GOLDEN PLAINS WIND FARM

EES REFERRAL
INITIAL BROLGA IMPACT ASSESSMENT

WestWind Energy

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ACRONYMS

AESDT	Australian Eastern Standard Daylight-savings Time
AusWEA	Australian Wind Energy Association
AVW	Atlas of Victorian Wildlife
BCS	Bioregional Conservation Status
BL&A	Brett Lane and Associates Pty. Ltd.
BOCA	Bird Observation and Conservation Australia
BOM	Bureau of Meteorology
CAMBA	China-Australia Migratory Bird Agreement
cm	Centimetre/s
C'wth	Commonwealth
CVU	Central Victorian Uplands bioregion
DBH	Diameter at Breast Height
DEWHA	(former) Department of the Environment, Water, Heritage and the Arts (C'wth)
DEPI	Department of Environment and Primary Industries (Vic)
DISTLM	Distance-based multivariate analysis for linear model
DNRE	(former) Department of Natural Resources and Environment (Vic)
DoEE	Department of the Environment and Energy (C'wth)
DSE	(former) Department of Sustainability and Environment (Vic)
DSEWPaC	(former) Department of Sustainability, Environment, Water, Population and Communities (C'wth)
EES	Environment Effects Statement under the *Environmental Effects Act 1978*
EPBC Act	Environmental Protection and Biodiversity Conservation Act 1999 (C'wth)
ESO1	Environmental Systems Overlay – Schedule 1
EVC	Ecological Vegetation Class
FFG Act	Flora and Fauna Guarantee Act 1988 (Vic)
FIS	Flora Information System
FZ	Farming Zone
GEWVVP	Grassy Eucalypt Woodland of the Victorian Volcanic Plain
GIS	Geographic Information Systems
GHCMA	Glenelg Hopkins Catchment Management Authority
GPS	Global Positioning System
ha	Hectare/s
intro.	Introduced
km	Kilometre/s
m	Metre/s
min	Minute/s
JAMBA	Japan-Australia Migratory Bird Agreement
NCR	Nature Conservation Reserve
NRC	National Research Council
NTGVVP	Natural Temperate Grasslands of the Victorian Volcanic Plain
NVIM	Native Vegetation Information Management system
NVMF	Native Vegetation Management Framework
NWCC	National Wind Coordinating Committee
OMNR	Ontario Ministry of Natural Resources
PVA	Population Viability Assessment

RDZ1	Road Zone Category 1
RoI	Radius of Investigation
RSA	Rotor Swept Area
SHWTLP	Seasonal Herbaceous Wetlands (Freshwater) of the Temperate Lowland Plains
VBA	Victorian Biodiversity Atlas
Vic	Victoria
VROTS	Victorian Rare or Threatened Species
VVP	Victorian Volcanic Plain bioregion
WBPGWFC	Western Basalt Plains (River Red Gum) Grassy Woodland Floristic Community
WPGC	Western (Basalt) Plains Grassland Community

1. EXECUTIVE SUMMARY

WestWind Energy Pty Ltd engaged Brett Lane & Associates Pty Ltd (BL&A) to undertake an assessment of the impacts on the state-threatened Brolga (*Grus rubicunda*) from the proposed Golden Plains Wind Farm (GPWF) in western Victoria. This report has been specifically prepared to accompany the Environment Effects Statement Referral, which is required under the *Environment Effects Act 1978.* The assessment follows the procedure and methods in DSE (2012) *Interim guidelines for the assessment, avoidance, mitigation and offsetting of potential wind farm impacts on the Victorian Brolga Population 2011* referred to hereafter as the 'Brolga Guidelines'.

This report presents the results of Brolga investigations undertaken between July 2016 and April 2017, describes how risks to the species have been minimised and provides a strategy for the project to achieve the objective of the Brolga Guidelines, namely to ensure that each wind farm development has *at a minimum a zero net impact on the Victorian Brolga population* (DSE 2012, p.6).

The proposed GPWF is 17,345 hectares of land in the Golden Plains Shire. The proposed wind farm comprises up to 231 turbines, access tracks, underground cabling and associated infrastructure, such as temporary site office, temporary batching plant, and a substation. The access tracks on the wind farm site connect to the public road network at several points.

Wind Farms in Victoria, regardless of whether they are assessed via a planning permit or Environment Effects Statement (EES) process must meet the policy objective of *Zero Net Impact* on the Victorian Brolga population. To achieve this objective of the Brolga Guidelines, three levels of assessment must be conducted. Information is gathered at each assessment level to inform impact assessment, mitigation and offset strategies. Each level also informs the next and all three levels are applied if there is potential for a significant impact that requires informed mitigation and offset. The Guidelines require regular consultation with the state Department of Environment Land Water and Planning (DELWP).

West Wind Pty Ltd and BL&A have undertaken extensive discussions with key environment, planning and technical personnel in DELWP to ensure that the application of the Brolga Guidelines to the Golden Plains Wind Farm is as required. DELWP have also been consulted in relation to the development of turbine-free buffers around breeding sites, as required by the Guidelines, and this report has benefited from extensive technical discussions with DELWP on how these buffers are defined and on the inputs to and results of the collision risk modelling (CRM) process.

The findings to date from this investigation are summarised below.

- A significant proportion of the wetlands in the RoI have been permanently drained and are no longer considered suitable for future use by Brolgas.
- A significant proportion of the RoI, in particular the western and northern portions lack wetlands and the Brolga has not historically been recorded there.
- An estimated population of eight pairs of Brolgas occurs in the southern and eastern parts of the RoI, representing less than two percent of the Victorian population of the species (estimated at between 800 and 900 birds);

- Selected suitable wetlands in the RoI occur mostly to the south of the proposed GPWF, with a small number of sites within and to the north of the southern section of the proposed wind farm.
- Two breeding wetlands occur within the southern section of the proposed wind farm.
- Brolgas have been recorded during the flocking season within the RoI, most regularly at Lake Weering, about 9 kilometres south of the proposed wind farm. Six flocking season records of 10 or more birds elsewhere in the RoI were found to be one-off flocking records and did not involve regular use of a wetland for overnight roosting purposes.
- Based on the activity of the Brolga in the RoI, the focus of assessment and mitigation has been on the use of the area for breeding. Much less risk is considered to arise from the sue of the area during the flocking season.
- Mitigation of risks to the Brolga involves the establishment of turbine free buffers around breeding sites on and near the wind farm. As no site-specific studies could be undertaken, it has been assumed that Brolgas move up to 3.2 kilometres from their breeding wetland. Turbine-free buffers have been developed by removing 12 turbines and adjusting the positions of five turbines at Brolga breeding sites within or closest to the wind farm.
- For remaining sites, the risks associated with the 99 turbines that remain within 3.2 kilometres of breeding wetlands have been considered based on the presence of wetland habitat (preferred by the Brolga beyond 400 metres from breeding wetlands) within this movement zone. In all cases this involves a very limited number of small wetlands.
- The impacts of the project on the Brolga have been assessed through the development of a collision risk model that integrates spatial modelling of the probability of occurrence of the Brolga at RSA height across the landscape and the Scottish Natural Heritage turbine collision risk model.
- Model inputs have been developed from available information on the movements of Brolgas around breeding sites elsewhere in its Victorian range.
- The collision risk model results indicate that between two and 21 Brolgas may be lost from the population as a consequence of the Golden Plains Wind Farm.
- The Brolga Guidelines require that any Brolgas impacted by a wind farm are replaced through the implementation of a Brolga Compensation Plan. For the proposed project, this will focus on producing more young Brolgas by effectively managing additional breeding sites in cooperation with private landholders for the life of the project.

The Population Viability Assessment, together with the full Brolga Compensation Plan will be presented in the final development application.

This impact assessment has relied upon a combination of empirical and modelled results. The modelled results have been based on conservative assumptions, including:

- The wind turbines will operate 24 hours per day;
- They will operate at their maximum rotation speed (12 revolutions per minute) all the time;
- The maximum likely number of eight breeding pairs occurs in the RoI every year, as occurred in 2016, a year of above average rainfall and breeding habitat availability.

- There is an equal likelihood that the 23 breeding wetlands will be used by the eight pairs each year. It is noteworthy that landowners indicated that the wetlands within the wind farm and some of those to the north east were used rarely, and much less frequently than assumed.

These conservative assumptions ensure that the modelled results used to assess the impacts of the wind farm on the Brolga are more likely to over-estimate impact than under-estimate it.

The Brolga Guidelines are designed to prevent the Victorian wind energy industry from having a cumulative, unacceptable impact on the Victorian Brolga population by requiring Zero Net Impact from each project. This assessment has demonstrated that this is feasible for the Golden Plains Wind Farm.

2. INTRODUCTION

WestWind Energy Pty Ltd engaged Brett Lane & Associates Pty Ltd (BL&A) to undertake an assessment of the impacts on the state-threatened Brolga (*Grus rubicunda*) of the proposed Golden Plains Wind Farm (GPWF) in western Victoria. This report has been specifically prepared to accompany the Environment Effects Statement Referral, which is required under the *Environment Effects Act 1978*, and it presents the results and conclusions to date from the extensive Brolga studies that are underway for the development application. The assessment follows the procedure and methods in DSE (2012) *Interim guidelines for the assessment, avoidance, mitigation and offsetting of potential wind farm impacts on the Victorian Brolga Population 2011* referred to hereafter as the 'Brolga Guidelines'.

Information is presented on the results of Brolga investigations undertaken between July 2016 and April 2017, including how risks to the species have been minimised and a strategy for the project to achieve 'zero net impact' on the Victorian Brolga population, as required of wind farms in Victoria in the Brolga Guidelines. Full results of the assessment will be provided in the final development application that will be prepared for the project. This will include the results of continuing monitoring of Brolga activity in the area as well as a Population Viability Assessment as required by the Brolga Guidelines and a full Brolga Compensation Plan demonstrating how Zero Net Impact is to be achieved.

The proposed GPWF is 17,345 hectares of land in the Golden Plains Shire. The proposed wind farm comprises up to 231 turbines, access tracks, underground and limited overground cabling, terminal station at the 500 Kv powerline that passes through the site and associated infrastructure, such as temporary site office, temporary batching plant, and a substation. The access tracks on the wind farm site connect to the public road network at a number of points. The GPWF is described in more detail in Section 3 below.

