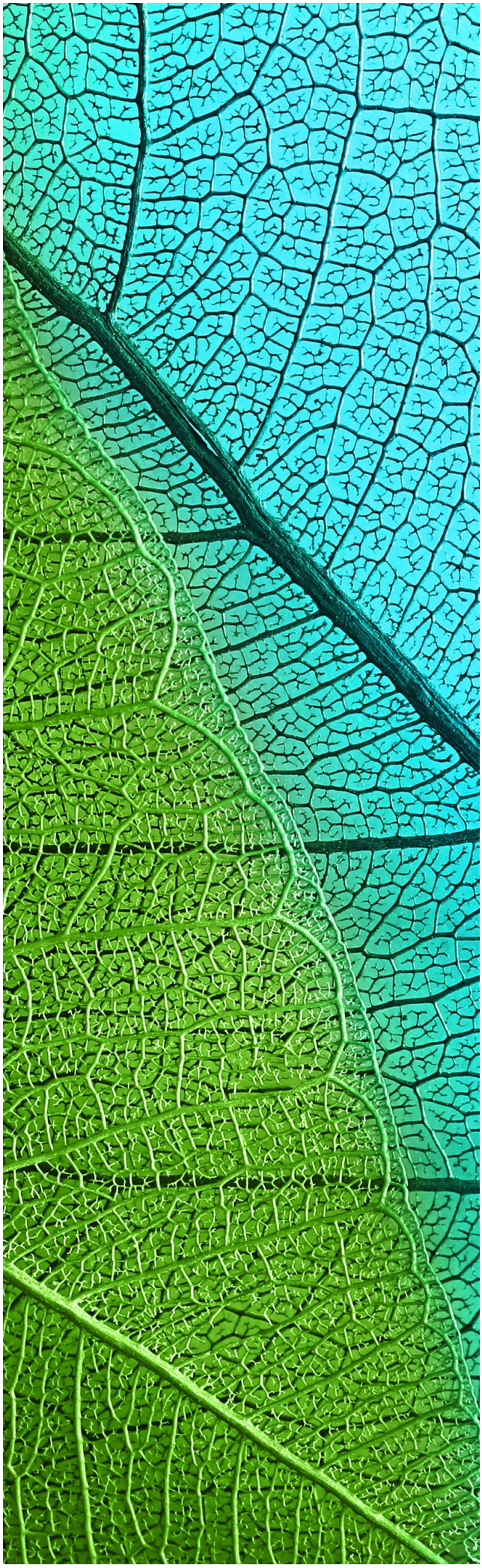

PLANNING and ENVIRONMENT ACT
Golden Plains & Corangamite PLANNING SCHEME

PERMIT NO. 20092820-A & 20091821-A
Condition 15
MODIFIED ENDORSED PLAN
Sheet 1 of 49

Signed: for
MINISTER FOR PLANNING
Date: 27 August 2020

BERRYBANK WIND FARM

Bat and Avifauna Management Plan

Prepared for

Berrybank Development Pty. Ltd.

July 2020
Report No. 14143 (12.8)

Nature Advisory

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1. Introduction

Berrybank Development has obtained planning permits to construct a wind energy facility comprising up to 79 wind turbines at Berrybank, 80 kilometers west of Geelong in south-west Victoria. It is located north of the Hamilton Highway and east of Chain of Ponds Creek, between Lismore and Cressy. The study area falls under the jurisdiction of the Corangamite Catchment Management Authority and lies within the Victorian Volcanic Plains bioregion.

Condition 15 of both the Corangamite and Golden Plains Planning Permits (Number 20092821-A and 20092820-A) states that a Bat and Avifauna Management (BAM) Plan must be prepared in consultation with the Department of Environment, Land, Water and Planning (DELWP) Environment Portfolio. The BAM Plan must include:

a) *A statement of the objectives and overall strategy for detecting, managing and mitigating any significant bird and bat strike arising from the wind energy facility operations;*

b) *A monitoring program of at least 2 years duration, either commencing upon the commissioning of the first turbine or alternatively such other time of commencement as is to the satisfaction of the Minister for Planning.*

   The monitoring program must include surveys during breeding and migratory seasons, and must aim to ascertain:

c) *The species, number, age and sex (if possible) and date of any bird or bat mortality arising from the operation of the wind energy facility;*

d) *The number and species of birds and bats struck at lit versus unlit turbines;*

e) *Any seasonal and yearly variation in the number of bird and bat mortalities;*

f) *Procedures for the reporting of any detected threatened bird or threatened bat mortalities to DELWP Environment Portfolio within 7 days of becoming aware of any mortality, identifying where possible whether the mortality was by a lit or unlit turbine;*

g) *Seasonal information on the efficacy of searches for carcasses of birds and bats and seasonal information on the rate of removal of carcasses by scavengers, so that correction factors can be determined to enable calculations of the total number of mortalities;*

h) *Procedures for periodic reporting, within agreed timeframes, of the findings of the monitoring to the Minister for Planning, DELWP Environment Portfolio and the local community;*

i) *Recommendations in relation to a mortality rate for specified species which would trigger the requirement for responsive mitigation or offset measures to be undertaken by the operator of the wind energy facility to the satisfaction of the Minister for Planning; and*

j) *Implementation measures development in consultation with DELWP Environment Portfolio to mitigate or offset any impacts detected during monitoring including turbine operation management and on-site or off-site habitat enhancement (including management or improvement of habitat or breeding sites).*

k) *In relation to Brolga the plan must also include:*

   (i) *A thorough assessment developed in consultation with the DELWP Environment Portfolio of the two Brolga sites and their significance to the wind farm layout with reference to the Interim Guidelines for Assessment, Avoidance, Mitigation and Offsetting of Potential Wind Farm Impacts on the Victorian Brolga Population (DSE 2012). The first site is approximately 1 km east of the project near Wilgul – Werneth Road and between Urches Road and Boundary Road whilst the second site is at the intersection of the Hamilton Highway and Foxhow – Rokewood Road. The assessment must include the results of*

fieldwork undertaken during flocking and/or breeding season as agreed with DELWP Environment Portfolio;

(ii) Implementation of measures to increase power line visibility of any new lines constructed as part of the project through marking to mitigate bird collisions to the satisfaction of the Minister for Planning;

(iii) Prior to the development commencing consult with the Lismore Land Protection Group or other local community member and DELWP Environment Portfolio to determine if there are any further known Brolga sites within 5 km of the wind energy facility;

(iv) If further sites are found, these must be reported to DELWP Environment Portfolio;

(v) Based on the above, if additional Brolga sites are found within 5 km of the site, development a mitigation program in consultation with the DELWP Environment Portfolio and to the satisfaction of the Minister for Planning.

This BAM plan details objectives and strategies that meet the requirements of these approval conditions. It is divided into two main sections; Compliance Assessments and Compliance Mitigation and Summary.

The BAM Plan for Berrybank Wind Farm (BWF) was prepared in 2012 and endorsed by the Minister of Planning. This updated iteration of the BAM Plan was prepared by a team from Brett Lane & Associates Pty. Ltd. (BL&A) comprising, Brett Macdonald (Senior Ecologist), Teisha Lay (Zoologist), Peter Lansley (Zoologist), and Brett Lane (Principal Consultant).

This updated BAM Plan was prepared with inputs from Cara Cappelletti (Technical Officer), Elinor Ebsworth (Senior Ecologist), Jackson Clerke (Zoologist), Bernard O'Callaghan (Senior Ecologist and Project Manager), Alan Brennan (Senior Ecologist and Project Manager) and Brett Lane (Principal Ecologist).

1.1. Site Description

The Berrybank Wind Farm site lies between Lismore and Cressy, approximately 80 km west of Geelong in south-western Victoria. It is located north of the Hamilton Highway and east of Chain of Ponds Creek, between Lismore and Cressy. The site lies on flat to gently undulating land that has been cleared of most of its original vegetation and is a mosaic of improved grazing pastures and crops. It has been highly modified from its pre-disturbance state and very little intact native vegetation remains. That which does is situated on public road reserves. Remnant trees such as River Red Gums are virtually absent within the boundary of the site, however many exotic trees have been planted as windbreaks around homesteads and along fence lines.

The site lacks wetlands except for a few small farm dams. A modified grassy wetland (and dam) is located near the corner of Boundary and Bennett's Roads, just outside the wind farm site. Native fauna habitat is limited to a small number of remnant linear native grassland patches within public road reserves, mainly along the Berrybank – Werneth Road and Urches Road.

The site is located in the Victorian Volcanic Plain bioregion. The catchment management authority is the Corangamite CMA and the local planning authorities are Corangamite and Golden Plains Shire Councils. The layout of the Berrybank Wind Farm is attached in Figure 1.

1.2. Aim and objectives

The aim and objectives of this Bat and Avifauna Management (BAM) Plan are considered in this section.

This plan aims to:

> *Ensure that any unanticipated bird and bat mortalities, if any, from the Berrybank Wind Farm are detected and strategies put in place to manage and mitigate them to an acceptable level.*

Based on the planning permit conditions, this plan adopts the following objectives:

- To monitor the presence, behaviour and mortality of birds and bats on and near the wind farm;
- To ascertain the impacts of the wind farm on Brolga;
- To detail land management measures that will reduce the risk of bird and bat collision with operating wind turbines; and
- To detail an investigation and reporting regime that responds to any unacceptable impacts on bird and bat populations caused by operation of the wind farm, and that provides for adaptive management to mitigate impacts, if required.

The strategy employed to ensure that any impacts are detected, managed and mitigated includes:

- Pre-construction surveys;
- Post-construction monitoring surveys; and
- Reporting.

The management plan will be adaptive. Therefore, management measures can be amended based on monitoring results to ensure a more efficient management plan is implemented.

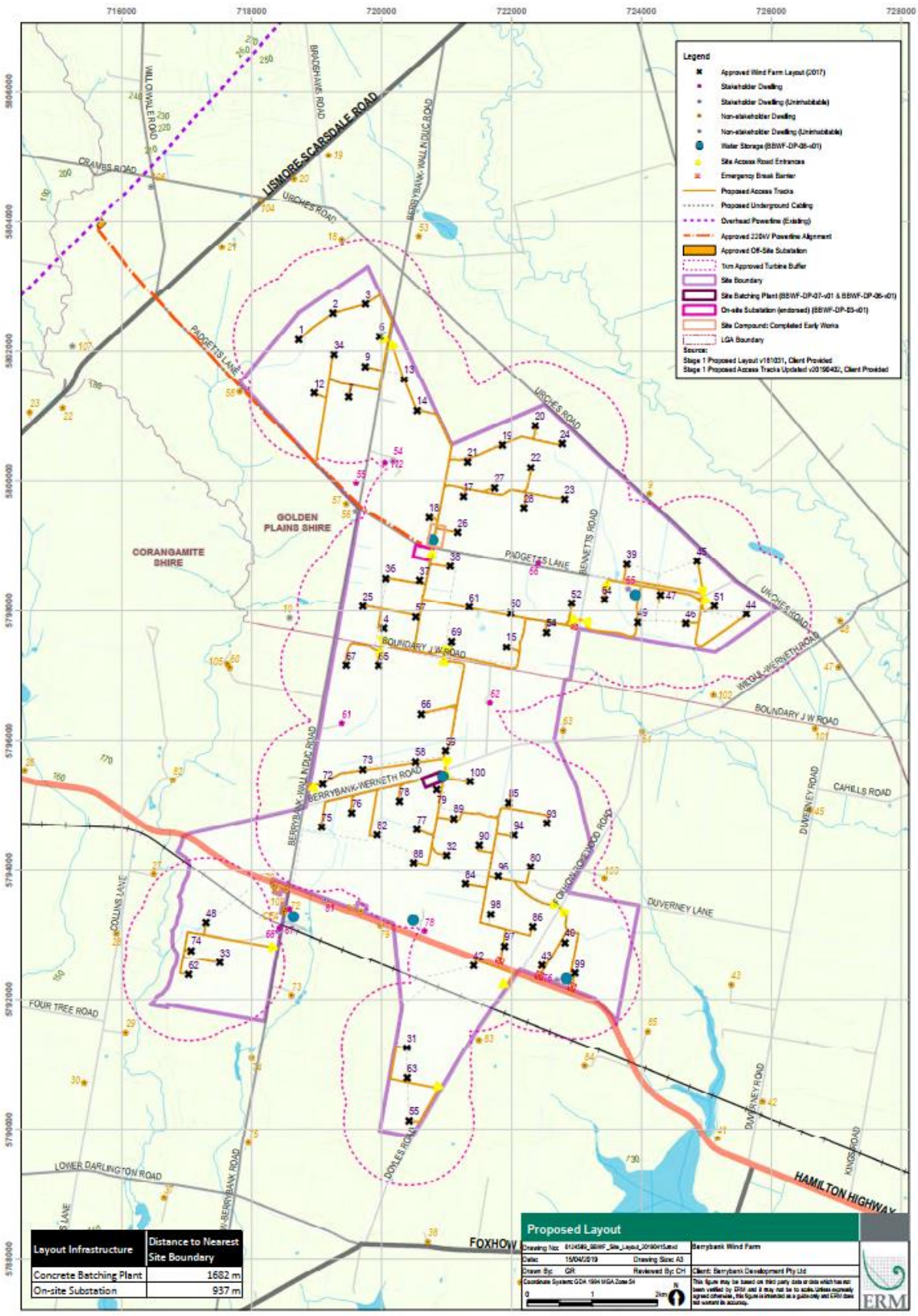
1.1. Compliance Summary

The following table (Table 1) indicates the sections of the Bat and Avifauna Management (BAM) Plan that comply with the specific conditions outlined in the Planning Permit (Number 20092821-A and 20092820-A). The conditions of the permit have been abbreviated but their full and correct wording can be found in the previous pages.

