Bango Wind Farm

Bird and Bat Adaptive Management Plan

Prepared for Bango Wind Farm Pty Ltd

April 2021

Report No. 18173 (1.24)

Nature Advisory

(Formerly Brett Lane & Associates Pty Ltd)

5/61-63 Camberwell Road
Hawthorn East, VIC 3123
PO Box 337, Camberwell VIC 3124

(03) 9815 2111
www.natureadvisory.com.au

Contents

1. Introduction 1
1.1. Background 1
1.2. Requirements of BBAMP 1
1.3. BBAMP Objectives 2
1.4. Consultations in the development of the BBAMP 3
1.5. Site Description 3
1.6. BWF project schedule 7
1.7. Additional information 7
1.8. Structure of this BBAMP 7
2. Monitoring program 8
2.1. Baseline monitoring 8
2.2. Operational phase monitoring 8
2.3. Operational Bird Utilisation Surveys 9
2.4. Monitoring 'at risk' groups 9
2.4.1. Birds of prey (Raptors) 9
2.4.2. Migratory bird species 12
2.4.3. Superb Parrot 12
2.4.4. Other species of concern 13
2.5. Bat Surveys 13
2.6. Ongoing carcass search monitoring 13
2.6.1. Turbine setting 15
2.6.2. Stratification and turbine selection 15
2.6.3. Carcass search protocol 16
2.6.4. Additional carcass searches (Superb Parrot; September - December) 16
2.6.5. Ongoing incidental carcass protocol 16
2.6.6. Analysis of results and mortality estimation 16
2.7. Summary of operational monitoring 18
2.8. Personnel Involved 20
2.9. Injured Bird and Bat Protocol 21
2.10. Data curation 21
2.11. Data presentation, reporting and review meetings 21
3. Measures to Reduce Risk 23
3.1. Carcass (carrion) removal program and stock forage control 23
3.2. Lighting on turbines and buildings 24
3.3. Minimise raptor perches on turbines 25
3.4. Minimise nesting close to turbines 25

4. Impact Triggers, Decision-Making Framework and Mitigation 26
4.1. Threatened Species 26
4.1.1. Definition of Impact Trigger 26
4.1.2. Decision Making Framework and Reporting 26
4.1.3. Impact triggers for Superb Parrot 27
4.2. Non-threatened Species 31
4.2.1. Definition of Impact Trigger 31
4.2.2. Decision Making Framework 31
4.3. Mitigation Measures 33
4.3.1. Superb Parrot mitigation response 33
4.3.1. Additional mitigation measures for other species 33
4.4. Reporting against performance criteria 37
4.5. Risks affecting the implementation of this plan 37
5. References 40

Figures

Figure 1: Regional location of Bango Wind Farm 5
Figure 2: Development footprint of Bango Wind Farm 6
Figure 3: Location of Wedge-tailed Eagle nests at BWF 11
Figure 4: Decision making framework for identifying and mitigating impacts on threatened species 30
Figure 5: Decision making framework for identifying and mitigating impacts on non-threatened species 32
Figure 6: Hollow-bearing tree assessment 44
Figure 7: Location of bird survey points. 48
Figure 8: Location of bat survey points 53
Figure 9: Inner and outer carcass search zones underneath the turbines 57
Figure 10: Scent dog search pattern – across the wind 58

Tables

Table 1: NSW BBAMP conditions 1
Table 2: Commonwealth BBAMP conditions 2
Table 3: Monitoring of species at risk and other non-listed species 19
Table 4: Mitigation measures in the event repeated collisions or risk behaviour by a threatened species. 35
Table 5: Specific management objectives (including relevant consent condition from Schedule 3), activities, timing and performance criteria for which the project owner is responsible 38
Table 6: Habitat associated with each survey point 46
Table 7: Baseline monitoring of non-listed and listed bird and bat species 54
Table 8: Timing for scavenger trials 60
Table 9: Number of replicates for each scavenger trial 60
Table 10: Number of replicates per season for detectability trials, given two factors of size and visibility 62

Appendices

Appendix 1: Baseline bird and bat information 43
Appendix 2: Statistical review of BUS methodology 55
Appendix 3: Statistical review of mortality monitoring 56
Appendix 4: Carcass search protocol 57
Appendix 5: Carcass Search Data Sheet 63
Appendix 6: Raptor monitoring data sheet 64

DECLARATION OF ACCURACY

I declare that:

1. To the best of my knowledge, all the information contained in this Bird and Bat Adaptive Management Plan is complete, current and correct.

2. I am duly authorised to sign this declaration on behalf of the approval holder.

3. I am aware that:

a. Section 490 of the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (EPBC Act) makes it an offence for an approval holder to provide information in response to an approval condition where the person is reckless as to whether the information is false or misleading.

b. Section 491 of the EPBC Act makes it an offence for a person to provide information or documents to specified persons who are known by the person to be performing a duty or carrying out a function under the EPBC Act or the *Environment Protection and Biodiversity Conservation Regulations 2000* (Cth) where the person knows the information or document is false or misleading.

c. The above offences are punishable on conviction by imprisonment, a fine or both.

Signed

Full name (please print)

Brett Alexander Lane

Organisation (please print)

Nature Advisory Pty Ltd

Date 01/04/2021

Glossary of Terms

Baseline	Any monitoring fieldwork undertaken before all turbines are commissioned, including monitoring undertaken while the wind farm is under construction but not fully operational.
BBAMP	Bird and Bat Adaptive Management Plan
BC Act	*Biodiversity Conservation Act, 2016(NSW)*
BCD	Biodiversity Conservation Division (NSW)
BMP	Biodiversity Management Plan
BUS	Bird utilisation survey
BWF	Bango Wind Farm
Commissioning	The period during which fully constructed wind turbines are brought into operation and before the commissioning of the last turbine.
Construction	Then period between commencement of works on site and the commissioning of the last wind turbine and the commencement of full operation (see below) of the wind farm.
DAWE	Department of Agriculture Water and Environment (formerly the Commonwealth Department of Environment and Energy (DoEE))
DPIE	Department of Planning Industry and Environment
EPA Act	*Environmental Planning and Assessment Act, 1979*
EPBC Act	*Environment Protection and Biodiversity Conservation Act, 1999*
EPBC 2013/6810	The Referral number of the Bango Wind Farm under the EPBC Act
EIS	Environmental impact statement
ERM	Environmental Resource Management
OEH	Office of Environment and Heritage (now BCD)
Operation	The period commencing from the final commissioning of the last turbine when all wind turbines officially commence operation together and deliver full power to the grid.
Pre-commissioning	The construction period before the first fully constructed wind turbine starts operating.
RSA	Rotor swept area
SSD 6686	State Significant Development Approval No. 6686 for the Bango Wind Farm in 2018.
WTG	Wind turbine generator

1. Introduction

1.1. Background

Bango Wind Farm (BWF) comprises 46 wind turbine generators (turbines) and is located 20 kilometres North of Yass and is bordered by Boorowa and Rye Park in the southern tablelands of New South Wales (see Figure 1). These 46 turbines have been located from a selection of 49 approved positions in the wind farm and have a maximum height (turbine tip height) of 200 metres above the ground (see Figure 2 for the development footprint). The rotor swept area (RSA) of the turbine blades is between 40m and 200m above ground level. The site features, biodiversity attributes and full project description are provided in the Environmental Impact Statement (EIS) for the Bango Wind Farm (CWP 2016) and associate documentation (refer to https://bangowindfarm.com.au/).

Approval of BWF was granted by the Land and Environment Court of NSW under the *Environmental Planning & Assessment Act 1979* (EPA Act) and the Commonwealth Department of Agriculture, Water and Environment (DAWE) (formerly the Commonwealth Department of Environment and Energy (DoEE)) under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) in 2018.

In accordance with State Significant Development Approval (SSD 6686) condition 21, Schedule 3 requires the preparation of a Bird and Bat Adaptive Management Plan (BBAMP) in consultation with the NSW Office of Environment and Heritage (OEH) (now the Biodiversity Conservation Division (BCD) of the Department of Planning, Industry and Environment (DPIE) and approved by the Secretary of DPIE. Similarly, EPBC approval (EPBC 2013/6810) condition 6 requires the preparation of a BBAMP for approval by the Australian Minister for the Environment.

This BBAMP has been prepared to satisfy the conditions of approval under both the NSW and Commonwealth approvals. The BBAMP will be implemented for the project and outlines a monitoring program to inform adaptive bird and bat management. In summary, the program includes targeted bird and bat utilisation surveys over a three-year period and an initial two years of carcass searches. This initial program will inform the requirements for subsequent surveys and carcass searches for the remainder of the operation of the BWF and associated trials.

This BBAMP will remain valid for the period of operation of the BWF and can be updated in accordance with the requirements outlined in and consistent with each Approval.

Conditions relevant to the BBAMP and relevant section references are outlined in Section 1.2 below.

1.2. Requirements of BBAMP

The specific requirements of the BBAMP from SSD6686 and EPBC 2013/6810, and where they have been addressed, are presented (respectively) in Tables 1 and 2 below.

Table 1: NSW BBAMP conditions

SSD6686 condition	BBAMP section
21. Prior to the commissioning of any wind turbines, the Applicant must prepare a Bird and Bat Adaptive Management Plan for the development in consultation with OEH and to the satisfaction of the Secretary. This plan must include:	
(a) at least 12 months' worth of baseline data on threatened and 'at risk' bird and bat species and populations in the locality that could be affected by the development;	Appendix 1, Section 4
(b) A detailed description of the measures that would be implemented on site for minimising bird and bat strike during operation of the development, including: ▪ minimising the availability of raptor perches on wind turbines; ▪ prompt carcass removal; ▪ controlling pests; and	Section 3

	▪ using best practice methods for bat deterrence, including managing potential lighting impacts;	
(c)	trigger levels for further investigation of the potential impacts of the projects on particular bird and bat species or populations;	Section 4
(d)	an adaptive management program that would be implemented if the development is having an adverse impact on a particular threatened or 'at risk' bird and/or bat species or populations; including the implementation of measures to: ▪ reduce the mortality of these species or populations; or ▪ enhance and propagate these species or populations in the locality; and	Sections 4
(e)	a detailed program to monitor and report on: ▪ the effectiveness of these measures; and ▪ any bird or bat strikes on the site;	Section 3, Appendix 4
(f)	provisions for a copy of all raw data collected as part of the monitoring program to be submitted to OEH and the Secretary.	Section 2.10
Following the Secretary's approval, the Applicant must implement the Bird and Bat Adaptive Management Plan.		

Table 2: Commonwealth BBAMP conditions

EPBC 2013/6810 condition	BBAMP section
6. The **approval holder** must submit a Bird and Bat Adaptive Management Plan (BBAMP) to the **Minister** for approval. The **approval holder** must not export electricity for sale from more than 23 wind turbines simultaneously, other than for the purposes of hold point testing and commissioning, unless the **Minister** has approved the BBAMP. The **approval holder** must implement the approved BBAMP. The BBAMP must include, but is not limited to:	
a. An on-going monitoring program, which must include a description of the methodology and frequency of monitoring.	Section 3, Appendix 4
b. Trigger levels to shut down any turbines when there is a high risk of collision based on monitoring data and results of research conducted as part of the EPBC condition 13 on **Superb Parrot** habitat use and breeding ecology.	Section 4
The results of the monitoring program from each year must be submitted as part of the annual report required under EPBC condition 17.	Section 4, Appendix 4

1.3. BBAMP Objectives

The overall aim of this BBAMP is to provide a program for monitoring the impact of operating turbines at the BWF on birds and bats and responding in an adaptive manner to better mitigate and manage any impact in response to the findings of monitoring and related investigations and, ultimately, to reduce mortality of species of birds and bats of concern.

This is achieved by establishing monitoring and management procedures consistent with the methods outlined by the Australian Wind Energy Association (AusWEA 2005) and endorsed in the Clean Energy Council's Best Practice Guidelines (CEC 2018).

The specific objectives of this BBAMP, derived from the conditions of approval, are set out below.

- To implement a monitoring program to estimate the impact of the project on at-risk birds and/or bats that can reasonably be attributed to the operation of the project, as an indicator of population impact;
- To directly record impacts on birds and bats through carcass searches;

- To document an agreed decision-making framework that identifies impact triggers[1] requiring a management response to reduce impacts and the management activities that will be considered; and

To identify matters to be addressed in periodic reports on the outcomes of monitoring, the application of the decision-making framework, mitigation measures and their success. Overall, it is intended to maximise the chances that the population of each threatened species remains at similar or greater levels after 25 years of BWF operation, unless factors unrelated to the wind farm prevent this.

The strategies to be employed to ensure that any impact triggers are detected includes the following:

- Baseline and operational phases bird and bat utilisation surveys;
- Carcass searches under erected and commissioned turbines;
- Statistical analysis of the results of carcass searches to derive estimates of mortality levels and rates; and
- Reporting.

Consistent with the requirements of the Approvals, this plan uses an adaptive management approach where management measures are adapted to more effectively manage and mitigate impacts based on the findings of the monitoring program. It is intended that the results of the initial monitoring program will inform the requirements of the ongoing monitoring program, depending on detected bird and bat impacts, and identify additional targeted carcass searching and surveys to be carried out to inform ongoing management and mitigation strategies.

1.4. Consultations in the development of the BBAMP

Consultation on the BBAMP has been ongoing with BCD and DAWE since early 2019. During this time, several meetings with the relevant agencies have occurred and iterative versions of the BBAMP prepared in response to written feedback from BCD and DAWE.

This BBAMP (version 21) has been revised to include an updated risk assessment following analysis of baseline monitoring results, revised trigger levels and additional information on the statistical methods to be used to generate estimates of changes in bird activity and estimates of bird and bat mortality.

1.5. Site Description

Figure 1 shows the regional location of the Bango Wind Farm. Figure 2 provides a more detailed map of the BWF development footprint and turbine locations on an aerial image of the site. The individual turbines are generally located on ridge lines with elevations between 600 and 760 metres Australian Height Datum (AHD). Approximately 91% of the site has been cleared or has had its tree cover heavily reduced. Patches of woodland and open forest remain in some areas ranging from intact, to treed areas with substantially modified understorey and ground cover. Areas of woodland regeneration also occur.

The area comprises primarily private farming properties used for grazing and cropping, many with an extensive history in these practices. Some areas have not been cultivated and areas of exposed rock remain and support grassland. In areas of heavy grazing, native flora cover is minimal and dominated by introduced pasture. Derived native grassland occurs in less extensively grazed areas. Intact woodlands are generally restricted to ridge tops and roadsides with lower elevation areas mostly cleared (ERM 2013).

The avifauna of the site is typical of this part of NSW, with birds of open country, farmland and fragmented woodlands dominating. Knowledge of the bat fauna in the region is developing as more survey work is done as part of assessments for proposed wind farms in the area. Some woodland remnants at the BWF site support a relatively intact tree canopy that would provide foraging habitat for insectivorous bats. More details of the birds and bats of the site can be found in Appendices 1 and 2 to this BBAMP.

[1] A definition of 'impact trigger' is detailed in section 4.2.1.

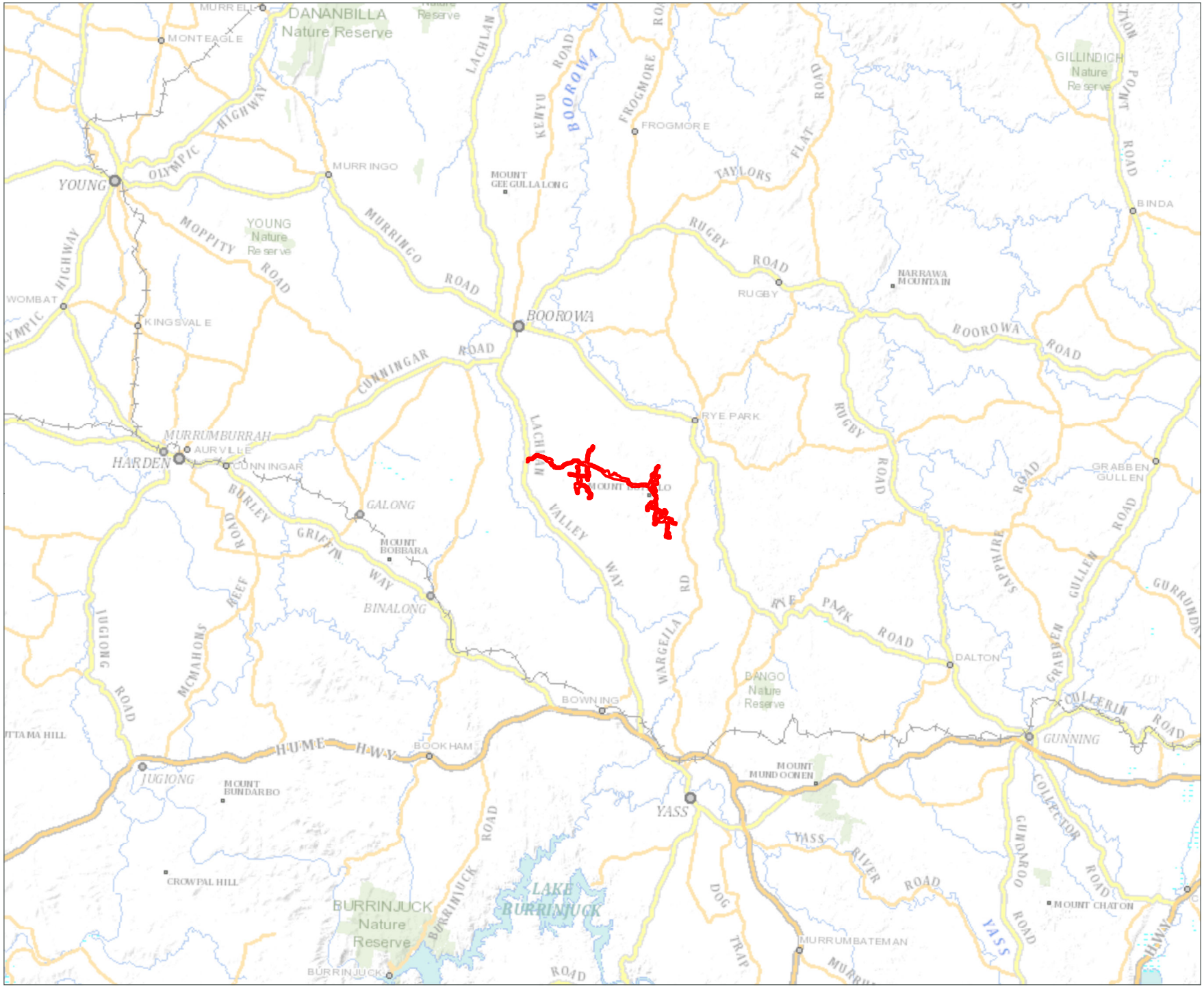


Figure 1: Locality and Wind Farm site

Project: Bango Wind Farm
Client: CWP Renewables Pty Ltd
Date: 26/06/2020

Development corridor

N

Metres
0 6,800

Nature Advisory
PO Box 337, Camberwell, VIC 3124, Australia
www.natureadvisory.com.au
03 9815 2111 - info@natureadvisory.com.au

Main frame - Created by: - E:\GIS\2018 Jobs\18173\18173 Location and site 200626.mxd

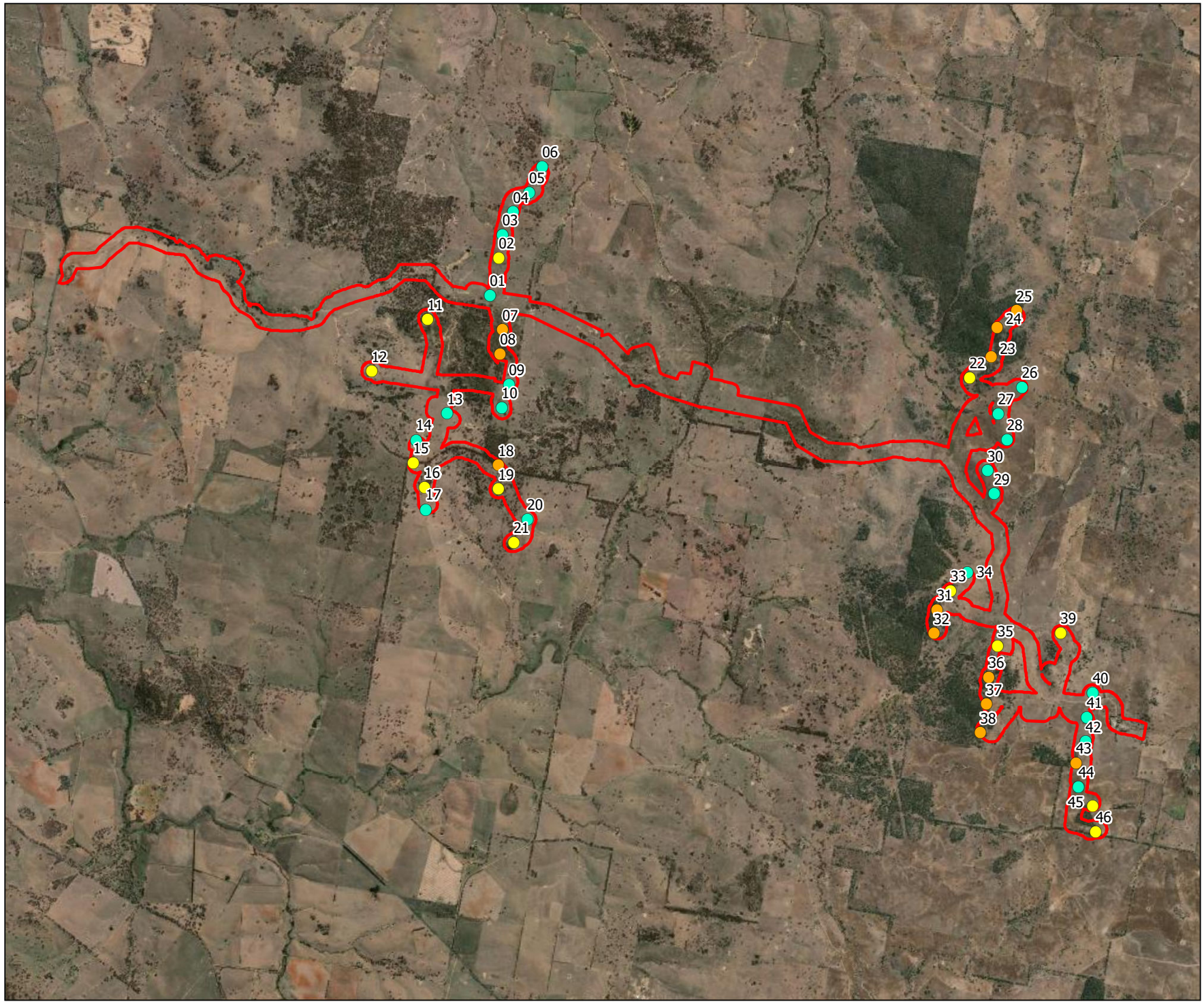


Figure 2: Turbine stratification

Project: BANGO WIND FARM
Client: CWP Renewables Pty Ltd
Date: 21/01/2021

Legend

Development corridor

Turbine class - dominant sorrounding vegetation

- Closed
- Open
- Pasture

N

Metres

0 750 1,500

Nature Advisory
PO Box 337, Camberwell, VIC 3124, Australia
www.natureadvisory.com.au
03 9815 2111 - info@natureadvisory.com.au

Habitat quality for birds and bats is low in the largely cleared parts of the site and moderate to good in most wooded areas. Figure 2 shows turbines considered to lie in areas of differing habitat quality/type.

Further details of the site's attributes and biodiversity values can be found in the EIS and the Biodiversity Management Plan (CWP 2020) (BMP) located on the BWF website.

1.6. BWF project schedule

At the time of finalising this BBAMP the BWF was in the construction phase and turbine erection had commenced. A summary of the key project milestones is provided below:

- Construction of BWF commenced in August 2019 with minor works such as intersection upgrades and compound construction;
- Wind turbine erection commenced November 2020;
- Wind turbine commissioning will occur progressively over the following 12 months;
- It is planned that BWF will be fully operational in October 2021; and
- Operation of the BWF is planned for 30 years at which time the project will be decommissioned.

1.7. Additional information

This BBAMP was prepared by a team from Nature Advisory Pty Ltd including Jackson Clerke (Zoologist), Curtis Doughty (Senior Zoologist), Bernard O'Callaghan (Senior Ecologist and Project Manager) and Brett Lane (Principal Consultant).

The approach developed for monitoring impacts on birds and bats has been refined from experience gained from the preparation, data review, and feedback from regulators and approval authorities on other BBAMPs. This BBAMP has incorporated learning and experience from past plans and incorporates the latest approaches to monitoring wind farm impacts on birds and bats.

Personnel undertaking the carcass searches will be an ecologist adequately trained to undertake the monitoring. A suitably experienced expert will be responsible for the design of monitoring, as well as training, data analysis, interpretation, formulating adaptive management measures and reporting.

1.8. Structure of this BBAMP

This BBAMP includes the following parts:

- **Section 2** describes the bird and bat monitoring program;
- **Section 3** details risk reduction measures;
- **Section 4** presents information on impact triggers and their associated adaptive management framework to identify the most effective mitigation and management responses, as well as those mitigation measures.

Detailed information to support the implementation of this BBAMP is provided in key technical appendices, including:

- Previous information on the birds and bats of the wind farm site (Appendix 1); and
- Statistical appendices addressing both the bird utilisation survey (BUS) method and the carcass search monitoring program (Appendices 2 and 3);
- A detailed description of the carcass search protocol and associated correction factor investigations (Appendix 4) and
- Data collection pro-formas (Appendices 5 and 6).

2. Monitoring program

2.1. Baseline monitoring

Baseline bird and bat investigations have been ongoing at BWF since 2012. The surveys listed below gathered baseline data to inform future monitoring.

- Hollow bearing tree survey
- Bird and bat overview assessments
- Bird utilisation surveys (BUS)
    - Initial BUS 2012-2013
    - Pre-commissioning BUS 2019-2020
    - Construction phase BUS
- Targeted parrot surveys
    - Superb Parrot
    - Swift Parrot
- Raptor surveys
- Woodland bird surveys
- Nocturnal surveys
    - Owl surveys
    - Bat surveys.

The full schedule of work, the methods used, and a summary of results are contained in Appendix 1.

2.2. Operational phase monitoring

Operational phase monitoring sits within an adaptive management framework. This means that monitored impacts, if considered a problem, will be mitigated based on focussed investigations to understand risk behaviour and its cause and associated targeted mitigation measures. To achieve this, two broad approaches have been adopted in this BBAMP:

- Investigations to monitor bird and bat activity (bird and bat utilisation surveys) and ongoing bird and bat mortality (carcass searches) that aim to monitor impacts (displacement, collisions) occurring on birds and bats in the initial years of project operation; and
- Specific responses to impact triggers involving stepped up carcass searching, investigation of risk behaviours and development of mitigation strategies and methods.

Sections 2.2 to 2.4 describe the survey methods to be implemented once BWF becomes operational. Section 2.5 and Appendix 4 describe the ongoing carcass search methods, including correction factor trials (scavenging and detection rates).

Specific responses to impact triggers, such as impacts on listed species, are an ongoing requirement for the life of the project and the scope and scale of the monitoring, as well as the nature of any mitigation measures will be governed by the decision-making framework set out in Section 6 of this report.

Carcass-searches will initially be carried out on turbines as they are progressively erected, but not yet commissioned in line the protocols outlined in Appendix 4. Following turbine commissioning (and subsequent operation of the turbines), carcass searches will continue initially for a minimum of two years with a review and compilation of all monitoring data gathered in the first and second years. This review will inform if further and/or more targeted monitoring of demonstrated threatened species impacts is required. It will also be used to guide the remainder of the bird and bat surveys in the years following commencement of implementation of the BBAMP.

The scale of the impact assessment will be the BWF site and impacts will be determined on the birds using the site.

2.3. Operational Bird Utilisation Surveys

A comprehensive operational phase BUS will be undertaken using the same methods as for the baseline BUS (see Appendix 1). One survey will be completed during each of the 4 seasons in:

- Year 1; and
- Year 3 of operation.