These assessments were undertaken by a team from BL&A, comprising Jackson Clerke (Zoologist), Teisha Lay (Zoologist), Peter Lansley (Senior Zoologist), Curtis Doughty (Senior Zoologist), Bernard O'Callaghan (Senior Ecologist & Project Manager), Inga Kulik (Senior Ecologist & Project Manager) and Brett Lane (Principal Consultant).

The complete Brolga assessment will be presented in the development application. The current report has been prepared to accompany the Environment Effects Statement (EES) Referral. The Referral will assist the Minister for Planning in deciding if an EES is required under the Victorian *Environment Effects Act 1978* (EE Act). This Brolga assessment follows the procedure and methods in DSE (2012) *Interim guidelines for the assessment, avoidance, mitigation and offsetting of potential wind farm impacts on the Victorian Brolga Population 2011* referred to hereafter as the 'Brolga Guidelines'. Whether the GPWF is required to be assessed through a planning permit or EES process, there will be no difference in the framework adopted for assessing, avoiding, mitigating and offsetting Brolga impacts

The objective of the Brolga Guidelines is to ensure that each wind farm development has *at a minimum a zero net impact on the Victorian Brolga population* (DSE 2012, p.6). To meet this objective, three levels of investigations must be conducted. Information is gathered at each investigation level to inform the impact assessment and mitigation strategies. Each level also informs the next and all three levels are applied if there is potential for a significant impact that requires informed mitigation and offset.

West Wind Pty Ltd and BL&A have undertaken extensive discussions with key environment, planning and technical personnel in DELWP to ensure that the application of the Brolga Guidelines to the Golden Plains Wind Farm and the method of achieving their required outcome of a Zero Net Impact on the Victorian Brolga population is to their satisfaction. DELWP have also been consulted in relation to the development of turbine-free buffers around breeding sites, as required by the Guidelines, and this report has benefited from extensive technical discussions with DELWP on how these buffers are defined and on the inputs to and results of the collision risk modelling (CRM) process. This report has also benefitted from extensive review and feedback from DELWP, for which BL&A is extremely grateful.

Further details on the Brolga Guidelines and their application in this work is summarised in Table 1. This also indicates where the relevant information can be found in this report.

Table 1: Three level assessment of wind farm impact on Brolga: current investigation

Level	Step	Assessment triggers (as per DSE 2012)	Current investigation - outcomes and actions
Trigger for Level 1		The proposed wind farm site is situated within the Victorian range of the Brolga The presence of Brolga within the radius of investigation (i.e. within 10 km of the proposed wind farm boundary) The presence of potential Brolga habitat within the radius of investigation OR The location of the proposed development is within an area that may be used by Brolga during seasonal movements between breeding and flocking habitats.	Level One Assessment triggered and conducted (see Section 4.2).
1	1	Undertake desktop studies into known and potential habitat areas for Brolga.	All available historical and recent Brolga records within the 10 km radius of investigation (RoI) have been collated and reviewed to identify the extent of Brolga occurrence in the RoI. (See section 4.2.1 and 4.2.2)
	2	Initial field inspection and local community consultation.	A site inspection was undertaken to identify potential Brolga breeding habitat on and around the proposed wind farm site. Extensive landholder consultation within the radius of investigation has been undertaken to identify potential Brolga flocking and breeding sites that may not be in the available databases or accessible during field studies. (See section 4.2.3)
Trigger for Level 2		Records of breeding or flocking habitats within the radius of investigation The proposed development is located in an area which may be used by Brolga moving seasonally between breeding and foraging sites, and may potentially create a barrier reducing movements between these habitats OR The proposed location of new powerlines associated with the development may create new collision risks for Brolga.	Level Two Assessment triggered and conducted. (See section 4.3)
2	-	The Level 2 Assessment collects comprehensive data about the location, nature and extent of	Site-specific investigations determined that the Brolga utilised the landscape surrounding the proposed Golden Plains Wind Farm and was

Level	Step	Assessment triggers (as per DSE 2012)	Current investigation - outcomes and actions
		Brolga habitats, and patterns of habitat use and behaviour at breeding, flocking and foraging sites within the radius of investigation.	recorded breeding in wetlands in the radius of investigation. The species does not flock within 5 kilometres of the wind farm (See section 4.3) Extensive site-specific field investigations were undertaken during breeding and non-breeding periods from 2016 to 2017 to document the extent of Brolga activity in the RoI and current and historical spatial patterns of activity. (See section 4.3.1)
Trigger for Level 3		Qualitative risk assessment (AusWEA 2005) of project following site design is greater than "low".	Level Three Assessment triggered by assessment of the project and conducted. (See section 4.4)
3	1	Avoid or mitigate all potential impacts to Brolga breeding and flocking home ranges within the radius of investigation with turbine-free buffer areas.	Existing data on the movements of Brolgas around their breeding sites was obtained from pooled data generated by past studies undertaken by BL&A in the species' range. (see Section 4.4.1) The turbine layout has been adjusted by removing 13 higher risk turbines from the layout based on the collision risk and by including corridors or turbine free areas between on-site breeding sites and habitats beyond the wind farm boundary. (See section 4.4.1)
	2	Develop a site-specific collision risk model for Brolga utilising or moving through the radius of investigation.	Turbine bird collision risk has been modelled for the life of the project. (See section 4.4.2, Appendix 3)
	3	Use PVA to estimate the impact of the proposed development.	The PVA will be prepared for the planning application. (see Section 5.1)
	4	Identify appropriate compensation strategies to ensure a zero net impact on the Victorian brolga population.	Compensation will focus on readily quantifiable outcomes, and the production of additional fledged young at restored and protected breeding sites at a rate that results in lost Brolgas being replaced in the population no later than 25 years after operations commence. (See section 5.2). Discussions are underway with the CCMA to identify restoration opportunities.

3. OVERVIEW OF PROJECT AND SITE

3.1. Proposed development

The Golden Plains Wind Farm will be located near Shelford, Rokewood and Barunah Park, approximately 60 kilometres north-west of Geelong, Victoria. It is roughly bounded by the Rokewood-Shelford Road in the north, Wingeel Road in the east, Cressy-Shelford Road and Ledwell Lane and Gillets Road to the south and Pitfield – Cressy Road to the west. The proposed Golden Plains Wind Farm is located in the Golden Plains Shire local government area and within the Corangamite Catchment Management Authority region.

It is estimated that the total area of all wind farm infrastructure will be around 178 hectares which will cover approximately 1% of the total site.

The GPWF is planned as follows.

- 231 wind turbines
- Wind turbine capacity - 3 to 5 Megawatts (MW)
- Wind turbine height - up to 230m from the natural ground level to the tip
- Wind turbine rotor - up to 150m in diameter
- Wind turbine lower rotor sweep - 40m from the natural ground level.
- Total installed capacity - Approximately 800 MW.

The wind farm layout has been adjusted to avoid, where practicable, and minimise impacts on native vegetation and fauna habitats on the site. All land within the site is currently used for agriculture and it will continue to be used for this purpose during and after wind farm construction.

Power reticulation will be underground within large clusters of turbines to collector stations and an internal set of transmission lines will connect from these to the 500 kV powerline that dissects the site. In total, the overground transmission lines will be 26 kilometres in length. They will be monopole configurations with the lowest insulators approximately 12.4 metres above ground with the highest wire mounted on each pole no higher than 21 metres above ground. Some sections of the line will have three wires attached to poles and other sections will have six wires attached to the poles. Poles will on average be approximately 150 – 180 metres apart. Figure 1 provides an overview of the project.

3.2. Geographic overview

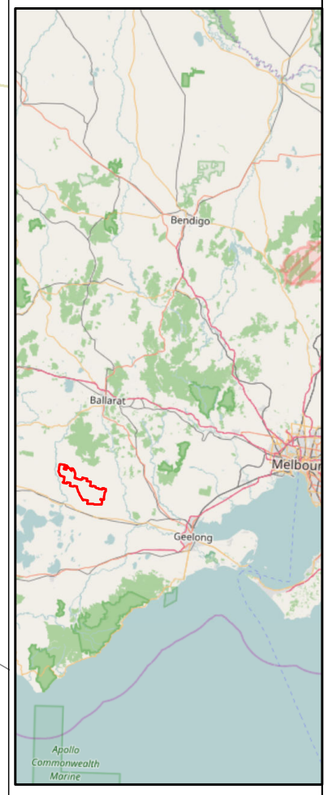
Most of the land is currently under agricultural use for both grazing and cropping. Wind breaks have been planted along some fence-lines with a mixture of native non-indigenous and introduced (exotic) trees. Grazed pastures are in places dominated by indigenous grass species and there are extensive areas of native grassland on the site. The need to minimise impacts on this grassland has been a significant constraint on the layout of the wind farm and extensive changes to the location of turbines, and many access tracks and underground power cable routes have been made to satisfy the principle of minimising the impacts of the project on native vegetation required under Clause 52.17 of the planning scheme. This is described in a separate flora and fauna assessment report that accompanies the EES Referral (BL&A 2017).

Figure 1: Overview and indicative layout

Project: Golden Plains Wind Farm
Client: WestWind Energy Pty Ltd
Date: 25/05/2017

Legend

- Wind Farm
- Turbines
- Overhead powerline
- Access tracks
- Underground cabling



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Wetlands occur on the site in the wet season (winter – spring) and several ephemeral creeks run through the site. Most of the wetlands in the study area are ephemeral, only filling to full capacity in very wet years. Most of these wetlands and waterways are dry by late December or earlier in dry years. Some deeper farm dams may hold water throughout the year.

4. BROLGA ASSESSMENT

4.1. Introduction

4.1.1. Policy and planning for wind farms

The policy and planning guidelines for wind farms in Victoria (DELWP 2016) require that the potential impacts of wind farms on species listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act) or the Victorian *Flora and Fauna Guarantee Act 1988* (FFG Act) be assessed.

One such species is the Brolga, which occurs in the region within which the proposed Golden Plains Wind Farm is located. The species is listed as threatened under the FFG Act and, consistent DELWP (2016), planning authorities must consider the impacts of wind farm developments on this species before making decisions on permit applications.

