 4: Histogram of the total losses distribution (bats). The black solid line shows the median.

4.2 Birds

During the two years of surveys, 21 birds were found during formal surveys. The resulting (median) estimate of total mortality is 1012 Birds lost on site over the two year period.

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 1012 Birds, and are 95% confident that fewer than 1464 individuals were lost, in the two year period.

Table 10: Percentiles of estimated total bird losses in the two years of surveys.

0%	50% (median)	90%	95%	99%
499	1012	1360	1464	1734

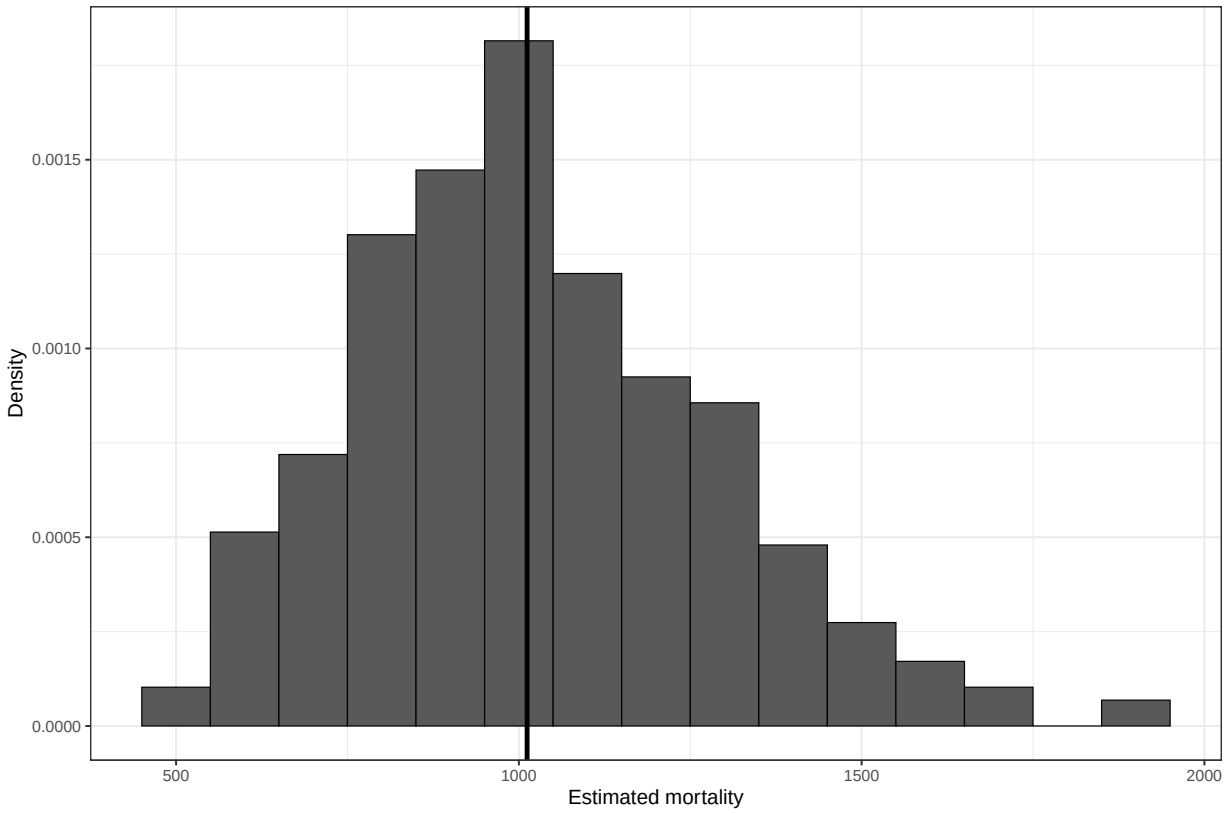

Figure 5: Histogram of the total losses distribution (bats). The black solid line shows the median.

4.3 Fork-tailed Swifts

During the two years of surveys, zero Fork-tailed Swifts were found during formal surveys. The resulting (median) estimate of total mortality is 64 Fork-tailed Swifts lost on site over the two year period.

We note that the mortality estimator has an assumption that at least one bird was struck. Although none were found during the formal surveys, two Fork-tailed Swift carcasses were found incidentally (Table 3), therefore there is evidence that this assumption is reasonable.

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 64 Fork-tailed Swifts, and are 95% confident that fewer than 182 individuals were lost, in the two year period.

Table 11: Percentiles of estimated total Fork-tailed Swift losses in the two years of surveys.