The requirement for additional BUS surveys will be assessed and recommended in the third-year annual report and during ongoing reviews undertaken at five yearly intervals (following the first review). These surveys will seek to demonstrate whether the site continues to be utilised by the range of species identified in the baseline surveys and assess any changes in activity levels or behaviour.

The BUS will generate data to determine if there are changes in bird utilisation at the site from the baseline BUS of the site. The surveys have been designed in a method (7 impact points and 3 reference points) that provides for statistical analysis to identify the impacts of the project (see Appendix 1, Figure 7).

2.4. Monitoring 'at risk' groups

Baseline information on the birds and bats of the site has been collated (see Appendix 1).

The key species or groups of concern have been identified from the work described in Appendix 1. These include:

- Wedge-tailed Eagle;
- White-throated Needletail and Other raptors, including Little Eagle;
- Superb Parrot;
- Large Bent-winged Bat (LBB);
- Yellow-bellied Sheathtail Bat; and
- Other Bat species.

In the event that threatened birds or threatened bats are found during carcass searches, or incidentally, an appropriate response will be identified in consultation with DPIE and DAWE, as described in the procedure in Section 4 of this BBAMP.

2.4.1. Birds of prey (Raptors)

BUS will be carried out during operation to record the presence of raptors out to two kilometres from the survey point. Appendix 3 describes the statistical basis for the method adopted. The surveys will be completed over four seasons using the fixed-point bird count method outlined in Appendix 1. They will be conducted in:

- Year 1; and
- Year 3 of operation.

In addition, monthly monitoring of Wedge-tailed Eagle flight movements and breeding activity will be undertaken during the operational monitoring period for an initial 2-year period during monthly carcass searches and will involve searching for Wedge-tailed Eagle from the turbine location sites during searches (one scan every minute or so of searching) and incidental recording of other raptors when moving between search sites. The period of observation will be for a minimum of 40 hours in the field on a monthly basis for the first two years, when the ecologist is travelling around the site. Information recorded during operational monitoring will include, at a minimum:

- Date;

- Location of beginning, end and route of flight path;
- Time and duration of flight;
- No. and age of birds;
- Flight height above ground (range);
- Flight behaviour;
- Habitat over which the flight was observed;
- Flight behaviour observed included soaring, directional flight (flapping), kiting, circling, gliding and diving; and
- Other occasional behaviours included feeding, territorial displays, fighting and perching.

Flight paths will be plotted as accurately as possible on large-scale maps of the site and nesting activity of Wedge tailed Eagle will also be recorded.

A Wedge-tailed Eagle nest survey has been previously undertaken at BWF and those identified nesting sites have been recorded (Figure 3). Based on eagle flight behaviour observed while on site it may be possible to identify additional nesting areas at BWF. Any eagle nest locations will be recorded with GPS and revisited during the breeding season to monitor nesting activity and outcome (from August to November for Wedge-tailed Eagle).

A series of adaptive management measures are proposed in this BBAMP to reduce the potential for high numbers of raptors to use the site. These are outlined in Section 3 of this document.

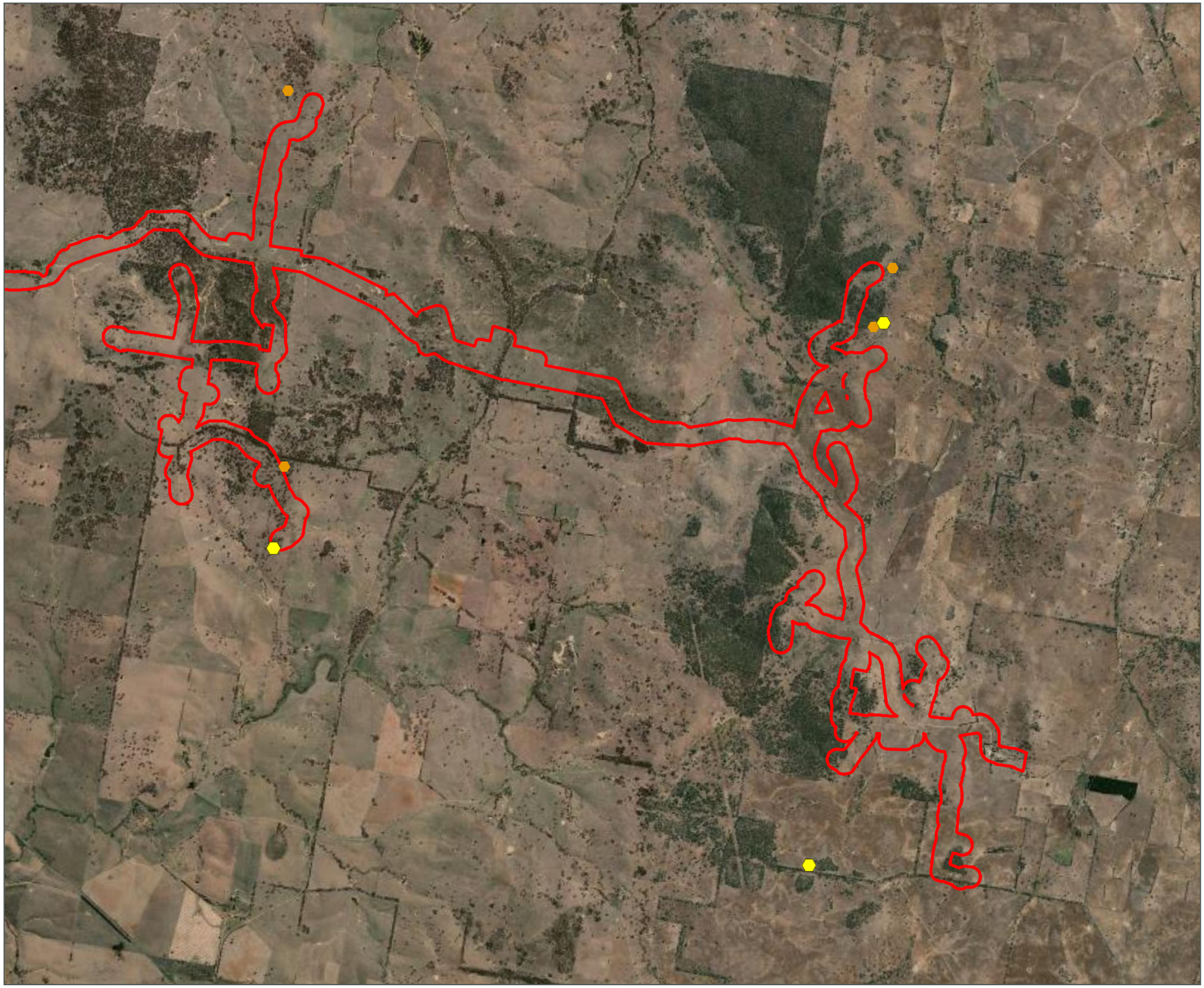


Figure 3: Wedge-tailed Eagle Nests

Project: Bango Wind Farm
Client: CWP Renewables Pty Ltd
Date: 20/03/2020

Development corridor
Active
Inactive

N

Metres
0 800

Nature Advisory
PO Box 337, Camberwell, VIC 3124, Australia
www.natureadvisory.com.au
03 9815 2111 - info@natureadvisory.com.au

Main frame - Created by: - \\Blagis01\e\GIS\2018 Jobs\18173\18173 Flight paths 191011.mxd

2.4.2. Migratory bird species

White-throated Needletail typically flies at and above RSA height. The initial two-year monthly carcass searches (during the appropriate season, October to early April) will monitor their presence and any impacts likely to occur from the BWF.

If a flock of Needletails is observed during any field work moving through the site, the numbers of birds and the zone of movement (where ascertainable) will be plotted on the maps of the site. The same information will be recorded for any observed flight paths of Needletails as described above for raptors. Mortality of listed migratory species will be investigated in line with the impact triggers and associated adaptive management framework in Section 4.

2.4.3. Superb Parrot

The Superb Parrot occurs at the Bango Wind Farm during the breeding season, from September to December. Previous breeding season surveys indicate numbers of Superb Parrot utilising the site and potential breeding occurring far to the north of the site (ERM 2013) and turbines have been positioned away from these areas. Superb Parrot baseline surveys were undertaken during the breeding season of 2019 for one week early in the breeding season (October) and for one week at the end of the breeding season (November). Superb Parrot were observed at BWF though no breeding activity was confirmed within 200 metres of turbines and no flights were observed at RSA heights (above 40m) (Nature Advisory 2021).

Operational phase targeted surveys will be implemented monthly during the Superb Parrot breeding season (i.e. the period the species occurs on the wind farm) using the same methods. A comparison of baseline data with the operational phase data will seek to identify potential effects or impacts on the species or its behaviour that the operation of the BWF may cause. Further surveys will be recommended if surveys demonstrate regular risk behaviour by the species (see definition below.

The aims of the survey are to:

- Determine whether breeding of Superb Parrots is occurring within 200 metres of turbines; and
- To determine whether Superb Parrots are observed demonstrating “risk behaviour”. “Risk” behaviour is defined for the purpose of this BBAMP as consistent observations of ten or more flights per day of flocks of ten or more birds between turbines at least 40 metres above the ground; and
- Superb Parrots utilising breeding hollows within 200m of a WTG and, during monitoring surveys observed multiple times flying at least 40m above ground towards turbines that could result in turbine collision.

The following methodology will be undertaken for targeted Superb Parrot surveys:

- Focussed transect surveys 250 metres either side of the wind farm infrastructure;
- Experienced bird observers would walk at a rate of up to 2 km/hour;
- All hollow-bearing trees that have been identified within 200 metres of turbines will be searched for breeding activity;
- If Superb Parrots are observed in focus areas, then monitoring will be undertaken to determine if they are nesting. This will include watching parrot activity to determine if nesting was occurring, determining the sex of birds in flocks and attempting to follow parrots to nest trees;
- If nest trees are located in the focus areas, these trees will be documented and recorded. Daily visits will be undertaken to record activity while surveys are ongoing;
- All Superb Parrot and other threatened species observations will be recorded and marked with a handheld GPS.

This information will be compiled and analysed in the first annual report. This will include a robust comparative analysis between baseline and operational data. This will provide an assessment and recommendations for additional surveys that will be provided to DPIE and DAWE.

2.4.4. Other species of concern

All other bird species were considered to be at a 'negligible' risk rating. These species would be subject to the standard protocols post construction, i.e. any bird found during the carcass searches (Section 4.4) or by BWF staff incidentally would be reported and stored in a freezer on site for confirmation of its identity and for use in trials.

2.5. Bat Surveys

The bat surveys spring and summer/autumn in the migratory season will be repeated in the first year of operation. The survey methods will where practicable repeat methods used in the baseline surveys. This will include:

- Sixteen survey sites across the BWF with a minimum of 10 days at each site (with at least one site at height);
- One month each during spring and summer-autumn; and
- The final timing of operational surveys will be developed in consultation with DPIE threatened bat expert Dr Doug Mills.

2.6. Ongoing carcass search monitoring

A monthly carcass search monitoring program will be ongoing for BWF and is intended to meet the requirement of condition 6(a) of approval EPBC 2013/6810. This program will be progressively implemented across BWF consistent with the phasing of turbine commissioning and operation.

It is intended that additional carcass searches will also be undertaken at turbines that are being erected and tested but not yet commissioned or operational. These searches will specifically target the Superb Parrot and be intensified during the Superb Parrot breeding season (October – December). The timing of these carcass searches will be subject to the construction schedule and the progress of turbine erection activities.

The carcass search protocol is detailed in Appendix 4.

The purpose of carcass searches is to determine the actual impact of the BWF on birds and bats by estimating the annual number of fatal turbine collisions. Mortality rates can be estimated for all bird species combined, and all bat species combined. If threatened species are found underneath a turbine, the mortality rate for that particular threatened species may also be estimated, subject to sufficient data being available.

Mortality is defined as any dead bird or bat detected under a wind turbine and within a distance of the turbine in which carcasses could potentially fall if struck. Detection can be either during the formal carcass searches (designed to generate an estimate in accordance with a statistically rigorous sampling design) or at other times (incidental observation, often by BWF operational staff). A protocol is triggered whenever a carcass is found, either within the formal searches or incidentally to collect consistent and useful data on the fatality event (Appendix 4). The datasheet that is required to be filled is presented in Appendix 6.

Collision by birds and bats with wind turbines will be monitored through a statistically rigorous carcass-search program for a minimum period of two years. This will involve systematic, monthly searches for dead bird and bat carcasses under a random selection of turbines (see Appendix 4). This will ensure statistically useable and robust results are generated from the carcass monitoring program that include an estimate of both bird and bat mortality rates, together with an estimate of sampling precision.

It will be assumed that any intact dead bird or bat, or bird feather spot (defined as a clump of five feathers or more), detected beneath a turbine has died as a result of collision or interaction with a turbine, unless there are obvious signs of another cause of death (e.g. being shot, caught in a fence etc.). Feather spots will be assumed to be remains of a bird carcass after scavenging and the scavenger correction factor will not be applied to them (see later).

Ongoing monitoring of mortality from blade strike at operating BWF typically serves to (i) provide data that can inform adaptive management of the collision risk (i.e. patterns of mortality related to seasonal changes or local conditions); and (ii) detect mortality of threatened and non-threatened bird and bat species, which can be used to understand actual bird and bat impacts.

The search protocol (see Appendices 4 and 5) has been designed to detect optimally species and groups of concern that have a higher than negligible risk of impact, as well as any other species that have fatally collided with turbines. The consistent application of this protocol will ensure that statistically robust, and spatially and temporally consistent data are collected on bird and bat mortality.

To derive accurate mortality rates, the carcass search program has been designed to be scientifically and statistically robust. Appendix 2 describes the statistical basis for the design of the carcass searches and the analytical methods proposed. Once two years of results are available, the precision of mortality estimates can be calculated and considered in determining requirements for further monitoring.

A number of factors, such as carcass scavenging and carcass detectability, can affect mortality rate estimates and must be measured and allowed for in any estimate of overall mortality rates.

A scavenged carcass may increase the variability in mortality rate estimates and thus carcasses will be assessed for possible scavenging and rates will be estimated from experimental trials (Appendix 4). Appendix 3 presents the statistical basis of this approach.

Detectability of carcasses is also a potential confounding variable and protocols have been developed to control for this factor in the final mortality estimates. Appendix 4 provides more detail on this issue and the investigations designed to quantify this factor. Appendix 3 presents the statistical basis of this approach.

The practical considerations that have informed the design of the carcass search program and associated trials are:

- Very few carcasses are found under turbines in Australia compared with Northern Hemisphere wind farms (i.e. on average, less than half the number in the Northern Hemisphere based on Nature Advisory data across seventeen wind farms) due to the much smaller number of night-migrating songbird species (which make up 50% of carcasses at Northern Hemisphere wind farms) and bird numbers due to the lack of land in the Southern Hemisphere at latitudes where severe winter has led to the evolution of widespread, long-distance migration;
- Carcasses of a suitable range of sizes for scavenger and detectability trials are difficult to source and usually involve a combination of carcasses found under turbines and those found along roads and other legal sources. It is illegal to source un-cleaned carcasses from poultry producers;
- For statistical reasons, it is likely to be very difficult to determine more than the grossest of differences in scavenging rate or detectability across the year and there is no evidence in the literature for significant differences between seasons in scavenger activity. Therefore, annual scavenger and detectability correction factors will be generated and applied (Appendix 3);
- It is known that detectability will be easier in short grass at the dry time of the year compared with in longer grass at the wet time of the year, and detectability trials have been scheduled accordingly (see Appendix 4).

Since 1998 the implementation of bird and bat monitoring programs in Australia continues to develop, and the techniques described here are based on lessons from a number of such programs already implemented (e.g. Hull *et al*. 2013, Nature Advisory unpubl. data from ten projects), knowledge of experimental design and statistical analysis, and recent feedback from the regulatory authorities.

The methodology contained within this BBAMP was reviewed by experienced statisticians in wind farm mortality estimation. A review of the methodology contained within this BBAMP is attached in *Appendix 3: Statistical review of mortality monitoring.* This methodology was reviewed with BCD in a meeting on the 10th of June 2020.

At the completion of the two-year operational phase monthly carcass search program, the findings will be reviewed to guide operational-phase monitoring activities in the following years of BBAMP implementation.

The following sections outline:

- **Turbine selection for searches**: how the turbines will be selected for the search;
- **Incidental search protocol:** outlining the procedure to be adopted in the event of an incidental carcass or feather spot find by BWF personnel outside the formal carcass-searches; and
- **Analysis and mortality estimation**: general outline of how the data will be analysed to gain estimates of bird and bat mortality.

Appendix 1 provides a statistical review of the carcass search method and Appendix 4 describes the method, including the following:

- **Search protocol** (Appendix 4): the size of area beneath turbines to be searched and how this area will be searched systematically and results recorded;
- **Scavenger rates and trials** (Appendix 4): definition of scavenging and how experimental trials will be conducted;
- **Detectability and trials** (Appendix 4): definition of detectability and the experimental trial methodology;

2.6.1. Turbine setting

Prior to the selection of turbines for carcass searches, each turbine will have the following recorded:

- Location (easting, northing);
- Distance to nearest turbine;
- Identification number of nearest turbine;
- Local vegetation (type, height, and density during each search to document change in vegetation cover over time); and
- Distance to key habitat feature, such as dam/wetland or waterway, or woodland remnant.

Overall, 16 turbines (33% of the approved 46 turbines) will be searched each month. This will ensure the calculation of accurate and precise mortality rate estimates (see Appendix 3 for a statistical review of the method).

2.6.2. Stratification and turbine selection

The turbines within BWF have been categorised as occurring in three distinct vegetation types on the site recommended by BCD. Based on this the turbines have been allocated to the following three strata (see Figure 2):

- Cleared areas - 21 of 46 turbines, (7 turbines (33% of strata) to be searched monthly)
- Open wooded areas - 13 of 46 turbines, (5 turbines (33% of strata) to be searched monthly)
- Closed wooded areas - 12 of 46 turbines, (4 turbines (33% of strata) to be searched monthly)

To ensure the overall statistical robustness the following will be carried out to select search turbines:

- Turbines are selected randomly within each stratum for carcass searches; and
- The adjunct surveys (searcher efficiency and scavenger trials) need to be conducted in each of the three strata.

Once randomly chosen, these 16 turbines will be searched every month during the carcass monitoring period.

In relation to the statistical analysis, regardless of power to determine differences, the three strata will not reduce the precision of the site-wide estimates, nor of the mortality estimate. At worst, it will do nothing to these estimates; at best, it will reduce the variability in the estimates. This is explained further in Appendix 3.

In the second annual report a full statistical analysis will be undertaken to determine the precision of estimates of mortality and carcass scavenging rate in the three strata. This will determine if these factors vary with differences in tree cover.

2.6.3. Carcass search protocol

The same randomly selected turbines will be searched out to 120 metres once per month. A second follow-up search, a 'pulse search' will be undertaken to 60 metres during the warmer months (September to April) when microbats are more active and when Superb Parrot are in the area. This pulse search will be conducted once a month within several days of the first search to detect additional mortality of bats and birds. The order of turbines searched will be randomized between searches. Refer to Appendix 4 for the detailed Carcass search protocol.

2.6.4. Additional carcass searches (Superb Parrot; September - December)

Additional carcass searches will also be undertaken each month during the Superb Parrot breeding season (September – December). Each month, the remaining 30 turbines not regularly searched will be searched once to 100 metres (this radius is sufficient to detect a medium sized bird carcass with weight: 132-157g – See Appendix 3).

These targeted Superb Parrot carcass searches will be part of the ongoing monitoring program. The results of these searches will be analysed in the second year to ascertain if any high-risk turbines should be targeted for further monitoring (separate from the stratified random set used for whole-of-project mortality estimates) to assist in detecting any ongoing impacts on the Superb Parrot and, if so, inform, identify and evaluate mitigation measures (see Appendix 3). Furthermore, the results will be analysed in conjunction with the BUS and targeted survey results at year three and at the ongoing five yearly review intervals. This ongoing monitoring will determine the scope and frequency of additional Superb Parrot carcass searches in the coming years.

2.6.5. Ongoing incidental carcass protocol

Personnel at the BWF may from time to time find carcasses during day-to-day operations and maintenance activities. In this case, the carcass will be handled according to the carcass detection protocol outlined in Appendix 4. All BWF personnel will be made aware of the carcass handling protocol as part of their training and induction. If a carcass find is made within five days prior to a scheduled carcass search, the carcass will be left *in situ* but photographed and its position recorded (GPS). A carcass search data sheet (Appendix 6) will be completed for each incidental carcass found (whether removed or not).

This incidental carcass protocol is valid for the life of the BWF project.

2.6.6. Analysis of results and mortality estimation

The results of the carcass searches will be analysed in order to provide information on:

- The species, number, age and sex (if possible) of birds and bats being struck by the turbines;
- Separate estimated annual mortality rates for all birds and all bats (and for particular species, if required) including an estimate of the number of carcasses per turbine per year; and
- Any detected spatial or temporal variation in the number of bird and bat strikes.

The search results will be detailed in the first annual report and the detailed analysis and estimates in the second annual report. The latter will identify if further detailed investigations or mitigation measures are required.

Statistically robust projections of bird and bat mortality for the entire BWF site will be presented, based on the data collected from mortality searches. Appendix 4 provides a statistical review of the carcass searches in this regard. It is acknowledged that this is a current and dynamic aspect of research and that the outcomes from such programs may be equally dynamic. The current program is designed to provide an acceptably accurate and precise estimate of BWF related bird and bat mortality within two years, so the full analysis and estimate will be provided in the second annual report, together with recommendations on the scope of future monitoring, if required.

All data will be analysed to provide the average estimated mortality of birds and bats, their standard error (variability) and ranges for the BWF. The mortality rate of each species (if estimates for individual species are possible) and size class detected will be calculated after two years. If possible, the standard error and range of these estimates will be reported. Note that it may not be possible to provide this due to the likely low number of carcasses detected. Where this is an issue, it will be reported. Mortality estimates will also take into consideration the actual operational time of the turbines (obtained from the project operator).

Estimating total mortality

The estimated mortality rate will be generated using the method detailed in Appendix 3 and summarised below.

The estimate of total turbine related mortality will be reported for bats, birds and individual species (where there are sufficient data for meaningful estimates) as the median and upper 95% percentile of the mortality.

Mortalities at turbine i during search j $\hat{M}_{ij}$ are estimated by (@Huso2017 and references therein)

$$\hat{M}_{ij} \simeq \frac{C_{ij}}{\hat{g}_{ij}}$$

where

- C_{ij} is the number of carcasses found
- $\hat{g}_{ij}$ is the estimate of the detection probability for that search and turbine

For a given turbine, $\hat{g}_{ij}$ is a function of (for each strata) the following estimates

- The fraction of turbines searched
- Coverage factor: the fraction of total carcasses expected to fall within the searched area
- Searcher efficiency: the probability that an existing carcass will be detected by the searcher
- Scavenger rate and time to loss: the fraction of the carcasses that arrived at turbine i but have not been lost to scavenge or decay before search j. it is a function of the rate of decay and the search interval, relative to the expected time to scavenge

Appendix 3 provides more detail.

Factor

Coverage Factor: This the ratio of the area searched to the (modelled) density of carcass. The density of carcasses as a function of distance will be estimated from methods in Hull (2010). The nominal coverage in Appendix 4 should be corrected accounting for any variation required in the field (e.g. surveys with restricted areas).

Searcher efficiency: The searcher efficiency (proportion of carcasses found see 4.4.4 above) will be reported as a mean and variance measure (standard error and / or 95% confidence interval) for each significant covariate. P-values will be reported for each significant covariate. Searcher efficiency is modelled using logistic regression (Agresti 2002). Logistic regression allows binary data (i.e. success = carcass found, failure = carcass missed) to be modelled, accounting for covariates such as carcass size and time of year.

A brief summary of the Generalised Linear Model (GLM) regression techniques are presented, but we suggest referring to Agresti (2002) categorical or a similar text for more detail.

We refer to the probability of success in a trial i as $\pi(x_i)$ where x_i is a vector of covariates. We model the relationship between the probability of success and the log odds using the logistic model

$$\text{logit}[\pi(x_i)] = \beta \cdot x_i$$

where $\text{logit}[\cdot]$ denotes the logistic function $\text{logit}(p) = \ln \frac{p}{1-p}$ and β is a vector of regression coefficients. As $\pi(x_i)$ is free to vary with each trial, this allows the mean to be modelled in a flexible manner depending on carcass size and so on. The logistic function is used because it allows probabilities (which are necessarily bounded between 0 and 1) to be modelled by a linear combination of predictor variables, without getting nonsensical outcomes like probabilities greater than 1, which can be obtained by ordinary least squares regression.

The estimates of regression coefficients $\hat{\beta}$ are obtained via maximum likelihood estimates, which is the standard method of estimation in GLMs. Both estimates of the mean, and standard errors of those estimates, are obtained by this technique. This allows significance testing of covariates and reporting of confidence intervals.

Scavenger efficiency

The time to scavenge will be reported as a mean and variance measure (standard error and/or 95% confidence interval) for each significant covariate. P-values will be reported for each significant covariate.

Time to scavenge will be estimated using survival analysis - we use the methods of Therneau & Grambsch (2000). Survival analysis is the standard statistical technique dealing with time-to-event data (in this case, "survival" can be interpreted as how long a carcass "survives" in field before taken by a scavenger or decay). It models the probability that a carcass will persist after a certain period of time.

A few key reasons why survival analysis is used over other techniques like simply taking the average are:

- It can account for *censored* data, generally one of: a) when the exact time of scavenge is known within an interval, but not exactly; or b) the carcass persists at the end of the trial.
- It can account for covariates, e.g. carcass size or ground type.
- It allows choosing different *hazard rates*, which are models describing how risk changes with time. Two common hazard rates in wind farm mortality monitoring are the exponential (constant hazard), and log-normal (a hazard-rate which initially increases, and then declines).

Survival regression is based around GLM modelling, so also uses maximum likelihood estimation. Standard errors, confidence intervals, and p-values can be obtained for the mean times to scavenge.

In addition to providing mortality estimates, this analysis will determine if any of the factors (i.e. size class or habitat stratification of turbine sites) are significant, where possible.

2.7. Summary of operational monitoring

The operational monitoring program includes both initial monitoring (surveys) and ongoing monitoring, with the following components:

1. Targeted surveys;
2. BUS; and
3. Ongoing carcass searches.

The initial monitoring and ongoing monitoring is explained below and summarised in Table 3 below.

Initial monitoring

The initial monitoring incorporates targeted surveys of Wedge-tailed Eagle, White-throated Needletail, raptors, Superb Parrot, Large Bent-winged Bat and Yellow-bellied Sheath-tail Bat. This targeted monitoring will generally be undertaken monthly for the first two years of operation of BWF (noting Suburb Parrot will be surveyed during breeding season from September to December, when present on the wind farm, and bats once per year due to survey requirements).

General monitoring will also be carried out by BUS for the same species and more generally non threatened bird species and other bat species. This general monitoring will be undertaken at year one and year three of operation of BWF.

At the end of this initial monitoring period a review will be undertaken to determine the requirements and scope of any further monitoring. Should specific, ongoing impacts on species of concern be detected, this initial monitoring will inform the requirements for subsequent surveys for the remainder of BWF operation as agreed with DPIE and DAWE.

Ongoing monitoring

As discussed above, initial monitoring will comprise targeted survey and BUS. These survey requirements will be reviewed at the completion of the initial monitoring period.

It is intended that the requirements for any further targeted surveys and BUS will continue to be reviewed every five years following the first review. At these review periods, consideration will be given to the results of the ongoing carcass search monitoring, survey results from the previous period (where available) and information from other surveys and broader threatened species research. This ongoing monitoring (at the five yearly intervals) will inform the need for future surveys, their scope and frequency.

Ongoing monitoring will also be carried out by way of carcass search monitoring. The ongoing carcass search monitoring program comprises:

1. An ongoing incidental carcass search protocol;
2. Monthly carcass searches of 33% of turbines within three vegetation strata; and
3. Additionally, during the Superb Parrot breeding season, the carcass search program will be intensified so that all turbines are searched monthly from September to December.

Full details of the ongoing carcass search program are provided in Section 2.6 and Appendix 4.