Table 1: Sections within the BAM Plan that comply with the conditions of the Planning Permit

Condition number	Abbreviated condition details	BAM Plan Section/s
15a	*statement of the objectives and overall strategy for detecting, managing and mitigating any significant bird and bat strike…*	1.2
15b	*A monitoring program of at least 2 years duration…*	4
15c	*Species and number of bird and bat strikes…*	4.4
15d	*The number and species of birds and bats struck at lit versus unlit turbines…*	4.4
15e	*Seasonal and yearly variation in the number of bird/bat strikes…*	4.4
15f	*Procedures for the reporting of any detected threatened species…*	3.1
15g	*Seasonal information on the efficacy of searches for carcasses of birds and bats and seasonal information on the rate of removal of carcasses by scavengers…*	4.4
15h	*Procedures for periodic reporting, within agreed timeframes, of the findings…*	3.1
15i	*Recommendations in relation to a mortality rate for specified species which would trigger the requirement for responsive mitigation or offset…*	5
15j	*Implementation measures development in consultation with DELWP Environment Portfolio to mitigate or offset any impacts detected…*	6
15k i), ii), iii), iv), v)	*In relation to Brolga: a thorough assessment, Implementation of measures to increase power line visibility, Prior to the development commencing consult with the Lismore Land Protection Group or other local community member, If further sites are found, these must be reported, Based on the above, if additional Brolga sites are found within 5 km of the site, development a mitigation program in consultation with the DELWP…*	2.3, 4.1. 4.4

Figure 1: Layout of Berrybank Wind Farm


Legend
Approved Wind Farm Layout (2017)
Stakeholder Dwelling
Stakeholder Dwelling (Uninhabitable)
Non-stakeholder Dwelling
Non-stakeholder Dwelling (Uninhabitable)
Water Storage (BBWF-DP-08-v01)
Site Access Road Entrances
Emergency Break Barrier
Proposed Access Tracks
Proposed Underground Cabling
Overhead Powerline (Existing)
Approved 220kV Powerline Alignment
Approved Off-Site Substation
1km Approved Turbine Buffer
Site Boundary
Site Batching Plant (BBWF-DP-07-v01 & BBWF-DP-06-v01)
On-site Substation (endorsed) (BBWF-DP-03-v01)
Site Compound: Completed Early Works
LGA Boundary
Source:
Stage 1 Proposed Layout v181031, Client Provided
Stage 1 Proposed Access Tracks Updated v20190402, Client Provided
LISMORE-SCARSDALE ROAD
GOLDEN PLAINS SHIRE
CORANGAMITE SHIRE
PADGETTS LANE
URCHES ROAD
BOUNDARY J W ROAD
BERRYBANK-WERNETH ROAD
DUVERNEY LANE
FOUR TREE ROAD
LOWER DARLINGTON ROAD
HAMILTON HIGHWAY
CAHILLS ROAD
Layout Infrastructure
Distance to Nearest Site Boundary
Concrete Batching Plant
1682 m
On-site Substation
937 m
Proposed Layout
Berrybank Wind Farm
ERM

2. PRE-CONSTRUCTION SURVEYS

Pre-construction surveys were undertaken by BL&A in 2007, 2008 and 2009 (BL&A 2009b). The results of these investigations constitute the baseline information (i.e. prior to the operation of the wind farm). This information can then be used to identify changes in population structure which may arise as a result of the operation of Berrybank Wind Farm.

2.1. Bat survey

2.1.1. Methods

Bat surveys were undertaken during April 2009 at six survey points in suitable habitat to be affected by proposed turbines. Calls were recorded on Anabat ultrasonic recorders and were analysed by Dr Greg Richards. A total of 20 recording nights were undertaken. The methods are detailed in the report BL&A (2009b).

2.1.2. Results

Nine bat species were recorded, presented in Table 2.

Table 2: Bat species recorded during the bat survey

Common name	Scientific name	Conservation status	Number of Calls
Southern Freetail Bat	*Ozimops planiceps*	Common, secured	1805
Southern Forest Bat	*Vespadelus regulus*	Common, secured	838
Large Forest Bat	*Vespadelus darlingtoni*	Common, secured	543
White-striped Freetail Bat	*Austronomus australis*	Common, secured	388
Gould's Wattle Bat	*Chalinolobus gouldii*	Common, secured	381
Inland Broad-nosed Bat	*Scotorepens balstoni*	Uncommon, secured	126
Long-eared Bat	*Nyctophilus sp.*	Common, secured	97
Little Forest Bat	*Vespadelus vulturnus*	Common, secured	91
Chocolate Wattle Bat	*Chalinolobus morio*	Common, secured	61
Total			**4330**

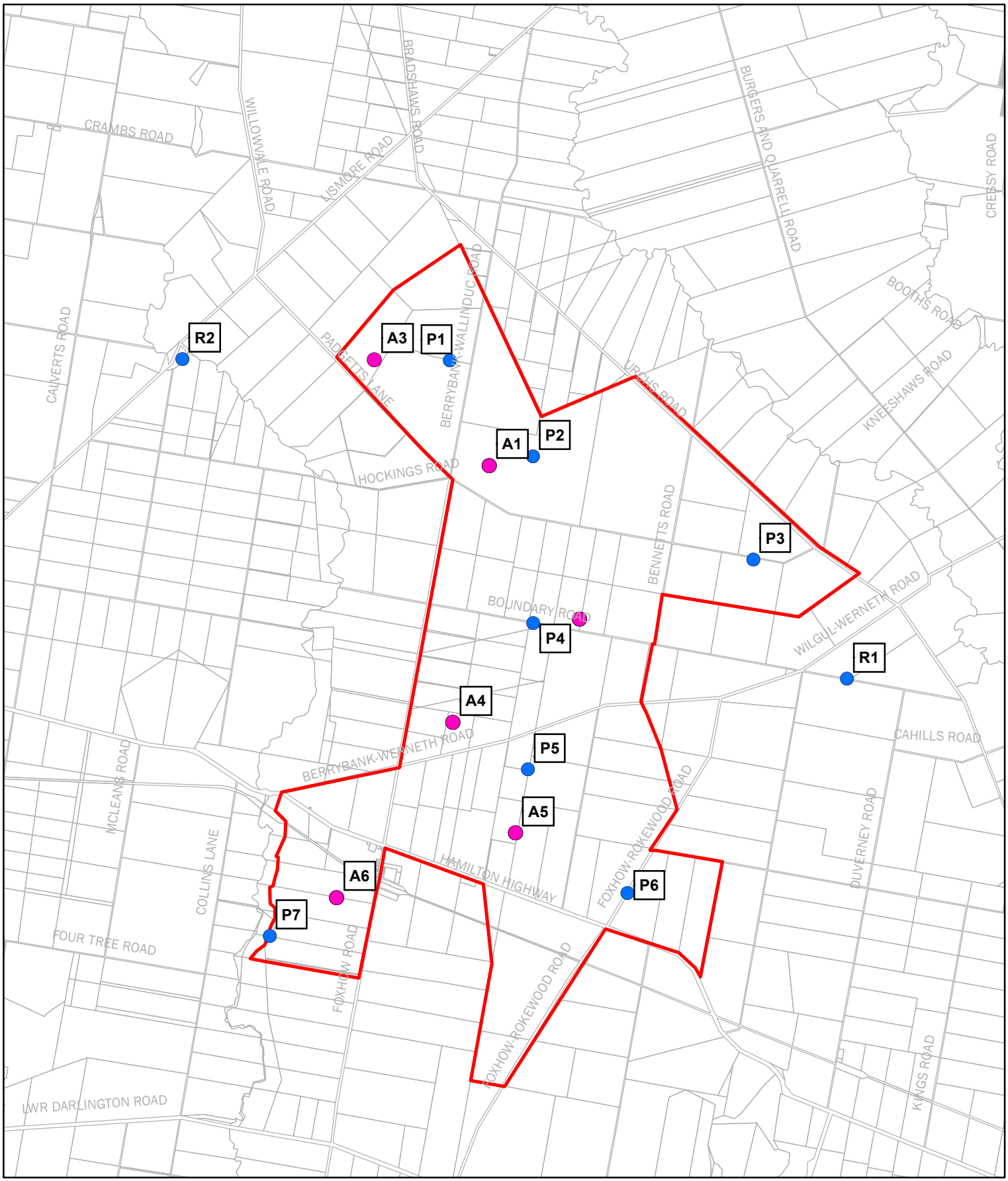
All species identified were non-threatened species. No significant impacts on threatened bat species were anticipated so no further investigations are warranted.

2.2. Bird utilisation surveys

2.2.1. Methods

The bird utilisation survey was undertaken in February 2009 (BL&A 2009b) using methods consistent with a Level 1 Bird Risk Assessment in accordance with "Wind Farms and Birds – Interim Standards for Risk Assessment" issued by the Australian Wind Energy Association (AusWEA 2006).

Surveys were undertaken at nine survey locations, seven of which were located near turbine locations, and two of which were situated in areas of similar habitat outside the wind farm boundary (Figure 2). Species, number of individuals, distance from survey location and flight height were documented.



Legend

- Study Area Berrybank
- Bat Survey Points
- Bird Utilisation Survey Points
- A4 Anabat Sites
- P7 BUS Sites

Metres

0 1,000 2,000 4,000

Figure 2: Bird and Bat Utilisation Survey Points

Project: Berrybank Wind Farm Flora and Fauna Management Plans

Client: Berrybank Development Pty Ltd

Project No.: 7152	Date: 1/03/2013	Created By: C. Doughty / M. Ghasemi

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2.2.2. Results

Twenty-five bird species were recorded at the impact sites during the survey and 17 species were recorded at the reference points. These were predominantly common farmland birds. The full list of species recorded during the assessment is presented in Table 3.

Table 3: Species recorded during the bird utilisation survey

Species	Recorded at impact site	Recorded at reference site
Australasian Pipit	✓	✓
Australian Magpie	✓	✓
Brown Falcon	✓	✓
Common Blackbird	✓	
Common Starling	✓	
Eastern Rosella	✓	✓
Eastern Rosella		✓
Eurasian Skylark	✓	✓
European Goldfinch	✓	
Fairy Martin	✓	✓
Galah	✓	
Horsfield's Bushlark	✓	
House Sparrow	✓	
Little Raven	✓	✓
Magpie Lark	✓	✓
Musk Lorikeet	✓	✓
Nankeen Kestrel	✓	✓
Noisy Miner	✓	✓
Red Wattlebird	✓	✓
Red-rumped Parrot	✓	✓
Wedge-tailed Eagle	✓	✓
Welcome Swallow	✓	✓
White-fronted Chat	✓	
White-plumed Honeyeater	✓	
Willie Wagtail	✓	✓
Yellow-rumped Thornbill	✓	✓

Nine bird species were observed flying at Rotor Swept Area (RSA) on 23 occasions. These were also predominantly common farmland birds. Species observed flying at RSA were:

- Eurasian Skylark
- Little Raven
- Willie Wagtail
- Brown Falcon
- Fairy Martin
- Galah
- European Goldfinch
- Nankeen Kestrel

- Wedge-tailed Eagle

Three birds of prey were recorded as flying at RSA: Brown Falcon, Nankeen Kestrel and Wedge-tailed Eagle.

The Wedge-tailed Eagle was seen on two occasions during formal counts and five times incidentally. This species is a bird of concern as it is prone to colliding with wind turbines. It was seen on one occasion at RSA height in the study area during the five-day survey. This indicates that the eagle may occasionally fly over the wind farm site, but the utilisation rate at the site is low compared with the utilisation rate at a number of other wind farm sites in Victoria (BL&A, unpubl. data). The wind farm site is believed to be within the foraging territory of one pair of eagles.

Significant risks to the Wedge-tailed Eagle population are considered unlikely therefore no further investigation of eagle use of the site is warranted. Impacts on a single eagle pair from the wind farm are not considered to represent a significant impact on the regional or wider population of this widespread species.