The application of the DSE (2012) Brolga Guidelines to this project is explained in more detail in Section 2.

4.1.2. This report

This report presents the results of Brolga investigations undertaken between July 2016 and April 2017, describes how risks to the species have been minimised and provides a strategy for the project to achieve the objective of the Brolga Guidelines, namely to ensure that each wind farm development has *at a minimum a zero net impact on the Victorian Brolga population* (DSE 2012, p.6).

The investigation area encompassed the proposed wind farm site as well as a ten kilometre zone around these areas, referred to as the 'radius of investigation' (RoI), as defined in the Brolga Guidelines (p. 13). Less frequent observations were made beyond the five-kilometre radius, the recommended maximum turbine-free buffer distance from wetlands used by Brolgas. The aerial survey however covered the entire 10 kilometre RoI.

The results of the Brolga assessment are presented in accordance with the three-level approach prescribed in the Brolga Guidelines, as follows.

- Level One Assessment
- Level Two Assessment, and
- Level Three Assessment.

In this section of the report, the methods and sources of information are described followed by the results for each level of investigation.

Before this, the biology of the Brolga in Victoria is discussed briefly below.

4.1.3. Species biology

Species description

The Brolga (*Grus rubicunda*) is listed as a threatened species under the FFG Act. Brolga belong to the family Gruidae (cranes), of which two species (including the Brolga) occur in Australia (Marchant and Higgins 1993). Cranes are generally large-bodied, long-legged and long-lived, with Brolga being very similar to other cranes in general ecology and biology.

Adults can range in weight between four and eight kilograms, and stand up to 1.8 metres tall with a wingspan of two metres. During the non-breeding season, Brolga can form large

flocks (occasionally as large as 200 birds) but typically are seen in small groups (10 - 20 individuals). Breeding pairs can form long-term bonds and, if one of the pair dies, the remaining individual can take several seasons to find another mate (Marchant and Higgins 1993).

Typically, pairs only produce one or two offspring per breeding season and therefore recruitment into the population is low.

The Brolga's annual cycle is divided into two principal parts:

- The breeding season, from July to December, during which territorial pairs nest in shallow freshwater wetlands that are often ephemeral, holding water reliably only in winter and spring; and
- The non-breeding (or flocking) season, from December to June, when Brolgas disperse from drying breeding wetlands to larger, often permanent wetlands to congregate with others to form flocks that roost at the wetland and move out to forage in adjacent terrestrial and wetland habitats (DSE 2012).

In between the breeding and flocking seasons, Brolgas move about the landscape between breeding and flocking sites or *vice versa* during two migration periods that can overlap with the months above.

Species status

The Brolga is a secure species nationally, numbering in the tens of thousands across northern Australia (Marchant and Higgins 1993). However, in Victoria the range of the Brolga has contracted since European settlement as a consequence of wetland drainage, loss of habitat due to agricultural development and predation of eggs and young by the introduced Red Fox. Its former range included northeast Victoria, Gippsland and the formerly extensive wetlands of the Melbourne region. Currently, birds are found in the south-west and in the north of the state in parts of the Murray River basin (Du Guesclin 2003).

Brolga distribution and movement in Victoria

The distribution of the Brolga in the main part of its Victorian range, the south- west, varies seasonally. In the breeding season adult pairs disperse to small and moderately sized seasonal or semi-permanent wetlands to breed as territorial pairs. At this time, small numbers of non-breeding birds can form flocks on larger wetlands. In the flocking season, birds congregate in larger wetlands as the smaller, seasonal wetlands dry out over summer.

Brolga movements in south-west Victoria are not yet completely understood. Seasonal movements, referred to as migration movements, occur in south-east Australia between flocking and breeding sites. Local movements can also take place when birds are moving between roosting and feeding sites. Long distance movements may take place in very dry years and populations may move from dry inland wetlands to wetlands associated with the Murray River (Marchant and Higgins 1993). In very wet seasons, birds may remain at breeding sites throughout the year and not move to flocking sites. Therefore, Brolga movements and distribution are heavily dependent on climate and foraging opportunities.

Consistent Brolga flocking sites in south-west Victoria that account for a significant proportion of the population occur in the locations listed below, based on information compiled by Sheldon (2004) and provided by the then-DSE.

- The Grampians region
- Strathdownie
- Cressy
- Streatham (mainly on Lake Wongan and in the Skipton area)
- Hamilton, Dunkeld and Penshurst areas
- Edenhope area
- Toolondo
- Willaura and Stavely areas and
- Darlington.

Brolga population size

The 1984 estimate of the Victoria brolga population was 600 – 650 birds, with approximately 550 – 600 of these birds (c. 92%) in south-west Victoria (Arnol *et al.* 1984). This and subsequent estimates are noted in Table 2.

Table 2: Brolga population estimates, south-west Victoria

Month/ year	Est. no.	% ≤2 yrs. old	Same day counts	Source
4/2013	907	17	Yes	http://bird.net.au/bird/index.php?title=Brolga#2013_Update_-_provided_by_Richard_Hill.2C_DEPI.2C_Casterton (viewed August 2014)
2012	448	16	Yes	http://bird.net.au/bird/index.php?title=Surveys#Survey_results_summary (viewed January 2014)
2011	250	20	No	
2010	401	10	No	
2004	675	-	No	Sheldon (2004)
2002	402	-	No	DSE (2007)
1984	550-600	-	No	Arnol *et al.* (1984)

The April 2013 count reported above was organised by DELWP and was conducted at Dundonnell, Penshurst, Willaura, Strathdownie, Lake Bolac, Streatham, Boole Lagoon (S.A.) and Lake Wongan. The largest flock recorded was 320 birds at Strathdownie. The counts were undertaken systematically by having different sites counted on the same day across the state, to avoid re-counting flocks that may have moved. The 2012 count was also conducted at multiple sites on the same day but appears to have missed some key sites or flocks.

Earlier, non-simultaneous counts (from the 1980s to 2011) are not directly comparable to the counts from 2012 and 2013, as counts conducted over multiple days may result in over-estimation of the number of birds due to multiple counting of individuals or flocks that have moved between count days.

From 2010, many young have been observed in flocks compared with the previous drought years. This indicates how effective improved availability of breeding habitat can be in

increasing the Brolga population. Years with high rainfall result in a larger number and longer inundation of breeding wetlands. This ensures habitat availability for adult and young birds for the entire breeding cycle until young fledge.

4.2. Level 1 Assessment

All four Level 1 assessment triggers apply to the proposed Golden Plains Wind Farm. The level 1 assessment is described in this section.

4.2.1. Step One: Undertake desktop studies into known and potential habitat

Methods

Records of the Brolga in the RoI were compiled from the sources described below.

- A list of the Brolga records in the study area was obtained from the *Victorian Biodiversity Atlas* (DELWP 2016b)
- The south-west Victorian flocking site database (complied by Sheldon 2004 and provided by the then-DSE)
- *The Atlas of Australian Birds and Birdata* (BirdLife Australia) accessed 2016
- *Handbook of Australian, New Zealand and Antarctic Birds – Volume 2* (Marchant and Higgins 1993)
- Action Statement No. 119. Brolga *Grus rubicunda* (Du Guesclin 2003)
- Arnol *et al.* (1984) unpublished records from the *Victorian Biodiversity Atlas* (up to 1984)
- Discussions with local landholders to obtain information on recent and historical flocking and breeding sites and movements within the RoI.
- Information kindly provided upon request by the Geelong Field Naturalists' Club and the Brolga Recovery Group.

These sources provided the most comprehensive available Brolga records that currently exist, apart from those collected during the targeted investigations described in the Level Two Assessment. Information on both breeding and flocking sites was collated.

Flocking site definitions

The Brolga Guidelines state that a flock roost site must meet all three criteria listed below in Table 3 (DSE 2012).

Table 3: Criteria used to identify a flock roost site (source: DSE 2012)

Criteria	Justification
More than one year of recording	To ensure the selection of traditional and regularly used sites.
One or more records of counts equal to or greater than 10 birds	To include sites which have been used often or traditionally by flocking Brolga. The assumption is made that if more than 10 birds are recorded on a wetland, flocking behaviour is likely.
Recorded in more than one month	To include sites where Brolga flock for periods greater than one day or one week, i.e. to include

Criteria	Justification
	sites used traditionally for the majority of the flocking or non-breeding season.

For initial analysis and short-listing of possible flocking sites, including during the landholder surveys, sites that had supported ten or more birds were identified from existing records. These sites were divided into two categories, discussed below.

- **Traditional flocking sites** are not specifically defined in the Brolga Guidelines, but are referred to as the wetland to which Brolga flocks return each night to roost during the dry, flocking season 'year after year'.
- **One-off flocking sites** are defined in the Brolga Guidelines as sites where a flock of Brolgas has been observed on a single occasion, but the site is not a traditional and regularly-used site. This includes single records of a flock or repeat records once within a month or less, and flocks observed foraging during the day away from wetlands.

Traditional flocking sites are considered to have much greater value for Brolga than one-off flocking sites, as they represent a key habitat used for safe overnight roosting after a day of foraging in the surrounding landscape. Movements to and from one-off sites are more likely to resemble the movements Brolga make in the migration season, movements that the Brolga Guidelines state can be considered in determining the residual risk of the project to the Victorian Brolga population. One-off flocking records may also correspond to an observation of a flock foraging during the day away from its traditional flocking site and can often be of birds using non-wetland habitats, such as crops.

Landholder consultations

Extensive interviews were held with landholders within the wind farm and the RoI in November and December 2016. As the RoI is very extensive, those landowners within five kilometres of the wind farm were prioritised for contact, although a number of landholders beyond this distance also participated in interviews. The questionnaire used is provided at Appendix 1.

Results

Historical breeding sites

The historical databases up to 2016 when this study commenced indicated that there were 27 locations that had breeding records of Brolga within the radius of investigation (Figure 2). Of these, thirteen records (crossed out in Figure 1) were too far from wetlands due to inaccurate co-ordinates so these have been excluded from the analysis as they are not located in suitable breeding habitat (Figure 2). Records accepted *near* wetlands generally occurred within 300 metres, whereas others were well beyond this distance. Such records are described in Table 5. All maps in this report are based on the DELWP wetland layer, plus any additional, confirmed wetland habitats in which Brolga breeding or flocking records were identified.