The five yearly reviews and carcass search monitoring provide for ongoing monitoring in accordance with condition 6(a) of EPBC 2013/6810. The project development assessment and the risk assessment presented in Appendix 2 did not identify any other bird or bat species of concern.

Table 3: Operational monitoring of species at risk and other non-listed species

Species groups to be monitored	Targeted survey / monitoring method	General survey / monitoring method	Ongoing Carcass search monitoring
Wedge-tailed Eagle	Monthly monitoring for at least 2 years	BUS at 1 and 3 years	Ongoing
White-throated Needletail	Monthly monitoring for first 2 years	BUS at 1 and 3 years	Ongoing
Other raptors, including Little Eagle	Monthly monitoring for first 2 years	BUS at 1 and 3 years	Ongoing
Superb Parrot	Targeted monthly activity surveys for at least the first two years during the breeding season (September – December).	BUS at 1 and 3 years.	Ongoing Additional monthly carcass searches of all remaining turbines during the Superb Parrot breeding season (September – December).
Non-listed bird species		BUS at 1 and 3 years	Ongoing
Large Bent-winged Bat (LBB) and Yellow-bellied Sheathtail Bat	Bat Surveys – one per year for first two years		Ongoing

Species groups to be monitored	Targeted survey / monitoring method	General survey / monitoring method	Ongoing Carcass search monitoring
Other Bat species		Bat Surveys – one per year for first two years	Ongoing

2.8. Personnel Involved

This section of the BBAMP outlines the personnel involved and any training required for the field work and report writing necessary for this BBAMP. All personnel implementing this BBAMP will be trained thoroughly, including background theoretical training, knowledge of policies and other administrative matters (e.g. OH&S) and technical and field methods. BWF will ensure that it engages suitably qualified and trained people to supervise and implement the monitoring program.

A suitably qualified ecologist with experience in supervising wind farm bird and bat monitoring programs will oversee in detail and be leading site implementation of the program, including the carcass searches, searcher efficiency trials and scavenger trials. Any person undertaking searches will be trained and supervised by a qualified ecologist familiar with the techniques. The searcher will receive training from the qualified ecologist in the following areas:

- Turbine searches, including transect spacing in inner and outer zones, number and location of turbines to search and transect search methods;
- Equipment usage, such as GPS;
- Data recording;
- Carcass storage; and
- Species identification.

The ecologist will supervise the initial carcass search to ensure that field methods are being undertaken correctly and undertake an audit in the first three months to ensure that methods are being implemented correctly. The qualified ecologist will also be responsible for identifying any recorded carcasses from photographs or from specimens transferred to the freezer on site after searches.

The first searcher efficiency trial will be initiated and set up by the ecologist, who will also train a separate person (the 'carcass controller') to run searcher efficiency trials. Training will include:

- Correct preparation and handling of trial carcasses;
- Correct methods for the random placement of trial carcasses within a randomly selected sub-set of the search areas; and
- The need to place trial carcasses without the searcher knowing where they are being placed.

If for some reason the searcher is unable to undertake the monthly searches as planned (due to illness etc) a back-up person will be identified in advance. If a back-up person is required to undertake searches it will be assumed that they have the same searcher efficiency as the other searcher tested and the average searcher efficiency for the site will be applied.

The scavenger trials will be set up by the approved qualified ecologist, with searches being undertaken by the trained searcher.

Analysis of mortality data will be undertaken by the approved qualified ecologist with support from a statistician.

Annual reports and all investigations resulting from an impact trigger (see section 6) will be prepared by the approved qualified ecologist and subject to an internal peer review process.

2.9. Injured Bird and Bat Protocol

All on-site staff and monitoring personnel will be advised of the correct procedure for assisting injured wildlife. BWF personnel who find injured wildlife will be required to report the find to the site manager, who will be required to place the animal immediately into a dark place (e.g. box or cloth bag, if safe to do so) for transfer to the nearest wildlife carer or veterinarian.

Contact details of local veterinary staff and wildlife carers are provided below to ensure that if injured wildlife is found and cannot readily be released back to the wild, they are treated accordingly and in a timely manner.

- Boorowa Vet Clinic, 110 Marsden St, Boorowa NSW 2586, Phone: (02) 6385 3877
- WIRES, 02 6778 4994 or 1300 094 737

This Injured Bird and Bat Protocol is valid for the operational life of the BWF.

2.10. Data curation

Data collected for this BBAMP will be collected using either paper or electronic consistent pro-formas and transcribed (where required) and stored electronically on behalf of the proponent. Appendix 5 provides the pro-forma to be used to the collection and storage of data on individual carcass finds (during both formal and incidental searches). Appendix 5 provides the pro-forma for collecting data of raptor flight behaviour.

Electronic storage will include fail-safe backup systems. All transcribed data will be reviewed by the ecology expert to ensure its completeness and any inconsistencies discussed with field staff before data sets for each search or survey are finalised.

Data analysis will be undertaken in accordance with the methods described in this BBAMP and detailed in Appendices 2 and 3.

Data will be available at any time for DPIE or DAWE inspection and review.

2.11. Data presentation, reporting and review meetings

In accordance with the NSW Project Approval Schedule 3, Condition 21, reports will be submitted to DPIE and DAWE on an annual basis. Any raw data collected during baseline and operational phase searches and surveys will be made available to DPIE and DAWE upon request. An annual report will be prepared within three months of the completion of the first year of operation phase monitoring. This annual report will focus on presenting the results of the mortality searches, identification of any high-risk turbines, any management measures implemented and recommended refinements to monitoring activities. It will include an evaluation of the triggering and implementation of mitigation measures and recommendations for their refinement, if relevant.

The second annual report will present the first full analysis of data collected and will be presented within three months of the end of the second year of monitoring. Matters to be addressed in this full report include, but will not be limited to:

- A brief description of the management prescriptions implemented and identification of any modifications made to the original management practices;
- The survey methods (including list of observers, dates and times of observations);
- Results of carcass searches and incidental carcass observations;
- Estimates of bird and bat mortality rates (per turbine per year) based on statistical analysis, stratified by habitat, if possible;
- Seasonal and annual variation in the number and composition of bird and bat strikes, where detectable;
- Any other mortality recorded on site but not during designated carcass searches (i.e. incidental records by site personnel and at turbines other than the fixed random sample);

- Identification of any high-risk turbines, unacceptable impacts or impact triggers, and documentation of when the decision-making framework and relevant adaptive management measures were implemented;
- Evaluation of the triggering and implementation of mitigation measures and recommendations for their refinement, if relevant;
- A summary of livestock carcass removal for the purposes of predator reduction; and
- Details of any landowner feral animal control programs and their timing.

A discussion of the results, including:

- Bird risk reduction measures;
- Any further recommendations for reducing mortality, if necessary;
- Whether the level of mortality was unacceptable for affected listed ('at risk') species of birds or bats;
- Usage of the BWF site by species of concern at more than negligible risk and factors influencing this (i.e. climatic, geographical and infrastructure);
- Evaluation of the triggering and implementation of mitigation measures and recommendations for their refinement, if relevant;
- Analysis of the effectiveness of the decision-making framework; and
- Recommendations about further monitoring and mitigation.

In accordance with the Commonwealth approval Condition 6, reports will be submitted to the DAWE on an annual basis. The annual reports will include the results of the monitoring as outlined above and in addition outline the results of research conducted as part of EPBC condition 13 on Superb Parrot habitat use and breeding ecology.

Where requested by DPIE or DAWE, review meetings can be arranged to discuss findings and resolve recommended approaches for the next stage of implementation.

3. Measures to Reduce Risk

Mitigation involves the prevention, avoidance and/or reduction of the risk of an impact trigger occurring or continuing to occur. An '*impact trigger*' is defined in section 4 as a threshold of impact on birds or bats that triggers an investigation and/or mitigation response. This section outlines such measures and addresses condition of approval 21 (b).

The overall objective of mitigation measures is to ensure that the operation of BWF does not lead to significant impacts on threatened or non-threatened birds and bats. Any future novel or new mitigation measures that are identified to be of potential benefit for birds and bats at the BWF should be incorporated into the BBAMP as part of the adaptive management approach, in consultation with the DPIE and DAWE.

Specific mitigation measures to be implemented in the event of an impact are described in Section 4.

3.1. Carcass (carrion) removal program and stock forage control

Land-use and stock management below and around turbines can influence the presence and behaviour of native birds on site. Examples that could elevate bird collision rates include:

- Grain feeding can attract parrots and cockatoos; and
- Carrion and rabbits can attract raptors.

This section proposes possible mitigation measures to address these matters.

Experience at other wind farms indicates that Wedge-tailed Eagles and other raptors make up a substantial proportion of birds that collide with wind turbines in Australia. The eagle and other raptors forage for carrion (and the fresh or decaying flesh of a dead animal) and also on small mammals and rabbits. To reduce the risk of raptors colliding with turbines, a regular carrion removal program will be implemented during operations, to reduce the attractiveness of the site to raptors and therefore reduce the potential for fatal collisions by this group of birds. This program will focus on an area of a minimum of 200 metres around turbines, where safe, feasible and practical. The procedures below will be adopted:

- A designated suitable person will be appointed (such as a BWF employee or landowner) to perform the function of Carrion Removal Coordinator who will ensure the activities described below will occur:
  - Monthly inspections of the BWF site to search for any stock, introduced or native mammal and bird carcasses (to be recorded as incidental finds) that may attract raptors (e.g. kangaroos, pigs, goats, foxes, rabbits, dead stock). This search will be undertaken via vehicle and visual checks in addition to using binoculars to look for larger carcasses within 200 metres of each turbine;
  - Additional, opportunistic observations by operators during normal inspections and work routines and by landowners as they travel around their properties will provide further opportunity to identify and report carcasses of stock or feral animals so that timely collection can be undertaken to remove them. This can be addressed by operator and landowner protocols within the operational phase environmental management plan and associated procedures;
  - Any carcasses and/or remains found that are within 200 metres of turbines, will be collected and disposed of within 2 days, in a manner that will avoid attracting raptors close to turbines;
  - Consult with the landowner or BWF manager in relation to the appropriate disposal of collected carrion, to be located at least 200 metres away from the closest turbine;
  - Wind energy facility maintenance staff and landowners will be required to notify the Carrion Removal Coordinator immediately following identification of carrion on site in between monthly searches;

- Carcass occurrence and removal will be recorded in a "management log book" maintained by BWF asset manager or delegated representative.

- During lambing season (usually late autumn / winter) young lambs are susceptible to death. Subject to the agreement of landowners, lambing will be located in paddocks at least 200 metres away from turbines to reduce the risk that raptors (Wedge-tailed Eagles in particular) are attracted to dead lamb carcasses under turbines;
- In order to reduce collision risks to birds, with landowner agreement the practice of grain feeding of stock within 200 metres of turbines will be minimised as it could attract parrots, such as the listed **Superb Parrot**, cockatoos or other birds to turbines, increasing collision risk;
- Any feral animal control on the BWF site should involve the timely removal and appropriate disposal of resulting carcasses;
- If a large active rabbit presence is observed during monitoring surveys, it will be necessary to conduct an integrated rabbit control program (to reduce site attractiveness to Wedge-tailed Eagles and other raptors). Methods to control rabbits include borrow destruction, poisoning and shooting. Any rabbit control program will require cooperation and agreement from the landowners;
- An annual summary of carcass removal, based on the 'management log' will be provided in the annual monitoring reports; and
    - The need for continuation of the carcass removal program and effort required will be assessed after one year of operation. In general, the criteria for continuation will be based on the frequency of carcass finds. For example, if carcass frequency is particularly low (e.g. one or two per quarter) outside of turbine search zones (i.e. not beneath turbines) the intense program may be discontinued or reduced considerably. Alternatively, if peaks occur at specific times or locations where there are turbines with intervening periods of low numbers, the effort may be focussed on the peak periods and/or locations.

3.2. Lighting on turbines and buildings

It has long been known that sources of artificial light attract birds, as evidenced by night-migrating birds in North America and Europe. Lighting is probably the most important factor under human control that affects mortality rates of birds and bats colliding with all structures (Longcore, *et al*. 2008). Most bird mortality at communication towers for example, occurs in poor weather with low cloud in autumn and spring, i.e. during migration periods (Longcore, *et al.* 2008).

It is postulated that bright lights may temporarily blind birds, particularly those accustomed to flying at night or in low light conditions causing them to fly toward the light source and collide with the lit structure (Gauthreaux and Belser 2006). Birds may be prone to saturation of their retinas, causing temporary blindness when subjected to bright light (Beier 2006) and mortality of both birds and bats can result from collisions with lit structures. Bats are also attracted to the increased numbers of insects that may congregate near bright light sources. Birds can also become disoriented or 'trapped' in the field of light beyond which they cannot see (Longcore *et al.* 2008).

The colour of lighting may also be important. Some studies have found that red lights resulted in a lower mortality than white lights (Longcore *et al*. 2008), but more recent research on oil rigs at sea suggests that blue or green lights may result in lower mortality than red or white lights (American Bird Conservancy 2014). Measures to reduce the impact of lighting will include using low pressure sodium or mercury lamps with UV filters to reduce brightness.

For the above reasons, building lighting should be baffled and directed to avoid excessive light spillage and security lighting should be baffled to direct it towards the area requiring lighting and not skyward. This will assist in meeting the bat deterrence requirements of Consent Schedule 3, Condition 21.

3.3. Minimise raptor perches on turbines

The turbines will be designed in a way that minimise the availability of raptor perches on turbines by reducing the number and length of horizontal external structures on turbine towers and nacelles. Early models of turbines that were constructed in the early 1980's in the United States of America had a lattice design that provided perching opportunities for raptors and would often result in collision when they would take off from their perch. Modern turbines have smooth aerodynamic designs with an enclosed nacelles and hub that does not provide perching opportunities for raptor species.

3.4. Minimise nesting close to turbines

Another management measure that could reduce collision risk of Wedge-tailed Eagle and other raptors with turbines is to discourage nesting near turbines. If nesting occurs within 200 metres of a turbine, the nesting event will be permitted to take place and run its course. After breeding is completed and outside the current breeding season, the nesting tree will then be removed unless inconsistent with project approval requirements.

4. Impact Triggers, Decision-Making Framework and Mitigation

This section identifies the circumstances that will result in notification, further investigation and additional mitigation for both threatened and non-threatened birds and bats ('impact triggers'). If an impact trigger is met, there must be an investigation into the cause of the impact, immediate stepped-up carcass monitoring to determine if the impact is ongoing and the development of mitigation measures informed by scientific studies.

By way of definition, an **impact trigger** may be an unacceptable impact in itself or may lead to an unacceptable impact if it continues. The purpose of defining an impact trigger is that it results in a more detailed investigation of the project's impact on the species concerned with the specific objective of determining the scope and nature of mitigation measures. If ongoing impacts are confirmed by further carcass searches or are considered likely from investigations and mitigation measures are known to be effective without further need to confirm their effectiveness they will be implemented as soon as practicable.

The procedure to respond adaptively to impact triggers documented in this section is implemented at any time an impact trigger is detected for the life of the project, from the commencement of operations until decommissioning. The aim is to understand how the impact happened or may have happened, and to identify and design targeted mitigation measures. If scientific uncertainty results in an incomplete understanding of whether an unacceptable impact is occurring this should not prevent the implementation of mitigation measures.

Ultimately, the BWF approval holder will be responsible for implementation of this BBAMP and the decision-making that goes with it, with technical support provided by the approved expert. Importantly, a clear basis for informing and consulting with DPIE and DAWE is documented and will be followed.

Triggers and responses are determined by the conservation status of the affected species. Triggers and responses have been defined for both threatened (section 4.1) and non-threatened (section 4.2) birds and bats.

4.1. Threatened Species

4.1.1. Definition of Impact Trigger

Generally, an impact trigger is where there is evidence of death or injury to birds and/or bats from collision with turbines. Under this program, the circumstances that define an impact trigger for threatened birds and/or bats are detailed below.

Impact Trigger for Threatened Species occurs if a threatened bird or bat species (or recognisable parts thereof) listed under the EPBC Act or NSW Biodiversity Conservation Act 2016 (BC Act) is found dead or injured within the search area under a turbine, or within 100 metres of it incidentally, either during any formal mortality search or incidentally by BWF personnel.

A separate impact trigger definition is provided for the Superb Parrot in section 4.1.3.

4.1.2. Decision Making Framework and Reporting

If a threatened species impact trigger occurs, further investigation will immediately be triggered, and the decision-making framework outlined below and in Figure 4 will be followed. This section complies with Schedule 3, Condition 21 of the project approval.

- An impact trigger will be immediately reported to BWF's responsible manager, who will report it to DPIE and DAWE within five business days of it being recorded.
- Carcass searching will be immediately expanded to cover all 46 turbines fortnightly in the subsequent six weeks to determine if the species concerned is colliding more than once.
- Within 10 days, an appropriately qualified ecologist will determine, if possible, the circumstances that lead to the death or injury. If the cause of death is considered to be due to turbine collision,

an investigation will be undertaken to identify any circumstances that could have led to the collision and the likelihood of further occurrences will be evaluated.

- The rapid investigation will aim to provide a clear understanding of the cause of the impact, informed by on-site investigations of the occurrence of the species on the BWF site and any risk behaviour it is displaying.
- This will identify the most effective available mitigation measures to be implemented with those measures to be implemented as soon as practicable (see also next point).
- If the cause of the impact trigger is not clear and definition of effective mitigation measures is not feasible, further investigation of the species' behaviour will be required over the following six weeks (in parallel with the stepped up carcass searches). This investigation will also consider:
    - Any recent data/information on the species e.g. academic literature, EPBC policy statements;
    - Information from implementation and information from other wind farms; and
    - A review of the effectiveness of management measures.
- If these investigations suggest that the impact was not continuing (e.g. the species had left the site) then no further action would be necessary. This decision will be determined in consultation with DPIE and DAWE, based on the collected evidence and adopting the most effective of the mitigation measures indicated in Section 4.
- If the onsite investigation suggests that the impact trigger indicates the potential for an unacceptable impact, species-specific monitoring *and* mitigation will be required. During species-specific monitoring and mitigation, periodic reports will be provided to DPIE and DAWE, and, additionally, fully evaluated for their ongoing effectiveness in annual reports.
- Examples of mitigation measures that will be evaluated include but are not limited to those outlined in Section 4. As wind turbine collision mitigation studies are ongoing throughout the world, as new knowledge is generated on the nature and effectiveness of mitigation it will be included in this evaluation.
- Based on these investigations, a report will be prepared and provided to DPIE. This report will consider any cumulative impact of BWF on threatened species to date, including previous strikes of threatened species which may have occurred throughout the operating period of BWF. Any mitigation measures proposed in the report must be to the satisfaction of the Secretary DPIE. If the Secretary DPIE is not satisfied that operations will no longer impact the threatened species, implementation of mitigation measures from Table 4 may be impelled.

4.1.3. Impact triggers for Superb Parrot

Impact trigger for Superb Parrot is either:

- A Superb Parrot is found dead or injured under a turbine during any formal mortality search or incidentally by BWF personnel;
- Superb Parrots are observed demonstrating "risk behaviour" during the investigations in section 4.1.2 or the targeted parrot surveys described in section 2.4.3. "Risk behaviour" is defined for the purpose of this BBAMP as consistent observations during the investigations in section 4.1.2 or the targeted parrot surveys described in section 2.4.3 of ten or more flights per day of flocks of ten or more birds between turbines at least 40 metres above the ground;
- Superb Parrots utilising breeding hollows within 200m of a WTG and during monitoring surveys, observed multiple times flying at least 40m above ground towards turbines that could result in collision with turbines.

If an impact trigger for Superb Parrot occurs, the decision-making framework outlined in Figure 4 will be followed, with the additional measures specific to Superb Parrot included, as described below. This

approach is designed as rapidly as possible to understand what is causing the impact and, therefore what the most effective mitigation measure will be.

- The responsible officer of BWF will be notified, who will then notify DAWE and DPIE within two working days.
- Carcass searching will be immediately increased to cover all turbines fortnightly for six weeks to determine if the species concerned is colliding repeatedly. If further searches are warranted due to an additional carcass find then this will continue until the species departs the area at the end of the breeding season.
- An immediate investigation (within 5 days) will be undertaken that will include monitoring within the vicinity where the impact or risk behaviour was observed. This will involve fix-point surveys for an hour repeated three times over the day (morning/noon/evening) and ongoing for three consecutive days.
- A report will be produced for DAWE and DPIE that states if the casualty or risk behaviour was a one–off or if there is potential for regular occurrence, demonstrated by either continued fatalities or risk behaviour. The report will be provided within 10 working days of the six-week stepped up carcass monitoring effort being completed.
    - If no additional turbine strikes and/or risk behaviour are detected, no further action would be required;
    - If additional turbine strikes and/or risk behaviour are detected, then mitigation will be required using the most effective measures from those described in section 4 or developed specifically in response to the circumstances of the ongoing impact.

If collisions and/or risk behaviour are observed more than once, monitoring for the breeding season will be further intensified, with:

- Weekly flight monitoring at the turbines where collisions have occurred one day a week, including one-hour surveys at three different time periods throughout the day until the end of the breeding season to ascertain if risk behaviour is continuing: and
- Carcass searches of turbines at and within 500 metres of the collision or areas where risk behaviour is observed continuing on a weekly basis until the end of the breeding season.

Based on these surveys, a detailed report will be prepared and provided to DAWE and DPIE. This report will consider any cumulative impact of BWF on Superb Parrot to date, including previous strikes of Superb Parrot that may have occurred throughout the operating period of BWF. This report will identify mitigation measures based on the investigations described above as well as their effectiveness where they can be implemented immediately (e.g, where it is obvious why additional collisions are occurring.

Mitigation measures that will be implemented include but will not be limited to the most effective of the measures identified in section 4 of this BBAMP as well as alternative measures deemed to be effective based on the investigations. As wind turbine collision mitigation studies are ongoing throughout the world, as new knowledge is generated on the nature and effectiveness of mitigation it will be included in this evaluation. Any mitigation measures proposed in this report must be to the satisfaction of the Secretary DPIE. If the Secretary DPIE is not satisfied that operations will no longer impact Superb Parrot, implementation of mitigation measures from Table 4 may be impelled.

If turbine shutdown remains the only mitigation option then turbine shutdown procedures will be generated from data collected from the foregoing investigations, which will indicate which turbines the Superb Parrot are at risk of colliding with and what times of day the parrots are most active. If the investigation can't inform a targeted turbine shutdown regime then turbines within 500 metres of the collisions and locations of risk behaviour will be shut down during daylight hours for the remainder of the period the Superb Parrot is on the site based on continuing weekly monitoring (see above) of its status in the area of concern.

The weekly monitoring of the effectiveness of mitigation measures (i.e. carcass searches) will be ongoing until the risk behaviour is no longer recorded and/or the species has left the area. Mitigation measures

will cease when Superb Parrot vacate the site (post-breeding migration), whichever is first. Implementation of mitigation measures will be documented in the site management log and detailed in annual reports. The success or otherwise of mitigation measures will be reported to and discussed with DAWE and DPIE as described above as well as summarised and evaluated in the annual report.

Trigger levels to shutdown turbines

To meet the requirements of Condition 6(b) of EPBC 2013/6810 the following two trigger levels will be applied to the operation of the BWF that will result in turbine shut down.

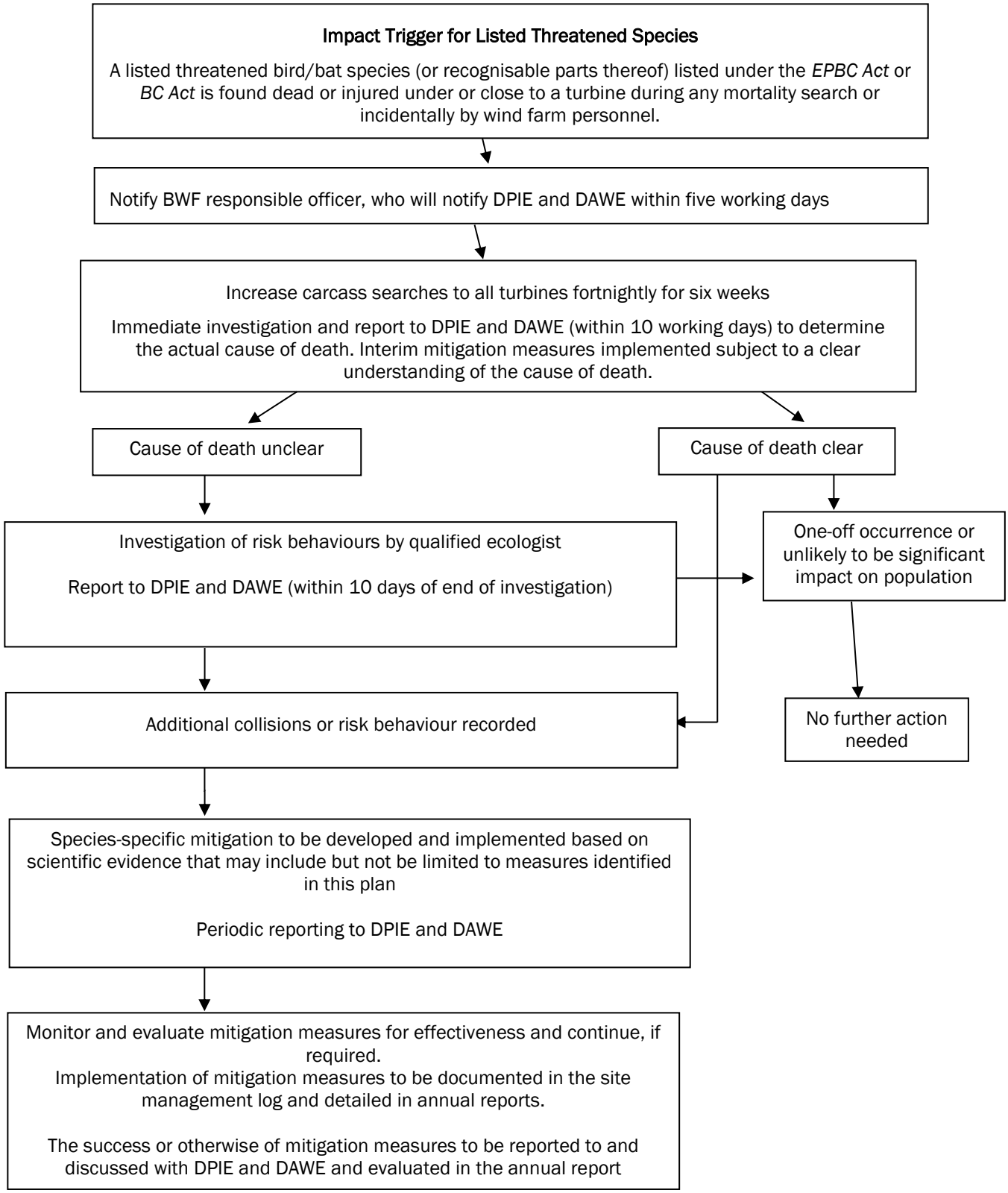
1) Superb Parrot found dead or injured under a turbine during any formal mortality search (ie monthly carcass searches and intensified Super Parrot breeding season searches) or incidentally (ie incidental carcass searches) at BWF where during the associated investigation period there has been a subsequent and related collision with a turbine and the only mitigation option available for implementation at the location is turbine shutdown.

2) Superb Parrots observed demonstrating risk behaviour at BWF as defined in section 4.1.3 as ten or more flights per day of flocks of ten or more birds between turbines at least 40m above ground, where during the associated investigation period there has been subsequent and related risk behaviour observations and the only mitigation option available for implementation at the location is turbine shutdown.

3) Superb Parrots utilising breeding hollows within 200m of a WTG observed multiple times flying at least 40m above ground towards turbines that could result in collision with turbines where the only mitigation option available for implementation at the location is turbine shutdown.

The full investigation process and protocol for establishing a specific strategy for turbine shutdown and recommencing operation is described in Section 4.1.3 above.