2.3. Brolga

2.3.1. Methods and results

The Brolga assessment included a review of existing information and field surveys including habitat assessment and a Level 2 breeding assessment in November 2008. The study area for the assessment included the wind farm boundary and a 20-kilometre buffer.

Methods used to undertake the surveys were consistent with the DSE Guidelines for Assessment of Potential Wind Farm impacts on Brolga 2011 (DSE 2012).

Two sites were surveyed including, one east of the windfarm near Wilgul-Werneth Road. The other was at the intersection of the Hamilton Highway and Foxhow-Rokewood Road. No known Brolga flocking sites occur within a five-kilometre radius of the windfarm, the established flight distance of Brolga during flocking season to and from flocking sites. As such, no impacts are expected to occur on Brolgas during flocking season and no surveys were undertaken.

Three historical brolga records were located within five kilometres of the wind farm boundary. None were in the wind farm boundary.

The majority of the 159 wetlands surveyed were of low quality (BL&A 2010). These took place during breeding and flocking seasons. During the assessment, six Brolgas were recorded. Two were in a moderate quality wetland, two in a moderate to high quality wetland and two in an unclassified wetland. No active nests were recorded during the assessment and none of the Brolgas sighted were situated in the wind farm boundary.

During the Panel Hearing, one Brolga breeding site was identified as having the potential to be used by the species. This record was provided by DELWP. It is located near the intersection of the Hamilton Highway and the Foxhow-Rokewood Road located in the south-eastern corner of the wind farm. The site has been used in recent years and anecdotal evidence from local community members suggest Brolga were recorded at this site during 2010.

The planning permit conditions also call for establishment of the significance of a second site located approximately 1 km east of the project boundary near Wilgul-Werneth Road and between Urches Road and Boundary Road. This site was visited by BL&A during November 2010; however, no Brolgas were recorded.

The review of existing information indicated the presence of 16 historical flocking sites in the 20-kilometre survey boundary. None were located in the proposed wind farm boundary.

An additional record was identified by DELWP as having the potential to support Brolga. This is located five kilometres east of the project site, west of Cressy-Werneth Road. Fifteen birds were recorded in this wetland in 1980.

Condition 15 k) (iii) of the planning permits states that:

Prior to the development commencing consult with the Lismore Land Protection Group or other local community member and DELWP Environment Portfolio to determine if there are any further known Brolga sites within 5 km of the wind energy facility.

Prior to construction, existing information will be sourced regarding known breeding and flocking sites within 3.2 kilometres and five kilometres of the turbines, respectively. Such information will be sourced through a review of the VBA, BirdLife databases, publicly available Brolga Assessment Reports (completed for other wind farms) and engagement with DELWP Environment Portfolio, the Lismore Land Protection Group, BirdLife Australia and the subject Councils.

Any Brolga breeding or flocking sites found within 3.2 kilometres and five kilometres of the turbines, respectively, as a result of the above-mentioned consultations, will be reported to DELWP Environment Portfolio and a Brolga monitoring program will be implemented in consultation with DELWP Environment Portfolio and to the satisfaction of the Minister for Planning.

Prior to the first turbine being commissioned an assessment will be undertaken identifying all known and potential Brolga breeding and flocking sites to be monitored within 3.2 kilometres and five kilometres of the turbines, respectively. All known and potential breeding and flocking sites will be listed and mapped to be included in the Brolga monitoring program including the two sites specifically noted in condition 15.k.i. and mentioned above.

3. ANNUAL REPORTS AND REVIEW

3.1. Routine reporting and review meetings

This section of the plan outlines the reporting arrangements for the Bat and Avifauna Management Plan. Specific reporting guidelines may also be discussed in their respective sections, and therefore further clarification should be sought in those sections if sufficient detail is not provided below. Review meetings may be required after reports are submitted and therefore the actual date of these meetings will be determined in the future.

The reports will be submitted to the Minister for Planning, DELWP Environment Portfolio, Corangamite and Golden Plains Councils and the local community.

The Planning Permit calls for monitoring to occur for at least two years upon the commissioning of the first turbine or upon another time agreed to by the Minister for Planning. This BAM Plan outlines a two-year monitoring program with a detailed review of results and impacts after the initial two years to inform any requirements for further or additional monitoring.

A first-year report will be prepared within two months of the completion of the first year of post-construction monitoring, including Brolga monitoring and bird and bat mortality monitoring.

The first-year report will not compare pre- and post-operational periods but will focus instead on reviewing the monitoring method and recommending refinements, where necessary.

Matters to be addressed in the first-year report include, but will not be limited to:

- Summary of post-construction carcass search results, including scavenger and detectability trials and total survey days (this will include the carcass data sheets, an example of which is included in Appendix 1)
- Discussion of any apparent seasonal or yearly variation in the number of bird or bat strikes within the year and from previously reported years
- Consideration of mortality of lit versus unlit turbines
- Electronic GPS search transect files for all searches
- Summary of any additional targeted monitoring surveys that were required (if relevant) as part of mitigation measures or species-specific monitoring (section 5)
- Changes to the final protocol of the methodology, for example, alterations to duration and frequency and areas sampled

The results will also be reviewed by a statistician to ascertain the likely level of precision in the estimate of bird and bat mortality for the given survey effort. Survey effort will be reviewed and recommended changes made based on this analysis.

The final report will be prepared within four months of completing two years of post-construction monitoring (bird and bat mortality) and will include:

- The survey methods (including list of observers, dates and times of observations).
- A review of the pre-construction BUS surveys and analysis in relation to carcass search results.
- Statistical estimates of bird and bat mortality rates (animals per turbine per year) of; priority species (raptors, Brolgas and any significant impact trigger species (Section 5)) and for each size class (i.e. bat, small bird, medium/large bird) or aggregated bird species and bat species separately found during the carcass searches, depending on what is feasible statistically.
- Seasonal and annual variation in the number and composition of bird and bat strikes.

- Any other mortality recorded on site but not during designated carcass searches i.e. (incidental records by site personnel).
- A summary of livestock carcass removal for the purposes of predator reduction.
- A discussion of the results, including:
    - Whether indirect impacts on bird and bat use of the site are of significance at a regional, state or national level, or if species of concern were affected;
    - Whether the level of mortality was unacceptable (see section 5);
    - Analysis of the effectiveness of the decision-making framework (Figure 3 and 4);
    - Whether continuation of the monitoring program after two years is warranted;
    - Any differences between lit and unlit turbines; and
    - Any recommendations for reducing mortality, if necessary.

At the end of the two-year baseline monitoring period for birds and bats (excluding Brolga monitoring) an overall assessment will be made of all the data obtained during this phase, and details of the management practices implemented, as well as recommended adjustments. The information from this assessment will determine whether additional bird and bat mortality monitoring is required and any changes to the management prescriptions made. If the Minister for Planning determines that additional assessments are required, the extent and details of the further investigation will be prepared in consultation with DELWP Environment Portfolio, Corangamite and Golden Plains Councils and to the satisfaction of the Minister for Planning. Investigations will be carried out to the satisfaction of the Minister for Planning.

The Brolga monitoring program will be written up within two months of completion of the twelve-month monitoring period in any given year. All Brolga observations will be presented, any impacts the wind farm has had on the Brolga will be discussed and recommendations of the need for further monitoring will be evaluated.

3.2. Data acquisition/submission and personnel involved

This section of the plan outlines the acquisition/submission of data and personnel involved in the field work, report writing and background research for the BAM Plan. Data for all work conducted for the BAM Plan will be provided to DELWP and other relevant authorities in both electronic and hard-copy format. Electronic submission of relevant data will coincide with the reports (above in section 3.1), however, it must be understood that some data will be in a very raw format and mid-collection. The submission of the data does not replace the summary of information and data outlined in the individual reports but is in addition to and is in accordance with DELWP requests. This data acquisition and submission applies to all following sections and therefore unless otherwise stated the procedure for inclusion of data follows the above guidelines.

All personnel working on this plan must be trained thoroughly, including background theoretical training, knowledge of policies and other administrative matters (e.g. OH&S) and technical and field training methods. BWF will undertake a tender process for the engagement of suitably qualified and trained people to supervise and implement the monitoring program.

A suitably experienced and qualified ecologist will oversee and be involved in the implementation of the program, including the carcass searches, searcher efficiency trials and scavenger trials. A qualified ecologist will undertake any required Brolga monitoring program.

Any person undertaking searches will be trained and supervised by a qualified ecologist who is familiar with the techniques. The searcher will receive training from the qualified ecologist in the following areas.

- Turbine searches i.e. transect spacing in inner and outer zones, number of turbines to search and transect search methods
- Equipment usage i.e. GPS
- Data recording
- Species identification.

The qualified 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.

The ecologist will also supervise the searcher efficiency trials and will set up and supervise the scavenger trials to ensure that the methodologies for these are carried out correctly.

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 on an ongoing basis, totalling two times in the first year. Training will include the following.

- 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 they are being placed.

If for some reason the searcher is unable to undertake the searches as planned (due to illness etc) the field searches will be extended at the end of the nominated search period to make up for the missed searches. If any additional personnel are required to undertake searches, they will also be trained and supervised by a qualified ecologist and will participate in searcher efficiency trials.

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

Analysis of mortality data will be undertaken by a qualified statistician or ecologist. Annual reports and all investigations as a result of an impact trigger being detected will be prepared and carried out by a qualified ecologist.

Confirmation of the qualifications and training of all personnel involved will be provided to DELWP at the commencement of monitoring.

4. POST CONSTRUCTION MONITORING

Post-construction monitoring comprises surveys required during the operational phase of the wind farm for at least 2 years commencing upon the commission of the first turbine. They include:

- Brolga monitoring program;
- Bird utilisation surveys; and
- Bat and bird mortality assessments.

4.1. Brolga monitoring program

From commissioning of the first turbine the Year 1 Brolga monitoring program will commence and will include twelve months of continuous monitoring. During the standard breeding season (July-December inclusive), monthly inspections of all accessible previously identified known and potential breeding sites within 3.2 kilometres of the turbines. During the standard flocking season (January – June inclusive), complete monthly inspections of all potential foraging habitat (known/potential night roosts, pasture and cropped areas) within 5 kilometres of turbines.

Each month data will be collected at each previously identified wetland including date of observation, counts of any Brolga (including age class) observed, behaviour (nesting, with young, foraging, flocking), location, wetland condition (surface water cover, emergent vegetation cover) and any other relevant information. Any observed Brolga flights will be noted including flight height, direction, distance and duration.

Following year one, complete an additional two years of Brolga monitoring within the first five years of wind farm operation. Monitoring must occur in the first available wet year following commencement of wind farm construction. A wet year is defined by having above average rainfall for the season (breeding/flocking). This program of monitoring allows for monitoring over non-consecutive years so that the results better reflect long-term utilisation of the site by Brolga.

4.1.1. Reporting of the Brolga monitoring program

If Brolga are found breeding within 3.2 kilometres or flocking within five kilometres of a turbine, this will be communicated to Berrybank Development and DELWP Environment Portfolio immediately, and will trigger a more intensive monitoring program. Any recorded Brolga breeding or flocking activity within 3.2 kilometres and 5 kilometres of turbines, respectively, triggers the requirement to undertake fortnightly observational surveys until the subject activity has ceased (i.e. breeding fails, chicks fledge or flocking birds move on).Annual findings (breeding and flocking season) of Brolga surveys will be reported to the Project Environmental Manager at Berrybank Development in the year that they were undertaken. The report will present all Brolga sightings and associated information as required by DELWP Environment Portfolio for incorporation into the Victorian Biodiversity Atlas and regional Brolga population management studies.

4.2. Bat and bird mortality monitoring

Collision impacts on birds and bats from the wind farm will be monitored through a rigorous carcass-search program. This involves searching under turbines for birds and bats that have collided fatally with turbines. The aim of the carcass search program is to derive an estimated mortality rate for birds and bats in terms of the number of birds or bats per turbine per year (the standardised measure adopted by AusWEA (2005)). Deriving this rate requires the following components in the monitoring program:

- Searches for bird and bat carcasses under turbines;

- Scavenging trials, the aim of which is to ascertain how many carcasses have already been scavenged before they could be found. A correction factor for scavenging rate will then be developed; and
- A searcher efficiency trial to develop a correction factor for carcasses that the observer misses while searching.

The carcass search program will inform surveys which form part of the monitoring program and which will aim to ascertain:

- The species, number, age and sex (if possible) and date of any bird or bat morality arising from the operation of the wind energy facility;
- The number and species of birds and bats struck at lit versus unlit turbines; and
- Any seasonal and yearly variation in the number of bird and bat mortalities.
- The efficacy of searches for carcasses of birds and bats and seasonal information on the rate of removal of carcases by scavengers, so that corrections factors can be determined to enable calculations of the total number of mortalities depending on the season in which the survey was undertaken.