During the Level Two investigations (see Section 4.2.2), seven additional breeding sites were found in the RoI during the Brolga breeding survey from the ground and the air and in discussions with landholders (see section 4.2.3). These observations have been discussed later in this chapter in sections 4.2.2 and 4.2.3 and brought the total number of accurately known breeding sites in the RoI to 21 wetlands. More recently, three

additional sites (one of which is no longer suitable) have come to light based on informal consultations with additional nearby landowners and information from local environment groups. This has brought the total number of confirmed breeding sites to 23.

As described in section 4.2.2, all wetlands that could be visited within the RoI (i.e. not subject to landholder access limitations) were assessed for their suitability for future Brolga breeding. Specifically, this inspection ascertained whether the wetland had been permanently drained, defined as having been altered hydrologically to the point of not functioning as a natural wetland capable of supporting breeding Brolgas due to drainage for agriculture, including the construction of a deep stock watering dam within it. In the latter case, dams in wetlands with small basins and catchments, in which the dam occupied a significant proportion of the natural wetland basin, prevent water from pooling in the original wetland basin, effectively draining it.

Table 4 summarises the results of the desktop and field assessments for all wetlands assessed and presents the information used to identify the 23 breeding sites as such. The wetland numbers in this table are shown on Figure 1.

Table 4: Wetland assessment and all known Brolga breeding activity within the Golden Plains Wind Farm RoI (refer to Figure 1 for wetland and breeding site numbers).

Wetland number	Breeding site number	Habitat Quality	Confirmed breeding record 2016	Past breeding record (year)	Wetland description	Drainage
52282		High			Small wetland fenced off from stock, has been dammed and trees planted around it. Some open water and emergent vegetation with a lot of Common Spike-sedge.	N
52289	21		BL&A confirmed from aerial survey Nov 2016		A pair of Brolgas was observed at this wetland with a nest during the aerial survey, though no eggs or chicks were observed.	
52291		Unsuitable	A pair of Brolga observed foraging at the wetland though no nest confirmed	1984	Wetland has been partly fenced off and also has a drain running through it. Held shallow water in September although the water drained away in subsequent surveys. Area that is fenced has tussock grass.	Y
52294		Unsuitable			This wetland has been drained, very little aquatic vegetation.	Y
52310		Moderate			Medium sized wetland, unfenced and in a grazing paddock. Emergent vegetation, sedges and grass.	N
52316	11	Low		Land holder mentioned Brolga have nested here previously.	Wetland now comprises a narrow, deeper, dammed channel and the original wetland basin is otherwise cropped and holds no surface water. Landholder indicated past Brolga breeding in this channel.	Part
52326	1		BL&A confirmed from aerial survey Nov 2016		Recorded a breeding pair during the aerial survey.	N
52347	9	Moderate		Land holder mentioned Brolga have nested here numerous times previously.	Large wetland inundated with surface water, semi filled compared to the extent mapped as wetland. Much of former wetland is now cropped. Emergent vegetation including tussock grass and lignum. Wetland held water from September through to December. Black Swan and Whiskered Tern were seen nesting here.	N

Wetland number	Breeding site number	Habitat Quality	Confirmed breeding record 2016	Past breeding record (year)	Wetland description	Drainage
52357	8	Moderate	BL&A confirmed Sep 2016	2011	Very large wetland in a low-lying area. Rarely has water in it and only semi-filled in September after heavy rainfall. Surface water not visible in November though there was much emergent vegetation.	N
52363		Unsuitable			Drainage line, only two dams remain. The wetland has been mostly cropped.	Y
52364		Moderate-high			High levels of water during September and October. Water levels starting to reside in November. Wetland in grazing land and is unfenced. Some emergent vegetation present.	N
52367		High			Large wetland that is unfenced. Lots of emergent vegetation. A pair of Brolga observed here during aerial survey but no evidence of breeding observed.	N
52371		Unsuitable			The wetland has been drained and is located in a grazed paddock.	Y
52383	7	Moderate	BL&A confirmed in aerial survey Nov 2016		This wetland has a drain running through it. It retains aquatic vegetation.	Y
52384		Unsuitable			Wetland permanently drained and does not hold water for long periods of time.	Y
52385		Unsuitable			Drained wetland in low-lying area, grazed by sheep.	Y
52394		Unsuitable			Low-lying modified landscape. Water running into three dams. Earth piles in area, very shallow surface water away from dams.	N
52397		Low-moderate			This wetland is now three dams, surface water was spread across all three dams during September though water levels receded after this time. One dam had emergent vegetation in October.	N
52399		Unsuitable			Very little surface water at this wetland during September. It is a small wetland in grazing land with some tussock grass. Unlikely to hold water long enough for Brolga to breed.	Y

Wetland number	Breeding site number	Habitat Quality	Confirmed breeding record 2016	Past breeding record (year)	Wetland description	Drainage
52401	2	Moderate	BL&A confirmed from aerial survey Nov 2016		A pair of Brolga was observed with a chick during the aerial survey.	N
52404		Unsuitable			Drained, no water, unsuitable for breeding brolga.	Y
52407		Unsuitable			Small degraded dam, no fringing or emergent vegetation.	N
52408		Low			Small wetland with some surface water, unfenced grazing land. The wetland does have a drain coming from it which flows into the wetland across the road (52409). Unlikely to hold water long enough for breeding purposes.	Y
52409		Moderate			Large freshwater wetland, sedges and tussock grass present during September, water receded in October. In November water only present in drainage line.	Y
52410	5*	Low		Landowner record, nearby non-wetland VBA record	Drained into a small dam in the middle of original wetland. This wetland when flooded has supported breeding Brolga. Landholder reported one breeding attempt at this wetland. A 2013 VBA record is mapped nearby (see Figure 1) that may refer to this wetland.	Y
52412		Unsuitable			Very large wetland in a low-lying area. Now in a highly-modified landscape with several drainage lines, exotic pasture, rocks removed and placed into piles.	N
52415	3*	Low		Landowner record, nearby non-wetland VBA record	Large lake, unsuitable for breeding brolga. Included as breeding site given proximity of nearby VBA breeding record (see Figure 1).	N
52418		Unsuitable			Drained wetland, grazed, tussock grass present.	Y
52428	20	Moderate - high		Sheldon database - breeding record	Not assessed. Aerial image indicates the wetland has been dammed to increase water level, planted with indigenous trees and an island has been constructed. Habitat is considered good.	N

Wetland number	Breeding site number	Habitat Quality	Confirmed breeding record 2016	Past breeding record (year)	Wetland description	Drainage
52500		Moderate			Large linear wetland that has been dammed that is surrounded by crops. An additional wetland has also been created from the overflow of the dam to the south in the road reserve.	N
52505		Unsuitable			Small artificial wetland on eastern side along Mia Mia Creek. The rest is a drainage line where there were small pools of water from September to November. Surrounded by crops.	N
52646	10	Low		1988, 1989, 1990	Wetland has been dammed, no fringing or emergent vegetation during September though vegetation did emerge later in October and November.	N
52653		Low			Wetland has been dammed and is unfenced. Very little aquatic vegetation, some emergent tussock grasses (Poa).	N
52659	6	High	BL&A confirmed from aerial survey Nov 2016		This wetland is a large dam along the Mia Mia Creek. It holds water throughout the breeding season. Emergent and aquatic vegetation is present. It has been fenced off from stock and trees planted around it. A pair of Brolgas and a nest with two eggs in it were observed in the far northern section of this wetland.	N
52668	4	Moderate-high		1984	Large wetland that has been dammed. Deep water though shallow around the edges where there was some emergent aquatic vegetation. A pair of Black Swan were nesting here. Fenced off from stock and trees planted.	N
52719		Unsuitable			Dammed wetland, surrounded by thistles.	N
52720		Unsuitable			No wetland present.	
52825		Low			Wetland has been dammed and the dam wall is located on the western side. Cannot see any overflow from the vantage point on the road. Surrounded by crops.	N
52826		Unsuitable			Wetland has been drained and cropped.	Y

Wetland number	Breeding site number	Habitat Quality	Confirmed breeding record 2016	Past breeding record (year)	Wetland description	Drainage
52878		Unsuitable			This wetland is located along a creek that has been fenced off and trees planted along it. It is not very wide with a dam located midway down the mapped wetland.	N
52995		Unsuitable			Wetland permanently drained and does not hold water for long periods of time.	Y
54001		Unsuitable			Drained wetland, no surface water, grazed by sheep.	Y
54002		Low			Small shallow freshwater wetland, grassy, no aquatic vegetation visible and not fenced.	N
54005		Unsuitable			Wetland has been drained and does not hold water long enough to support breeding Brolga.	Y
54007		Low-moderate			There are two dams located here. In times of high rainfall they would overflow and merge into one large medium sized wetland with shallow water.	N
54008		Unsuitable			Wetland has been drained and is unlikely to hold water long enough to support breeding Brolga.	Y
54009	14	Moderate	BL&A confirmed in aerial survey Nov 2016		Medium sized freshwater wetland with limited surface water present in November. A pair of Borlga and their two chicks were observed foraging along the creek behind the wetland.	N
54010	13	Moderate		1983, 1988, 1991, 2008	This wetland has been cropped though held water from September to December. There was a drain running from it to the creek. Some emergent vegetation in November.	Y
54011		Unsuitable			Drained wetland, cropped	Y
54012		Unsuitable			Mapped wetland in a low-lying area, some sedges, no surface water. Not a wetland.	N