Figure 4: Decision making framework for identifying and mitigating impacts on threatened species



4.2. Non-threatened Species

4.2.1. Definition of Impact Trigger

The circumstances that define an impact trigger and significant impact for non-threatened birds and/or bats under this BBAMP are detailed below. Note native species not listed as protected are not considered of conservation significance and therefore are not subject to adaptive management or this impact trigger. These species are Sulphur-crested Cockatoos, galahs, magpies, crows, ravens, pipits and introduced bird species[2]. All other native bird and bat species are subject to adaptive mitigation arising from this impact trigger.

Impact Trigger for Non-threatened Species: The trigger is defined as a total of four or more bird or bat carcasses, or parts thereof, of the same species in two successive searches at the same or adjacent turbine(s) of a non-threatened species (excluding species mentioned above).

Note that although the impact trigger does not include ravens, magpies, Sulphur-crested Cockatoos, corellas, pipits and introduced species, detected mortalities for these species will still be reported as part of the annual reporting process.

Non-threatened species are not listed under the Commonwealth EPBC Act so this section only applies to species of concern at a state level that are not threatened. For this reason, reporting to DAWE is not required, only to DPIE.

4.2.2. Decision Making Framework

In the event that an impact trigger for non-threatened species is detected the following steps will be followed:

- DPIE and DAWE will be **notified** of the impact trigger within seven days of recording the event;
- An **evaluation** of impacts to the non-threatened species' bioregional population will be undertaken; and
- A **report** on the investigation will be provided to DPIE and DAWE within three weeks.

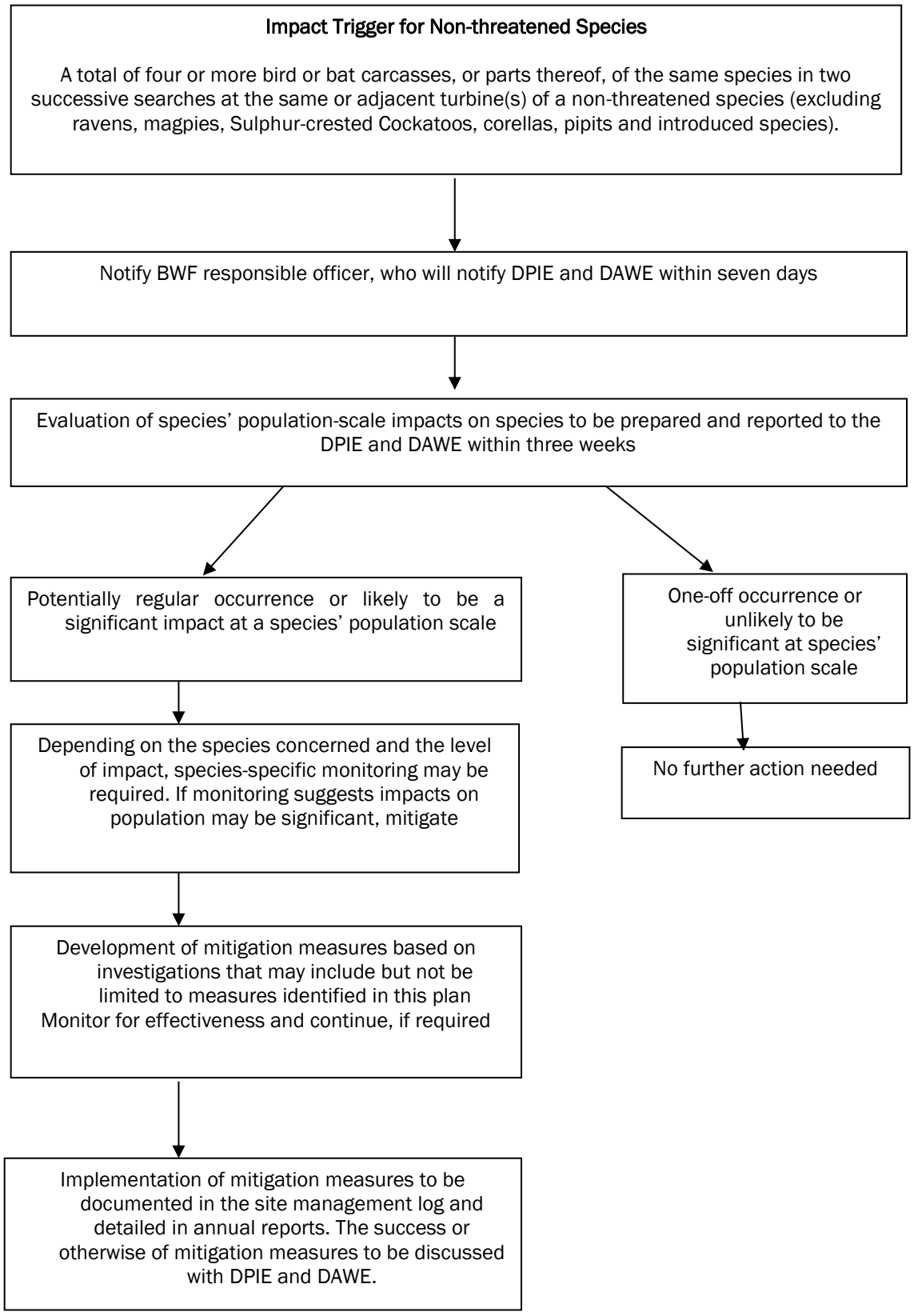
If the evaluation indicates that the event was a one-off occurrence or is unlikely to be an unacceptable impact at a bioregional population scale for the species in question, no further action will be necessary (as outlined in Figure 5).

If the event is deemed to be a potentially regular occurrence or likely to lead to an unacceptable impact on the species in question, species-specific monitoring may be required (Figure 5). If further monitoring confirms that impacts are likely to lead to an unacceptable impact on the species, mitigation measures will be required. Potential mitigation measures are outlined in Table 4, however specific mitigation measures will be determined based on the species involved and the outcome of investigations.

Any evaluation of impacts and decisions regarding mitigation measures and further investigations required will be undertaken in consultation with DPIE and DAWE. Any required investigation, and recommended management and supplementary mitigation measures, will be documented in the site management logs and detailed in annual reports. This log will be available for inspection by DPIE and DAWE.

[2] All bird species will be subject to the injured bird protocol detailed in section 2.9.

Figure 5: Decision making framework for identifying and mitigating impacts on non-threatened species



4.3. Mitigation Measures

Mitigation measures will be implemented in consultation with DPIE and DAWE if the investigation of an impact trigger concludes there is potential for an ongoing impact. The purpose of mitigation measures will be to prevent the impact from continuing to occur at a scale that leads to an unacceptable impact. Specific mitigation measures will be implemented depending on the nature, cause and significance of any impact recorded and in response to the results of investigations of the event and of the species concerned on the BWF site.

Turbine shutdown will be considered as a last resort, once all alternative mitigation options are found in post-trigger investigations not to be effective. Information needed to inform consideration of turbine shutdown will include but not be limited to:

- Additional collisions by threatened species, including the level of risk to the species' population;
- The findings of detailed investigations undertaken in response to the impact trigger, focussing on the species' use of the immediate area around turbine where the collision occurred; and
- Clear scope for on-going monitoring to identify triggers for turbine shut-down.

4.3.1. Superb Parrot mitigation response

If Superb Parrot are found during the monthly surveys to breed within 200 metres of a turbine, the following response will be triggered:

- A fixed camera will be mounted near the nest to monitor with time-stamped photographs, the frequency of adult visitation and the activity of young birds, including if the breeding attempt is successful;
- Additionally, carcass monitoring of all WTGs within 200 m of the breeding hollow will be undertaken on weekly;
- The results of this monitoring will be used to determine if the breeding attempt has been successful and, where possible, whether there was a loss of any adult bird during breeding due to turbine collision;
- Monitoring should continue until the end of the breeding season or until the hollow is vacated, whichever occurs first;
- If the breeding attempt is successful, then no action will be taken, and monitoring will continue if the birds return to the same nest the following breeding season; and
- Where the breeding has failed and a strike is detected at the monitored WTG that can reasonably be attributed to the WTG, a mitigation approach will be developed for consideration and approval of the Secretary DPIE.

BWF will implement a Superb Parrot Conservation Research Plan (SPCRP) which will include annual reports on progress and results of the research. As per condition 7 of the commonwealth approval, after review of the annual reports of the SPCRP and carcass monitoring at BWF, if the Minister considers that BWF is having a detrimental impact on the Superb Parrot the Minister may impose turbine shut down on specified turbines for a specified period of time.

4.3.1. Additional mitigation measures for other species

An '*impact trigger*' is defined in Section 4 as a threshold of impact on birds or bats that triggers an investigation and/or mitigation response. This section outlines such measures and addresses condition of approval 21 (b). It is not possible to identify every potential impact trigger and if there is a significant impact on the population of a listed species. This BBAMP provides mitigation actions to address a significant impact on the local population of a listed species. These are detailed in Table 4 as mitigation measures that will be considered for listed species with a significant risk of ongoing/adverse impacts.

Table 4: Mitigation measures in the event repeated collisions or risk behaviour by a threatened species.

Hypothetical cause of impact	Mitigation Measure[3]	Likelihood of impact continuing following mitigation	Time to implementation
Foraging source identified that attracts threatened species and "at risk" species to impact areas (All species)	The use of acoustics (i.e. loud music/irregular noise) to discourage birds from foraging in this location where such noise would not impact neighbours.	Low	Implement according to "decision making framework for identifying and mitigating impact triggers" (Figures 4 & 5), to respond to a "risk" as outlined in Section 4, a decision may be made to implement in a manner agreed to between DPIE, DAWE and BWF.
	Encourage species into alternative areas outside of the BWF boundary, where available, through the use of social attraction techniques offsite (decoys and audio playback systems), as well as supplementary feeding (e.g. grain) where practicable.		Implement according to "decision making framework for identifying and mitigating impact triggers" (Figures 4 & 5) to respond to a "risk" as outlined in Section 4, a decision may to implement in a manner agreed to between DPIE, DAWE and BWF.
Farming practice attracts threatened species to risky areas (e.g. grain feeding of stock, lambing) (All species)	Investigate whether farming practice is a contributing factor and if so, subject to landowner agreement relocate farming further from turbines to reduce risk. Determine if affected bird species is feeding on rabbits and control rabbits to reduce the attractiveness of turbine surrounds to the species.	Low	Immediately.
Wind/rain/fog causing low visibility (All species)	Carcass searches will be repeated during periods of low visibility to measure mortality rates. Temporary shutdown of those turbines found to generate repeated impact triggers will be necessary during periods of extreme low visibility.	Low	Immediately low visibility is identified as the cause of unacceptable impacts on threatened species.
Attraction to lights on the wind farm site (Night flying species)	Except where otherwise required by CASA, avoid high intensity lighting within the BWF site (e.g. use of light hoods) or switch off lighting temporarily while species is on or near the BWF site based on the surveys described in section 3. Additional measures include: • Synchronise any flashing lights; • Use red rather than white or yellow lights; or • Remove lights, where practicable. All other lights switched off except when needed for service work.	Low	If lights can be switched off, this should occur immediately. Alternative measures should be implemented as soon as practicable after recording the impact trigger.
Attraction to small dams on site (Waterbirds, bats)	Subject to landowner agreement, fill in dam and provide alternative stock watering arrangements.	Low	In accordance with "decision making framework for identifying and mitigating impact triggers" (Figures 4 & 5) after recording the impact trigger if the dam is the cause of the problem.
Nest site close to turbine (All species)	Conduct an assessment by a qualified ecologist and depending upon species and the clear risk identified, develop options for mitigation measures for consultation with DPIE and DAWE. Agree on species-appropriate actions to discourage nesting close to turbines. Specific action to be agreed between DPIE, DAWE and BWF with advice from a qualified ecologist. For example if a raptor is observed nesting within 200 metres of a turbine, let	Low	Prior to breeding season.

[3] Note that the mitigation measures in this table are examples of what may be possible. Ultimately, the chosen mitigation measure will be identified as part of the impact-trigger investigations shown in Figures 4 and 5 may not include any of these examples if they are not relevant. As wind turbine collision mitigation studies are ongoing throughout the world, as new knowledge is generated on the nature and effectiveness of mitigation it will be taken into consideration in finalising recommended mitigation measures for discussion with DPIE and DAWE..

Hypothetical cause of impact	Mitigation Measure[3]	Likelihood of impact continuing following mitigation	Time to implementation
	the breeding attempt run its course, when raptors are no longer using nest in non-breeding season remove the tree to discourage nesting nearby.		
Perching/foraging close to turbines (All species)	Minimise perching opportunities near turbines. Depending on species and "risk" arising from the utilisation of the perch, a decision may be made to discourage perching close to turbines in a manner agreed to between DPIE and BWF and consideration will be given to removing the perch. If the perch is not otherwise part of protected vegetation (e.g. part of a planted wind break) it can be removed immediately.	Low	Implement according "decision making framework for identifying and mitigating impact triggers" (Figures 4 & 5) to respond to a "risk" as outlined in Section 4, a decision may to implement in a manner agreed to between DPIE, DAWE and BWF.
On-going turbine collisions with threatened bat species with assessed significant impact on populations	Vary turbine cut in speed where turbines operate based on species and sites specific research and monitoring with demonstrated ability to decrease significant impact on populations.	Low – site and species specific	Implement according "decision making framework for identifying and mitigating impact triggers" (Figures 4 & 5) to respond to a "risk" as outlined in Section 4, a decision may to implement in a manner agreed to between DPIE, DAWE and BWF.
	Targeted turbine curtailment based on site- and species-specific understanding of risk behaviours with demonstrated ability to decrease significant impact on population.	Low – site and species specific	Implement according "decision making framework for identifying and mitigating impact triggers" (Figures 4 & 5) to respond to a "risk" as outlined in Section 4, a decision may to implement in a manner agreed to between DPIE, DAWE and BWF.
	Ultrasonic deterrents for threatened bat species that deter based on specific understanding of risk behaviours with demonstrated ability to decrease significant impact on population.	Low – site and species specific	Implement according "decision making framework for identifying and mitigating impact triggers" (Figures 4 & 5) to respond to a "risk" as outlined in Section 4, a decision may to implement in a manner agreed to between DPIE, DAWE and BWF.
On-going turbine collisions with threatened bird species with assessed significant impact on populations	Video and radar detection of bird activity and turbine curtailment for specific actions based on species and sites specific research and monitoring with demonstrated ability to decrease significant impact on populations.		
	Vary turbine cut in speed where turbines operate based on species and sites specific research and monitoring with demonstrated ability to decrease significant impact on populations.	Low – site and species specific	Implement according "decision making framework for identifying and mitigating impact triggers" (Figures 4 & 5) to respond to a "risk" as outlined in Section 4, a decision may to implement in a manner agreed to between DPIE, DAWE and BWF.
	Targeted turbine curtailment based on information site- and species-specific understanding of risk behaviours with demonstrated ability to decrease significant impact on populations.	Low – site and species specific	Implement according "decision making framework for identifying and mitigating impact triggers" (Figures 4 & 5) to respond to a "risk" as outlined in Section 4, a decision may to implement in a manner agreed to between DPIE, DAWE and BWF.

4.4. Reporting against performance criteria

Table 5 summarises specific management objectives, activities, timing and performance criteria for the implementation of this BBAMP. It can be used for monitoring and reporting on the implementation of this BBAMP.

4.5. Risks affecting the implementation of this plan

The field work required to ensure that the operational phase monitoring of birds and bats is subject to the and possible factors set out below that may disrupt the implementation of the plan.

- Vehicle breakdown;
- Operational safety limitations, including:
  - wind farms generally ban outdoor activity of personnel during thunderstorms
  - flooding and bushfire limiting site access and activities for safety reasons;
- Operational and maintenance events that occasionally limit access to all or part of the site; and
- Government imposed controls on personnel movement during a pandemic.

Experience of such risks indicates that (with the exception of the last) these risks are short-term and can be overcome by rescheduling field work without compromising the integrity of the sampling design and statistical analyses.

Experience during the recent Covid-19 pandemic indicates that work on electrical supply infrastructure is considered essential and, subject to meeting personnel movement permit and site workplace number requirements, the implementation of BBAMPs has not been disrupted.

DAWE (in litt, November 2020) have requested these factors be subject to a risk assessment using their criteria. In conclusion, these factors are *possible* in the lifetime of the project, will have *minor* consequence in that they are short-term and do not compromise the integrity of the impact monitoring and mitigation framework of the plan and therefore represent a *low* risk that the BBAMP will not be implemented as planned.

Table 5: Specific management objectives (including relevant consent condition from Schedule 3), activities, timing and performance criteria for which the project owner is responsible

Management objectives	Management activities and controls	Timing [4]	Performance criteria for measuring success of methods	Corrective action
Baseline surveys 21 (a)	Obtaining baseline bird and bat utilisation data.	Baseline ▪ BUS – Spring 2019, Summer 2019/20 ▪ Superb Parrot – surveys in 2019 and 2020 ▪ Bats – Spring 2019, Summer 2020 ▪ BUS – Four further BUS surveys will occur during the construction schedule (in spring 2020, and summer, autumn and winter 2021)	BUS (point count) undertaken in accordance with the methods and schedule described in this BBAMP. Bat utilisation surveys undertaken in accordance with the methods and schedule described in this BBAMP.	NA – all bird surveys in Appendix 1 have been undertaken. NA – all bat surveys in Appendix 1 have been undertaken.
	Obtaining operational phase bird and bat utilisation data.	Operational phase ▪ BUS – Year 1 and 3 ▪ Superb Parrot – Year 1 and 2 ▪ Bats – Spring and Summer/autumn – Year 1	Completion of operational phase surveys in accordance with the methods and schedule described in this BBAMP. Continuation of monitoring based on the outcomes of the second annual report and discussions with DPIE and DAWE, with relevant elements of the bird and bat utilisation surveys and/or targeted threatened species monitoring (see Section 4) to continue if impacts are continuing.	If operational phase bird, bat and Superb Parrot surveys are not commenced at practical completion of the wind farm, (with all turbines operating) they are to commence immediately the error has been detected.
Operational Phase Mortality monitoring 21 (c) and (e) 6(a) and (b)	All turbines to be searched each month to a radius of 120 metres in accordance with the inner- and outer zone search protocol for a period of 24 months, following which the need for further surveys will be reviewed based on the results of the first two years of monitoring.	Operational phase monthly ongoing.	Operational phase mortality surveys undertaken monthly at least 16 turbines, with a review after the first year to determine if a change in the methodology is required.	If operational phase turbine carcass searches are not commenced at practical completion of the wind farm, (with all turbines operating) they are to commence immediately the error has been detected.
	Calculating annual mortality of birds and bats per turbine based on operational phase repetition of monitoring activities. Mortality estimates should include correction factors from scavenger and detector efficiency trials.	Operational phase monthly ongoing.	Scavenger and detector efficiency trials undertaken in accordance with the methods and schedule described in this BBAMP. Estimates of mortality for birds and bats made in accordance with the methods and schedule described in this plan (including Appendix 4) after full year of monitoring. Final, more precise estimates of mortality made after two years to inform consideration of any requirement for further monitoring. Estimates are to be included in annual reports.	If estimates of bird and bat mortality are not included in annual reports they are to be made the included in an amended/updated annual report.
	Ongoing mortality monitoring as agreed with DPIE and DAWE in response to impact triggers, as described in section 4 of this BBAMP	Operational phase as required.	Responses to impact triggers implemented in accordance with the scope, methods, reporting requirements and schedule in section 4 of this BBAMP.	If responses to impact triggers are not implemented, they are to be implemented immediately the error becomes evident (e.g. as part of a project environmental management plan audit).

[4] Appendix 1 provides full details of the timing of all baseline studies to date.

Management objectives	Management activities and controls	Timing [4]	Performance criteria for measuring success of methods	Corrective action
Annual Reports 21 (e) And EPBC Condition 17.	Preparation and submission of Annual Reports submitted to the Secretary DPIE and DAWE.	Initial Operational phase reporting – after years one, two and three.	Annual reports for the first three years delivered within three months of completion of yearly monitoring. Annual reports to include (but not be limited to) results of monitoring surveys for that year, any impact triggers or unacceptable impacts identified, mitigation measures implemented, application of the decision-making framework and recommendations for the following year. Further annual reports upon agreement at a meeting of DPIE, DAWE and BWF at the end of year two of monitoring.	If annual reports are not prepared and submitted to DPIE and DAWE, they are to be prepared and submitted immediately the error is evident e.g. as part of a project environmental management plan audit).
		Ongoing annual reporting during the operational phase.	Ongoing annual reporting based on an agreed BBAMP after the initial two years of carcass searches based on ongoing monitoring agreed at a meeting of DPIE, DAWE and BWF after the year-two annual report.	If annual reports are not delivered, they will be prepared and delivered as soon as the error is evident (e.g. as part of a project environmental management plan audit).
Measures to reduce risk 21 (b) and (d)	Carrion removal program - stock and kangaroo carcasses will be removed from within 200 metres of wind turbines on a monthly basis and disposed of.	During operation.	Carcasses removed. Activity recorded in management logbook. All mitigation actions recorded in a project site management log on the same day they are undertaken.	If carrion/carcass removal has not been undertaken based on an audit of the management log this is to be commenced immediately.
	Subject to landowner agreement, restrict lambing to paddocks at least 200m from turbines.		No increase in raptor mortality during lambing season.	If raptor mortality is well above average at turbines near lambing in the lambing season, discussions will be initiated with the relevant landholder(s) to explore options for moving lambing further away in subsequent years.
	Subject to landowner agreement, stock will not be fed grain underneath turbines.		No continuing bird mortality due to grain underneath turbines during the operational phase of the project.	If mortality of birds occurs that is attributable to grain feeding under turbines, discussions will be initiated with the relevant landholder(s) to explore options for moving grain-feeding further away in subsequent years.
Mitigation measures to reduce risk 21 (b) and (d)	Pest control program - Implement rabbit control if the carrion removal program suggests rabbit carcasses are an issue, subject to landowner agreement.	During operation.	Collision rates of rabbit-feeding birds at affected turbines are similar to rates at unaffected turbines.	Monitor effectiveness of rabbit control and adjust program immediately it is found not to be reducing the attractiveness of turbine surrounds to birds that feed on rabbits.
	Minimising external lighting. There are only low levels of lighting on the wind farm during operation.	During operation.	Bird and bat mortality rates at turbines near light sources must not regularly exceeds that of activity at unlit turbines.	Type and duration of lighting will be reviewed and modified, subject to security and OH&S requirements, as per timing and approach detailed in Section 3.
	Remove permanent lights on buildings and sub-stations to avoid light spillage and visibility from above.			
	Baffle security lighting to avoid light spillage and visibility from above, consistent with the requirements of consent schedule 3, condition 4.			
	Use of deterrents –Overhead powerlines on the site that cross waterways should have marker balls and/or flags where they cross waterways.		No incidental records of bird mortality from power line collision around waterways.	More obvious powerline marking will be implemented.

5. References

Agresti, Alan, 2002. Categorical data analysis, Second Edition, John Wiley & Sons

Atlas of Living Australia (ALA) 2021. http://www.ala.org.au Accessed 4th February 2021.

Australian Wind Energy Association (AusWEA) 2013. Best Practice Guidelines for Wind Energy Developments in Australia. Australian Wind Energy Association, Melbourne.

American Bird Conservancy 2014, http://www.abcbirds.org/newsandreports/stories/080319_oil.html Accessed 25th January 2014.

Arnett EB, Erickson WP, Kerns J and Horn J 2005. Relationships between bats and wind turbines in Pennsylvania and West Virginia: An assessment of fatality search protocols, patterns of fatality, and behavioural interactions with wind turbines. A final report submitted to the Bats and Wind Energy Cooperative. Bat Conservation International. Austin, Texas, USA.

Beier, P 2006. Effects of artificial night lighting on terrestrial mammals. Pp 19-42 In "Ecological Consequences of Artificial Night Lighting". (Rich, C. and T. Longcore, eds.). Island Press. Washington, D.C.

Brett Lane and Associates 2009, Bald Hills Wind Farm, Bat and Avifauna Management Plan, Report No. 9067 (2.0), September 2009.

Brett Lane & Associates 2011a, Capital Wind Farm, Bird and Bat Adaptive Management Program, Report No. 9142 (1.2) approved in Dec 2009 and revised in 2010 and 2011. Prepared for Renewable Power Ventures Ltd (now Infigen).

Brett Lane & Associates 2011b, Mt Gellibrand Wind Farm, Bird and Avifauna Management Plan, prepared for Acciona Energy Oceania Ltd, Report No. 8229 (4.13), approved December 2011.

Brett Lane & Associates 2011c, Woodlawn Wind Farm, Bird and Bat Adaptive Management Program, prepared for Infigen Energy Ltd, Report No. 11035 (1.4), October 2011.

Brett Lane & Associates 2012a, Hawkesdale Wind Farm, Bird and Avifauna Management Plan, prepared for Union Fenosa Wind Australia Ltd, Report No.9067 (2.4), February 2012.

Brett Lane and Associates 2012b, Mount Mercer Wind Farm, Bat and Avifauna Management Plan, Report No. 8076 (2.8), approved September 2012.

Brett Lane & Associates 2012c, Mortlake South Wind Farm, Bird and Avifauna Management Plan, prepared for Acciona Energy Oceania Ltd, Report No.12020 (1.16), approved December 2012.

Brett Lane & Associates 2012d, Ryan Corner Wind Farm, Bird and Avifauna Management Plan, prepared for Union Fenosa Wind Australia Ltd, Report No.9067 (4.4), February 2012.

Brett Lane & Associates 2013a, Berrybank Wind Farm, Flora and Fauna Management Plan, Report No. 7152 (10.8) approved in August 2013. Prepared for Berrybank Development Ltd.

Brett Lane & Associates 2013b, Crowlands Wind Farm, Bird and Bat Management Plan, prepared for Pacific Hydro, Report No. 11176 (1.10), April 2013.

Brett Lane & Associates 2013c, Lal Lal Wind Farm, Bird and Bat Management Plan, prepared for WestWind Energy Ltd, Report No. 6150 (5.0), February 2013.

Brett Lane & Associates 2014, Taralga Wind Farm, Construction Environmental Management Plan, Report No. 8129 (1.12). Prepared for CBD Energy, January 2014.

Brett Lane & Associates 2016, White Rock Wind Farm Stage 1, Bird and Bat Adaptive Management Program, 2016 Report No. 15009 Report (2.6). Prepared for White Rock Wind Farm, July 2016.

Brunner, H, Loyd, JW and Coman, BJ 1975. Fox scat analysis in a forest park in south-eastern Australia, *Australian Wildlife Research*, 2: 147-154.

Catling, PC 1988. Similarities and contrasts in the diets of foxes, *Vulpes vulpes*, and cats, *Felis catus*, relative to fluctuating prey populations and drought, *Australian Wildlife Research,* 15: 307-317.

Churchill, S. 2008. Australia Bats. Jacana Books, New South Wales.

Clean Energy Council (CEC) 2018. Best Practice Guidelines for Implementation of Wind Energy Projects in Australia. Clean Energy Council, Australia.

Debus S 2017, Australasian Eagle and Eagle-like Birds, CSIRO Publishing, Clayton South, Victoria.

Department of the Environment and Energy 2018a, EPBC Act Protected Matters Search Tool, Commonwealth Department of the Environment, viewed 18th September 2018, http://www.environment.gov.au.

Department of the Environment and Energy 2018b, *Species Profiles and Threats (SPRAT) database*, Commonwealth Department of the Environment, viewed September 2018, http://www.environment.gov.au

Environmental Resources Management (ERM) 2013, *Bango Wind Farm: Ecological Impact* Assessment, Report No. 0170898_Bango_Rpv01, May 2013.

Environmental Resources Management (ERM) 2017, Letter to CWP Renewables Pty Ltd, Bango Wind Farm – Biodiversity Response to Submissions, 0404134 BWS RTS_Draft V4.

Ferguson-Lees, J & Christie, DA 2001, *Raptors of the World*, Christopher Helm Publishers.

Gauthreaux Jr., S A & Belser C G 2006. Effects of artificial night lighting on migrating birds. Pp 67–93. In "Ecological Consequences of Artificial Night Lighting". (Rich, C. and T. Longcore, eds.). Island Press. Washington, D.C.

Higgins, PJ (ed) 1999, Handbook of Australian, New Zealand and Antarctic Birds, Volume 4: Parrots to Dollarbird, Oxford University Press, Melbourne.