Procedures for each of the components of the carcass search program are provided below.

4.3. Carcass searches

A carcass search involves intensively searching around a turbine for dead or injured birds and bats. Direct evidence of dead birds and bats includes actual remains of individuals (e.g. body, wings, skeleton). Indirect evidence of dead birds includes feather-spots, which is a clump of feathers (minimum of 10 feathers or three flight feathers – primaries, secondaries or tertiaries: Hull and Muir 2010). Feather spots may be evidence of dead birds that have been scavenged.

Qualified and experienced ecologists will undertake monitoring. If outside contractors are to undertake monitoring, it is important that personnel involved in the carcass searches be adequately trained to undertake the assessments. Personnel will have experience in bird and bat identification and be able to identify species, particularly EPBC Act, FFG Act and Victorian Advisory List listed species, in the field. Personnel will be familiar with proper search protocols and carcass procedures. Training of personnel will be undertaken by a qualified ecologist.

Outcomes of the carcass searches will be recorded in a carcass data sheet (as relevant), an example of which is included in Appendix 1.

4.3.1. Site selection and survey frequency

The equivalent of at least a third (33%) of 79 turbines which is 27 turbines of the commissioned turbines in the wind farm will be searched every month for two years. After this time, the need for further carcass monitoring will be reviewed and recommended in the second annual review (Section 3). To provide an adequate sample representative of the entire turbine population, turbines will be selected at random. The random sampling is the most statistically appropriate approach because there is no known or foreseeable reason why any turbine would kill more birds or bats than another turbine, given the uniform habitats and environmental conditions on the wind farm. Thirty-five turbines will have aviation safety lighting on them. These turbines are to be included in the overall 33% of selected turbines and will be searched every month representing 12 turbines.

There are several conditions that will apply so that the mortality rates from the sample population can be scaled up to the entire site.

- Each turbine has an equal chance of being selected for the searches (randomly selected by number generation table)
- Once the turbines have been selected, the selection will not change for the duration of the monitoring program.

The 27 turbines randomly selected for searching are below. However, each turbine will be reviewed in relation to OHS issues prior to commencing searches.

39	59	24	26	88	21
69	1	77	28	79	48
82	46	17	86	9	
80	51	64	31	3	
2	4	85	98	58	

Note: Green indicates turbine with aviation safety lighting.

The number of turbines to be selected for searches has been calculated based on, firstly, what will provide the most accurate mortality rate given high variability shown on other wind farms, and secondly, that humans/dogs will have search limits (e.g. OH&S). Each turbine selected for the searches will have basic information recorded including number, location and information on surrounding vegetation and habitats.

The search area beneath each turbine has been determined to best detect Brolga and microbat carcasses. However, the search area will also detect any other bird or bat that may collide with turbines. The order of turbines searched will be randomised.

In addition to the search protocol, searchers will observe areas beyond the search radius (up to 140m from the turbines) with binoculars to detect any large birds, such as Wedge-tailed Eagles and Brolgas, which may have fallen further away from the turbines. Birds of this size are easily detectible from a distance. If a carcass is detected in this manner and can reasonably be attributed to the turbine being searched, i.e. it is not hundreds of metres away, it will be included in the carcass search results to be analysed. If not, it will be considered as an incidental find which is not included in the formal carcass search results.

To understand more about the rate scavenging of bat and bird carcasses, a pulse search regime will be undertaken to determine the rate at which carcasses may be removed. The aim of this "pulsed search" is to detect new carcasses at turbines. This will provide information on how often carcasses appear under turbines, which will assist in interpreting the results of carcass searches.

Pulse searches will be undertaken two to three days after the initial search of a selected turbine has been completed (where practicable) and include only the inner search zone (Figure 3).

Pulse searches will initially operate for the first year of BAM Plan implementation and the need for continuation of the pulse searches will be reviewed and recommended in the first annual review (Section 3). They will be undertake in the spring to autumn period from October to April (bat peak activity time).

As detailed in section 4.4, any person carrying out carcass searches will be trained and supervised by a qualified ecologist who is familiar with the techniques described below.

Scent dog option

It is recommended that trained dogs are prioritised over humans to complete carcass searches. Dogs have been found to be more efficient at detecting carcasses than humans (Mathews et al. 2013).

This section has been added to allow more flexibility and aligns with industry practice. Dogs will search the same search area within a 120 metre radius from the tower. Dogs will begin the search on the downwind end of the search area and will generally walk in the direction of the wind. Under ideal conditions dogs and handlers may walk up to 20 metre spaced transects, which is reduced in unfavourable conditions. A small GPS will be fitted to the dog's collar to record the search track. The dog handler will also have a GPS with the search areas pre-loaded to provide consistent searching and to enable the handler to ensure the dog is reaching the full perimeter of the search area. The handler will make daily decisions on weather and topography and how this will impact the dogs searching ability and make any necessary alterations to methodology.

Searching protocol will be based on a minimum detection ability where dogs must maintain a searcher efficiency of 50% or greater during efficiency trials. Carcasses found outside the defined search area will be recorded and collected as an incidental find.

Dog handler(s) must have demonstrated capacity to identify bird and bat species of south-east Australia.

Trained ecologist searcher option

Should a trained ecologist be required to complete the searches the following methodology will be used. Searches by trained ecologists without dogs should only be undertaken if for operational reasons dogs cannot be used.

A circle search zone surrounding the turbine will be uploaded onto a GPS. The inner core zone targets the detection of small bird and bat species. In the inner zone, transects are spaced at 4 metres and carried out up to 60 metres. Nearly all microbats, and the majority of small to medium birds are expected to be found in this inner zone (based on the Hull and Muir model, 2010). Very few bats are found beyond 40 metres (BL&A unpublished data).

The outer zone will aim at detecting the much larger bodied birds (Brolga) but also medium-sized birds. Transects are spaced at 12 metres and carried out from the edge of the inner zone out to 120 metres. This transect spacing and total search area will be ample to detect the two species of concern and are based on previous studies (e.g. Arnett *et al*. 2005, Hull and Muir 2010). All of the search area (4.5 hectares) will be traversed each month. Both search zones, inner and outer, are demonstrated in Figure 3.

The total distance walked by a searcher within the inner and outer core zone will be five kilometers and two kilometers respectively. The observer will walk along straight transects or circular patterns at the spacing indicated above for each zone. Searcher behaviour will be standardised with the same searchers conducting the trial where possible. Searchers will record the search pattern with a GPS. The GPS records will be available through the annual reporting process.

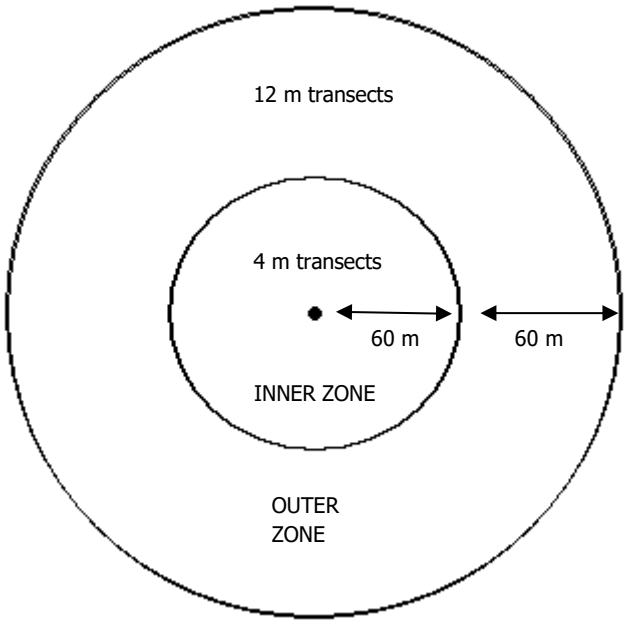


Figure 3: Carcass search zone for turbines

Carcass detection protocol

If a carcass is detected the following variables will be recorded (see Appendix 1).

- GPS position, distance and compass bearing of the carcass from 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, visibility, maintenance to the turbine and any other factors that may affect carcass discovery, e.g. season.
- Whether the turbine has aviation lighting installed.

The following procedure will be followed when handling carcasses.

- Carcass to be removed from the site to avoid re-counting
- Carcass will be handled by personnel wearing rubber gloves, packed into a plastic bag, wrapped in newspaper and put into a second plastic bag
- The carcass will be clearly labelled to ensure that its origin can be traced at a later date, if required
- Carcass to 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 scavenger and/or detectability trials
- Stored carcasses will be made available to DELWP staff members to view upon request if they have not already been used in scavenger and/or detectability trials.

It will be necessary for the wind farm operator to obtain from DELWP a permit under the state *Wildlife Act 1975* to handle and keep native wildlife (even dead wildlife) as part of the monitoring program. An application for this permit will be submitted in a timely manner to ensure approval has been obtained prior to commissioning of the turbines.

Any carcasses not required for searcher efficiency and scavenger trials will be retained for 12 months prior to disposal.

Any detected threatened bird or threatened bat mortalities will be reported to DELWP Environment Portfolio within 7 days of becoming aware of any mortality. Where possible, it will be identified whether the mortality was caused by a lit or unlit turbine. This information will be reported by submitting data carcass sheets (see Appendix 1).

4.3.2. Scavenger rates and trials

It will be important to ascertain the rate at which carcasses are removed by scavengers. These can include ground-based animals, such as foxes and rats, as well as aerial scavengers such as birds of prey and ravens. The scavenger trial described below is designed to ascertain the scavenging rate, usually expressed as an average carcass duration. This assists greatly in interpreting the results of carcass searches.

The interpretation of carcass search results, including the design of the search program, scavenger trials and detectability trials (see Section 4.4.1) are determined by statistical considerations. In developing the methods for this plan, advice has been sought from Symbolix Pty Ltd, who provided general statistical advice for the development of BAM Plan carcass search methodology (Symbolix 2012a – See Appendix 2). The points in this report and in relation to practical considerations that are relevant and that have informed the design of the trials below are listed here.

- Very few carcasses are found under wind turbines in Australia compared with Northern Hemisphere wind farms (i.e. less than half the number in the Northern Hemisphere based on BL&A data across a number of wind farms)
- 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. 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 across seasons in scavenger activity (see Appendix 2).
- We know that detectability will be easier in short grass in the dry time of the years compared to in longer grass in the wet time of the year.

A more detailed discussion is provided Appendix 2 of how the methods described herein have been developed and their statistical basis.

An intact carcass will be defined as a carcass that does not appear to have been scavenged by a vertebrate predator. Carcasses that have decomposed due to insect activity or weather exposure remain in the landscape for a very long time and it is highly unlikely that these carcasses would have been missed during searches. 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 remains. Intact or partial carcasses and feather spots will all be recorded as a “find” in accordance with the search protocol (section 4.3). A feather spot is defined as being a cluster of ten or more feathers.

Scavenger trials will be undertaken twice during the first year of monitoring – once when the grass is long and once when the grass is short. Based on our experience, grass is expected to be longest in late spring (most probably November), following rainfall and higher temperatures. Grass is expected to be short during the colder months of winter (July), or when stock have been grazing an area. The actual month of scavenger trials will be based on grass growth at the time. Scavenger trials will be undertaken twice per year for the first year of post-construction monitoring, after which the results of

monitoring will be reviewed and the need and frequency of further scavenger trials in the following year of monitoring, and thereafter, will be reviewed and agreed upon with DELWP. As detailed in section 3.2, any person undertaking scavenger trials will be trained and supervised by a qualified ecologist who is familiar with the techniques. The qualified ecologist will be responsible for overseeing the trials and selecting location and type of carcass to be used in the trials.

Scavenger trials

Scavenger trials will be undertaken to determine the probability of scavenge loss at a given time, and the nature of scavenge removal (e.g. an early peak in activity, or activity that peaks after carcasses have been in place for a period of time). The search area will be the same as in the search protocol (above) and will be located under operating turbines. Turbines used for scavenger trials will be the same as those used for mortality searches and will be selected based on the random selection process outlined in section 4.1.1.

To determine the scavenge rates on birds and bats, three size categories of carcasses will be used. Where carcasses of the species of concern cannot be found, a similar sized substitute will be used. Carcass substitutes will be a similar size and colouration to birds and bats that would have ideally been used for the trials.

The size classes will correspond to:

- Microbats/Small birds;
- Medium/Large birds; and
- Brolga equivalent birds.

The number of carcasses for each size category to be used during each scavenger trial are outlined in Table 4. This is expected to generate estimates of average carcass duration with relative standard error of 25-30% per trial, or 20% annually (Symbolix 2012a, Figure 2 – see Appendix 1).