0%	50% (median)	90%	95%	99%
2	64	154	182	246

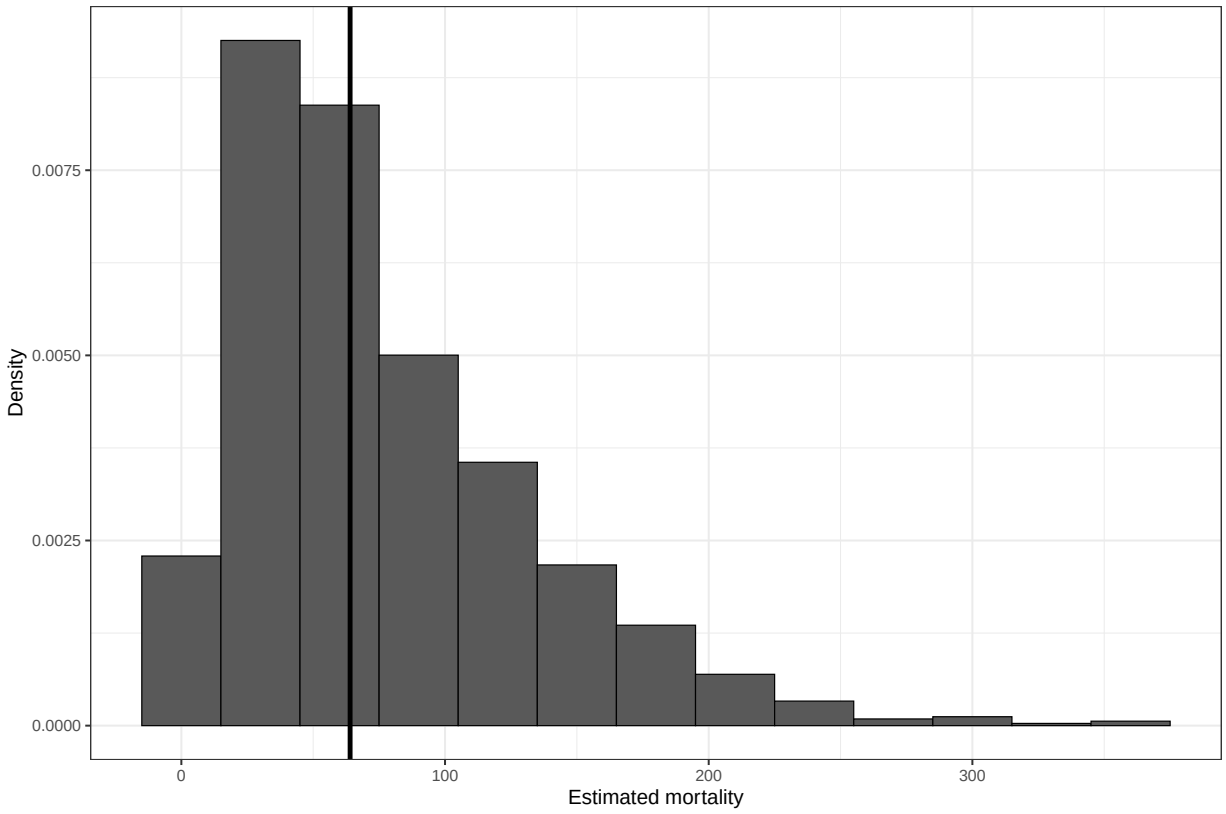

Figure 6: Histogram of the total losses distribution (Fork-tailed Swifts). The black solid line shows the median.

5 Analysis of Lit Turbines

Six of the turbines at Murra Warra Wind Farm Stage 2 (A01, A02, A03, A04, A05 and A07) have aircraft lighting. The turbine lights are activated when the Warracknabeal Airport lighting system is activated, which is done as required by incoming pilots, or by airport personnel[2]. Note that we had no data on exactly when the lights were activated.

We performed some analysis to check if there is a difference in the mortality rates at the lit turbines compared to the unlit turbines (i.e. the rest of the farm). First, we confirmed that

[2] K. Smith, *pers. comms*

there was a) no significant difference in detectability or scavenging rate at these turbines, and b) and that the average coverage factors were similar between the lit vs unlit parts of the farm (Table 12).

Table 12: Comparison of parameters for lit vs unlit turbines.

Parameter	Unlit	Lit
Mean proportion detected	0.95	0.92
Median days to scavenge	1.58	1.29
Mean coverage factor (Birds)	0.71	0.73

Since the detection rate, scavenging rate and fall zone coverage are all similar between the lit and unlit turbines, the count of mortalities found at each set of turbines should be comparable (i.e. we can simply compare the raw finds data). We fit a Poisson distribution (with log link) to the carcass finds per survey. From this analysis we found there is no significant difference ($p = 0.26$) between the mortality rates at lit vs unlit turbines (Figure 7).

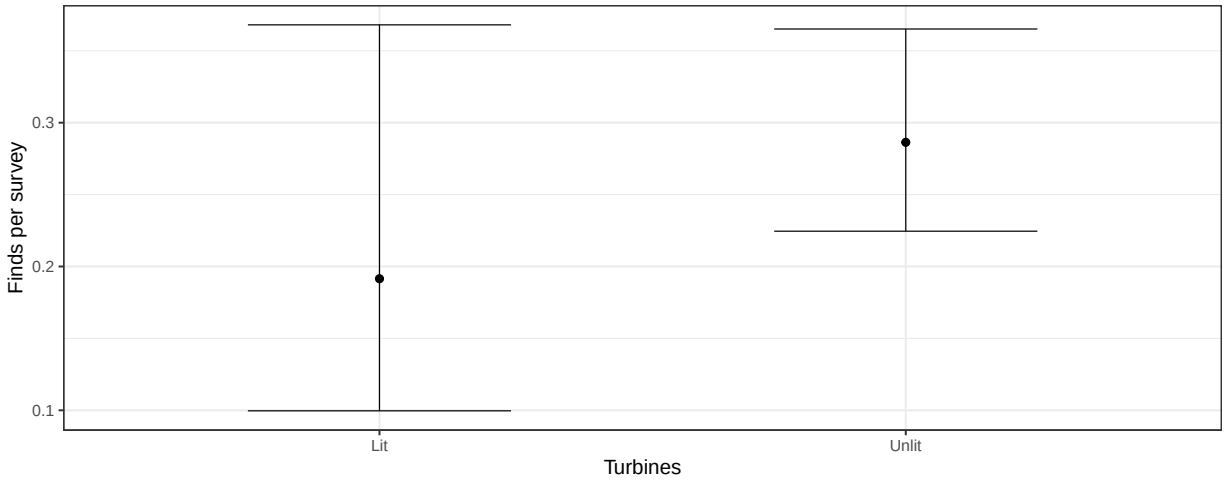

Figure 7: Mean and confidence intervals of the finds per survey at lit and unlit turbines.

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