Higgins, PJ & Davies, SJJF (eds) 1996, *Handbook of Australian, New Zealand & Antarctic Birds,* Volume 3 Snipe to Pigeons, Oxford University Press, Melbourne.

Higgins, PJ & Peter, JM (eds) 2002, Handbook of Australian, New Zealand and Antarctic Birds, Volume 6: Pardalotes to Shrike-thrushes, Oxford University Press, Melbourne.

Higgins, PJ, Peter, JM & Cowling, SJ (eds) 2006, *Handbook of Australian, New Zealand and Antarctic Birds*, Volume 7: Boatbill to Starlings, Oxford University Press, Melbourne.

Higgins, PJ, Peter, JM & Steele, WK (eds) 2001, Handbook of Australian, New Zealand and Antarctic Birds, Volume 5: Tyrant-flycatchers to Chats, Oxford University Press, Melbourne.

Hull, CL and Muir, Stuart 2010. Search areas for monitoring bird and bat carcasses at wind farms using a Monte-Carlo model Australasian Journal of Environmental Management Vol 17, No. 2, Pages 77—87, Publisher is Taylor & Francis.

Hull, C L & Muir, S, 2010, Search areas for monitoring bird and bat carcasses at wind farms using a Monte-Carlo method. Austr. J. Env. Management 17:77-87.

Hull, C L, E M Stark, Peruzzo, C and Sims, C C, 2013, Avian collisions and two wind farms in Tasmania, Australia. NZ J Zool 40:47-62

Huso, Manuela M. P. and Dalthorp, Dan and Korner-Nievergelt, 2015. Statistical principles of post-construction fatality monitoring in Wildlife and Wind Farms - Conflicts and Solutions, Volume 2, Chapter 4, Pages 227—237, ISBN 9781784 Pelagic Publishing

Kennedy, SJ & Tzaros, CL 2005, Foraging ecology of the Swift Parrot *Lathamus discolor* in the Box-ironbark forests and woodlands of Victoria, *Pacific Conservation Biology* 11, 158 – 173.

Longcore, T, Rich, C & Gauthreaux Jr., S 2008, Height, guy wires, and steady-burning lights increase hazard of communication towers to nocturnal migrants: A review and meta-analysis, *The Auk*, 125(2): 485-492.

Marchant, S & Higgins, PJ (eds) 1993, Handbook of Australian, New Zealand and Antarctic Birds, Volume 2, Raptors to Lapwings, Oxford University Press, Melbourne.

Molsher RL, Gifford EJ, McIlroy JC 2000, "Temporal, spatial and individual variation in the diet of red foxes (*Vulpes vulpes*) in central New South Wales", Wildlife Research 27, 593–601.

Nature Advisory 2021. Bango Wind Farm - Pre-commissioning fauna assessments. Prepared for CWP Renewables, Report No. 18173 (3.2), January 2021.

Office of Environment and Heritage (OEH) 2018a, NSW BioNet, NSW Office of Environment and Heritage, viewed 7th September 2018, http://www.bionet.nsw.gov.au

Office of Environment and Heritage (OEH) 2018b, Threatened species profile search, NSW Office of Environment and Heritage, viewed 7th September 2018, http://www.environment.nsw.gov.au

Pizzey, G & Knight, F 2003, Graham Pizzey & Frank Knight: The Field Guide to the Birds of Australia, HarperCollins Publishers, Australia.

Therneau. Terry M, & Grambsch, Patrica M, 2000. Modelling Survival Data: Extending the {C}ox Model, Springer New York ISBN = 0-387-98784-3

Wetlands International 2018, "Waterbird Population Estimates", wpe.wetlands.org viewed 7th September 2018.

Appendix 1: Baseline bird and bat information

The pre-commissioning ecological investigations included habitat, bird and bat surveys. The results of these investigations carried out since 2013 at BWF are summarised in this Appendix. Detailed methods can be found in the ERM (2013) report.

In addition, a range of additional baseline monitoring surveys has been undertaken at Bango Wind Farm. These are also detailed below. These surveys have been used to inform the risk assessment, monitoring and mitigation as described in this BBAMP.

Hollow bearing tree survey

This survey was undertaken between January and February 2013 and during 2018 and 2019. An area of a 500 metres buffer around all proposed turbines was assessed for hollows. Trees were assessed visually using binoculars where necessary. Hollows were classed as follows 0-5cm = small, 6-10cm = medium and 11cm and above = large. The survey also assessed height of the hollow, and species, height and diameter at breast height of the tree.

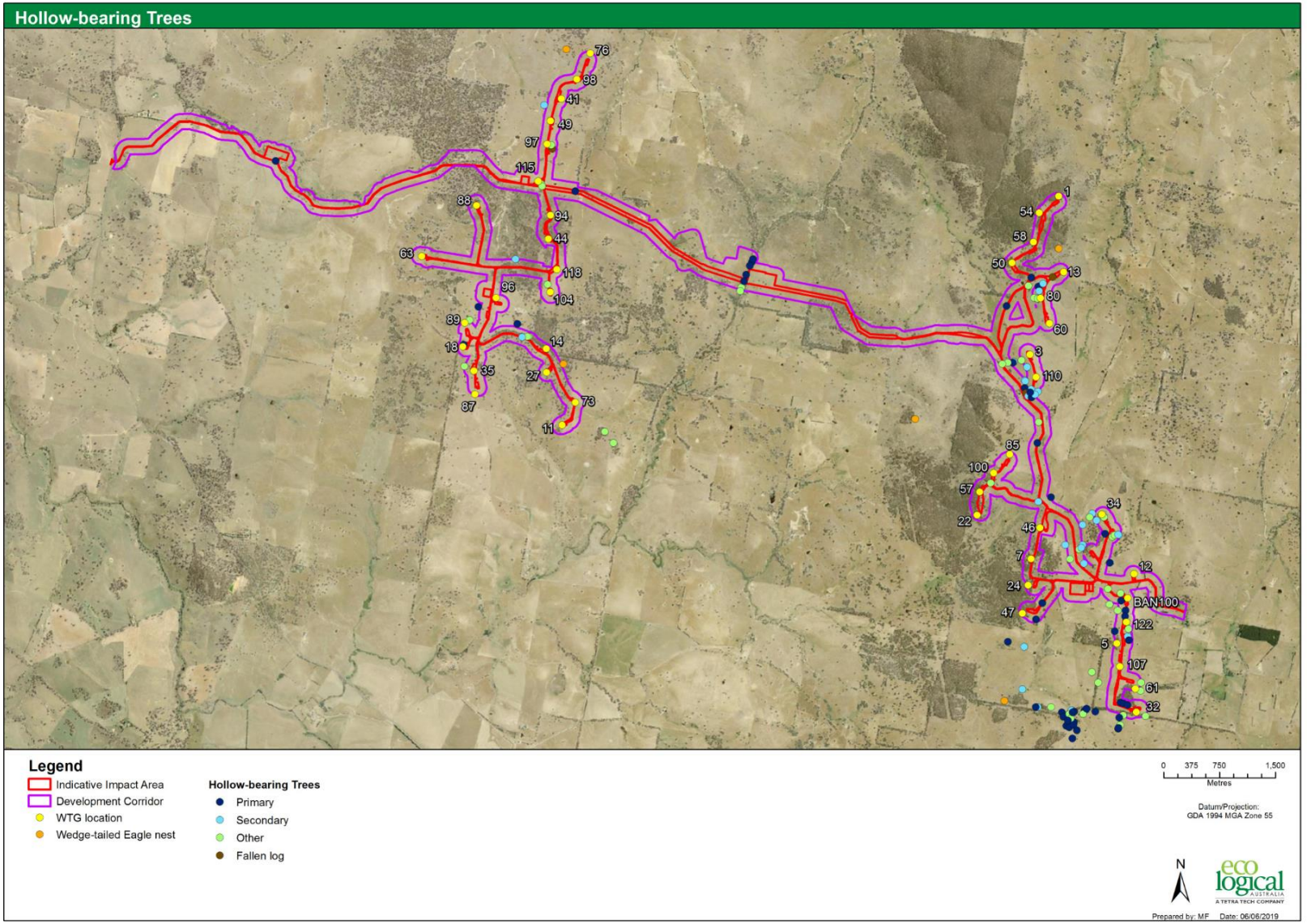
This information was used to assess habitat for a range of fauna including Superb Parrot and large owls.

A total of 449 hollow bearing trees were identified within 500 metres of proposed turbines totalling 1,237 hollows of 556 small, 509 medium and 172 large hollows. It was determined that this would provide suitable habitat for a range of species, including; Superb Parrot and microbats.

Primary Hollow Bearing Trees for Superb Parrot on the inland slopes include trees of the Blakely's Red Gum, Yellow Box, Apple Box, White Box species or dead stags, containing hollows 5-13 metres above the ground of greater than five centimetres in diameter. An analysis of the potential nesting trees for the Superb Parrot was undertaken by ERM (2017) and it found that 48 Primary Hollow Bearing Trees, containing approximately 78 suitable hollows for nesting were recorded within 500 metres of the original turbine layout of 72 turbines.

More recently hollow bearing trees were identified and validated, by ELA 30/50/100 metres from the micro–sited turbine locations. Accordingly, Primary Hollow Bearing Trees (as defined by EPBC2013/6810) have been identified as suitable for Superb Parrot nesting and mapped, along with other categories of hollow bearing trees. Appendix C of EPBC2013/6810 shows the categories and location of hollow bearing trees in relation to the turbines (WTGs as referred to on the map) and the development corridor and indicative impact area. The map is also reproduced in Figure 6 below. The proposed layout of the BWF has been refined throughout the planning process, detailed design and construction to minimise the removal of potential Superb Parrot nest trees.

Figure 6: Hollow-bearing tree assessment



Summary of initial investigations of birds and bats at Bango Wind Farm

During the planning approval phase of the development, investigations of fauna were undertaken by Environmental Resources Management (ERM). These surveys included BUS, targeted parrot surveys, flight path monitoring and incidental observations. The data was collected during surveys from July 2012 to February 2013, providing winter and spring baseline data. The methods and results of these investigations were included in the Bango Wind Farm Environmental Impact Statement, specifically, *Appendix 12 – Bango Wind Farm Part 3A Ecological Assessment (ERM 2013)* and are summarised below. These surveys were considered sufficient to inform the impact assessment of the approvals of the BWF.

In addition, Nature Advisory completed a four seasonal BUS surveys with a fixed point count methodology that commenced in Autumn 2019 (see below). The results of these surveys will be compiled in the baseline survey report to be provided to DPIE and DAWE.

In summary, as a result of the initial surveys (ERM 2013) a total of 108 species of birds have been identified including 104 native species. Nine species identified were listed as threatened under the EPBC Act and/or the BC Act and included:

- Brown Treecreeper (*Climacteris picumnus victoriae*);
- Diamond Firetail (*Stagonopleura guttata*);
- Grey-crowned Babbler (*Pomatostomus temporalis*);
- Little Eagle (*Hieraaetus morphnoides*);
- Scarlet Robin (*Petroica boodang*);
- Speckled Warbler (*Pyrrholaemus sagittatus*);
- Spotted Harrier (*Circus assimilis*);
- Superb Parrot (*Polytelis swainsonii*); and
- Varied Sittella (*Daphoenositta chrysoptera*).

Raptors observed on site included:

- Black-shouldered Kite;
- Brown Falcon;
- Brown Goshawk;
- Collared Sparrowhawk;
- Little Eagle;
- Nankeen Kestrel;
- Peregrine Falcon;
- Wedge–tailed Eagle; and
- Whistling Kite.

A review of past surveys and a description of baseline surveys are presented in the sub-sections below.

Bird utilisation surveys

Initial Bird utilisation survey (BUS) -2012-2013

ERM undertook spring and summer BUS surveys in 2012-2013. The results of these surveys are detailed in the BWF Environmental Impact Statement, specifically, *Appendix 12 – Bango Wind Farm Part 3A Ecological Assessment (ERM 2013).*

The results of these surveys will be considered in the baseline survey report to be provided to DPIE and DAWE.

Baseline bird utilisation surveys – 2019-2020

Specifically, this BBAMP implemented the fixed-point bird count method detailed below.

Fixed-point bird count method (BUS methodology)

The fixed-point bird count method involves an observer stationed at a survey point for 15 minutes. Previous experience has shown that using 15 minutes as an interval to record the presence of birds during BUS indicates that 82 to 100 percent (average 88 percent) of species seen in one hour of surveying were seen in the initial 15 minutes of observation. Based on this result, the period of 15 minutes used in the formal BUS is considered adequate to generate representative data on the bird species in the area during the survey.

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

Each survey point was counted eight times each season over the survey period at different times of the day (twice early morning, twice late morning, twice early afternoon and twice late afternoon), totalling 32 repetitions. This schedule ensured that all points were visited equally at different times of day to allow for time-of-day differences in bird movements and activity.

The fixed-point bird count method, used seven fixed survey impact points and three control/reference points. Impact points were located near turbine locations. The survey points were distributed as evenly as possible (subject to access constraints) across the BWF to maximise coverage in areas where turbines are proposed to be sited. These impact points were positioned as far as possible on elevated ground, allowing a clear view in all directions. Bird survey points 6 and 21 are in cleared areas, 17 and 22 in open wooded areas and 5, 7 and 12 in closed wooded areas (Figure 7).

Three control or reference points were established at least 500 metres from the impact sites (see Figure 7). These three reference points will continue to be used for the on-going monitoring of the site. Table 6 below provides a description of the habitats associated with each impact and reference point.

Table 6: Habitat associated with each survey point

Survey point	Habitat
5	Located on top of a rocky granite ridge. Grassy forest habitat, the overstorey dominated by Scribbly Gum and Bundy with some Red Stringybark, lots of fallen timber present.
6	Located on top of a flat ridge, the area was rocky with a lot of dead trees and fallen timber. Some lightwood still standing and dominated with native understorey. North facing slope had some scattered trees including Yellow Box and White Box with some Blakely's Red Gum and cassinia middle storey.
7	Located on top of a ridge. Habitat in this area was a mixture between open pasture with scattered trees and woodland. The overstorey was dominated by Red Stringybark, Bundy and Scribbly Gum, some Spreading Wattle shrubs present and native pasture grasses.
12	Located along a granite ridge with a mixture of open native pasture on east facing slope and woodland on west facing slope. Woodland dominated by Bundy, Scribbly Gum and Yellow Box.
17	Located on top of a ridge in pasture land. Remnant trees located along fence lines and scattered in paddocks dominated by White Box, Yellow Box and Scribbly Gum.

Survey point	Habitat
21	This point was located on top of a ridge that runs north-south. It has granite boulders, native pasture, scattered trees dominated by Bundy and some Scribbly Gum and Silver Wattle. Grazed by sheep.
22	Located along a ridge with granite outcrops and boulders. Woodland habitat dominated by Yellow Box, Bundy, Scribbly Gum and White Box. No middle storey, sparse native grasses and leaf litter.
R1	Roadside vegetation dominated by a strip of mature Yellow Box, some Blakely's Red Gum, and Lightwood and Cassinia shrubs as understorey. Grazing paddocks outside the roadside with some scattered mature gums.
R2	Open grazing paddock flanked East and West by two streams that run N-S dominated by planted Willows and mature gums. Understorey comprised Silver Wattle, small shrubs, and rushes.
R3	Located on a lower ridge to other sites, may be considered the slope with pasture and roadside habitats. The roadside was dominated by mature eucalypts including Blakely's Red Gum, Bundy and Yellow Box and some Lightwood with cassinia shrubs throughout and native grasses. The pasture areas had regenerating eucalypts, cassinia and native grasses.

Timing of baseline BUS

The four season baseline surveys were completed in:

- Autumn 2019;
- Winter 2019;
- Spring 2019; and
- Summer 2020.

Bird survey points are shown in Figure 7.

The results of these surveys will be provided to DPIE and DAWE in a baseline survey report. This report will also compile the results of the bat surveys (detailed below).

This will provide the baseline for before and after impact assessment (BACI) bird surveys. This methodology was assessed by Symbolix and concluded that the BUS program design is statistically valid and consists of a sufficient number of observations (see Appendix 3: Statistical review of BUS method 16th March 2020).

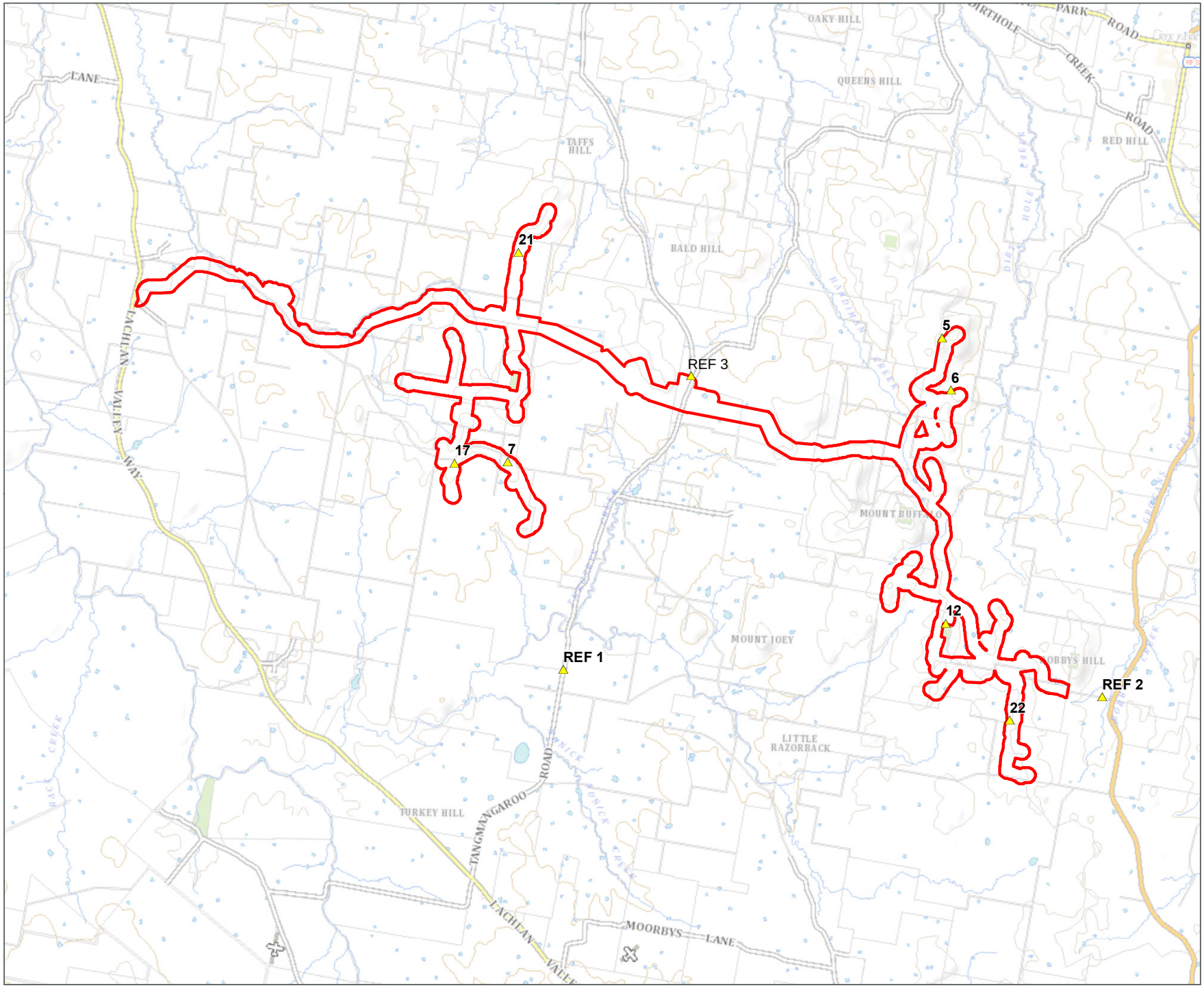


Figure 7: BUS points

Project: Bango Wind Farm
Client: CWP Renewables Pty Ltd
Date: 12/02/2020

Development corridor
BUS locations

N

Metres
0 1,000

Nature Advisory
PO Box 337, Camberwell, VIC 3124, Australia
www.natureadvisory.com.au
03 9815 2111 - info@natureadvisory.com.au

Construction phase BUS surveys

In addition to the surveys discussed above, DPIE requested additional BUS surveys are conducted during construction which will add data to the baseline surveys. As such, four BUS will be carried out. To date two surveys have been completed including spring 2020 and summer 2021. If the construction schedule permits, two more surveys will be undertaken during autumn and winter 2021. These four construction phase surveys will be completed utilising the fixed-point bird count methodology (as described above).

These construction phase BUS will provide baseline data for the species of birds and utilisation rates recorded at BWF prior to commissioning. The results of these construction phase BUS surveys will be compiled and presented in the first annual report and will be compared with BUS results for the first year of operational monitoring.

Targeted surveys

Superb Parrot

Point and transect bird surveys were undertaken within suitable habitat between 1st August and 13th December 2012. A total of 17 surveys were conducted. Detection was made by sighting with binoculars or by the species calls. Opportunistic sightings were also recorded whilst traversing the site and surrounding roads. Sightings were recorded via GPS.

Superb Parrot was one of the most commonly observed threatened species, along with Diamond Firetail. The species was observed at numerous locations during its breeding season (October – December) but not outside the breeding season.

A total of 147 Superb Parrot were recorded flying at 0-20 metres high and one at 20-40 metres above the ground across the 17 surveys in 2012.

As a result of the bird surveys, hollow bearing tree survey and targeted Superb Parrot investigations, an entire cluster of turbines from the Langs Creek section of the proposed BWF was removed from the design layout due to frequent activity of Superb Parrot in this section of the proposed BWF.

To inform risk behaviour, two Superb Parrot surveys were undertaken in the breeding season of 2019. Surveys were for one week, beginning early in the breeding season (October) and toward the end of the breeding season (November).

A comparison of baseline data and operational phase data will identify potential affects or impacts on the species or its behaviour that the construction and operation of the BWF might cause.

The aims of the survey were to:

- Determine whether breeding of Superb Parrot was occurring within 200 metres of turbines; and
- To determine whether Superb Parrots are observed demonstrating “risk behaviour”. “Risk” behaviour is defined for the purpose of this BBAMP as consistent observations of ten or more flights per day of flocks of ten or more birds between turbines at a height that would result in levels of collision of potential consequence for the regional and wider population of the species.

It is noted that DPIE are working on a Community-based monitoring program for the Superb Parrot (see https://www.environment.nsw.gov.au/news/community-based-monitoring-for-the-superb-parrot-the-benefits-of-citizen-science).

The following methodology was implemented for targeted Superb Parrot surveys:

- Focussed transect surveys 250 metres either side of the BWF infrastructure;
- The observer would walk at a rate of up to 2 km/hour;
- All trees with hollows identified within 200 metres of infrastructure will be surveyed;
- If Superb Parrots are observed in focus areas, then monitoring will be undertaken made to determine if they are nesting. This will include watching parrot activity to determine if nesting was occurring, determining the sex of birds in flocks and attempting to follow parrots to nest trees;

- If nest trees are located in the focus areas, these trees will be documented and recorded. Daily visits will be undertaken to record activity while surveys are on-going;
- All Superb Parrot and other threatened species observations will be recorded and marked with a handheld GPS and flight height recorded.
- A reference site comprising a transect of two kilometres will be established at least 500 metres from the infrastructure footprint where Superb Parrots were observed in the initial surveys.

Swift Parrot

No records of Swift Parrot have been recorded within 10 kilometres of BWF (OEH 2018a, ALA 2021) however Swift Parrot habitat does occur at the BWF. Swift Parrot are known to forage in White Box-Yellow Box-Blakley's Red Gum Grassy Woodland community which has been identified as occurring at BWF. Swift Parrot was not observed during baseline surveys for the application of the BWF.

Suitable habitat does occur at BWF and the site is within its distribution range there is potential for this species to pass through the area and/or forage in trees within the study area. Given that there are no records of the species within the search region (10km form the edge of the development footprint) it is considered that presence at BWF would occur infrequently.

Birds of prey (Raptors)

This group includes the diurnal raptors than have been recorded at BWF, namely Little Eagle (listed Vulnerable in NSW), Wedge-tailed Eagle and Other raptors (Australian Hobby, Black-shouldered Kite, Brown Falcon, Brown Goshawk, Collared Sparrowhawk, Nankeen Kestrel, Peregrine Falcon, Whistling Kite). It will also apply to any other species of diurnal raptor that may occur at Bango WF in future.

Monitoring of raptor flight movements and breeding activity was required to determine whether operating turbines affect the behaviour of Wedge-tailed and Little Eagles in particular. This raptor monitoring will be incorporated into the baseline BUS.

In addition, DPIE has requested that targeted baseline surveys of Wedge tailed eagle and Little Eagle are undertaken in conjunction with the BUS survey. During the BUS, all raptors that were observed during surveys and while traversing the site were recorded and flight paths marked on a map. The following data was documented for each flight observed during the monitoring program (see data sheet Appendix 6).

- Species name;
- Number of birds;
- Time first observed;
- Time the bird/s flew out of sight or landed;
- Distance and bearing from observer;
- The location of the bird (either Air, perched or ground);
- Height of the bird when first observed;
- The height range of the bird (minimum and maximum heights);
- Elevation of the fixed point;
- The landscape the bird was observed in (either valley, slope or ridge);
- Flight direction (either toward, away, parallel to ridge or circling); and
- Flight behaviour (either soaring, gliding, hovering, flapping, display, resting, mobbing or foraging).

Raptor information was collected in conjunction with the BUS surveys.

The baseline report for raptors includes:

- Consideration of the qualitative data from the 2012/13 raptor survey;
- Incidental observations while on site;

- Baseline BUS in autumn 2019, winter 2019, spring 2019 and summer 2020; and
- Construction BUS over four seasons.

Woodland birds

Surveys for subject bird species occurring in woodland identified as requiring surveys by DPIE were undertaken between 1st August and 13th December 2012. These surveys were carried out in early morning and late afternoon across 17 sites by two observers for one hour per site. This was repeated at all sites (ERM 2013).

A total of 99 species were detected in woodlands, these are included in the species under the BUS surveys. Several threatened species were observed in woodlands including:

- Brown Treecreeper;
- Diamond Firetail;
- Grey-crowned Babbler;
- Scarlet Robin;
- Superb Parrot;
- Speckled Warbler; and
- Varied Sittella.

Nocturnal surveys

Surveys for nocturnal species, particularly owls (Powerful Owl and Barking Owl), were undertaken during November and December 2012 and February 2013 at four sites and included call playback and spotlighting. Two playback sessions were conducted on two nights at woodland survey sites (ERM 2013).

No threatened nocturnal bird species were detected.

Bat surveys

A range of bat surveys were utilised to detect bat species at the site from November 2012 to February 2013. Anabat recorders, used to detect microbat calls, were deployed twice at 13 locations over 624 detector hours. Two harp traps were deployed over two locations over three nights. 'Stag-watching' was also undertaken to determine if bats were using areas of potential habitat, such as two disused mines within the study area (ERM 2013).

Up to May 2019 a total of 13 species of microbat were detected at the BWF site. Two of these species are listed as Vulnerable in NSW under the BC Act:

- Large Bent-winged Bat (*Miniopterus orianae oceanensis*); and
- Yellow-bellied Sheathtail Bat (*Saccolaimus flaviventris*).

Bat utilisation is difficult to determine using the current standard surveying techniques as numbers of individuals and their patterns of use are unclear using these standard sampling techniques. For example, if there are ten calls of the same species in one night it could be the same individual or up to 10 individuals flying past the survey site. Presence and absence data during the peak activity times (October – April) is considered adequate.

Grey-headed Flying-Fox was not recorded during these surveys and there are no camps of this species nearby.

To provide more information on bat presence and utilisation at the site, in addition to these initial baseline surveys, there have been a substantial effort to undertake additional bat surveys since 2019.

The first focussed survey period was:

- 29th April – 2nd May 2019 four Songmeters were deployed at four sites at BWF (Figure 8) over two–three nights.