Improvements on this require an impractical and (likely) unavailable number of carcasses on all size classes given the factors being investigated (Table 4). Appendix 2 describes the statistical implications of the proposed carcass numbers for these trials and indicates the limited additional benefit of using more than a total of 30 carcasses across all size classes. Currently 60 in total are proposed (ten of each type/class for each trial)

Table 4: Number of replicates for the scavenger trials

Micro Bat/Small birds	Medium/Large birds	Brolga equivalent
10	10	10

The trials will be conducted at the randomly selected turbines that have been selected for the mortality searches. The carcasses of each category will be placed under one of the randomly-selected turbines in the morning.

There are two options for monitoring the carcasses. These are:

- Motion sensor camera installed within 1-2 metres of the carcass; or
- Regular checking of the carcasses (a methodology is provided below)

During two trials, half the carcasses will be monitored by a person and half using a remote camera. The results will determine if using a remote camera increases the detectability of carcasses for visual scavengers by creating a nearby perch for them.

Methodology for sensor camera for scavenger evidence

- Carcass placed on the ground at random positions (using carcasses from observer trial if possible);
- Camera secured within 1-2 metres of carcass using most appropriate method;
- Camera checked after day 2, 4 and then weekly until day 30 and repositioning of cameras occurs if a carcass has been moved outside the field of view,
- If carcass has been removed, remove the camera during inspections;
- Remove camera and download pictures to determine if scavenger was recorded.

Methodology for checking carcasses for scavenger evidence

For carcasses to be searched by a person, each of the carcass will be checked every morning for the first five days, then every 48 hours for the following four days, then every three days until they disappear or at the end of 30 days (see Table 5).

Table 5: Scavenger trial search timetable

Day (Time)
Day 1: Early morning
Day 2: Early morning
Day 3: Early morning
Day 4: Early morning
Day 5: Early morning
Day 7: Anytime
Day 9: Anytime
Day 12: Anytime
Day 15: Anytime
Day 18: Anytime
Day 21: Anytime
Day 24: Anytime
Day 27: Anytime
Day 30: Anytime

Additional procedures for scavenger trials are provided below.

- The timing of searches is based on experience at a number of other wind farms (BL&A unpublished records) where scavenger trials have been undertaken that show almost all carcasses have been scavenged after five to ten days. More frequent monitoring than that proposed herein will not significantly affect consideration of scavenging and its impact on mortality estimates.
- The monitoring will be terminated after 30 days, after which the remaining carcasses will be removed, or until all carcasses have been scavenged (experience suggests that most carcasses disappear within five to ten days)
- Native birds (collected from road-kills before the monitoring begins) and bat 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 colouration substitute will be used

- 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, two carcasses will be placed randomly within a 120-metre radius search area around the turbine. Carcasses will be thrown in the air and allowed to land on the ground to simulate at least some of the fall and allow the potential ruffling of feathers
- Carcasses used in the trial will have their coordinates recorded to ensure that they are not confused with an actual fatality found under a turbine during the trial searches
- Notes will be taken on evidence remaining at sites where carcasses have been scavenged (e.g. scavenger scats, bones, feather[s], 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) (Appendix 1)
- Notes will be taken on the state of remaining carcasses each search day.

The scavengers that are likely to be present (and of concern) on the wind farm site fall into two broad categories: visual and olfactory. The visual are usually raptors and corvids and these will detect carcasses in almost any vegetation (as long as they can access it) as they are rapid onset scavengers that will monitor the area for movement and once they see the animal fall will detect its location regardless of vegetation. Olfactory scavengers, including mammalian predators (e.g. foxes, cats) and corvids will "smell" the carcass and will locate it without the use of visual cues.

Previous studies have found that the Red Fox is 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 to summer/autumn as rabbit availability dropped. 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. Therefore the repeated scavenger trial is designed to account for this occasional winter/spring increase in carrion use. The Red Fox will be the dominant scavenger on-site, raptor and corvids are unlikely to scavenge to the same extent and their use of the site is likely to be seasonally uniform.

The number of carcasses per category is based on obtaining a reasonable level of statistical confidence in the average scavenge time calculated, as reflected in software requirements for current mortality estimation programs, and also on wanting to minimise the number of carcasses used. 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. Raptors are 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. Additionally, 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 (i.e. sourced from surrounding areas). Fox reproductive success is limited by prey availability and hence any increase in carrion availability may increase the number of cubs produced in later seasons.

The final scavenger trial herein is therefore a necessary compromise between high numbers of trials and practicality.

4.3.3. *Detectability trials*

These trials aim to determine the likelihood that a searcher will detect an existing carcass, given the prescribed search pattern. These trials are based on the four and 12 metre transects being walked by searchers. In accordance with the overall aim of the mortality surveys we will be testing the detectability of the two size categories of the species of concern. However, this will also broadly encompass all birds and bats that may occur on-site. In addition, as humans are reliant on visual cues to determine carcass location, two visibility categories of long and short grass will be compared. Detectability trials will be undertaken once in each season (long and short grass), twice in the first year, concurrently with carcass searches. Ten carcasses of each carcass type, will be used on each occasion representing 60 carcasses (20 of each carcass type will be deployed) in both detectability trials. The actual month of trials will be determined based on grass growth at the time. Any person (or scent dog, where relevant) undertaking mortality searches will participate in the detectability trials. Trials will be initiated and supervised by a qualified ecologist who is familiar with the technique and the training for observers mentioned in section 4.4 will ensure that all trials are undertaken as required. If scent dogs are used; only natural bird carcasses will be used. Processed poultry will not produce the same "scent" as a decaying unprocessed natural bird. Bat carcasses may be substituted with mice where required as these are not processed, and the dog is adequately trained to find these carcasses.

Power analysis (see Appendix 2) indicates that only relatively large seasonal changes in detection (~20% or more) will be resolvable from normal background variation. To produce a distinct average detectability for four seasons could require over 100 carcasses per size class, which is logistically unfeasible and likely to influence the numbers of scavengers onsite. For this reason, we prescribe sampling the greatest change in vegetation cover, using a number of trials that is logistically manageable (Table 6). Detectability trials will be conducted will occur two times in the first year. At the end of the first year, a review of the methodology will be undertaken in the first annual review (Section 3) to inform the need and extent of detectability trials for the following year of monitoring.

Statistical confidence analysis (Appendix 2) indicates that this will result in a reasonably precise detectability estimate after one trial, and optimal precision after two.

Table 6: Detectability trials given two factors of size and visibility

	Micro Bat/Small birds	Medium/Large birds	Brolga equivalent
Long grass	10	10	10
Short grass	10	10	10

To account for individual observer variability, each of the searchers (including a scent dog, where relevant) will be involved in the trials and this variable will then be incorporated into later statistical analyses. Any model of average detectability must investigate and report on observer effect as a factor or random effect. Using proposed turbine locations (this design can be conducted before the actual turbine is operating) all bat and small bird carcasses will be placed within the inner zone. The remaining carcasses will be distributed though the outer zone. Trials will be performed as per the mortality search protocol. Carcasses will be thrown in the air and allowed to land on the ground to simulate at least some of the fall and allow the potential ruffling of feathers. The total number of carcasses will be at least the values of Table 6.

The controller of the carcasses will note the placement of carcasses (GPS). Searchers will not observe each other's trials, but it is not feasible to undertake a genuine 'blind trial', where searchers are unaware they are undertaking a trial. Substitute carcasses may have to be used, such as mice or the introduced Common Myna and therefore it would be impossible to conduct a genuine 'blind trial'.

There is no reason to suspect that searchers will be anything less than vigilant and alert so a placebo effect need not be countered. Notwithstanding this, to overcome possible differences in searcher vigilance in response to a detectability trial, they will not be informed that the trial is being undertaken, or how many trials or carcasses are involved.

For searches by ecologists, if sufficient carcasses cannot be sought, stuffed, realistic-looking artificial substitutes may be used. It is not essential to use real carcasses as long as the substitutes appear similar once on the ground. Humans are entirely visual searchers (i.e. olfactory senses not adequate) and therefore artificial substitutes would satisfy this requirement. Additionally, the artificial substitutes will not attract scavengers and should not increase the likelihood of raptor collisions and the number of introduced predators on-site. As these trials can be undertaken separately from scavenger trials, artificial substitutes may be ideal (i.e. mice substitute for bats). For scent dog observer trials only natural carcasses are to be used.

4.3.4. Analysis and data limitations

All data will be analysed to provide the average, standard error (variability) and range (of the study turbine population). The data from the scavenger and detectability trials will be analysed using relevant techniques based on GLM (Generalised Linear Modelling) and (censored) Survival Analysis. Censored measurements are only partially known, such as the exact time of mortality or the exact time to scavenge loss (see, for example, Kaplan & Meier 1958). In addition to providing mortality estimates, this analysis will determine if any of the factors are significant and their inclusion pertinent and required.

It is difficult to provide the actual format (e.g. fatalities/turbine/year) of the results, in this current BAM Plan, as it is subject to the results of the experimental trials and the variability of the data. As stated above we will be able to provide the number, average, standard errors and other basic statistics of recorded fatalities per study population for the sampling time/effort, but we are uncertain whether this data can be generalised to a larger population. All species carcass data will be analysed and presented with species-specific information.

All data analysis will be undertaken by a qualified ecologist or qualified statistician who is familiar with the proposed techniques.

4.3.5. Incidental carcass protocol

Personnel operating the Berrybank Wind Farm may from time to time find carcasses within the wind farm site. In this case, the person concerned will respond in the way described below.

Over the operational life of the wind farm, the site manager will immediately be informed and, for each carcass, will ensure that the following is undertaken.

- The GPS position is recorded
- The distance and compass bearing of the carcass from the wind turbine tower base is measured and recorded
- The carcass is removed from the site to avoid re-counting

- The carcass is handled by trained personnel wearing rubber gloves, packed into a plastic bag, wrapped in newspaper, then put into a second plastic bag
- The carcass is transferred to a freezer at the site office for storage so the carcass or partial remains will be identified by a suitably qualified and experienced ecologist and used in observer efficiency and scavenger trials, if suitable
- The carcass will be appropriately labelled to ensure later identification
- A copy of the carcass search data sheet (Appendix 1) will be given to the relevant project manager supervising carcass searches, for inclusion into the annual report
- If the find is made within five days prior to a scheduled carcass search, the carcass will be left in situ but photographed and position recorded (GPS)
- All bird and bat carcasses (not used for experimental trials) found beneath turbines during searches and incidental finds will be retained (frozen) for at least 12 months
- After 12 months, available carcasses (not used in trials) will be offered to DELWP if not required to be provided to any other institution, or will be dealt with in accordance with wildlife permit requirements.

The same information for an incidental carcass find will be recorded as for carcass monitoring program outlined in 4.4.1.

Following the completion of the active avifauna monitoring period all incidental finds (dead and/or injured bird and bats) by wind farm staff will be treated in the same manner as outlined in the above protocols for the life of the project.

All incidental finds will be recorded and reported in the annual reports. The number of incidental finds is to be reported in the annual reporting of mortality.

4.3.6. Injured bird and bat protocol

All on-site staff and monitoring personnel will be advised of the correct procedure for assisting injured wildlife. All ecologists are very familiar with the correct and ethical treatment of injured wildlife and are often able to provide necessary care to aid in quick release (e.g. dehydration, shock). Contact details of local veterinary staff and wildlife carers will be provided to ensure that if injured wildlife are found and cannot readily be released back to the wild, they are treated accordingly and in a timely manner.

Wind farm personnel who find injured wildlife will be required to report the find to the wind farm site manager, who will require a trained person to place the animal immediately into a dark place (e.g. box or cloth bag) for transfer to the nearest veterinarian (list to be maintained at the wind farm office). Alternatively, Wildlife Victoria (1300 094 535) will be contacted and informed of any injured wildlife. A member of the organisation will be required to collect any raptors injured. The Injured bird and bat protocol is valid for the operational life of the wind farm.

4.3.7. Analysis of results

It is recommended to report modern, statistically robust mortality projections for the entire wind farm site. It is acknowledged that this is a current and dynamic aspect of research and that the outcomes from such programs may be equally dynamic and so offer little potential for compliance monitoring at this stage.

Due to the rapidly advancing techniques, the adherence to meta-data collections (data about the underlying data) is paramount, as are correct, statistically valid selection processes. There are two groups of concern; raptors, in particular Wedge-tailed Eagle, and Brolga, and mortality estimates are

targeted to these species. The seasonal and annual mortality (if applicable) of each size group detected will also be estimated, if feasible. Turbine operational times will also be considered in mortality estimates.

To be a statistically robust estimate, all protocols will be unbiased and controlled. If these conditions are met then the results can be generalised to other sites within Victoria and any information gained may be applicable (possibly with some caveats that can be determined from the process itself) to other developments.

Current mortality estimates require the following.