Wetland number	Breeding site number	Habitat Quality	Confirmed breeding record 2016	Past breeding record (year)	Wetland description	Drainage
54013	12	Moderate-high		1988 1991 Landholder records	Large wetland, unfenced with a lot of emergent vegetation including sedges, rushes, Water Ribbon and tussock grass. Not fenced though stock was excluded from September to November. Had a drain running into it from wetland on neighbouring property. There are two records from the VBA for this wetland. The landholder also indicated that Brolga breed here. There is potential habitat for the Brolga to breed in the future.	Y
54014		Moderate-high			Small wetland, unfenced though no stock present from September to November. Sheep present in December. Emergent vegetation present including tussock grass, Common Spike-sedge and Water Ribbon.	N
54015		Moderate			Small wetland in a depression, no stock present from September to November. Vegetation emerged in November.	N
54016		Low-moderate			Large wetland not fenced, large extent of surface water lots of emergent vegetation from October to December. May waterbirds here and a single Brolga observed foraging here in November. Water had receded in December. Sheep graze the area.	N
54017		Moderate-high			Large wetland in an unfenced grazing paddock. Stock excluded from September to November. Emergent vegetation present including Common Spike-sedge and tussock grass.	N
54018		Unsuitable			Wetland has been drained and cropped.	Y
54028		Unsuitable			Low-lying area along drainage line, no visible surface water, tussock grass.	N
54030		Moderate			Medium sized wetland, unfenced in a grazing paddock. Emergent vegetation present, surrounded by crops.	N
54031	17	High	BL&A confirmed Nov 2016 and Dec 2016	1978, 1979, 1987, 1988, 1991.	Large wetland with a lot of surface water. Cereal crop around the edge of the wetland. Wetland has emergent vegetation. Two nesting attempts here and the pair were observed with a chick in January 2017.	N

Wetland number	Breeding site number	Habitat Quality	Confirmed breeding record 2016	Past breeding record (year)	Wetland description	Drainage
54032		Moderate-high			Large wetland that is usually dry. Held water from September to November. Emergent grassy vegetation, shallow freshwater wetland.	N
54036		Low			The wetland has been dammed at the southern end. The northern end is vegetated with phalaris and cereal crops, stock has access to southern section.	N
54037	16	Moderate-high		Landholder breeding record from the 1980's	Large freshwater wetland, there is a drain the runs into the southern section of the dam and the wetland to the north (54036) has been dammed preventing water from running into it. It is a grazed paddock with some emergent vegetation in it and an island in the centre of the wetland. Held water from September to November.	Y
54042		High			Fenced off small wetland with emergent aquatic vegetation.	N
54044		Unsuitable			Wetland has been permanently drained and does not hold water long enough for breeding.	Y
54049		Low			Dam along creek/drainage line, small some emergent and fringing vegetation.	N
54056		Low			Large farm dam, deep water, more shallow up the norhtern end of the wetland though not a lot of emergent vegetation. A lot of waterbirds present including, Pacific Black Duck, Grey Teal, Hardhead, Hoary-headed Grebe, Straw-necked Ibis, Black-fronted Dotterel and Masked Lapwing. Many Growling Grass Frog heard calling.	N
54057		Low			Farm dam, some emergent vegetation present, cropped around the border of wetland.	N
54062		Unsuitable			No obvious sign of a wetland from the road.	N
54073		Low			Dam with fringing vegetation though not a lot of emergent vegetation. Pacific Black Duck, Australian Wood Duck, Grey Teal, Chestnut Teal, White-faced Heron and Growling Grass Frog all present.	N

Wetland number	Breeding site number	Habitat Quality	Confirmed breeding record 2016	Past breeding record (year)	Wetland description	Drainage
54074		Unsuitable			Wetland on private property has been dammed and use to be a reservoir used to pump water into Rokewood Lagoon. Freshwater with some trees around edges, no fringing, emergent or aquatic vegetation.	N
54075		Unsuitable			Old open cut mine, steep banks, often saline mixed with freshwater runoff. Planted trees around it mainly pine trees, no emergent or aquatic vegetation.	N
54077		Unsuitable			Old open cut mine, steep banks, often saline mixed with freshwater runoff. Planted trees around it mainly pine trees, no emergent or aquatic vegetation.	N
54088	23	Low		Landholder record (Unknown date but 'not recently')	Wetland has been dammed. Emergent vegetation including, Poa, sedges and Phalaris. Only small pool remaining at time of assessment.	N
54090		Moderate			Small freshwater wetland, overflow from dam (54091) flows into this wetland. It is an unfenced wetland in a grazed paddock with emergent vegetation. Not a lot of water present in November.	N
54091		Low			The wetland has been damed at the southern section. Stock do have access, there is little emergent vegetation, Common Spike-sedge, phalaris and tussock grass present in the shallow end.	N
54097		Moderate			Dam along Warrambine Creek. Holds water throughout breeding season and has a lot of fringing and emergent vegetation dominated by water ribbon. It is an unfenced linear dam, not too deep in parts in the north.	N
54100		Unsuitable			Two dams, deep, little emergent vegetation.	N
54103	19	Not assessed - suitable		VBA records 1986, 1988	The wetland has been dammed. Did not visit due to access issues. From aerial imagery, there is potential habitat for Brolga to breed in the future.	N

Wetland number	Breeding site number	Habitat Quality	Confirmed breeding record 2016	Past breeding record (year)	Wetland description	Drainage
54177		Low			Large dam full of deep fresh water. Trees planted along western boundary. Some fringing vegetation in the northern end where there is shallow water.	N
54178		Unsuitable			No wetland present.	N
54180		Unsuitable			Salty water though dry in November, Common Spike-sedge and tussock grass present.	N
54181		Low			Small unfenced wetland some emergent vegetation.	N
54182		Unsuitable			Drained wetland, not holding any water, grazed land.	Y
54183		Unsuitable			Located on top of a rocky rise, no water at time of survey, surrounded by crops, unlikely to support breeding habitat	N
54184		Unsuitable			Low lying area, between rocky rises. No aquatic vegetation, no water, unlikely to hold water long enough to support breeding Brolga.	N
54186		Unsuitable			Wetland is now a dam with no overflow at the time of the survey.	N
54187		Unsuitable			Wetland has been drained and does not hold water long enough to support breeding Brolga.	Y
54203		Unsuitable			Mainly comprised a drainage line, half the wetland has been planted with a Blue Gum plantation at northern end of wetland.	N
54209		Low			Wetland has been dammed. Drain flowing into it, has been scraped to lengthen surface water. No emergent vegetation and unfenced.	Y
54210		Unsuitable			Drained wetland, grazed, area around wetland has been recently ploughed.	Y
54211		Unsuitable			Area mapped as wetland is old stony rise (barrier) - no standing water. Scattered *Juncus* & Tussock Grass in a a grazed paddock.	N
54212		Unsuitable			Cereal crop surrounding, no surface water present, used to graze sheep.	N

Wetland number	Breeding site number	Habitat Quality	Confirmed breeding record 2016	Past breeding record (year)	Wetland description	Drainage
54217		Unsuitable			Deep man made dam. River Red-gum trees around the edge. Very little fringing or emergent vegetation.	N
54220		Low			Small wetland along a natural drainage line. Dry at time of survey, some emergent sedges, tussock grass and *Phalaris* present. In December, there was bare ground where water had been.	N
54221		Low			Wetland has been dammed. Emergent vegetation including, tussock grass, sedges and phalaris. Only small pool remaining at time of assessment in December.	N
54224		Unsuitable			No surface water present, grazed land with some tussock grass.	N
54226		Unsuitable			Wetland has been drained.	Y
54227		Unsuitable			Drained, ploughed, cropped with lucerne.	Y
54228		Low			The wetland has reduced in size from when wetland mapping was undertaken. Just a small pool now though no water in November. Surrounded by canola crop.	N
54229		Unsuitable			Dammed creek with permanent water, steep banks through erosion, no emergent vegetation.	N
54230		Low			Dammed in centre; dam formed by barrier which bisects drainage line. Extensive tussock grass, some *Juncus*. Small area of semi-permanent water, the remainder would be dry most years.	N
54279		Unsuitable			Wetland has been drained and cropped.	Y
54295		Unsuitable			No wetland present, dominated by phalaris, located next to a creek.	N
54296		Low			This wetland is unfenced and grazed by sheep. Water is drained into two dams, very shallow surface water in parts5 cm deep. Lots of tussock grass.	Y

Wetland number	Breeding site number	Habitat Quality	Confirmed breeding record 2016	Past breeding record (year)	Wetland description	Drainage
54297		Low			Was a large wetland in September, part of the wetland has been dammed and is likely to permanently hold water. Some emergent vegetation, surrounded by Sharp Rush, pasture and crop. Growling Grass Frog present to the west along drain.	N
54298		Low			No water in November, aquatic vegetation present (sedges), the wetland is unfenced in grazing land.	N
54299		Unsuitable			No wetland present.	N
54300		Unsuitable			No wetland present.	N
54313		Unsuitable			Wetland has been drained and minimal surface water present. Mostly tussock grass, no aquatic vegetation, too shallow for nesting Brolga.	Y
2	15	High		Landholder record 2000	This wetland is a dammed section of the Mia Mia Creek. It has been fenced off from stock and trees planted around it. In time of high rainfall the dam walls create large expanses of surface water with emergent vegetation. Water levels had dropped by November and by December it was mostly dry with only some water in the northern section.	N
3	18	Moderate	BL&A confirmed Sep 2016		Small flooded wetland in road reserve. Stock is excluded, emergent sedges, not drained, soil banks to hold water. Brolga observed nesting here in September but had abandoned the wetland in October.	N
4	22	Moderate		Geelong FNC 2000 (Landholder indicated no other breeding observed)	Small creekside floodplain above road in which a small dam has been constructed.	N

Wetland number	Breeding site number	Habitat Quality	Confirmed breeding record 2016	Past breeding record (year)	Wetland description	Drainage
Wetland in open cut mine (next to 54077)		Unsuitable			Filled with runoff, damed, bare banks, very little fringing vegetation. Many Growling Grass Frog heard calling. Dries out when no rain.	N

* A VBA breeding record is between breeding sites 3 and 5 and the landowner reported past breeding in both these wetlands. It is possible that the record refers only to one of the wetlands but both have been included in case both were used for breeding in the past.