To provide further information on the bat presence at BWF more detailed pre-commissioning migration investigations were undertaken. This included the surveys below:

- Spring 2019 – five sites across the BWF for 4 weeks; and
- Summer/ Autumn 2020 with sixteen locations/sites (Figure 8) surveyed for a minimum of 10 days in summer/autumn including two recorders at height at 50 metres at height.

The report on the 2019 and 2020 deployment of Songmeters will be presented in the bird and bat baseline data report to be provided to BCD. This report will combine data from the earlier 2012-2013 ERM surveys and the 2019/20 survey periods.

Summary of baseline surveys

Condition of Consent 21 (a) requires at least 12 months of baseline data on threatened and 'at risk' species that could be affected by the project. Surveys to date, summarised above, regarding birds and bats on the BWF covered a period roughly from July 2012 to February 2013 undertaken by ERM and the more recent surveys from April 2019 to present and ongoing.

Baseline BUS surveys were initially undertaken in four seasons from Autumn 2019-Summer 2020 and then further baseline surveys have been undertaken during the construction phase of the wind farm including spring 2020 and summer 2021 and are ongoing. During the BUS, recording and plotting the movements of raptor species utilising the BWF site was undertaken. In addition, records of the presence of Superb Parrot were noted.

Bat surveys were undertaken in Autumn 2019. These surveys were lengthened and repeated in Spring 2019 and Autumn 2020 to coincide with the migration period of the Large Bent-winged Bat.

Targeted Superb Parrot surveys were undertaken during two periods in the 2019 breeding season.

The following reports will be provided to DPIE and DAWE:

- Compiled results from the baseline studies outlined above conducted up to April 2020 and summarised in Table 7 below will be submitted to DPIE and DAWE. The aim is to provide a baseline dataset to allow monitoring of impacts after operations have commenced.

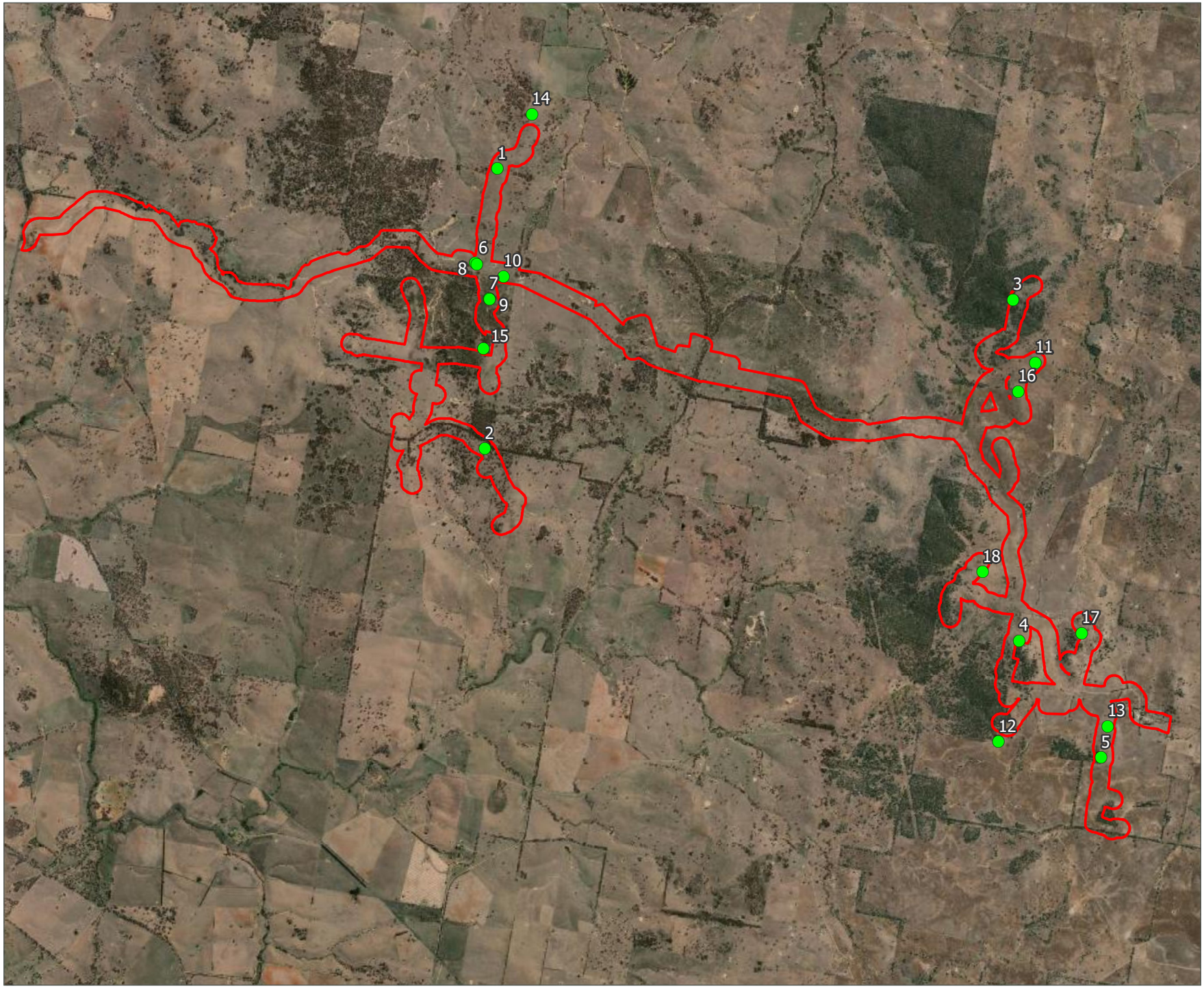


Figure 8: Location of the Song Meters at Bango Wind Farm during Spring (1-5) and Summer-Autumn (1-18)

Project: Bango Wind Farm
Client: CWP Renewables Pty Ltd
Date: 4/08/2020

Development corridor

Songmeter locations

N

Metres
0 1,000

Nature Advisory
PO Box 337, Camberwell, VIC 3124, Australia
www.natureadvisory.com.au
03 9815 2111 - info@natureadvisory.com.au

Main frame - Created by: - E:\GIS\2018 Jobs\18173\18173 Bat recorder locations 200427.mxd

Table 7: Baseline monitoring of non-listed and listed bird and bat species

Species groups to be monitored	General baseline surveys	Targeted surveys
Non-listed bird species	BUS (see Section 2.2.1): ▪ Autumn 2019 ▪ Winter 2019 ▪ Spring 2019 ▪ Summer 2020	
	Construction period surveys: ▪ Spring 2020 ▪ Summer 2021 If the construction schedule permits: ▪ Autumn 2021 ▪ Winter 2021	
Wedge-tailed Eagle	BUS: ▪ Autumn 2019 ▪ Winter 2019 ▪ Spring 2019 ▪ Summer 2020	Targeted survey as part of BUS in: ▪ Autumn 2019 ▪ Winter 2019 ▪ Spring 2019 ▪ Summer 2020
	Construction period surveys: ▪ Spring 2020 ▪ Summer 2021 If the construction schedule permits ▪ Autumn 2021 ▪ Winter 2021	Construction period surveys as part of BUS in: ▪ Spring 2020 ▪ Summer 2021 If the construction schedule permits ▪ Autumn 2021 ▪ Winter 2021
Other raptors, including Little Eagle	BUS (see Section 2.2.1): ▪ Spring 2019 ▪ Summer 2020	Targeted survey as part of BUS in: ▪ Spring 2019 ▪ Summer 2020
	Construction period surveys: ▪ Spring 2020 ▪ Summer 2021 If the construction schedule permits ▪ Autumn 2021 ▪ Winter 2021	Construction period surveys as part of BUS in: ▪ Spring 2020 ▪ Summer 2021 If the construction schedule permits ▪ Autumn 2021 ▪ Winter 2021
Superb Parrot	BUS (see Section 2.2.1): ▪ Autumn 2019 ▪ Winter 2019 ▪ Spring 2019 ▪ Summer 2020	Targeted pre-commissioning surveys in October and December 2019
Bats – non listed	Bat Surveys ▪ Autumn 2019 ▪ Spring 2019 ▪ Summer/Autumn 2020	
Large Bent-winged Bat (LBB) and Yellow-bellied Sheathtail Bat		Bat Surveys ▪ Spring 2019 ▪ Summer/Autumn 2020

Appendix 2: Statistical review of BUS methodology

symbolix

making your data work harder

To: Bernard O'Callaghan
Nature Advisory
Via email

Ref #: BLABANG20200316
Date: 16 March 2020 (amended 2020-02-05)
CC: Brett Lane

Re: Review of survey design at Bango Wind Farm

To whom it may concern:

Thank you for requesting our review of the proposed Bird Utilisation Survey and Eastern Bent-wing Bat acoustic surveys (pre- and post-commissioning) at Bango Wind Farm, NSW. This letter outlines the scope of the review, our background in this area, our appraisal of the study and final comments.

Scope of works

We were engaged by Nature Advisory, on behalf of Bango Wind Farm Pty Ltd, to carry out the following tasks:

- Review the proposed design of the Bird Utilisation Study (hereafter **BUS**) for Bango Wind Farm, NSW
- Review the statistical aspects of the proposed Eastern Bent-wing Bat acoustic surveys (pre- and post-commissioning)
- Review existing review comments from the Office of Environment and Heritage (now Department of Planning, Industry and Environment) on same
- Prepare a letter of advice regarding the efficacy of the proposed design, referencing statistical and industry best practice

In reviewing the documentation, we refer specifically to the following documents

- Nature Advisory (2020) *Bango Wind Farm Bird and Bat Adaptive Management Plan*. Report No. 18173 (1.15). Prepared for Bango Wind Farm Pty Ltd (Hereafter **BBAMP**)
- We specifically refer to
  - Section 2.3.2 *(Pre-commissioning) Bird Utilisation surveys - 2019-2020 and beyond*

and
  - Section 4.1 *Operational Bird Utilisation Surveys* and
  - other sections only as relevant to the sections under review.
- *Nat Adv response to OEH comments on BBAMP of jan 2020 - 20200120.docx*
- Email clarifications regarding turbine location and placement (2020-02-27, see Attachment A)

About the reviewers

Symbolix is an Australian business specialising in data science and statistical analysis services. We have provided these services to the Australian Wind Energy Industry from 2004. We have provided statistical methods, models and advice throughout all stages of the wind farm lifecycle; from pre-approvals, BBAMP plan design and operational monitoring.

Our wind farm research work has been published in the Australasian Journal of Environmental Management, New Zealand Journal of Zoology, and Wildlife Society Bulletin. Our research has also been presented at industry and research conferences in Australia, New Zealand and Europe.

Our principle reviewer for this work is Dr Elizabeth Stark.

Elizabeth is a co-founder of Symbolix. She has over a decade's experience supporting environmental practice through data and analytics. She is a current Board member of the Environment Institute of Australia & NZ (the professional body for environmental professionals) and a member of the American Ecological Association. Elizabeth has delivered a number of projects for environmental management and is currently leading a project for DEWLP (Vic) to deliver a state-wide analysis of wind farm post-construction data from multiple sites in Victoria.

Appraisal of the Eastern Bent-wing Bat acoustic survey

The BBAMP (with clarifcations proposed on page 5 of the '*Nat Adv response to OEH comments on BBAMP of jan 2020 - 20200120.docx*' document proposes acoustic monitoring of bat activity at five locations across the site for six weeks during Spring and Summer/Autumn periods.

The exact timing will be finalised in consultation with DPIE threatened bat experts. We provide no comment on the timing or length of surveys as that is an issue best decided by species experts.

Based on our experience analysing data from different sites, the survey as specified is suitable for:

- Collecting presence / absence and a basic vocal activity count during potential migration periods.

- Contextualising the results of the carcass searches. This is particularly important in the first year, so that decisions about mitigation and survey timing can be taken before the second year of carcass searches.
- Providing a baseline data set for bat activity presence onsite. This is important to ground truth the performance mitigation measures that might be triggered down the track (e.g. low wind speed curtailment).

We do not recommend attempting to assign this activity directly to a count of bats, or fine-grained site utilisation patterns. That would require abundance data which cannot be robustly collected.

Appraisal of the Bird Utilisation study

What are the required objectives for the BUS?

From the NSW conditions of consent the BBAMP is required to deliver:

> *At least 12 months' worth of baseline data on threatened and 'at risk' bird and bat species and populations in the locality that could be affected by the development;*
>
> *An adaptive management program that would be implemented if the development is having an adverse impact on a particular threatened or 'at risk' bird and/or bat species or populations*

The EPBC requirements include

> *An on-going monitoring program, . . .*

There is no direct requirement for BUS, but a properly scoped BUS could be of use as part of a broader adaptive management plan.

For example, if the carcass search program suggests unexpected mortality of a particular species group, the BUS data can provide context about the background site activity (and any increases or declines in that activity).

As far as this reviewer is aware there are no published studies indicating species site use declines at Australian wind farms due to barrier or macro-avoidance behaviour. With this in mind, the most appropriate aim for the BBAMP BUS is to

- Provide descriptive and quantitative analysis of the changes in bird species richness, diversity and species mix from before to after construction.
- Contextualise any unexpected findings from the carcass surveys.

What is the proposed design?

This information is sourced from Section 2.3.2 of the BBAMP.

The methodology is a point-count method, using a 15 minute observation window.

Birds are only recorded if within 200m. For all birds with 200m the following information will be recorded:

- number of individuals
- height (below, above or at rotor height) at first detection
- minimum and maximum height (for threatened species)
- species

Placement and labelling of observation sites

'Impact' observation points are turbine-adjacent (Attachment A - Curtis Doughty, Nature Advisory *in response to reviewer questions*).

We understand they were chosen to be compatible with sites used in previous surveys by ERM (to increase the possibility of combining datasets). The time elapsed between the initial survey and the 2019 baseline surveys meant one of the sites is now 2645m from the nearest turbine and is best re-labelled as a reference site.

Two additional reference sites were added in Winter 2019.

We note that the same turbine locations are proposed for the construction and the post-construction surveys. We support this decision. The locations were chosen to be adjacent to turbines and have good visibility. As such the population sampled is the *"cohort of bird-life that in good visibility areas near turbines"*. To ensure the same population is sampled in the construction and post-construction phases, it's recommended to maintain the same observation points and methodology.

Detailed sampling methodology

Pre construction:

- Number of sites
  - Seven turbine-adjacent points; all within 300m from turbine site
  - Three reference points; all over 1km from turbine sites. Two of these were employed for the first time in Winter 2019
- Number of seasons/surveys - Four (Autumn 2019, Winter 2019, Spring 2019, Summer 2019/20)
- Number of replicates per site per survey season - Eight

During construction:

- Number of sites - Seven turbine adjacent sites; three reference
- Number of seasons/surveys - Four (though presumably this depends on the construction window)

- Number of replicates per survey - Eight

Post construction:

Repeat of the pre-construction methodology in years 1 and 3

- Number of sites - Seven turbine adjacent sites; three reference
- Number of seasons/surveys - Four (Autumn, Winter, Spring, Summer)
- Number of replicates per survey - Eight

Appraisal of the design

Compliance with requirements

The survey design will enable creation of:

- Species mix matrices
- Species Richness
- Species Diversity (Shannon and Weaver (1949), Hill (1973))

for each individual point count.

The species mix matrices would support descriptive multivariate analysis, like ordination plots (Clarke 1993).

Univariate measures like the Richness and Diversity can be analysed as a before-after; control-impact (BACI) design. The proposed BACI design is imbalanced (less reference sites) but this is a reasonable decision to maximise effort in areas adjacent to turbines. The design itself is sufficient for ANOVA or generalised linear model style analysis.

This reviewer considers this design to deliver adequately on the requirements of the permit conditions. The combination of descriptive and quantitative hypothesis testing provides important contextual information in support of the data collected during the carcass searches.

Statistical adequacy

In keeping with an adaptive management approach to post-construction monitoring, it's arguable the BUS survey should focus on descriptive and species mix statistics. Maximising statistical power is admirable, but the nature of hypothesis testing requires focussing survey design on achieving precision to answer one or two specific questions. This can have the adverse effect of not collecting sufficient descriptive data to contextualise the findings of the quantitative statistics.

With this in mind we would still, at the least, desire the survey design to have sufficient power to detect a difference in species richness and/or diversity from before to after (onsite) that's not present in the before to after (reference sites).

For the purposes of this discussion, 'after' might refer to any one of

- the construction period
- year one post construction
- year three post construction

The study is a BACI design but the imbalanced control-impact ratio and the difficulty in interpreting standard 'effect sizes' means we need modern solutions to estimating the potential power. Analytical estimates (e.g. Cohen (1988)) can be applied here, but they are not so easy to interpret.

To assess the statistical power of the proposed survey, we used the techniques of Lyles, Lin, and Williamson (2007), implemented using custom code written in the **R** statistical language.

We tested the survey design as proposed above, and a second design consisting of the same three control sites and an additional six impact sites. This checks if gains could be made with additional survey effort.

We have tested for the power to detect

- A decline in species richness from before to after at the impact sites
- We have assumed no change in the control sites
- We have assumed confidence level of `p = 0.1`. This means a change will be noted as significant at a lower confidence than the standard `p = 0.05`. This is appropriate for ecological tests in an adaptive management framework (where you want early warning signs).
- We have assumed the average species richness (per point count observation) is five species and follows a Poisson distribution. This benchmark aligns with results from other NSW sites we have analysed.

We tested for the power to detect different effect sizes from 0.01 (a 1% decline in average species richness, from 5 to 4.9) up to 0.75 (a 75% decline from 5 to 1.25 species per observation).

The plot below shows the predicted power to detect the changes for the proposed survey and for the same design with six additional sites.

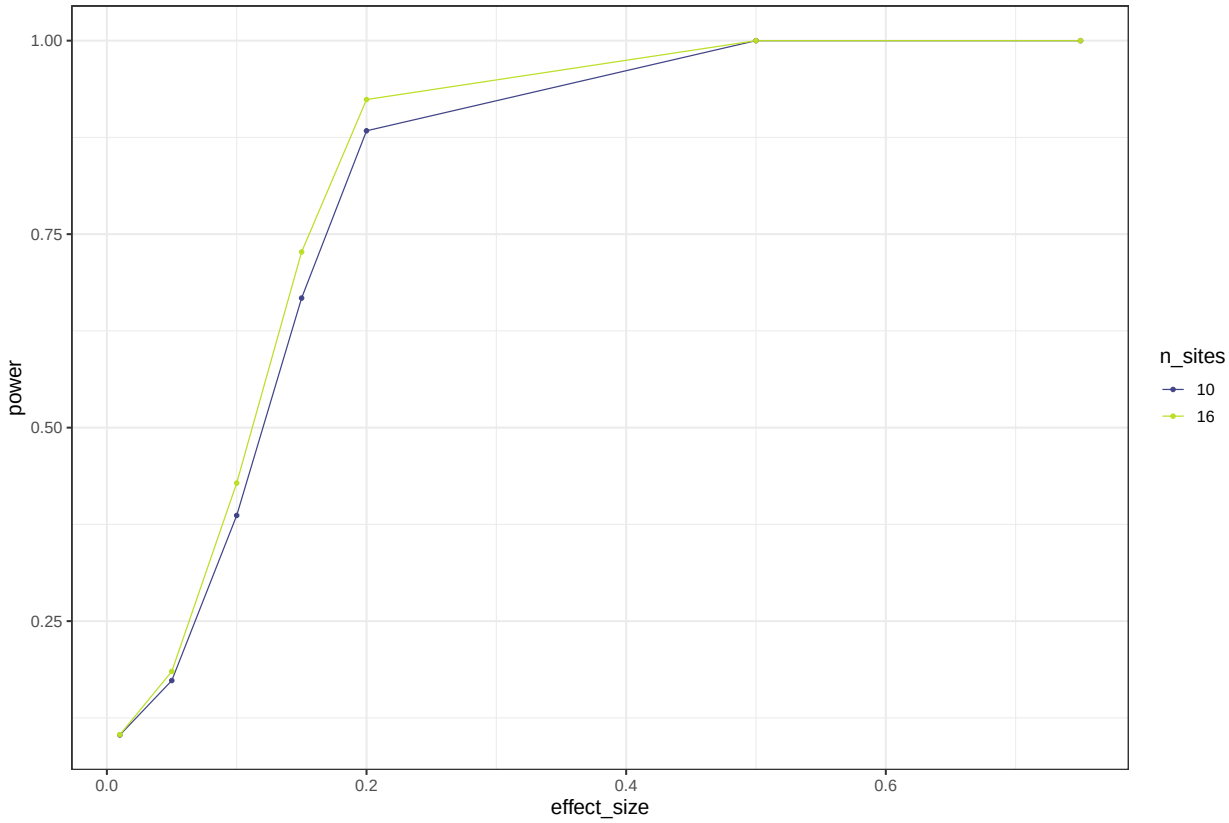


Figure 1: Comparison of power for different effect sizes and number of sites

Declines of around 15% will be detected around 75% of the time. A decline in species richness for more than 20% will be almost certainly detected (>90% power).

Small changes are less likely to be confirmed by statistical significance testing. This cannot be substantively changed by increasing more observation effort, but is an inherent difficulty when using this type of survey for strict compliance testing.

We recommend that the survey design as proposed should not be relied on to test for significant (but perhaps not enironmental substative) small changes. It should not be relied on (in isolation) to detect changes in the occurance of rare species (that start with a very low baseline).

It is sufficient to test for changes in the structure of the ecological community statistics (like richness and diversity).

Overall, the survey is sufficient to provide a representative set of data that will be useful to describe local changes and patterns, and changing the design (or increasing effort) to try to focus on an unrealistic level of statistical power would be ill-advised.

Final remarks

Based on the points above the reviewer is satisfied that the BUS program design is statistically valid and consists of a sufficient number of observations.

This finding is dependant on a couple of key factors staying consistent in the design from before construction to during- and post-construction.

Because the sites have been chosen to allow visibility and be close to proposed turbine locations, they are representative of "good visibility areas near turbines." It's important the construction and post construction surveys use the same site locations as the 2019-20 baseline surveys.

We have assumed a particular approach to analysis, based on our experience with this sort of study at other wind (and non-wind) sites. We do not guarantee the same statistical power if other statistical questions are asked of the data. However, the data set collected is reasonably standard and should support a range of descriptive analysis and the quantitative hypothesis testing as described above.

Regards,

Dr Elizabeth Stark

Managing Director - Symbolix Pty Ltd;

e: estark@symbolix.com.au; m: 0412 075 235.

A Attachment A

Extract from email on 2020-02-27 showing location of BUS observation points from turbines. Locations 8, R1 and R2 are designated as reference sites.

symbolix

Elizabeth Stark <estark@symbolix.com.au>

Bango Wind Farm - some questions

Curtis Doughty <curtis@natureadvisory.com.au> 27 February 2020 at 15:41
To: Elizabeth Stark <estark@symbolix.com.au>, Bernard O'Callaghan <Bernard@natureadvisory.com.au>
Cc: Brett Lane <Brettl@natureadvisory.com.au>, Stuart Muir <smuir@symbolix.com.au>

Hi Elizabeth,

We have just been given the most up to date turbine locations. Please see the table below with distance from BUS points to nearest turbine.

BUS point	Distance from nearest turbine (m)
5	20
6	50
7	35
8	2645
12	115
17	230
21	70
22	70
R1	1445
R2	2255

References

Clarke, K. R. 1993. "Non-Parametric Multivariate Analyses of Changes in Community Structure." *Austral Ecology* 18 (1): 117–43.

Cohen, J. 1988. *Statistical Power Analysis for the Behavioral Sciences*. Lawrence Erlbaum Associates.

Hill, M. O. 1973. "Diversity and Evenness: A Unifying Notation and Its Consequences." *Ecology* 54 (2): 427–32.

Lyles, Robert H., Hung-Mo Lin, and John M. Williamson. 2007. "A Practical Approach to Computing Power for Generalized Linear Models with Nominal, Count, or Ordinal Responses." *Statistics in Medicine* 26 (7): 1632–48. https://doi.org/10.1002/sim.2617.

Shannon, C. E., and W. Weaver. 1949. *The Mathematical Theory of Information*. Urbana, Illinois: University of Illinois Press.

Appendix 3: Statistical review of mortality monitoring

symbolix

Bango Wind Farm Mortality Monitoring Program - Statistical Design

Prepared for Nature Advisory, 4 February 2021, Ver. 0.91

1 About this document

As part of the preparation and review of this Bird and Bat Adaptive Management Plan (BBAMP), a peer review highlighted concerns regarding the design and communication of the carcass search program (including estimation of mortality due to turbines).

This document provides a renewed survey design and statistical recommendations for this component of the BBAMP. This detail underpins the field instructions in the main body of the BBAMP.

2 Design considerations

2.1 Site specifics

The EPBC Act listed Superb Parrot is the only species of concern that requires a trigger level for mitigation activities, as documented in the conditions of approval.

There is a requirement to monitor and report on the mortality of birds and bats more generally.

The peer review process instigated by DPIE suggested the existence of three distinct vegetation types on the site:

1. Cleared areas **(21 of 46 turbines)**
2. Open wooded areas **(13 of 46 turbines)**
3. Closed wooded areas **(12 of 46 turbines)**

The review suggested that these could potentially have different carcass visibility and also scavenger rates.

In keeping with this advice we will stratify the program into these areas. This will ensure site coverage and a mortality estimate that appropriately accounts for variability.

2.2 Mortality program objectives

The **primary** objective of a wind farm post-construction mortality program is to generate a statistical estimate of the number of bird and bat fatalities due to turbine collision over a period of time (typically annually). We will need to estimate total mortalities for groups of species and individual estimates for species of concern.

A **secondary** consideration is to inform the application of triggers for adaptive management. These triggers are based on raw carcass data in Australia (unlike the US which uses a 'take permit' system based on total mortalities).

The primary objective requires a statistical design so that the carcass counts can be expanded to estimate total mortality. This does not require full coverage of the site - only a randomised statistical sample. However, we attempt to ensure there is 'reasonable'[1] coverage, to assist with adaptive management.

2.3 Components of the study

Mortalities are estimated with a Horvitz-Thompson style estimator of the of the form (Huso 2011):

$$\hat{M}_{ij} \cong \frac{C_{ij}}{(\hat{g}_{ij})} \tag{1}$$

where

- $\hat{M}_{ij}$ is the estimated mortalities at turbine i during search j
- C_{ij} is the number of carcasses found
- $\hat{g}_{ij}$ is the estimate of the detection probability for that search and turbine

For a given turbine, $\hat{g}_{ij}$ is a function of

$$\hat{g}_{ij} \cong a_i r_{ij} p_{ij} \tag{2}$$

- a_i is the fraction of total carcasses within the searched area (note this is *not* the same as the fraction of area searched)
- r_{ij} is the fraction of the carcasses that arrived at turbine i but have not been lost to scavenge or decay before search j
- p_{ij} is the probability that an existing carcass will be detected by the searcher

Therefore, a robust mortality program requires the following components:

- a formal mortality monitoring survey where found carcasses are recorded, to determine C_{ij}

[1] *Noting that 'reasonable' is a somewhat subjective term based on risk appetite and managing the OH&S of the field teams.*

- an estimate of the fall zone of carcasses to determine a_i (this also accounts for potentially only searching a subset of all turbines)
- scavenger trials to estimate r_{ij}
- searcher efficiency trials to estimate p_{ij}

We outline the field protocol in the remainder of this report, making reference to best practice guidelines.

3 Field design

3.1 Scavenger trials

Scavenger trials involve leaving carcasses out in field, monitoring their time until removal.

3.1.1 Aim

The purpose of scavenger (or carcass persistence) trials is to quantify the mean and confidence interval of the time to removal of carcasses from the study area.

This is needed as an input into the mortality estimate.

To derive an annual mortality estimate, we require an annual value for scavenge. We suggest surveying in more than one season to capture some of the seasonal variability, but we do not need multiple scavenge rates at different times of year.

3.1.2 Metric studied

The metric studied is the *survival function* $S(t)$, which determines the probability that a carcass will "survive" in-field past time t. When this is estimated, the mean and confidence interval on time to scavenge can be found.

3.1.3 Field methodology

Scavenger trials are proposed in two seasons of the year (winter and spring). Winter (Jul - Aug) reflects shorter vegetation cover and heavy stock load, and spring (Sept - Nov) reflects growth and lower stock load.