- Sampling protocol (to enable generality and scaling up to site-wide estimate): Section 4.4.1
- Search protocol (to collect the raw data in a consistent fashion compatible with the two protocols above): Section 4.4.1
- Modelling protocol (to account for losses): Sections 4.4.2, 4.4.3 and statistical modelling.

The projected mortality rate will be generated through modeling the scavenger losses, detectability, proportion of turbines searched and number of carcasses recorded. Currently, the most appropriate model is that of Huso (2010), however, prior to the finalisation of the whole of wind farm mortality estimate, agreement will be reached with DELWP and the statisticians on the most suitable "peer reviewed" method for modelling mortality.

It is unnecessary for the purposes of the BAMP to detail the analysis process, which should be flexible and respond to specifics of the data collected. However, the basic premise of these approaches is to calculate the expected counts of carcasses, accounting for modeled losses (both scavenger and detection) and to account for sampling fraction, stratification and to produce an estimate wind farm mortality.

Due to the intensive data load required, this will be done for the priority species and those other species detected (i.e. carcasses) that fall into the Microbats/Small birds; Medium/Large birds; and Brolga equivalent birds categories.

Finally, as the analysis process needs to be flexible and respond to the data collected, it is not possible to predict the format of the results (e.g. estimated fatality/turbine/year).

The analysis results will be reported in the annual report, discussed below, and will identify the need for further detailed investigations or mitigation measures.

4.4. Bird risk reduction measures

To provide for the regular removal of carcasses likely to attract raptors to areas near turbines the procedures below will be adopted.

- Fortnightly inspections of the wind farm site will be undertaken to search for any dead stock or kangaroo carcasses that may attract raptors within 250 metres of all turbines.
- Any carcasses found will be immediately collected and quickly disposed of in a manner that will avoid attracting raptors close to turbines (such as burying them in a designated location).
- Inspections during lambing season (usually late autumn / early winter) need to occur at an increased frequency of once a week, since young lambs are susceptible to death.
- Carcass occurrence and removal will be recorded in a "management log book" maintained by the project operator/owner.
- Rates at which carrion are found will be reviewed after three months of wind farm operation to ascertain if the carrion removal schedule needs to be refined.

- Based on the 'management log book', an annual summary of carcass removal will be included in the final report and submitted to the DELWP Regional Manager of the South West region and the Responsible Authority.

Pest animal and pest plant management will be carried out post-construction to decrease the risk of birds of prey being attracted to the site. The pest animal and pest plant management plans are detailed in a separate report (BL&A 2011).

Additional general risk reduction measures required to be implemented include:

- Exclusion of grain feeding within 250 metres of turbines to reduce the attractiveness of foraging close to turbines, and
- The use of appropriate lighting (i.e. baffled lighting) to reduce attracting birds and bats to turbines or disorienting avifauna.

All powerlines associated with the windfarm are to be marked to increase their visibility to birds.

Additional mitigation measures to be implemented in the event that an unacceptable impact to birds and bats occurs are detailed in section 6.

5. MANAGEMENT TRIGGERS AND SIGNIFICANT IMPACTS

The following section identifies the circumstances that will result in notification, further investigation and mitigation/offset for both threatened and non-threatened birds and bats (impact trigger). If an impact trigger occurs, there must be an investigation into the cause of the impact, and whether the event was likely to be a one-off occurrence or a regular event. The impact trigger may be a significant impact in itself, or may lead to a significant impact

Significant impact reporting, mitigation and offsets apply for the life of the wind farm, particularly during monitoring.

All investigations, decisions regarding significant impacts, and implementation of mitigation and/or offset measures will be undertaken in consultation with DELWP and Corangamite and Golden Plains Councils. Implementation measures will be enacted to the satisfaction of the Minister for Planning. The chapter complies with planning permit condition 15 i).

5.1. Threatened Species

5.1.1. Definition of Impact Trigger and Significant Impact

Generally, an impact trigger is where there is evidence of death or injury to birds and/or bats by collision or other interaction (e.g. barotrauma) with turbines. Under this Management Plan, the circumstances that define an impact trigger and significant impact for threatened birds and/or bats is detailed below.

Impact Trigger for Threatened Species: A threatened bird/bat species (or recognisable parts thereof) listed under the *EPBC Act*, *FFG Act* or DSE's Advisory List of Threatened Vertebrate Fauna in Victoria – 2013, is found dead or injured within the wind farm site during any mortality search or incidentally by wind farm personnel.

Definition of Significant Impact on Threatened Species: Any impact that leads to a long-term decrease in the size of the local population.

For the purpose of this management plan, the **local population** comprises those individuals that occur in a geographically distinct region that is ecologically relevant to the species in question.

Note that the wind farm related mortality of a Brolga will be immediately assessed as a significant impact at a local population level and mitigation applied accordingly, in accordance with the 'no net impact' objectives in DSE (2011).

5.1.2. Operational Procedure

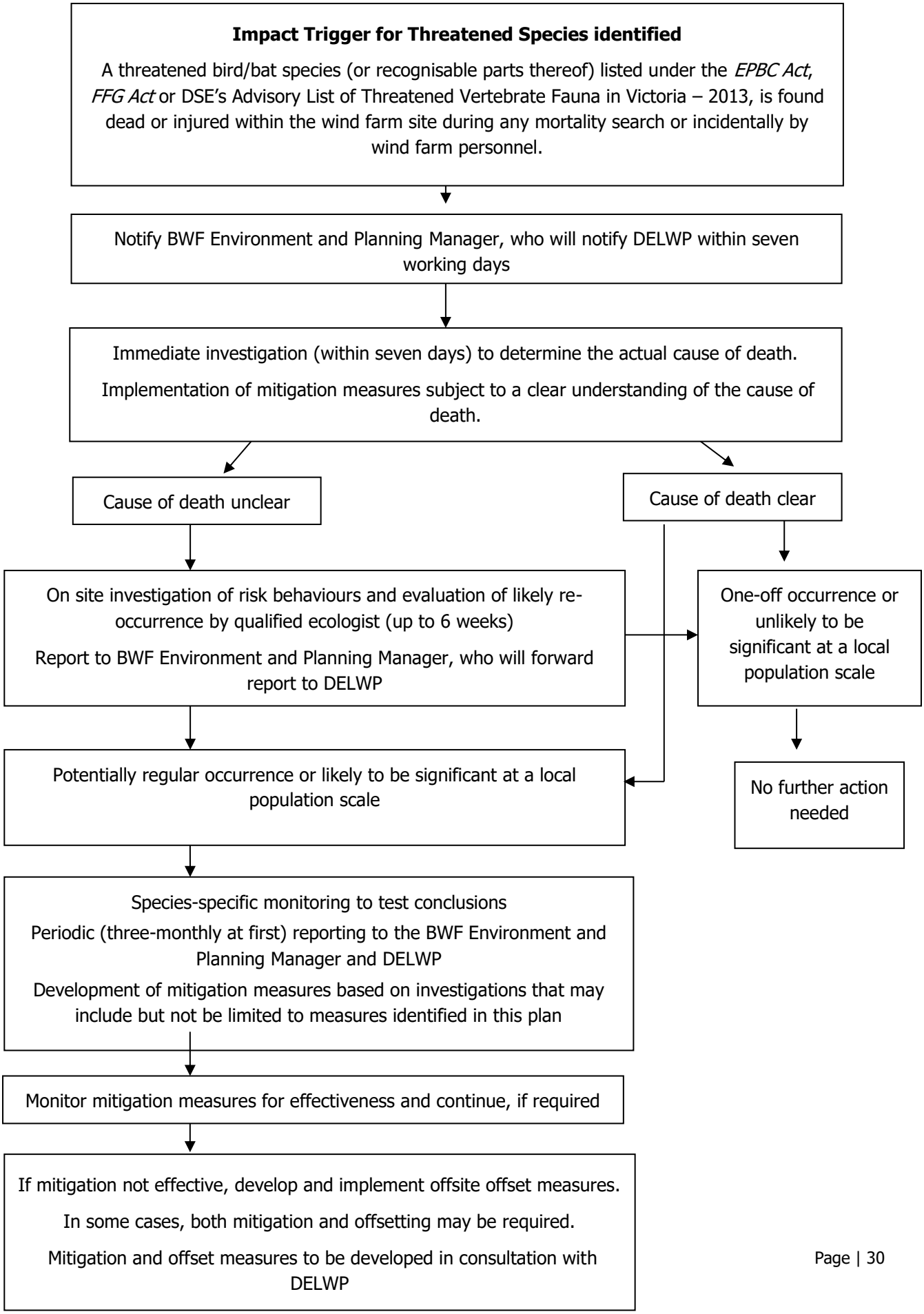
If an impact trigger on threatened species occurs, further investigation will immediately be triggered and the procedures outlined below and in Figure 4 will be followed. All investigations, decisions regarding significant impacts and implementation of mitigation and/or offset measures will be undertaken in consultation with DELWP and Corangamite and Golden Plains Councils and will be enacted to the satisfaction of the Minister for Planning.

- Immediate reporting of the impact trigger to BWF Environment and Planning Manager, who will report it to DELWP within seven days of it being recorded.
- Immediate investigation (within seven days) by an appropriately qualified ecologist of the on-site occurrence of the affected bird or bat species to identify any particular risk behaviours that could have led to the collision or lead to further collisions. An investigation is necessary to determine the actual cause of death/injury (in the unlikely event that the animal was, for

example, shot). The impact trigger may be one-off or cluster events. The investigation should therefore also focus on the evaluation of the likelihood of further occurrences (e.g. through engagement with key species experts, undertaking a literature review, assessment of habitat, etc).

- The rapid one-week investigation will assess the most effective mitigation and will ensure that the mitigation is implemented correctly and quickly (within seven days), if possible, subject to a clear understanding of the cause of the potential significant impact.
- If the cause of the fatality is deemed to be a one-off occurrence or unlikely to be significant at a local population scale, no further action may be necessary.
- If the cause of the impact trigger is not clear, further onsite investigation of risk behaviours and evaluation of likely re-occurrence will be required over the following weeks (up to six weeks). If these investigations suggest that the impact trigger was a one-off or unlikely to be significant at a local population scale, no further action may be necessary.
- If the onsite investigation suggests that the impact trigger may be a regular occurrence or significant at the local population scale, species-specific monitoring may be required. During the monitoring period, periodic (three-monthly at first) reports will be provided to DELWP.
- Responsive mitigation measures will be developed and implemented as needed and in a timely manner. Examples of mitigation measures may include but are not limited to those outlined in section 6.1.
- If mitigation measures are not possible or effective, offsetting measures will be implemented, as outlined in section 6.2. In some circumstances, both mitigation and offsetting may be required.

Figure 4: Operational procedure for identifying and mitigating significant impacts for Threatened Species



5.2. Non-threatened species

5.2.1. Definition of Impact Trigger and Significant Impact

The circumstances that define an impact trigger and significant impact for non-threatened birds and/or bats under this Management Plan is detailed below.

Impact Trigger for Non-threatened Species: In any two successive monthly carcass searches, two or more bird or bat carcasses (or parts thereof) of a non-threatened species, other than ravens and magpies, are found within the wind farm footprint (i.e. a total of four or more carcasses of the same species in two successive searches)

Definition of Significant Impact for Non-threatened Species: Any impact that leads to a long-term decrease in the size of a population at a relevant population scale.

Note that although the impact trigger does not include ravens, magpies and introduced species detected mortalities. These species will still be reported as part of the annual reporting process.