Figure 2: Brolga breeding records and wetlands

Project: Golden Plains Wind Farm
Client: WestWind Energy Pty Ltd
Date: 25/05/2017

Legend

- Wind Farm boundary
- Wind Farm
- Record not used due to imprecision

Wetland assessment

- Likely breeding wetlands (numbered 1-23)
- Suitable (Low to High quality)
- Unassessed
- Unsuitable

Sheldon database

- Breeding site

Historical breeding records 1971 - 1992 (as of 2011)

- Brolga breeding

BLA unpublished records (2009 - 2017)

- Brolga breeding

VBA 2016 records

- Brolga breeding

Birdlife Australia (2016)

- Brolga breeding

Brolga Recovery Group

- Brolga breeding

Geelong Field Naturalists Club

- Brolga breeding

N

Kilometers
0 2

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Historical flocking sites

The review of the databases, landholder records and observations within the RoI prior to 2016 when this study commenced identified one traditional flocking site and five one-off flocking sites, including four sites where flocks were recorded well away from wetlands where they would not have roosted for the night (see Table 5 and Figure 3).

There is one known *traditional* flocking site within ten kilometres of the proposed wind farm site. Wetland 52302 (Lake Weering) is a large lake that attracts low numbers of Brolgas in the flocking season. This wetland is located approximately 9.6 kilometres from the nearest proposed turbine.

No traditional flocking sites were found through the landowner interviews (see Section 4.2.3) nor during the current flocking season surveys (January to April 2017). Flocking season surveys will continue until June 2017.

Table 5: Flocking records and assessment of flocking sites

Point Number	Wetland number	Year	Month	Count	Comments	Type of flocking site
1	No wetland	1989	Mar	2	Point located in cleared agricultural land, not associated with a wetland. Only one record of 10 or more Brolgas.	One off flocking site
		1992	Mar	14		
		2002	Apr	3		
2	54010	1983	Jan		Point located just outside awetland. Only one record with 10 or more Brolgas.	One off flocking site
		1988	Jan			
		1991	Jan			
		1994	Jan	31		
3	52316/52347	1988	Jun	19	This point is located in agricultural land between two large wetlands. Only one year reported to have 10 or more Brolgas. Considered a non-	One off flocking site
		1988	Jul	22		
		1988	Jul	20		
		1988	Aug	16		
		1988	Sep	2		
		1996	Feb	2		

Point Number	Wetland number	Year	Month	Count	Comments	Type of flocking site
					wetland foraging site	
4	No wetland	1951	Mar	14	This point is located in the middle of agricultural land with no wetland nearby. Only one record of 10 or more Brolgas.	One off flocking site
		1980	May	9		
		1980	Jul	3		
		1988	Jan			
5	No wetland	1980	Jun	17	No wetland associated with this point. The birds recorded here may have been foraging in the paddock and flown from flocking sites at Lake Martin, Cundare Pool or Lake Weering.	One off flocking site
6	52302 (Lake Weering)	1965	Mar	72	This wetland is a well known site where Brolga roost for the night in the flocking season; generally below 40 birds.	Traditional Flocking Site
		1983	Jan	5		
		1988	Apr	26		
		1989	Feb	2		
		1995	Mar	30		
		1995	Apr	40		
		1996	May	30		
		2000	Apr	36		
		2000	Apr	40		
		2000	May	2		
		2001	Feb	26		
		2001	Mar	22		
		2001	Mar	23		

Point Number	Wetland number	Year	Month	Count	Comments	Type of flocking site
		2001	Apr	36		
		2003	Mar	32		
		2004	Apr	40		

Notes: Refer to Figure 3 for site locations and numbers

Figure 3: Flocking records investigated

Project: Golden Plains Wind Farm
Client: WestWind Energy Pty Ltd
Date: 25/05/2017

Legend

- Wind Farm boundary
- Wind Farm boundary 10km
- Wetlands 2013
- Flocking records

N

Kilometers
0 2 4

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4.2.2. Step Two (Part 1): Field inspections

Methods

Wetland quality assessment and Brolga wetland use

To provide information on the status, distribution and possible occurrence of Brolga on lakes and swamps in the RoI, a Brolga survey was undertaken by a BL&A observer over four days, once a month from September to December 2016, focussing on wetlands within five kilometres of the proposed wind farm and in particular on those within 3.2 kilometres of the wind farm (this is the maximum turbine-free buffer distance for breeding sites in the Brolga Guidelines.

The rainfall in winter and spring 2016 was above average and therefore most seasonal wetlands that were capable of holding water would have held water. Wetlands that did not hold water in spring 2016 were considered unsuitable due to drainage or extensive alteration that effectively drained them, such as deep farm dams.

The survey area for the field inspection was the wind farm site and the RoI within five kilometers from the boundary of the wind farm although it also included some wetlands beyond this in the radius of investigation. As far as possible, all wetlands not subject to private land access limitations were visited and surveyed. Within the five-kilometre radius 102 wetlands were assessed totalling 88% of wetlands in that radius. Within the 10-kilometre radius 113 wetlands were assessed totalling 54% of all wetlands within that radius. Many parts of the RoI, particularly north and west of the proposed GPWF had comparatively few wetlands (see Figure 2 and Figure 3).

Wetlands were visited multiple times throughout the survey period if they continued to hold water. Once they were dry they were no longer surveyed for breeding Brolgas. If a wetland was initially classified as unsuitable for Brolga breeding due to the wetland having been permanently drained or no visible wetland being present (even in a year of above average rainfall), it was not surveyed again.

The 2016 survey was undertaken after above-average winter - spring rainfall, when lakes and many small seasonal wetlands were holding water. For this reason, the field assessment was considered to represent good conditions for breeding.

Habitat quality

Habitat quality of each wetland was assessed using the criteria detailed below, which are based on current information on Brolga breeding habitat requirements in western Victoria (Marchant and Higgins 1993, Du Guesclin 2003).

High: Habitat components listed below are usually all present.

- Permanent, or largely permanent, shallow freshwater body guaranteed to hold water
- Shallow freshwater marsh or shallow freshwater meadow less than 0.5 metres deep
- Waterbody with some aquatic and emergent vegetation (e.g. rushes, tussock grass)
- Little or no signs of changed water regimes (e.g. drained wetlands)
- Little or no signs of disturbance (e.g. cultivation, native vegetation removal, grazing).

Moderate: Some fauna habitat components are often missing although wetlands still provide some characteristics to provide flocking opportunities.

- Waterbody likely to hold water long enough for breeding (i.e. permanent or largely permanent)
- Waterbody with some aquatic and emergent vegetation (e.g. rushes, tussock grass)
- Some changes to water regime may have occurred (drainage lines)
- Wetland shows some signs of disturbance (such as some limited access to stock, cultivation).

Low: Many habitat elements have been lost.

- Are likely to be ephemeral or drained (only hold water for limited time of the year)
- Have little or no aquatic or emergent vegetation
- Have a changed water regime, little water present
- Show signs of disturbance (such as being heavily grazed by stock, being cultivated, or feral predators).

Any wetland found to have been permanently drained was not considered suitable for Brolga breeding, in line with the Brolga Guidelines.

All other historical records of breeding were assumed to indicate sites where breeding could occur in the future, so long as the recorded locations were situated at wetlands that had not been permanently drained.

Results

A total 113 wetlands in the radius of investigation were assessed using the methods described above. Three additional wetlands that support breeding Brolgas could not be visited or assessed due to property access issues.

Many wetlands marked on the 1:50 000 topographic map sheets were dry during the survey, or had been dry for many years, as they had been converted for agricultural use. These sites no longer held water and were unsuitable as breeding habitat for the Brolga. Predictably, no birds were seen on these sites or reported by landholders (see Section 4.2.3).

A summary of the results from the 2016 wetland assessment is presented in Table 6. Many wetlands (45.7%) were unsuitable for breeding habitat. Low quality wetlands accounted for 25.9% of surveyed wetlands, low to moderate quality 2.6%, moderate 12.9%, moderate to high 6.9% and high quality 3.4%. Three wetlands (2.6%) that support breeding Brolgas were not assessed due to property access limitations. The wetland quality has been mapped and is shown in Figure 4.

Table 6: Summary of the 2016 breeding habitat quality assessment and Brolga use data

Habitat quality	No. of wetlands	% of wetlands	No. of Brolga (Sept – Dec 2016)
Unsuitable	53	45.7	0
Low	30	25.9	2
Low - moderate	3	2.6	1

Moderate	15	12.9	10
Moderate - high	8	6.9	2
High	4	3.4	2
Unassessed	3	2.6	
Total	**116**	**100**	

Of the 113 wetlands assessed, 60 wetlands were considered potentially suitable habitat for Brolga breeding. A detailed assessment of each wetland has been presented in Table 4.

Figure 4: Brolga breeding wetland assessment

Project: Golden Plains Wind Farm
Client: WestWind Energy Pty Ltd
Date: 25/05/2017

Legend

- Wind Farm boundary
- Wind Farm boundary 10km buffer

Weltand quality (BL&A

- High (6)
- Moderate-high (8)
- Moderate (14)
- Low-moderate (3)
- Low (26)
- Suitable - not rated (3)
- Unsuitable (58)
- Unassessed (84)

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4.2.3. Step 2 (Part 2): Local community consultation

Overview

The results of detailed landholder surveys, when combined with historical data, enabled a more complete and longer term picture to be assembled of Brolga activity in the RoI to supplement and provide context for the field investigations.

Methods

Landholder surveys were undertaken within the RoI to identify additional Brolga flocking and breeding sites that may not be in the available databases. As many landholders as possible up to 5 kilometres from the wind farm site in the RoI were contacted. This included landholders within the proposed wind farm boundary as well as neighbouring landholders. For a minority of properties within this zone, landowner information was unavailable so not all could be included.

Figure 5 shows the properties whose owners kindly participated in the one-on-one interviews. Table 7 and

Table 8 summarise the extent of coverage of the wind farm and RoI from these surveys.

Landholder interviews were undertaken at the Barunah Park Hall and Rokewood Memorial Hall from 29th November to 2nd December 2016. During the interviews, each participant was questioned for a period of up to 30 minutes. Some participants who were unable to attend consultations during these times were contacted by phone in the days following. Information sought from landholders is noted below.

A copy of the questionnaire is provided at Appendix 1. In addition to presence and location of historic and current Brolga activity on their property, landholders were queried about historical and current land use/s and land type/s, and the property in general.