In each strata and season, the survey will consist of

- 7 bat or bat proxy (e.g. mouse) proxies
- 7 small/med birds

That translates to 14 replicates per size (bat/bird) and geo-strata (three vegetation types) a year; leading to a total of 84 carcasses annually.

We note that sourcing carcasses, particularly for larger birds can be difficult to do humanely and reliably. This is why we propose a smaller number of carcasses. It may be necessary to use a nominal value from data from other sites or published nominal values (e.g. Stark and Muir (2020)).

The carcasses will be distributed among different turbines and cameras will be used to obtain as accurate as possible loss time.

3.1.4 Sample size

How precisely can we measure time to (scavenger) loss?

If we assume an exponential loss function for carcasses (the simplest of the standard choices), the relative standard error is a simple function of the number of carcasses lost: RSE $= 1/\sqrt{n}$. As Figure 1 shows, the precision is not vastly improved by increasing the numbers of trials.

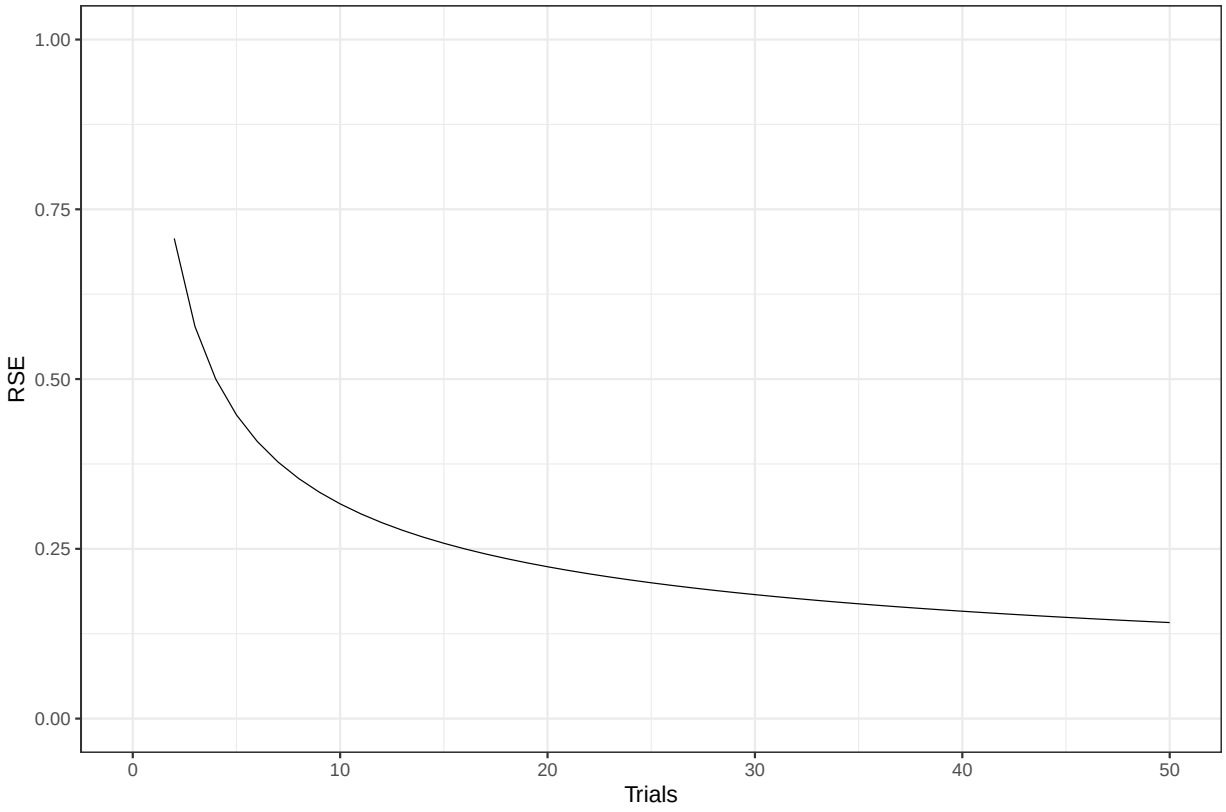


Figure 1: Relative standard error of scavenger rate as a function of carcasses lost

Carrying out 14 trials per size and geo-strata in the first year (84 trials overall) balances the precision requirements with the operational difficulty of sourcing carcasses.

3.1.5 Analysis methodology

Although motion-capture cameras record the exact time to removal, it is our experience that sometimes the event is only known to within an interval (e.g. the instrument misses the moment of removal).

Therefore, data is likely to be *censored*. There are two forms of censoring encountered in scavenger trials:

- Interval censoring: this means that we know an interval in which the scavenge event

happened (e.g. we checked after 1 hour and the carcass was there, then checked after 2 hours and the carcass was gone), but we don't know the exact time of the event.

- Right censoring: the scavenge event happened after completion of the trial (e.g the trial ran for 30 days, and a carcass persisted until the end of the trial). This can also be conceptualised as an interval with the right side being infinity.

Simple methods such as the mean time to scavenge fail to account for censoring, and also fail to account for any time-dependence in the carcass loss function. To properly account for this, we use survival analysis (Kaplan and Meier (1958), Terry M. Therneau and Patricia M. Grambsch (2000)).

Survival regression properly accounts for interval censoring, and allows variously shaped loss functions to be fit to the scavenger trial data.

The calculation can be carried out in statistical software. We recommend the `R` packages `survival` or `GenEst` (which provides a helpful wrapper for the `survival::survreg` function specifically for carcass persistence). Analysis should

- Fit a range of carcass persistence distributions (at least exponential, Weibull and log-normal) to determine the best fit.
- Test for the significance of the covariates for carcass size and site strata.
- Generate an estimate (mean and confidence interval) for each significant covariate group. Covariate groups may be combined if no significant difference is found.

The report should identify

- The software/methods used
- The distribution chosen
- Time to scavenge (mean and confidence interval) for each covariate (e.g. bats in open woodland or bats - total)

3.2 Searcher efficiency trials

Searcher efficiency trials involve the surveyors going out into field with identical survey technique to the main mortality program, and looking for prior (manually) placed carcasses.

3.2.1 Aim

The aim of searcher efficiency trials is the quantify the probability (and confidence interval on that probability) that the searcher will find a carcass, under the planned survey protocol.

This is needed as an input into the mortality estimate.

To derive an annual mortality estimate, we require one, annual value for searcher efficiency. We suggest surveying in more than one season to capture some of the seasonal variability, but we do not need multiple searcher efficiency rates at different times of year.

3.2.2 Metric estimated

We are specifically interested in the Bernoulli parameter p, which is the probability that a searcher finds a carcass, given it is within their search area. We treat each carcass placed as a Bernoulli random variable with probability p of success where success = finding the carcass.

3.2.3 Field methodology

We suggest the carcasses and placements used for the scavenger trials are also used for the searcher efficiency trials. This is an efficient use of carcasses and should not impact the efficacy of either survey.

In each strata and season, the survey will consist of

- 7 bat or bat proxy (e.g. mouse) proxies
- 7 small/med birds

That translates to 14 replicates per size (bat/bird) and geo-strata (three vegetation types) a year; leading to a total of 84 carcasses annually.

Transect spacing in the searcher efficiency trials will be identical to those used in the main mortality survey program.

Carcasses should be placed randomly throughout the search area. The majority of bats should be placed in the inner 'bat' search zone but a few carcasses will be placed in the outer zone to represent the small percentage that will fall into the upper percentiles of the fall zone. (See carcass search section for more information about survey zones and transect spacings).

Carcasses do not need to be the same species as expected in the carcass searches but should have similar detection profiles. For example brown mice might suit as a proxy for bats but white lab mice would not.

The same type of observer (human or canine) used in the carcass searches should be tested in this survey.

Blind trials are not feasible. Reasons for this include:

- the searcher efficiency trial requires a higher density of carcasses than by chance due to turbine fatalities, making it difficult not to alert the surveyors
- carcasses can't be always procured that match the species profile of the site, which would also alert surveyors.

3.2.3.1 Sample size Figure 2 shows the trade-off between sample size and the size of the confidence interval.

We take the expected mean searcher efficiencies from the values reported in Stark and Muir (2020). This report shows that human observers have an expected searcher efficiency of

approximately 50% for bats. Dogs (for bats or birds), and humans searching for birds, have an expected searcher efficiency of approximately 85%.

The coarse black line shows us the estimated efficiency, given a field trial of known sample size, and some number of detections. The 95% confidence window is shown by the grey shaded area. The jaggedness of all curves is a known effect, due to the nature of a dichotomous variable (i.e. "I found it/I did not find it").

There is little precision gain for adding more than 15-20 replicates for a given species class.

The BBAMP suggests 14 trials per size and geo-strata in the first year with a review of results (84 trials overall). This is reasonable and leaves scope to revise the approach based on the mortality estimates from year 1.

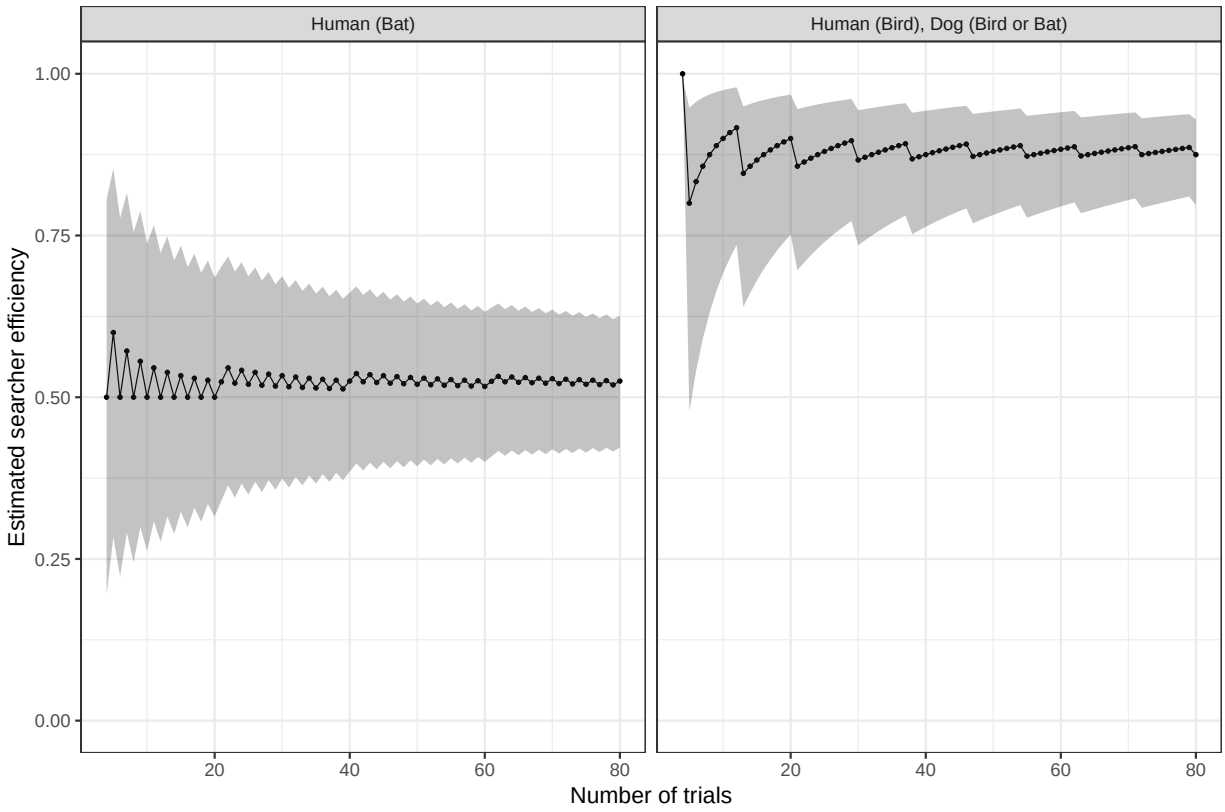


Figure 2: Mean and confidence intervals for varying numbers of searcher efficiency trials.

3.2.4 Analysis methodology

Binomial generalised linear modelling (otherwise known as logistic regression) is used to analyse this type of data. For more details see McCullagh (1989).

Analysis should:

- Test for the significance of the covariates for carcass size and site strata.

- Generate an estimate (mean and confidence interval) for each significant covariate group. Covariate groups may be combined if no significant difference is found.

The report should identify

- The software/methods used
- A summary of the covariates tested and the results
- Probability of detection (mean and confidence interval) for each covariate (e.g. bats in open woodland or bats - total)

3.3 Proportion of area searched

3.3.1 Aim

Quantify an expansion factor to account for carcasses that fall outside the searched area of a turbine.

3.3.2 Metric estimated

The landing position of a struck carcass forms a radial distribution from the base of the turbine, and is dependant on the mass, size, and shape of the animal, as well as the size and height of the turbine (Hull and Muir 2010).

We need to estimate the proportion of this distribution covered by the proposed survey protocol.

3.3.3 Analysis method

Hull and Muir (2010) uses a Monte-Carlo simulation to generate the distribution of landing positions (the 'fall zone'), using a physics-based ballistics equation.

We have used that same software to generate fall zone distributions for Bango Wind Farm, with hub height 120m and blade length 72m. We calculated fall zones for each of:

- Bat (minimum area 0.0028m^2, maximum area 0.014m^2)
- Medium birds (minimum area 0.045m^2, maximum area 0.1m^2)
- Wedge-tailed Eagle (minimum area 0.07m^2, maximum area 0.6m^2).

The results are shown in Figure 3.

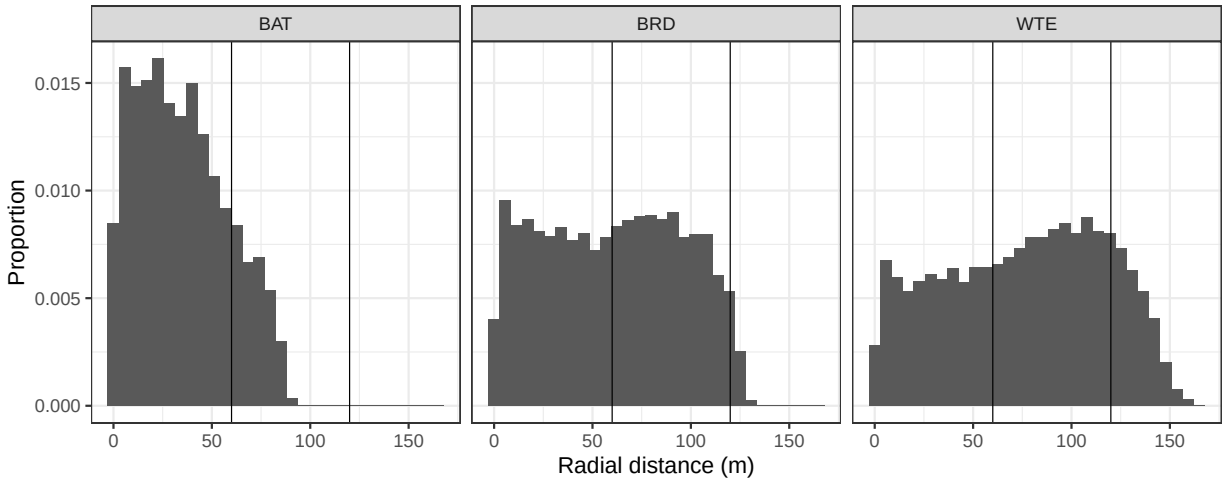


Figure 3: Fall zone distributions for bats, and medium birds, and Wedge-tailed Eagles.

3.3.4 Results

From this distribution, we see that

- the 60m circular search zone covers approximately:
  - 83% of the bat fall zone
  - 49% of the medium bird fall zone
  - 36% of the Wedge-tailed Eagle fall zone
- and the 120m circular search zone covers approximately:
  - 100% of the bat fall zone
  - 97% of the medium bird fall zone
  - 83% of the Wedge-tailed Eagle fall zone

3.4 Carcass searches and mortality estimation

3.4.1 Aim

The carcass searches sample the actual turbine collision mortalities, as the final input to estimate the total mortality.

Mortality estimation aims to quantify the total collision mortality of a species or species cohort. It provides a comparison metric between sites, and adds to cumulative modelling.

While it can be used for compliance with long term trigger values, this only applies if a trigger or 'permitted take' is specified.

3.4.2 Metric studied

The metric estimated consideration is the total mortality of a species (cohort) of interest due to wind turbine operation.

3.4.3 Field methodology

Turbines are selected for inclusion from each vegetation stratum with probability proportional to the fraction of turbines in each strata. The overall proportion of turbines surveyed is 33.3% or, which corresponds to 16 turbines.

1. Cleared areas (21 of 46 turbines) - 7 turbines surveyed
2. Open wooded areas (13 of 46 turbines) - 5 turbines surveyed
3. Closed wooded areas (12 of 46 turbines) - 4 turbines surveyed

These turbines will be chosen at random prior to the first survey and will be surveyed each month.

Following requests from the NSW regulatory review process, we will also survey an additional turbines during the Superb Parrot high activity season (September to December), incluing the remaining 30 turbines monthly during that time.

The additional turbines provide coverage of the site to mitigate against the risk of missing important triggers for action because they happen at an surveyed turbine.

For human observers, circular transects are walked, with the inner zone (<60m) using 6m transect spacing and the outer (60-120m) using 12m transects. The inner zone is designed to increase visibility of smaller carcasses. Dogs handlers can modify this protocol to optimise for scent detection.

3.4.4 Timing

The proposed survey timing is

Winter (May - Aug inclusive)

- The 16 fixed turbines are searched out to 120m each month

Spring Superb Parrot targeted search (Sept - Nov inclusive)

- The 16 fixed turbines are searched out to 120m each month
- The 16 fixed turbines are resurveyed out to 60m, approximately three days later.
- The 30 remaining turbines are searched to 100m each month

Summer to Autumn (Dec - Apr inclusive):

- The 16 fixed turbines are searched out to 120m

- The 16 fixed turbines are resurveyed out to 60m, approximately three days later.

The October to April is associated with higher bat activity, and September to November is associated with Superb Parrot activity. By increasing the survey frequency in these months we increase the opportunity to discover carcasses if present. The pulsed survey design has a short time period between survey and re-visit, which is preferable for easily scavenged species.

The additional search of all turbines in the September-November period is aimed at increasing coverage of the survey to maximise the chance of finding Superb Parrot carcasses.

Note all these searches can be included in the mortality estimate but not all analytical estimators will support such a niche design (see section on analysis).

3.5 Carcass survey - statistical justification

There is no 'golden rule' governing the optimal frequency of searches. For example, we are not trying to determine the difference between classes, so a power analysis is not applicable.

We can use simulation methods to estimate the proportion of carcasses that will be found given this survey design. The same method can help us understand the likelihood of a true absence by simulating the frequency of the search protocol missing all mortalities.

For full details on the algorithm used see Stark and Muir (2020) or the analysis methodology section below.

We simulate the following survey protocols:

- **Monthly**: fixed selection turbines searched once per month, out to 120m
- **Summer pulse**: Monthly with a pulse search from Sept - April of the fixed selection turbines only
- **Summer pulse+plus**: Monthly with a pulse search from Sept - April and additional searches of all remaining turbines monthly from Sept - Nov. This is the proposed protocol

In all cases we have assumed human searchers, and bird mortalities. Humans are less effective than dogs so we are simulating the 'worst case' detection rates. We use the nominal values for searcher efficiency and loss rate from Stark and Muir (2020), and assume the same searcher and scavenger efficiency for all scenarios.

It's worth remembering that the mortality estimate itself does not require coverage of all turbines and dates - only that the sample is chosen in a way that does not fail the assumptions of the Horvitz-Thompson estimator.

In this exercise we are exploring the question of whether absence of evidence (of collision) is evidence of absence. We do this by reporting the percentage of simulations that 'found' at least one carcasses, for different numbers of actual mortalities.

If some (small) number of collisions occur, what is the chance we will detect it? Could modifications to the survey design substantively impact this chance?

Figure 4 shows the chance of finding **at least one carcass** for a range of actual mortalities. In this result we are allowing the collision to happen **any time in the 12 month period**.

Each scenario has about a 20-25% chance of finding a single carcass. That increases as more collisions occur.

Under the proposed design, if we find no carcasses we can be quite certain that less than 8-10 happened.

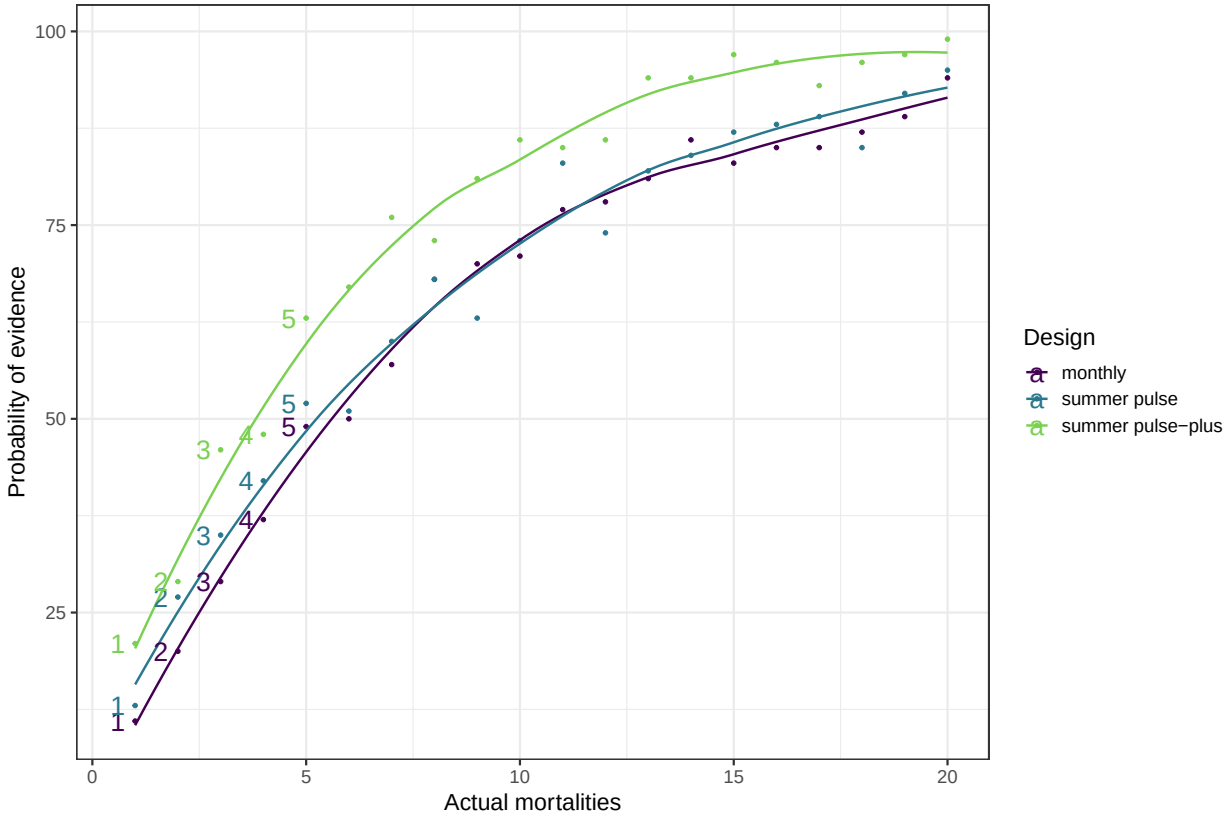


Figure 4: Percentage chance of finding some evidence of mortality for different actual mortalities. Numbers on chart denote actual mortalities

If we can be confident the risk is limited to part of the year, we can have more certainty. In figure 5 we have simulated the proposed survey design's efficacy in finding a collision that occurs during September to December (i.e. a Superb Parrot).

There remains a one in four chance of finding a single carcass, but the odds of finding evidence of loss increase rapidly. There's an even chance of finding evidence if two collisions occur and more for more collisions.

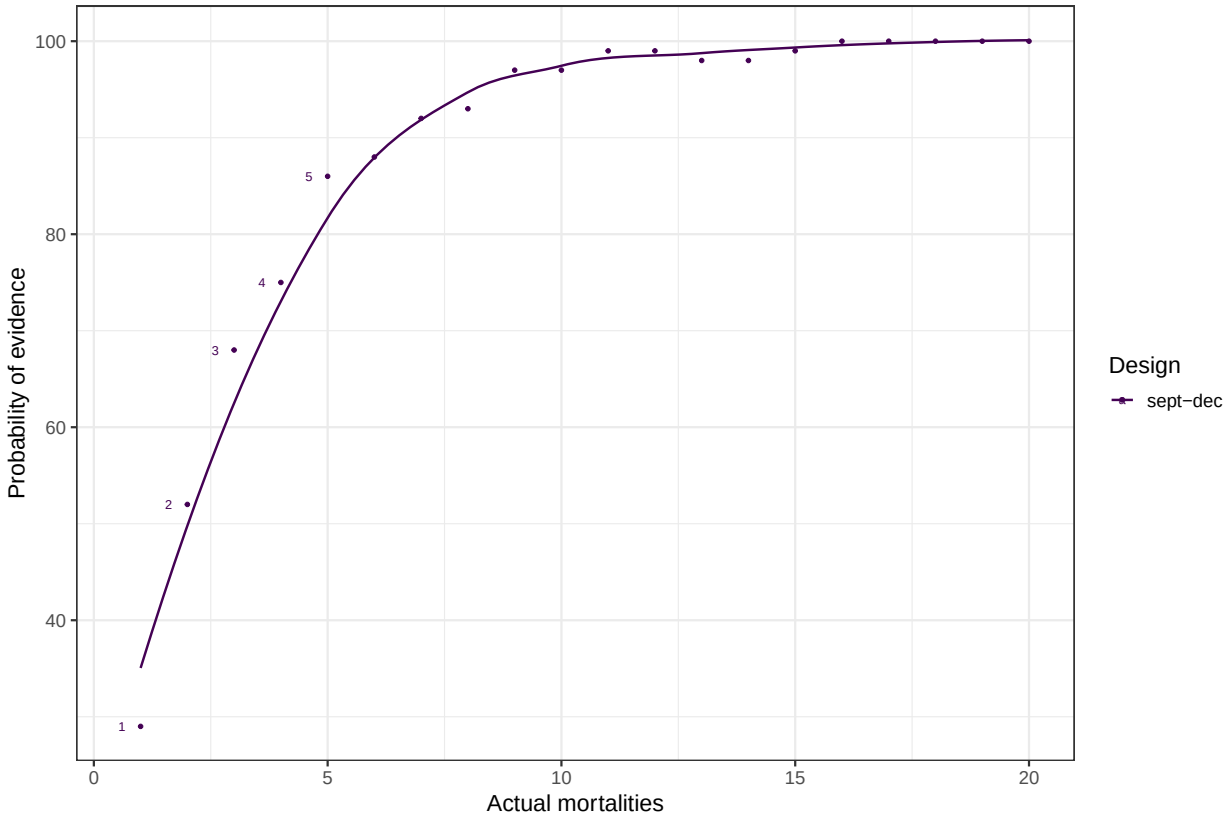


Figure 5: Percentage chance of finding some evidence of mortality for different actual mortalities for surveys from Sept - Dec inclusive. Numbers on chart denote actual mortalities

The important points are this:

- There is little difference in the three efforts when it comes to detecting very small counts. In fact, even with daily surveys, it's difficult to statistically guarantee you will detect every single carcass.
- The proposed survey design balances physical constraints, with a reasonable ability to detect low numbers (as well as being shown to provide suitably precise estimates of mortality at a number of Australian sites).
- If adaptive management trigger values are set very low, you need additional 'leading' indicators of risk in the management framework to augment the information from the carcass searches.

3.6 Analysis methodology

3.6.1 Background

There are a number of current analytical and numerical methods suitable for estimating total mortality from carcass counts. Analytical methods include Huso (2011) and Korner-Nievergelt

et al. (2011), while Dalthorp et al. (2018) presents an numerical package that extends the analytics estimates.

A number of earlier mortality estimators exist (e.g. Erikson, M. D., and K. (2000), Smallwood (2007)), but these are rarely used today because they produce biased results or exclude some inputs. Bernardino et al. (2013) provides a good overview of these limitations.