5.2.2. Operational Procedure

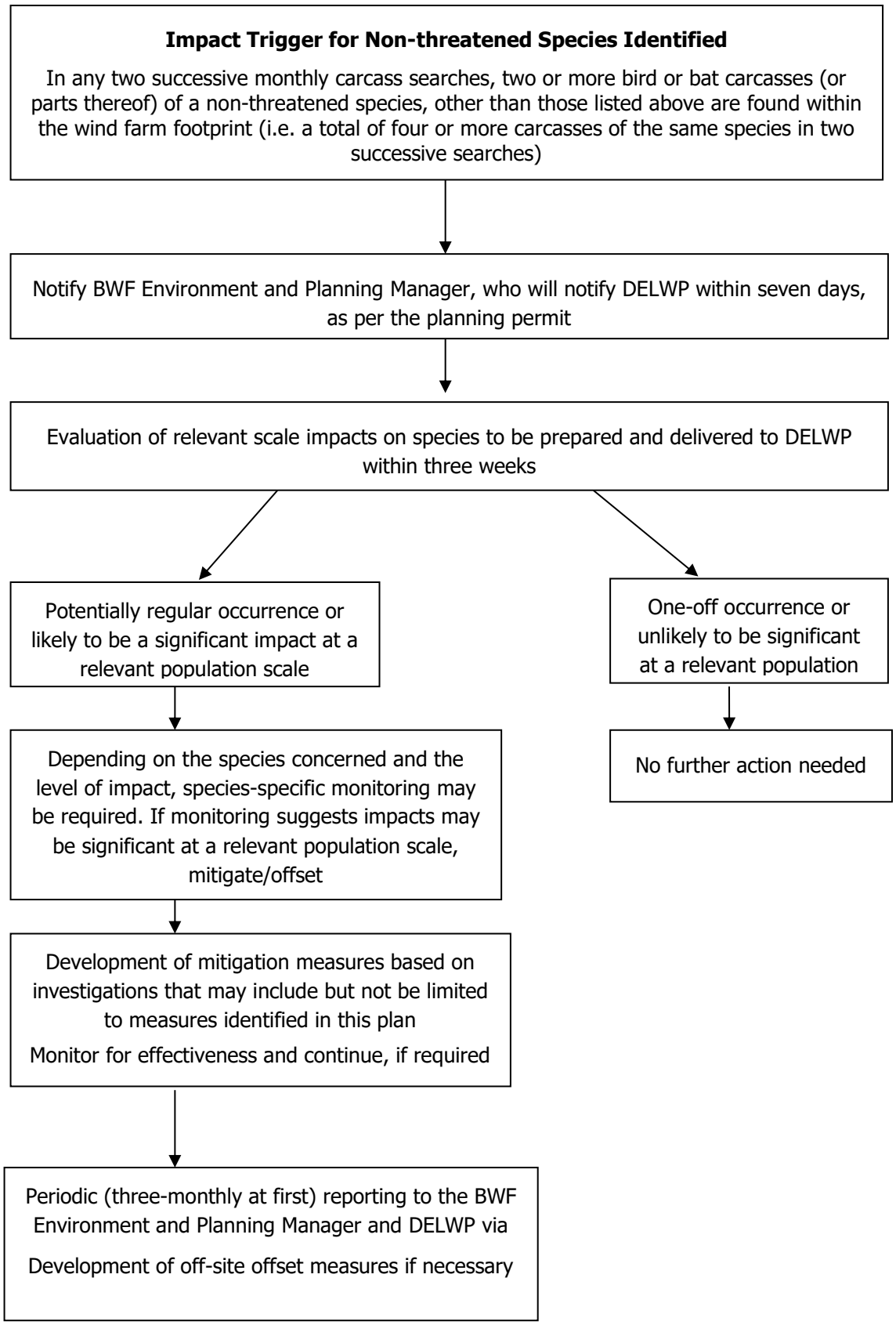
In the event that an impact trigger for non-threatened species is detected, an evaluation of impacts to the non-threatened species will be undertaken. DELWP and Corangamite and Golden Plains Councils will be notified of the impact trigger within seven days of recording the event. An appropriate scale to consider population effects (e.g. local, regional, entire population) will be agreed between DELWP, Corangamite and Golden Plains Councils and the proponent on a case-by-case basis with consideration given to the species in question.

A report on the investigation will be delivered to DELWP within three weeks. If the evaluation indicates that the event was a one-off occurrence or is unlikely to be a significant impact at a relevant 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 be a significant impact at a relevant population scale for the species in question, species-specific monitoring may be required (Figure 5). If further monitoring confirms that impacts are likely to be significant at a relevant population scale, mitigation measures will be required. Potential mitigation measures are outlined in section 6.1, however specific mitigation measures will be determined based on the species involved and outcome of investigations.

Any evaluation of impacts and decisions regarding mitigation and/or offsets required will be undertaken in consultation with and agreement from DELWP.

Figure 5: Operational procedure for identifying and mitigating significant impacts for non-threatened species



6. MITIGATION AND OFFSET MEASURES

Depending on the nature, cause and significance of the impact trigger, mitigation and offsetting may be required. The objective of mitigation and offset measures is to ensure that the Berrybank Wind Farm does not lead to significant impacts on threatened or non-threatened bats and/or birds over the life of the wind farm.

6.1. Mitigation measures

Mitigation involves implementation of measures to avoid and reduce the risk of an impact trigger occurring or continuing to occur. Any mitigation measures deemed necessary will be developed and implemented in consultation with DELWP Environment Portfolio, Corangamite and Golden Plains Councils and to the satisfaction of the Minister for Planning.

Mitigation measures may include but not be limited to the following.

- Habitat modification, vegetation planting/removal
- Changes in land use practices (including stock management, stock grain-feeding) near turbines, subject to negotiation with landowners.
- No or reduced cropping/sowing around or near turbines
- Bird deterrence
- Increasing turbine and powerline conspicuousness by rotor patterns, marking and/or audible signals/echolocation
- Changes to lighting of turbines
- Temporary turbine curtailment for high risk periods/locations
- Using acoustics to deter bats at night.
- In relation to the Brolga, measures to increase powerline visibility of any new lines constructed as part of the project will be undertaken.

It is difficult to anticipate how a significant impact may arise and therefore what mitigation would be required. However, if a significant impact is detected, the cause may be evident immediately (e.g. particular land use practice) in which case immediate mitigation must be implemented (within seven days). Where a solution is not immediately evident, it will be the subject of further investigation and subsequent response. If further investigations show that mitigation measures are not possible or effective, offsetting measures will be implemented, as outlined in the following section.

Any required investigation, and recommended management and mitigation measures, will be documented in a specific management plan, consistent with the consent conditions. This management plan will be discussed with relevant authorities. A monitoring program to determine the effectiveness of any ongoing mitigation measures will be included in any specific management plan. The monitoring program will be of a duration and frequency to adequately determine success or failure of mitigation measures.

6.2. Offsetting significant impacts

When offsetting a significant impact, the type of offset should reflect the type and degree of impact and the species involved. For significant impacts, the objective of any offset should be ‘no net impact’ for that species. The required offset will be determined in consultation with DELWP Environment Portfolio, Corangamite and Golden Plains Councils and will be undertaken to the satisfaction of the Minister for Planning.

Potential offset options include the following.

- Habitat/wetland rehabilitation (bird and bat)
- Supporting captive breeding programs (bird and bat)
- Roosting and maternity cave rehabilitation (bat)
- Increasing food availability away from wind farm site (bird and bat).

A generalised framework is described below to ensure that if significant impacts cannot be completely mitigated then off-setting arrangements can be discussed and agreed upon with the relevant authorities. In some circumstances both mitigation and offsetting may be required, regardless of the effectiveness of mitigation measures. Arrangements for agreeing on offsetting measures are summarised below.

- Should a significant impact not be mitigated through on-site management then offsetting off-site would be triggered
- A meeting would be organised between BWF and the relevant authorities and government (e.g. DELWP) experts to discuss and agree on offset options
- Offsetting would be commensurate with the level of impact (to be determined after the investigations undertaken as part of the operational procedure in Figure 4 and 5)
- Offsets must be initiated within 12 months of the detection of a significant impact and continued for as long as a significant impact continues that cannot be mitigated through on-site management. Offsets will be monitored and evaluated for their effectiveness and any alterations will be made accordingly to achieve the desired outcomes (in consultation with the relevant authorities).

In the case of the Brolga, the recent regional framework for impact assessment established by DELWP (then DSE) provides an excellent basis for agreeing offset measures (DSE 2011). This framework is based on a Population Viability Assessment that can model the population impacts of wind farm effects, as well as the population impacts of mitigation and offsetting

7. SUMMARY OF BAT AND AVIFAUNA MANAGEMENT PLAN

Season / Timing	Management Strategy	Management Activity	Persons responsible	Performance Indicator
Pre-construction	Consultation with the Lismore Land Protection Group	Identify all known or potential breeding and flocking sites within 3.3km and 5km of turbines respectively. These previously identified Brolga breeding and flocking sites will be included in the annual Brolga monitoring program.	Berrybank Wind Farm owner/operator	Consultation undertaken
Pre-construction	Adopt bird risk reduction measures (section 4.4)	Marking of powerlines to increase visibility for birds	Berrybank Wind Farm owner/operator	No change in bird mortality, species number, species diversity as a result of the wind farm and associated infrastructure
Prior to implementation of BAM	Pre- Bat and bird mortality monitoring	Source a permit under Wildlife Act to collect and store carcasses on site. Provide DELWP with details of qualification of personnel undertaking monitoring program.	Berrybank Wind Farm owner/operator	Permits obtained and qualifications of personnel involved provided to DELWP prior to implementation of BAM
3 months prior to implementation of BAM	Pre- Bat and bird mortality monitoring	Pre-monitoring meeting with DELWP and the subject Councils, at least three months prior to the commencement of monitoring	Berrybank Wind Farm owner/operator	Meeting undertaken
Post-construction	Bat and bird mortality monitoring	Carcass searches Scavenger trials Searcher efficiency trials Incidental carcass finds Analysis of results	Approved monitoring program consultant	Monitoring complete
	Brolga monitoring program	Undertake one survey per month during the breeding season (July to December) and flocking season (January to June) within 3.2km and 5km respectively All Brolga observed will be recorded and their behaviour noted. If breeding or flocking activities observed this will trigger a more intensive monitoring program. Breeding and flocking surveys will be undertaken in Year 1 after the first turbine has been	Approved monitoring program consultant	Ensure Brolga breeding or flocking within 3.2km and 5km respectively will not be impacted by the wind farm

Season / Timing	Management Strategy	Management Activity	Persons responsible	Performance Indicator
		commissioned. Two more annual surveys will be undertaken in the following four years of operation including one annual survey to be undertaken in a wet year.		
Post-construction	Implement mitigation measures in the event that an unacceptable impact is identified	Habitat management		Reduce perching and roosting opportunities near the turbines Reduce habitat for prey species under the turbines through reducing foraging, commuting and nesting opportunities
		Turbine and associated structure management		Manage external lighting Turbine switch-off protocol where unacceptable bird and / or bat mortality has been detected
		Powerline management		Place visibility tags (or other markers) along any new powerlines constructed as part of the project to reduce collision risk
		Carcass management		Removal of foraging opportunities under the turbines.
		Pest management		Refer to separate report (BL&A 2019)
Post-construction	Documentation	Annual report at the end of years one and two documenting mortality monitoring and other results. Annual report documenting Brolga monitoring completed in the same year that monitoring undertaken (three years over the first five years following commission of the first turbine)		Report completion

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Appendix 1: Carcass search data sheet

BERRYBANK WIND FARM - BIRD IMPACT 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**					
Collector:					
Date:					
Start Time:					
Finish Time:					
Turbine Number:					
Vegetation	**Type**				
	Height				
	Density				
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):					
Post Find Actions: 1. Place carcass in sealable plastic bag then wrap it in newspaper and take to freezer at site office. 2. A copy of this completed form will be sent to the Regional Manager, South West Region, Department of Sustainability and Environment, PO Box 103, Geelong, Vic 3220 within seven days of the date of the carcass find.					
* One form should be completed for each carcass found					
** Please attach photo to this form					

Appendix 2: On Generating Mortality Estimates in Australia/New Zealand

symbolix

To: Annabelle Stewart
Brett Lane & Associates
via email

Ref #: BLAMERCL20120612
Date: 12th June, 2012
CC: Brett Lane

Re: **On generating Mortality estimates in Australia/New Zealand**

Dear Annabelle,

In response to recent conversations about mortality searches in Australia we have compiled the following overview of mortality estimation for wind farms. This letter outlines the background information that has guided our recent advice. This information forms part of our ongoing research in the field and is currently under preparation as part of a journal paper.

We note that mortality searches and estimation is an area of ongoing research. As such our advice is guided by a combination of statistical tests, current best practice, and practices on-ground at other Australian wind farms (as this increases the ability to compare sites in future).

Estimating mortality

Simply put, all approximations amount to accounting for the area surveyed (as a proportion of the area of concern) and accounting for the probability of detection, which consists of the searcher efficiency confounded with the probability of sample loss.

Attesting to the speed of output and effort of exploration in this space, there are multiple approaches to choose from and no clear supreme option. As a starting list, one might use: raw detection count, simple probabilistic scaling, Johnson et al. 2003, Kerns & Kerlinger 2004, Schoenfeld 2004 , Jain et al. 2007, Baerwald and Barclay 2009, Huso 2010 through to Korner-Nievergelt et al. 2011.

The amount of effort that has gone into these methods should be acknowledged, and not taken lightly. However, there remain issues, and application to local wind farms should be done with knowledge, care, and an adaptive attitude that allows later techniques to be applied.

Sampling effort – sampling fraction

This is the simple question of how many wind turbine generators (WTGs) to include in the sample. We do not specify a set fraction, as sampling fraction corrections are a staple of any mathematician, with history of application and correction extending well into last century (See for example Kish 1965 for an excellent overview). Issues such as stratification, clustering and sampling methods are all well established.

Best here is a logistic choice, being the most WTGs that can be consistently and meaningfully surveyed. Stratification considerations need also be applied, with the barest minimum being two WTG's per stratum (under a specific paired design), with a realistic preference for a minimum of 6 randomly selected WTGs per stratum to adequately capture variation.