Note that the summary of Brolga occurrence in the RoI presented in Section 4.2.1 included this landholder information.

Table 7: Percentage by area of wind farm and RoI surveyed by landholder interviews

Area (ha)	Surveyed area (ha)	Unsurveyed area (ha)	No landholder data available (ha)
RoI within 5 km of wind farm			
61,723	25,928	22,055	13,740
	42%	36%	22%
RoI within 10 km of wind farm			
119,035	28,732	24,608	65,695
	24%	21%	55%
Wind farm site			
17,337	11,583	5,375	379
	67%	31%	2%

Table 8: Number and percentage of properties interviewed

Total Number	Surveyed number	Unsurveyed number	No data
RoI within 5 km of wind farm			
110	74	33	3
	67%	30%	3%
RoI within 10 km of wind farm			
201	71	42	88
	35%	21%	44%
Wind farm site			
32	28	4	0
	88%	13%	0%

Limitations

All landholders within the wind farm and the RoI who responded to the request to attend the interviews were interviewed. Some property owners declined to be interviewed and did not participate in the survey and therefore there are gaps in the information (see Figure 5).

The quality of this data is likely to vary due to landholder interest and length of residency; however the information obtained has added information to the overall picture of Brolga activity and, importantly, provided information on Brolga activity from a much longer period than the period of the current project-specific field investigations.

Figure 5: Landholders surveyed

Project: Golden Plains Wind Farm
Client: WestWind Energy Pty Ltd
Date: 25/05/2017

Legend

- Wind Farm boundary
- Wind Farm boundary 5km buffer

Landholders

- Unsurveyed
- Surveyed

CAPE CLEAR TP
PITFIELD TP
PITFIELD PLAINS TP
DEREEL TP
CORINDHAP TP
ROKEWOOD TP
CRESSY TP
SHELFORD TP

Linton - Naringhil Rd
Lismore - Scarsdale Rd
Snowgum Rd
Mt Mercer - Dereel Rd
Buninyong - Mt Mercer Rd
Meredith - Mt Mercer Rd
Rokewood - Skipton Rd
Imries Rd
Cape Clear - Rokewood Rd
Dereel - Rokewood Junction Rd
JACOBS ROAD
IMRIES ROAD
LITTLEHALES ROAD
ROKEWOOD-SKIPTON ROAD
Pitfield - Cressy Rd
JACKAS ROAD
GILLETTS ROAD
BOYLES ROAD
MILL ROAD
COLAC-BALLARAT ROAD
ROKEWOOD-SHELFORD ROAD
Shelford - Mt Mercer Rd
Wilgul - Werneth Rd
Urches Rd
KENNERSLEYS ROAD
MEADOWS ROAD
TWO BRIDGES ROAD
GEGGIES ROAD
Colac - Ballarat Rd
LEDWELL ROAD
BELLS ROAD
GUMLEY SOUTH ROAD
Rokewood - Shelford Rd
WINGEEL ROAD
EASTERN ACCESS ROAD
CRESSY-SHELFORD ROAD
Cressy - Shelford Rd
Wingeel Rd
Berrybank - Werneth Rd
Foxhow Rd
Hamilton Hwy
Cundare - Duverney Rd
Colac - Ballarat Rd

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Results and discussion

A total of 35 landholders participated in the interviews, often representing multiple properties or multiple family owners of properties. The following is a summary of their observations of Brolgas.

- Twelve landholders reported not having seen a Brolga on their property during their occupation of the property.
- Four landholders reported observing breeding events on wetlands on their property.
- One landholder reported both breeding and flocks of Brolgas on their property.
- One landholder reported a one-off flock of Brolgas on their property.
- Nineteen landholders reported general observations of Brolga in both breeding and/or flocking seasons, with observations of between one and three Brolgas occurring on their property, with varying frequency or as one-off events.

The results from these interviews and informal discussions with other landholders identified three additional breeding wetlands at wetlands 52316, 52347 and 54088. These wetlands did not have breeding records from the literature review and were not found to support Brolgas during field surveys. These three wetlands have been included in the 23 breeding sites identified in Table 4 and Figure 2.

Three Brolga flocking events were identified by two landholders on separate occasions. Two of the flocks identified occurred in the same location in open farmland but in different years. The other flocking event occurred in a paddock as a once-off event.

On each occasion flocks were identified by the land holder to be outside of any wetlands and situated in arable, mixed use (cropping and grazing) paddocks, therefore discounting these sites as flock roost locations (see section 4.2.1). For this reason these landholder records are considered as very infrequent, one-off flocking sites and do not indicate traditional flocking sites.

4.3. Level Two Assessment

At least the first and third triggers for a Level Two assessment apply to the proposed GPWF.

4.3.1. Overview of methods

A variety of survey methods may be used to gather relevant information, including roaming surveys, aerial surveys, flight behaviour studies and gradient studies. The choice of methods varies with the nature of the questions (e.g. flocking versus breeding activities), the type of countryside and its accessibility. The following methods were used in this assessment.

- Ground-based roaming observational surveys (greatest effort)
- Liaison with landholders in the radius of investigation
- Wetland quality assessments
- A comprehensive aerial survey of the 10 kilometre RoI for breeding Brolgas
- Incidental observations

These methods and relevant dates are summarised below.

4.3.2. Breeding Season Survey

A range of methodologies was used to maximise the detection of breeding Brolga. In 2016, ground-based searches were undertaken for breeding Brolgas, as well as assessments of wetland quality. This included an aerial survey in November 2016. The survey methods and timing for these methods are detailed below.

2016 Breeding season survey

Brolga breeding activity and locations were recorded during searches of the any of the 117 wetlands that held water on the dates listed below.

- 20th – 23rd September 2016
- 24th – 27th October 2016
- 22nd – 25th November 2016 and
- 21st – 23rd December 2016.

Wetlands were visited each month to see if any Brolga were present. If Brolga were present at a wetland then an effort was made to find a nest or young chicks through prolonged observation, without disturbing birds.

Monthly surveys were undertaken as Brolga will spend a few days at a wetland performing mating rituals and making their nest and spend at least a further 30 days incubating their eggs. Thus, monthly surveys will identify if a pair of Brolga are utilising a wetland for a concerted breeding attempt[1]. . It is possible that failed incubation may have been missed but experience (BL&A, unpubl. data) indicates birds will attend a wetland for a period after egg loss (usually to fox predation) and often re-lay.

2016 breeding-season aerial survey

The survey was undertaken during fine weather conditions on 24th and 25th November, 2016 and 12th December 2016. Although late in the season, above average rainfall had maintained water levels in wetlands and Brolgas were still breeding throughout their range up to late December (I. Veltheim, pers. comm.). The aerial survey detected the greatest number of Brolgas of any method adopted (and covered the largest area – the complete RoI – see Figure 6).

The aerial survey was designed to identify Brolga breeding sites within the proposed wind farm site, and in the RoI. Prior to undertaking the survey, east-west flight lines were defined throughout the study area at 500 metre (north-south) intervals (see Figure 6).

The survey was undertaken in a fixed-wing, four-seat Cessna 182 RG (retractable undercarriage) flying between 90 and 120 metres above ground, at a speed ranging between 209 and 240 km/hour (105 knots). Variations were made in height and speed depended on flight safety and regulatory requirements near powerlines and towns.

The survey team comprised the pilot, a navigator and two observers. The two observers (Inka Veltheim and Brett Lane) were experienced aerial wildlife surveyors who have undertaken aerial surveys of Brolga and other waterbirds in the past. Transect details were provided to the observers by the navigator. One observer was located on each side of the

[1] The average duration of breeding events monitored in south-western Victoria across wind farm projects on which BL&A has worked is 50 days and only in two out of 27 breeding attempts were young successfully raised (BL&A, unpubl. data).

plane. Observers scanned an area of approximately 250 metres either side of each transect, using binoculars when necessary. When Brolga were observed, their location was recorded on a map and transect information was noted. This included the transect number, the direction and distance of the birds from the observer and general description of habitat and the wetland number (DELWP database number) on which the Brolga was sighted. When flying over the birds, it was observed that the Brolga looked up, but did not appear distressed or fly off.

No ground-truthing was considered necessary as Brolga were readily identified from the air and they most were standing next to nests when observed.

Limitations of aerial surveys

Aerial surveys can miss individuals of targeted species. Their speed means that some nests and birds may be missed; the distance at which aerial observers operate may miss birds hidden in vegetation. Notwithstanding this, at 250 metres, most Brolgas are visible in wetlands and they were regularly detected where they are historically known to occur regularly in the RoI (i.e. in the southern part of the survey area). Furthermore, the observers involved in the survey are experienced at detecting birds during aerial surveys; experience is a significant factor in the accuracy of such surveys.

The combination of the initial on-ground assessment and the aerial surveys provided information consistent with historical records of breeding Brolga. Therefore, the combination of ground and aerial survey results are considered to generate representative data on breeding locations and Brolga numbers.

Figure 6: Aerial survey transects

Project: Golden Plains Wind Farm
Client: WestWind Energy Pty Ltd
Date: 25/05/2017

Legend

- Wind Farm boundary
- Wind Farm boundary 10km buffer
- Aerial survey transects
- Example of one survey flight
- All Brolga records

Wetland suitability

- Suitable
- Unsuitable
- Unassessed
- All other wetlands

Lake Struan
Lake Rosine
Lake Gnarpurt
Lake Corangamite
Cundare Pool
Eurack Swamp

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4.3.3. Survey results

The number of breeding sites recorded during the studies, and based on historical information, is provided in Table 9 and the locations of these wetlands are presented in Figure 2.

A total of 23 wetlands within the RoI have been used for breeding since 1980; these are tabulated in Table 9, along with the likelihood that a wetland will be used in the future for breeding based on the current condition of the wetland. Of these 23 wetlands, two are within the proposed wind farm, 15 are within 5 kilometres of the wind farm boundary and six are between 5 and10 kilometres from the wind farm boundary. This distribution is likely to reflect a combination of the distribution of wetlands in the landscape in the RoI, as well as the greater focus on gathering information from the area within five kilometres of the wind farm.