One limitation of analytical methods is estimating r_{ij} 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 or the use of a pulsed design in which the turbine is searched monthly with a return visit a few days later.

To allow for survey protocols with non-standard interval, we developed a Monte-Carlo simulation method (Stark and Muir 2020).

Monte-Carlo methods (Sawilowsky (2003), Ripley (1987)) simulate a large set of possible survey results, by simulating the actual sampling protocol and sampling from the empirical distributions for scavenge loss and searcher efficiency. In this way, we can directly sample the probability a carcass was lost before the survey, negating the need to calculate r_{ij} analytically each time.

The Monte-Carlo simulation generates a representative coverage of the phase space influencing the probability of detection. To generate an estimate of mortality, we extract all simulations with the same number of discovered carcasses as the 'real' survey data under consideration (Figure 6).

The distribution of simulated carcass arrivals is a direct estimate of the mortality estimate. From it, we extract the median and confidence intervals.

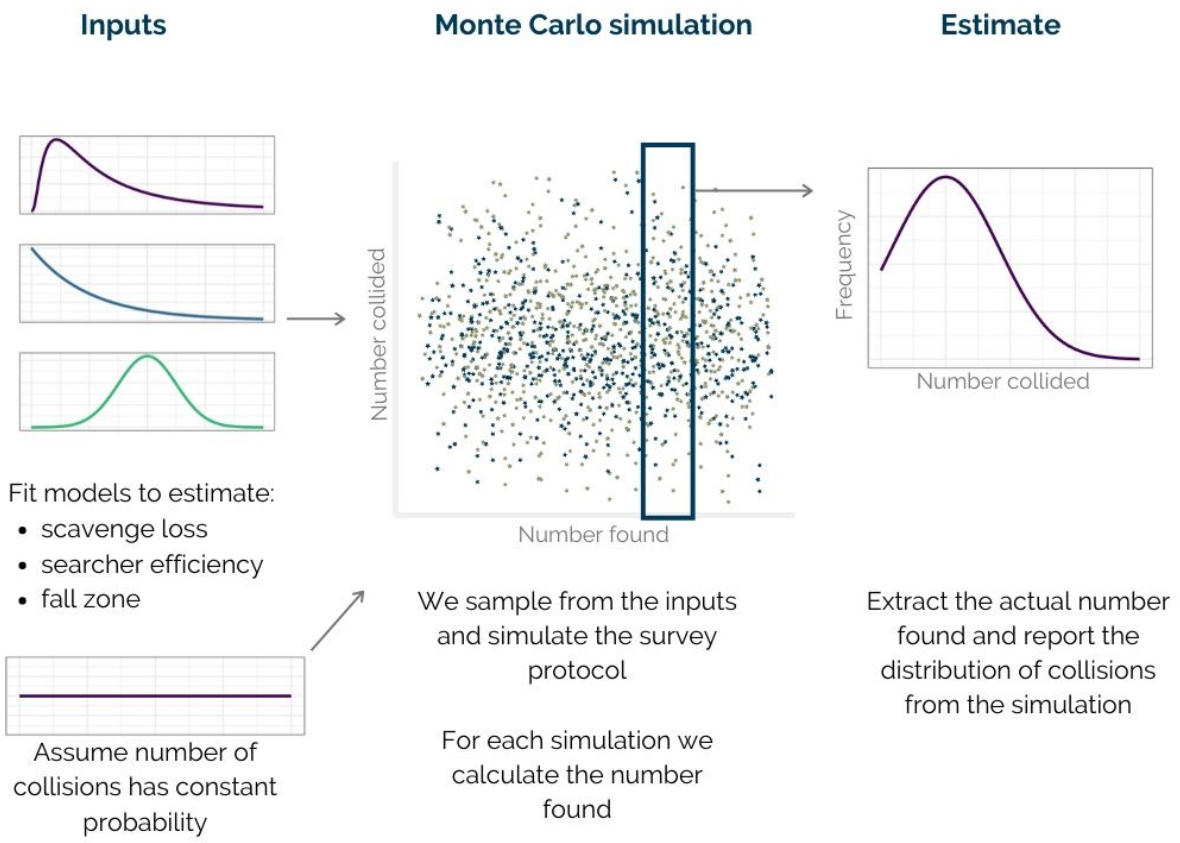


Figure 6: Schematic showing the application of the Monte-Carlo method to simulate the phase space of possible collisions and subsequent carcass finds. The inputs are based on empirical distributions estimated from field trials.

The Monte-Carlo simulator is an algorithmic approach to solving equations (1) and (2).

3.6.2 Which estimators can be applied at Bango?

The Symbolix mortality estimator (Stark and Muir 2020) or GenEst (Dalthorp et al. 2018) provide suitable and proven methods for estimating all the component survey results and the annual mortality range and are the two main options for this site (as of Jan 2021).

The Symbolix estimator is proven at Australian sites for pulse-type surveys.

GenEst (a generalized estimator of mortality) is a suite of statistical models and software tools for generalized mortality estimation. It was specifically designed for estimating the number of bird and bat fatalities at solar and wind power facilities (Dalthorp et al. 2018). However, GenEst has (to our knowledge) never been used with a variable survey design (i.e. additional turbines each month and changes in timing throughout the year). It is not clear to these authors that

it can be applied, or that it would produce unbiassed estimates (we are currently testing this independently and hope to publish our results late this year).

If GenEst is used, the analyst should provide evidence that it is suitably precise for this sort of design.

If another method is chosen the analysis documentation should outline how it solves equation (1) and any limitations, assumptions and benefits.

References

Bernardino, J., R. Bispo, H. Costa, and M. Mascarenhas. 2013. "Estimating bird and bat fatality at wind farms: A practical overview of estimators, their assumptions and limitations." *New Zealand Journal of Zoology* 40 (1): 63–74. https://doi.org/10.1080/03014223.2012.758155.

Dalthorp, Daniel, Lisa Madsen, Manuela M Huso, Paul Rabie, Robert Wolpert, Jared Studyvin, Juniper Simonis, and Jeffrey Mintz. 2018. "GenEst Statistical Models—a Generalized Estimator of Mortality." US Geological Survey.

Erikson, W. P., Johnson G. D. andStrickland M. D., and Kronner K. 2000. "Avian and Bat Mortality Associated with the Vansycle Wind Project, Umatilla County, Oregon: 1999 Study Year." Technical report pre- pared by WEST Inc. for Umatilla County De- partment of Resource Services and Development, Pendleton, OR.

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

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

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

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

McCullagh, Nelder, P. 1989. "Generalized Linear Models." *CRC Monographs on Statistics & Applied Probability, Springer Verlag, New York*.

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

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

Smallwood, Shawn K. 2007. "Estimating Wind Turbine–Caused Bird Mortality." *Journal of Wildlife Management* 71 (8): 2781–91. https://doi.org/10.2193/2007-006.

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

Terry M. Therneau, and Patricia M. Grambsch. 2000. *Modeling Survival Data: Extending the Cox Model*. New York: Springer.

Appendix 4: Carcass search protocol

The search method will involve either:

- Searches on foot along pre-determined transects by an adequately trained ecologist; or
- Searches by a trained scent dog.

Searches by a trained searcher

The search area beneath each turbine has been determined to best detect bats and medium to large bird carcasses, based on the turbine dimensions (Hull & Muir 2010). Based on the Hull and Muir model (2010) the fall area for a turbine with hub height 120m and blade length 72m, the following is noted from the model:

- Bats – 100% and 83% of carcasses should fall within circles 120 metres and 60 metres from the turbines respectively;
- Medium birds - 97% and 49% should fall within circles 120 metres and 60 metres from the turbines respectively; and
- Large birds – 83% and 36% should fall within circles 120 metres and 60 metres from the turbines respectively.

Given this evidence, inner and outer circular search zones have been designated. The inner zone targets the detection of carcasses of bats and small to medium and large sized birds. In the inner zone, a circle is formed with a 60-metre radius from the turbine and transects are spaced every six metres across this circle (Figure 9).

The outer zone will comprise the zone between the 60-metre and 120-metre radius circles. Although they are still recorded in the inner zone, the outer zone will ensure the adequate detection of carcasses of medium to larger sized birds, which can fall further away from turbines. Search transects in the outer zone are spaced at 12 metres and carried out from the edge of the inner zone out to the edge of the outer zone (see Figure 9). Given that the defined transect spacing and total search area are based on experience and evidence from previous studies (e.g. Arnett *et al*. 2005, Hull and Muir 2010) they are considered to be ample to detect bats and the bird species of concern arising out of the risk assessment.

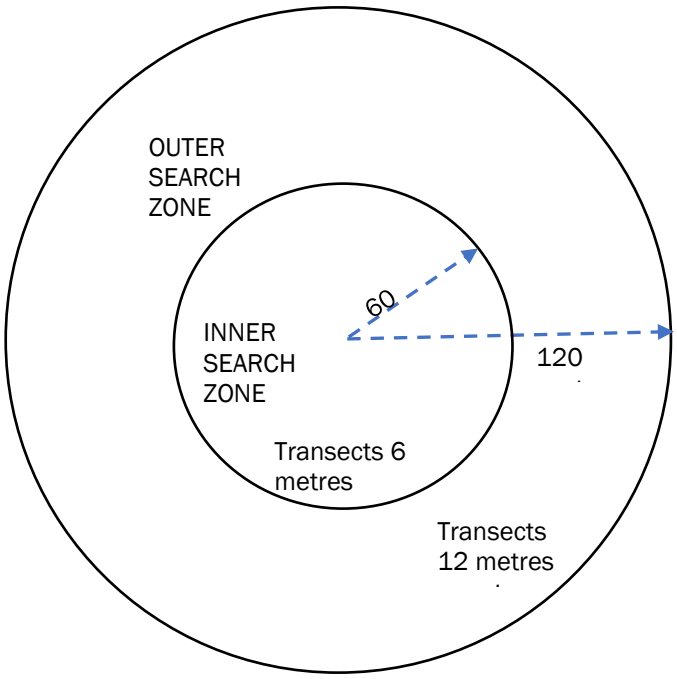


Figure 9: Inner and outer carcass search zones underneath the turbines

During searches turbines will be searched out to 120 metres once per month. A second follow-up search, a 'pulse search' will be undertaken to 60 metres during the warmer months (October to April) when

microbats are more active and when Superb Parrot are in the area, once a month within several days of the first search to detect additional mortality of bats and birds. The order of turbines searched will be randomized between searches.

All searchers will operate under the supervision of a qualified ecologist experienced in wind farm bird and bat monitoring, who will ensure adequate training in the monitoring methods and reporting requirements.

Searches by a trained scent dog

Scent dogs can be trained to locate a variety of targets. The same search area will be targeted out to 120 metres. The dog does not 'look' for carcasses but finds them via scent. Therefore, it does not need to cover as much ground as if were looking with its eyes but only needs to cover enough ground to encounter all possible 'scent cones' within the search radius. The scent cone is the area downwind of the target, in this case a carcass, in which the scent will drift with the wind. So, if the wind is strong; the scent will drift further but in a narrower scent cone, and if the wind is light; the scent cone will be wider but will not drift as far. In the case of strong wind, then transects will need to be narrow to ensure scent cone areas will be encountered. Transects of approximately 30 metres wide will be adequate to cover an area in moderate wind conditions.

The handler can start down wind of the turbine and walk across the direction of the wind allowing the dog to freely zig zag across the searcher's transects, using whistle commands to control how far the dog moves to each side of the transect (i.e. 30 metres). This will ensure all scent cone areas will be encountered (Figure 10). As represented in Figure 10 the search pattern walking across the wind any carcasses scent cone will be encountered several times, or for a long duration, allowing the dog to easily detect and track down the carcass.

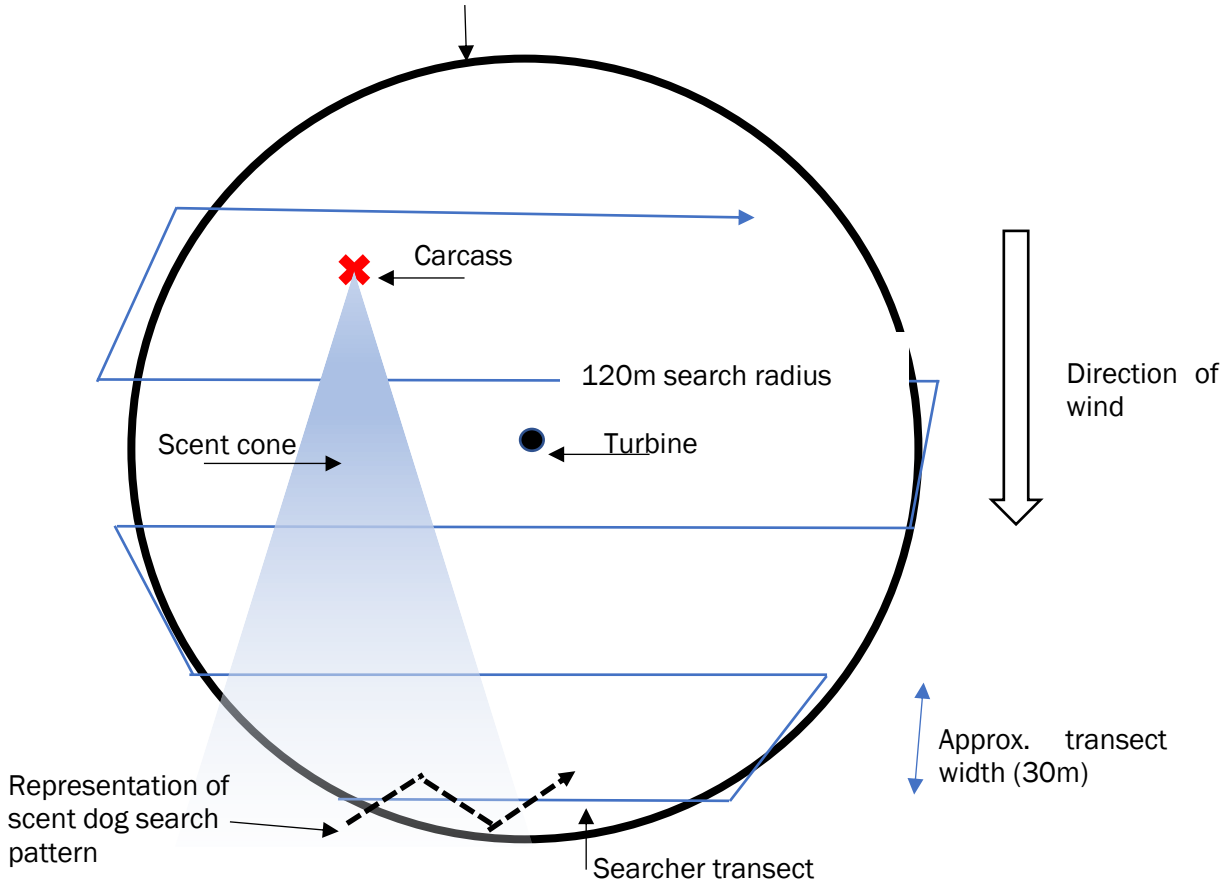


Figure 10: Scent dog search pattern – across the wind

Carcass detection protocol

If a carcass is detected (a 'find') the following variables will be recorded in the carcass search data sheet (see Appendix 7):

- GPS position, distance in metres and compass bearing of the carcass from the base of the wind turbine tower;
- Substrate and vegetation, particularly if it was found on a track or hard-stand area without vegetation as this may assist in quantifying the number of carcasses not found in areas where ground cover makes carcasses less visible;
- Species, age, number, sex (if possible) signs of injury and estimated date of strike;
- Weather (including recent extreme weather events, if any), visibility, maintenance to the turbine and any other factors that may affect carcass discovery; and
- If the species is not able to be immediately identified because there is not a qualified ecologist on-site (i.e. an incidental find), photographs will be provided to the qualified ecologist within 2 business days of the find for identification and the ecologist must reply within 5 business days for the possible reporting to DPIE and DAWE of an impact on a threatened species within 2 business days of confirmation.

The carcass will be handled according to standard procedures, as follows:

- The carcass will be removed from the site to avoid re-counting;
- The carcass will be handled by personnel wearing rubber gloves, packed into a plastic bag, then wrapped in a sheet of newspaper then in a second plastic bag;
- The carcass will be clearly labelled with a reference number linked to its completed carcass search data sheet in the second plastic bag to ensure that its origin can be traced at a later date, if required; and
- The double-bagged and wrapped carcass will be transferred to a freezer at the site office for storage so a second opinion on the species identity may be sought, if necessary, and for use in later scavenger and detectability trials.

The handling and storage of native wildlife (including dead wildlife) as part of the monitoring program has been approved as part of the approval of the project based on advice provided by DPIE.

Scavenger rates and trials

It will be important to ascertain the rate at which carcasses are removed by scavengers. This can be used to develop a 'correction factor' that informs the estimate of wind farm impacts on birds and bats (mortality rate). Scavengers can include ground-based animals, such as foxes and rats (more likely to detect carcasses by scent), as well as aerial scavengers such as birds of prey and ravens (more likely to detect them visually). The scavenger trial described below is designed to ascertain the scavenging rate, usually expressed as average carcass duration in the field.

An intact carcass will be defined as a carcass that does not appear to have been scavenged by a vertebrate scavenger. A partially eaten carcass will be any skeletal or flesh remains found. Feather spots will be defined by their presence and the absence of any other remains (a feather spot being a cluster of five or more feathers). Intact or partial carcasses and feather spots will all be recorded as a 'find'. However, the scavenger correction factor will not be applied to feather spots as these are most likely to represent the remains of carcasses after they have been scavenged.

Scavenger trials will be undertaken twice over the initial two year of operational phase monitoring. The objective of having two trials is to account for different vegetation conditions, so one will be held when the grass is long and one when the grass is short. The two periods for scavenger trials are shown in the Table 8, below.

Table 8: Timing for scavenger trials

Vegetation condition	Likely time period	Weather	Stocking
Short grass	Winter (August-July)	Cold weather	Heavy stock levels
Long grass	Spring (September - November)	Follow rain and higher temperatures	Light stock levels

After the scavenger trials conducted over the first two years, the need and frequency of further scavenger and detectability trials will be reviewed and discussed with DPIE.

Provided enough carcasses have been collected and are available, the scavenger trial will be stratified into the turbine classes indicated below. If species carcasses cannot be sourced, comparable substitute carrion species will be used (e.g. brown mice as bat substitutes, birds from control programs including Common Myna and Common Starling etc).

Scavenger Trials

Scavenger Trials will be undertaken by a trained person to determine the rate of loss by scavengers, and the nature of removal by scavengers. Carcasses for scavenger trial purposes will be deployed within the inner search zone of turbines of randomly selected turbines monitored as part of the monthly monitoring program.

To identify potentially different scavenging rates, three categories of carcass will be used (Table 9). Based on current mortality estimation software requirements, every endeavour will be made to find all carcasses of each category. Improvements on this method would require an impractical and unlikely availability of required carcass numbers, and do not lead to a commensurate improvement in the statistical power of estimates. In addition, large birds (raptor size) may be substituted with data from previous grouped studies with approval from DPIE and DAWE.

Table 9: Number of replicates for each scavenger trial

Trial period	Micro-bat – small bird	Medium sized birds	Large birds (large raptor size)
Winter	7	7	Data will be used from previous studies
Spring	7	7	

14 carcasses will be randomly placed under different turbines for each trial period and motion sensor cameras will be used to monitor scavenger activity taking place. All carcasses will not be placed at once, but rather a number of carcasses will be placed during monthly searches that occur during each trial period until all 14 carcasses have been deployed. This will more accurately reflect numbers of mortalities on the ground each month and be less likely to attract additional scavengers to turbines. It will also allow for additional carcasses to be deployed in the event any cameras do not record sufficient information (through technical difficulties, stock interfering with cameras, etc.)

A 1.5 metre star picket will be driven into the ground approximately 3-4 metres away from each randomly placed carcass and a camera attached using cable ties. The camera will record any scavenging activity on a 16gb SD card. The placement of the carcass will be reviewed at each deployment to ensure that the carcass is appropriately in frame of the camera before being left in the field. The carcass will then be left for a period of 30 days after which the camera and SD card will be collected and scavenging activity reviewed. If the carcass remains after this time, it is assumed that the carcass will not be scavenged. The information recorded will capture the exact time and date and provide a photograph of which scavenger, if any, has taken the carcass.

This method eliminates the need for scavenger trial carcasses to be monitored regularly.

Additional information on scavenger trials includes:

- A mix of small and medium to large carcasses (if available) will be obtained for use in the scavenger trial. Where carcasses of the species of concern cannot be found, a similar-sized and coloured substitute, e.g. mice for bats will be used to reduce bias by visual predators;
- Birds bred for consumption must not be used as substitute for detectability or scavenger trials;
- Carcases may come from on-site, road kill or feral animal control programs (e.g. Common Myna);
- Latex gloves will be worn at all times while handling carcasses to minimise contact with human scent, which may alter predator responses around carrion and to minimise disease risk to the handler;
- At each trial site, one carcass (or more) will be placed randomly within the 60-metre search area. Carcasses will be thrown in the air and allowed to land on the ground to simulate at least some of the fall and allow for ruffling of fur or feathers;
- Carcasses used in the trial will have their coordinates recorded;
- Notes will be taken on evidence remaining at sites where carcasses have been scavenged (e.g. scavenger scats, bones, feathers, animal parts and type of scavenging) if visible, such as tearing, pecking, complete removal of carcass, partial removal of carcass, bird or mammal predator evidence); and
- Notes will be taken on the state of remaining carcasses.

Conduct of two scavenger trials at seasonally different times is designed to account for occasional winter/spring increase in carrion use by some scavenger species. Previous studies have found that Red Foxes are reliant on rabbits and carrion in agricultural and forested areas (e.g. Brunner *et al*. 1975, Catling 1988, Molsher *et al.* 2000). Feral cats show little but uniform use of carrion throughout the year, whereas fox prey type is dependent on availability (Catling 1988). Catling (1988) found that foxes ate more carrion in winter/spring compared with summer/autumn, when they fed on adult rabbits. However, Molsher *et al*. (2000) found that there was no overall significant difference between seasons for carrion use. Seasonal differences only occurred in other prey types (not carrion), such as lambs, invertebrates and reptiles, as these are only available at certain times of the year.

Scavenger trials for large raptors will only be conducted once in either winter or spring due to lack of availability of suitable carcasses for a technically sound trial. Experience from other wind farms indicates a low level of scavenging of these carcases and a high level of detectability that is consistent across the year (Nature Advisory, unpubl. data).

The number of carcasses per animal and size category is based on obtaining a reasonable level of statistical confidence in the estimate of average carcass duration, as reflected in software requirements for current mortality estimation processes, whilst seeking to minimise the number of carcasses used, as they can be difficult to source. Large numbers of carcasses (e.g. on-site, road-kill) are difficult to obtain and it may be very complicated to find alternative sources (e.g. farmed and culled animals). It is also possible that large numbers of carcasses, more size categories and more replicates may attract more scavengers to the area. Previous studies (e.g. Molsher *et al*. 2000) have shown that fox prey use is related to availability and therefore more foxes may be attracted to the area if more carcasses are used, thereby biasing the resulting correction factor. In addition, raptors are potentially more susceptible to collision when preying on carrion beneath turbines. However, it is necessary to conduct these trials under turbines as some scavengers may alter their behaviour in response to the turbines. The final scavenger trial design is therefore a necessary compromise between high numbers of trials and practicality whilst ensuring a statistically-valid trial design without altering either the behaviour of scavengers or the number of birds that may collide with turbines.

Detectability (Observer) trials

Detectability trials are conducted to test the rate at which the trained searchers, or scent detection dog, detect carcasses under wind turbines. This enables a correction factor to be applied in calculating the rate at which turbines strike birds and bats.

As outlined above, the trial will be supervised by a qualified ecologist and undertaken by trained ecologists or personnel trained by the ecologist.

To account for searcher variability in detecting carcasses, only personnel who have carried out monthly searches at BWF will be involved in the detectability trials. Detection efficiency (percentage of carcasses detected) will then be incorporated into later analyses that derive mortality estimates (i.e. how many carcasses are potentially not found each monitoring period). The number of carcasses to be employed in each trial is detailed in Table 15 and explained below.

The number of turbines used in the detectability trials will be based on how many turbines searches the person undertaking monthly monitoring can do in one day. For example, if the searcher completes seven turbines on average a day then the 14carcasses required for a trial will be deployed in random amounts, but less than five, per turbine.

A carcass controller (a person not involved in monthly carcass searches) will throw each carcass into the air and allow it to land on the ground to simulate at least some of the fall and the potential ruffling of fur and feathers. The carcass controller will note the placement of carcasses (via GPS) which will be placed at random under each turbine, however all bats should be located within the inner search zone.

The searcher will then undertake turbine searches as usual (see above) and record and mark with GPS coordinates any carcasses they find during the search. This will be reviewed by the carcass controller upon completion of the trial to determine their detectability rate.

All carcasses should be collected during or on completion of the trial and returned to the on-site freezer for use in scavenger trials.

Table 10: Number of replicates per season for detectability trials, given two factors of size and visibility

Season	Micro-bat	Medium sized birds	Large birds (large raptor size)
Winter	7	7	5
Spring	7	7	

Analysis indicates that there is a large confidence interval on the estimate of searcher efficiency, even for a high number of trials (plus or minus ten percent even with 50 replicates). This means that only relatively large seasonal changes in detection (~20 - 30% or more) will be resolvable from normal background variation. Sampling will be undertaken during the two periods that represent the greatest change in vegetation cover (therefore visibility), using a number of carcasses that is logistically manageable and aligned with the number and timing of scavenger trials. Statistical confidence analysis indicates that this will result in a reasonably precise detectability estimate after one year, and optimal precision after two, although as second year of trials is not currently planned.

Any substitute carcasses for these trials will be of both similar size, colour and form to the species being represented or species of concern (i.e. brown mice rather than birds should be substituted for bats as birds do not have the same body shape, colour and appearance).

If sufficient carcasses cannot be obtained, then stuffed, realistic-looking artificial substitutes may be used. As humans are entirely visual searchers, it is not essential to use real carcasses as long as the substitutes appear similar once on the ground. It is considered to be more time efficient and cost effective to undertake scavenger and detectability (observer) trials concurrently.

Appendix 5: Carcass Search Data Sheet

BANGO WIND FARM - BIRD AND BAT MORTALITY MONITORING PROGRAM CARCASS SEARCH DATA-SHEET*				
Please fill out all details above the heavy line for each site searched All details below the line are required if a carcass is found Do not move a carcass until the details below have been completed				
Bango WF				
Date:				
Start Time:				
Finish Time:				
Turbine Number:				
Wind direction and strength in preceding 24 hours:				
Any unusual weather conditions in last 48 hours?				
Distance of Carcass from Tower(m):				
Bearing of Carcass from Tower (deg):				
Preliminary Species Identification:				
Photo Taken**	Yes / No			
Signs of injury:				
How old is carcass estimated to be (tick category):	<24 hrs	1-3 days	> 3 days	Other
Other Notes (ie. sex/age of bird, substrate and vegetation at site of find):				
Post Find Actions: Place carcass in sealable plastic bag then wrap it in newspaper then in a second plastic bag with a copy of this data-sheet and take to freezer at site office.				
* One form should be completed for each carcass found				
** Please attach photo to this form				

Appendix 6: Raptor monitoring data sheet

_____

Station No.: Co-ordinates: Datum Easting Northing Location:

Date: Start time: Finish time: Observer:

Temp: Cloud cover (%): Wind speed: Wind direction: Rain:

	Species	No.	Time[1] start	Time[2] end	Dist.	Bearing	Location	Height	Height[3] range	Elevation	Landscape	Direction	Behaviour

[1]record time bird first observed, [2]record time bird last observed, [3]height range for bird throughout observation period.
Location: Air, Perched, Ground.**Landscape:** Valley, Slope, Ridge. **Direction (flight):** Toward, Away, Parallel to ridge, Circling.
Behaviour: Soaring, Gliding, Hovering, Powered (flapping) flight, Displaying, Resting, Foraging (hunting).