Sampling to optimise mortality estimation

It is common to come across complicated arguments for stratification and large surveying efforts when what is really desired is coverage, i.e. a sample that captures the background variability. Mortality sampling should be unbiased, and have coverage. This is again, a problem that is not unique to wind farms, and has simple, well-heeled solutions that do not contribute to the issues of mortality monitoring.

Our recommendations for carcass searches are simply based on published research of how far a carcass might fall from a given turbine (Hull & Muir 2010). The pulsed survey timing (one month for all species with a second survey 2-3 days later for small, readily scavenged species) is an attempt to reduce bias in mortality estimation due to scavenge rates much smaller than time between searches.

Detectability and scavenge loss

The two main contributors to a mortality estimate (regardless of the method used) are the detector efficiency and the sample loss rate due to scavengers. To determine these two parameters, one should be aware of the statistical difference between power and confidence.

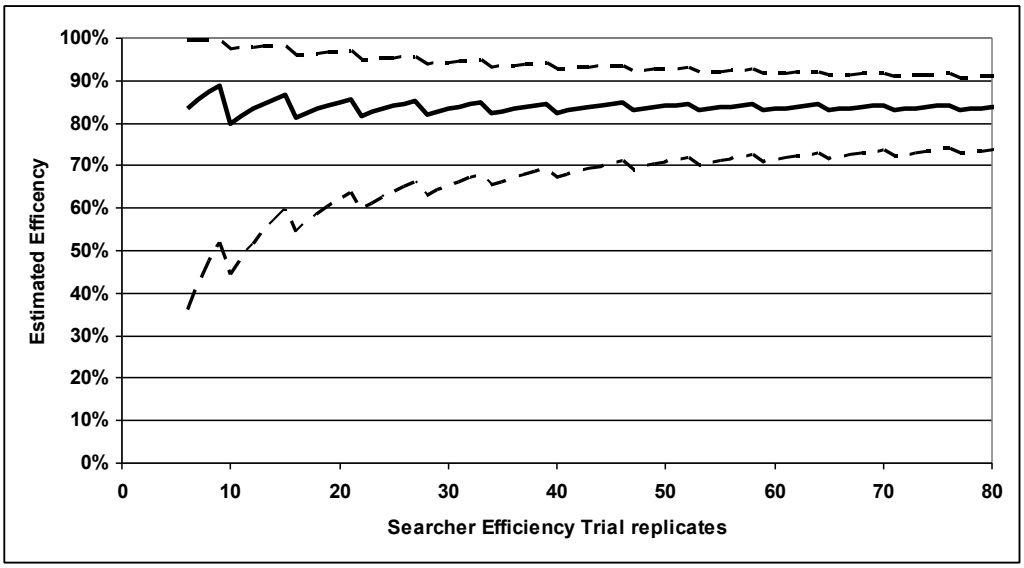
Power is only necessary if one wishes to "difference" the inputs, i.e. work with the difference between winter and summer parameters. For most instances, stakeholders are more concerned with confidence, or the resulting uncertainty in the measurement of a parameter.

Detector efficiency

As one is unlikely to be trying to determine the difference in detector efficiency between seasons or detectors, it is usually entered as a single parameter in mortality estimation. [1]

The issue of replicates for determining optimal replication and coverage is explored below. In this case a replicate is a single carcass of a given size class.

[1] On a technical note, it has been shown that having a non-constant detectability leads to a bias in the current field of estimators (Huso 2010 and Korner-Nievergelt et al. 2011). Consequently, incorporating changeable searcher efficiency will result in less variance in the output, but almost assuredly at the cost of a consistent bias in the projection.



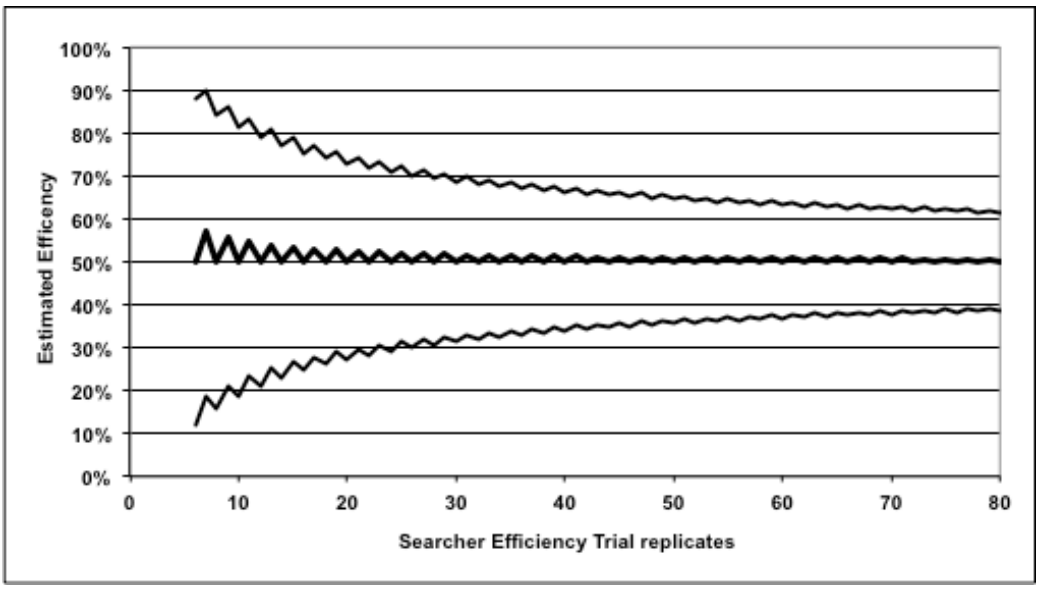


Figure 1 : Estimated searcher efficiency and 95% confidence bounds for N trials. Assumes searcher efficiency of 83.7% (top) and 50% (bottom).

The above chart (Figure 1) has been calculated (Cloppers & Pearson 1934) as a scenario to highlight the issues with detectability trials. We have assumed that the "true" observer efficiency is 83.7% (top) and 50% (bottom). The relative size of the confidence interval is not sensitive to the actual observer efficiency.

Note that, like most measures, detectability cannot be precisely measured in integer counts until at least one thousand replicates have been performed. Consequently, 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 dashed lines. 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").

Notice that 10 replicates is the minimum amount of effort to have a meaningful measure. This indicates why 10 replicates is a commonly used rule of thumb for minimum effort, and is an enforced minimum in recent software estimators (Bispo et al 2010). Note also, that there is very little to be gained in trialling more than 40 samples.

At this point, it may be worth considering differencing a covariate, such as spring/autumn. The effort required to separate detectability in autumn from spring can be deduced formally from a power analysis. However, the above chart indicates that you will be unlikely to be able to split the two seasons (to 95% confidence) unless the difference between the average detectability is greater than 20-30% (even with 20 replicates in each season).

Given that there is a possibility of a large difference between autumn and spring, and surveying in both also allows coverage of the year, we suggest two detectability surveys timed for maximum detectability difference. Because of the natural variability within a survey, splitting data collection into multiple surveys is unlikely to improve either confidence or power for the additional cost.

We also suggest 20 replicates per carcass size class per year (10 in spring, 10 in autumn), which will provide a reasonable detectability estimate after one year, and optimal after two. This balances statistical confidence with the logistic difficulties in sourcing carcasses.

Scavenge loss rate

The issues attached to determining a loss rate are not as awkward as those of the searcher efficiency, due to the nature of the variable. However, the loss rate is intimately connected to the accuracy of the projections, possibly much more so than the searcher efficiency.

Loss of the sample, and the resulting correction term in mortality estimates, is affected by the shape of the loss curve as well as its average value, as follows:

There are basically three processes through which the sample can be lost, and these interact intimately with the surveying frequency.

1) The loss rate is a constant over time (known as an exponential form)
2) The loss rate is initially very low, then accelerates (can be considered the "olfactory" scavenger's form)
3) The loss rate is highest initially, then diminishes (the "visual" scavenger form)

Whether one is determining the shape, or the expectation, "windows" are very important. That is, we cannot ever know the exact time of loss, only the interval in which it occurs.

What is often overlooked though, is the fact that irrespective of the form of loss, interval uncertainty "costs" more at the lower end of the scale than at the upper. For instance, if the time at loss is 6 hours, being uncertain to plus or minus twelve hours is catastrophic to the utility of the datum point. If the loss was at five days, knowing to plus or minus twelve hours amounts to little additional loss of insight. This is the case even for the simplest assumption of constant loss rate (exponential).

So, for scavenger trials, one needs to focus on an uneven time sample, to generate the information. Check the samples early and often, then taper off the effort.

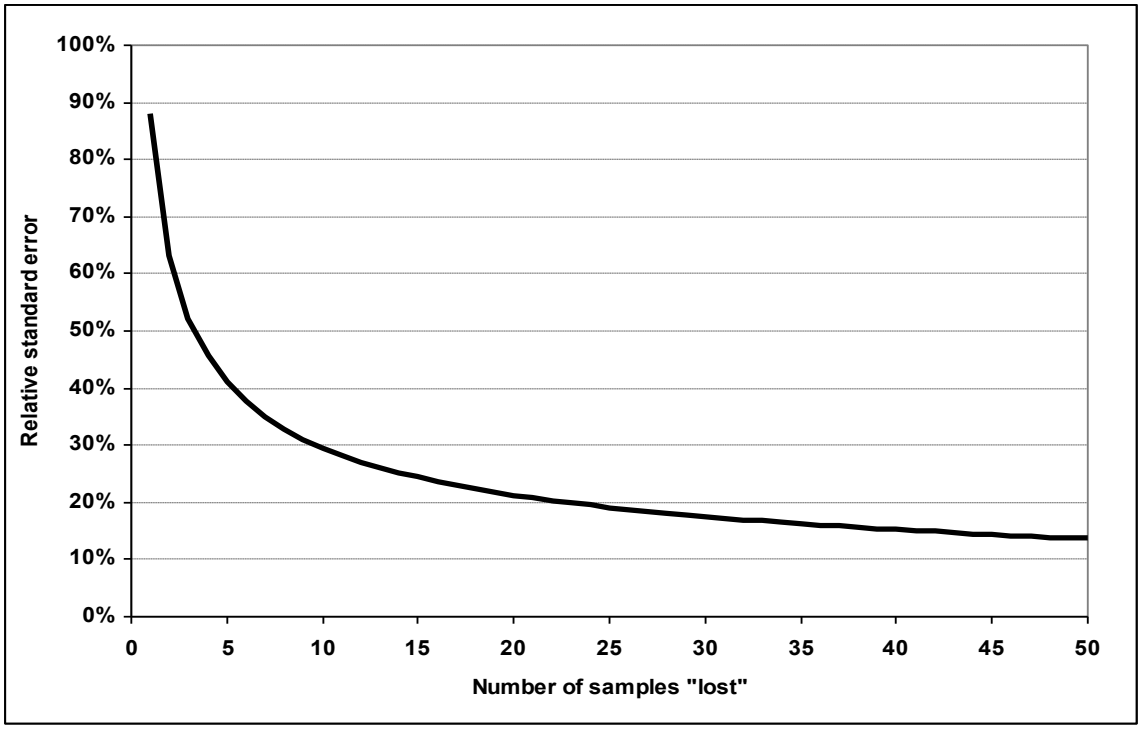


Figure 2 : Simple RSE of average loss time, assuming N losses in the trial period

To determine how many replicates are needed for confidence in the loss rate estimate, we take the simplest loss scenario – a constant rate of loss. Without a pilot study, this is a reasonable scenario to base the survey design upon, as it is the 'middle ground' of the three scenarios above and the most commonly assumed form in mortality estimation. Under this assumption, Figure 2 is the analytical relationship between the number of carcasses lost in a survey period and the relative standard error (RSE) in the average estimate.

The mathematical properties of the constant rate of loss scenario (Poisson distribution) mean that the actual survey length does not come into play. That is, a loss of 10 carcasses over one month yields the same RSE as the loss of 10 carcasses over a week, or three months. Nor is the RSE affected by changes in the survey interval length throughout the month. For an informative exposition of this distribution we suggest Engelhart. 1994.

From Figure 2 we can see that 10 replicates is a good start and any more than 40 or 50 trials produces diminishing returns. As for the searcher efficiency, we wish to treat the two size classes independently, and so are interested in our resolution confidence (above chart) and not the resolution power.

Considering these points, running scavenge trials concurrently with detectability trials (10 replicates, twice per year) is reasonable to establish the rate and 'shape' of scavenge for the purpose of mortality estimation.

Summary

We hope that the technical information provided here will assist in understanding the statistical considerations that underpinned the management recommendations we have provided as inputs to recent BAM plans.

Regards,

Dr Stuart Muir
Director, Design & Analysis; Symbolix Pty Ltd

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