Eleven wetlands were used as a breeding site in 2016. However, some breeding attempts failed and birds re-commenced breeding at nearby wetlands or were not seen again during roaming surveys. The maximum number of Brolga pairs detected simultaneously was seven, during the aerial survey. This, as well as the history of usage of breeding sites during the roaming surveys indicated that up to eight breeding pairs used the RoI. The additional pair occurred to the north of the wind farm (not detected there during the aerial survey).

The combination of methods, all of which are required under the Brolga Guidelines, has provided a good picture of where and how many Brolgas breed in the area in a year of above average rainfall. This lead to the conclusion that breeding activity this year was at the maximum level compared with average or below average years when habitat availability would be less as would be the number of actively breeding pairs. The field studies occurred when breeding habitat availability was at its peak so this number is considered to represent a likely maximum breeding population for the area. The estimated breeding population within the RoI represents 16 birds, or 1.7 percent of the most recent south eastern Australian population estimate for the Brolga.

No behaviour or flight observations were made at breeding sites during the survey. Four breeding records were obtained during the ground-based survey in locations that were accessible for such observations. None of these breeding attempts however persisted for long or successfully raised young. During the aerial survey, two pairs were found with young, indicating that a number of breeding attempts had succeeded but these were in locations that were not detected or accessible during roaming surveys. Therefore, no targeted flight behaviour monitoring was undertaken. This is taken account of by reference to pre-existing data on Brolga movements from their breeding sites, which is described in detail in the next sub-section.

4.3.4. Conclusions from Level Two assessment to date

Conclusions about Brolga activity on and near the wind farm are provided below.

- A significant proportion of the wetlands in the RoI have been permanently drained and are no longer considered suitable for future use by Brolgas.
- A significant proportion of the RoI, in particular the western and northern portions lack wetlands and the Brolga has not historically been recorded there.

- An estimated population of eight pairs of Brolgas occurs in the southern and eastern parts of the RoI, representing less than two percent of the Victorian population of the Brolga (estimated most recently at about 900 birds);

  Suitable breeding wetlands in the RoI occur mostly to the south of the proposed GPWF, with a small number of sites within and to the north of the southern section of the proposed wind farm site.
- Two breeding wetlands occur within the southern section of the proposed wind farm.
- Most breeding wetlands occur to the south west of the southern section of the proposed wind farm.
- Occasional flocks of Brolgas occur during the flocking season within the RoI, most regularly at Lake Weering, about 9 kilometres south of the proposed wind farm. Six flocking season records of 10 or more birds elsewhere in the RoI were found to be one-off flocking records and did not involve regular use of a wetland for overnight roosting purposes.
- The principal focus of impact mitigation is therefore ensuring that there is an acceptable impact on the breeding activities of the species that can be compensated for with a high level of confidence to achieve the objective of the Brolga Guidelines, which is Zero Net Impact on the Victorian Brolga population.

Table 9: Summary of known breeding records and likelihood of future breeding attempts at wetlands

Wetland No.	Brolga Breeding Wetlands (numbered 1-21)	Date	Comments	Likelihood of future breeding attempts
52289	21	24/11/2016 Aerial survey	A pair of Brolga was observed at this wetland with a nest during the aerial survey, though no eggs or chicks were observed.	Likely
52316	11	Landholder record	The wetland was assessed as low quality. Landholder reported that pairs of Brolga were recorded most breeding seasons.	Likely
52326	1	24/11/2016 Aerial survey	Recorded a breeding pair during the aerial survey.	Likely
52347	9	Landholder survey	Numerous records from landholders. Linked through hydrology to wetland 52357 below.	Likely
52357	8	18/08/2011 Sep-16	Historical record in VBA. Brolga were observed breeding at this wetland in September 2016.	Likely
52383	7	24/11/2016	A Brolga was observed sitting on the nest in this wetland during the aerial survey.	Likely
52401	2	24/11/2016 Aerial survey	Recorded a breeding pair during the aerial survey.	Likely
52410	5	Landholder record	This wetland when flooded has supported breeding Brolga. Landholder reported one breeding attempt at this wetland. A 2013 VBA record is mapped nearby – this may refer to either this wetland or 52415. Note that the 2016 edition of the VBA does not include this record.	This wetland is sub-optimal breeding habitat because it has been dammed and cropped. Due to Brolga attempting to breed previously at this wetland, this is likely to occur again in the future in wet years.
52415	3	Possible VBA record and landholder record	Wingeel Swamp – various records of breeding over a number of years. A 2013 VBA record is mapped nearby – this may refer to either this wetland or 52410. Note that the 2016 edition of the VBA does not include this record.	Likely

Wetland No.	Brolga Breeding Wetlands (numbered 1-21)	Date	Comments	Likelihood of future breeding attempts
52428	20	1984	Assessment of imagery indicates a small dam has been constructed in this site and that earthworks have been undertaken. The same imagery shows good vegetation cover and extensive filling in 2016 notwithstanding these modifications. It is likely to be suitable for Brolga breeding.	Likely
52646	10	1988 1989 1990	This wetland has been dammed and there are three breeding records from the VBA. Landholder also commented that Brolga have nested in this wetland several times. It has potential to support breeding in the future.	Likely
52659	6	24/11/2016 Aerial survey	A nest was confirmed at the far northern end of this wetland with two eggs in it in the aerial survey. Landholders have also confirmed that Brolga have bred in this wetland in previous years.	Likely
52668	4	1984	This wetland was potential habitat for breeding Brolga. The landholder also indicated that Brolga have bred at this wetland in the past.	Likely
54009	14	Landholder record	This wetland was reported by a local landholder as being used by Brolga for breeding. A pair of Brolga with two chicks was observed near this wetland during the aerial survey.	Likely
54010	13	1983 1988 1991 2008	There are four breeding records for this wetland from the VBA. The landholder has also indicated that Brolga do breed here from time to time. It has the potential to provide breeding habitat in the future.	Likely
54013	12	11/12/1988 1991	There are two breeding records from the VBA for this wetland. The landholder also indicated that Brolga breed here. There is potential habitat for the Brolga to breed in the future.	Likely
54031	17	4/09/1978 1/10/1979 1987 11/06/1988 1989 24/09/1991	There are five breeding records from the VBA for this wetland. BL&A confirmed two breeding attempts at this wetland in November and December 2016. The landholder also confirmed regular breeding here.	Likely

Wetland No.	Brolga Breeding Wetlands (numbered 1-21)	Date	Comments	Likelihood of future breeding attempts
54037	16	pre 1993	There are historical records breeding from the VBA for this wetland. Records were drawn from *A database of Brolga (Grus rubicundus) nest sites in Victoria: A report by Richard Hill, Royal Australasian Ornithologists Union, Melbourne, August 1992.* The current landholders have been at the property since 1988 and have recorded Brolga infrequently at the wetland. A pair was recorded for a few days in 2013 and a pair with a chick was recorded in 2010 – however a nest was not recorded. In 2016 the wetland was reported as holding water for several months during an above average rainfall winter and spring. During wet years Brolga are likely to attempt to breed at this wetland.	Likely
54103	19	1986 1986 13/09/1988 4/12/1988	The wetland has been dammed. Did not visit due to access issues. From aerial imagery it appears to be potential habitat for Brolga breeding in the future.	Likely
Wetland 15	15	18/10/2000	There is one record of Brolga breeding at the wetland in 2000. The breeding site was along the Mia Mia Creek in a section that had been dammed. Since 2000 this section of the creek has been planted with many trees and shrubs to aid with salinity issues. The wetland remains functional and despite tree planting nearby, Brolga are likely to attempt breeding in this wetland in the future.	Likely
Wetland in road reserve along Rokewood - Shelford Rd (Wetland number 18)	18	20/09/2016	A pair of Brolga observed nesting in a flooded section of the road reserve	Likely

4.4. Level three assessment

A Level Three assessment involves four steps, as summarised in Table 1. Each step is described in more detail below.

Step One: Avoid or mitigate potential impacts

Turbine-free buffers should be designed to remove any significant impact on Brolga breeding and flocking home ranges[2] within the RoI. The Brolga guidelines require that turbine free buffers be established to avoid impacts within Brolga breeding and flocking home ranges such that:

- For **breeding sites**, "turbine siting would be used to exclude any reduction in breeding success caused by turbines" (DSE 2012, p. 8); and
- For **flocking sites**, "turbine-free buffers should… exclude any significant impact on the survivorship of Brolgas whilst occupying that flocking site" (DSE 2012, p. 8).

To address these objectives, the final turbine layout has been informed in part by knowledge of the movements of Brolgas around breeding sites from a range of studies, including observations at the Macarthur Wind Farm since 2012, and by the collision risk modelling results for alternative turbine layouts. As no flocking sites occur within five kilometres of the proposed wind farm, mitigation needs only to address impacts on breeding sites. Turbine-free buffers represent the distance between the edge of the breeding wetland and the outer limit of the rotor swept area (RSA), and factor in the proposed 75 metre turbine blade length.

Step Two: Collision risk model (CRM)

The objective of CRM is to estimate the residual number of Brolga flights which have the potential to interact with wind turbines on the proposed site and from this estimate the annual collision risk.

Step Three: Population Viability Assessment (PVA) model

The site-specific collision risk output is then used in the PVA to model the potential impact of the proposed wind farm on the Victorian Brolga population. The PVA will be undertaken for the development application. It will provide an indication of the impact of the wind farm on the future population size of the Brolga in Victoria.

Step Four: Compensation to achieve zero net impact on the Victorian Brolga population

Improving Brolga breeding habitat to enhance breeding success is considered an appropriate compensation strategy to replace the birds lost to the population because of the proposed wind farm.

The first two of these steps are described in more detail in the sub-sections below. The last two of these steps is discussed briefly in Section 5 of this report.

4.4.1. Step 1: Mitigating Brolga impacts

The Brolga Guidelines require the establishment of turbine-free buffers around turbines to mitigate direct, turbine collision-related impacts on birds. It has been assumed for this exercise that the zone around each breeding site in which the Brolga could move is a 3.2-kilometre radius from each breeding site. Studies elsewhere in Victoria (BL&A unpubl.

[2] The Brolga Guidelines refer to 'breeding' and 'non-breeding' home ranges. Strictly speaking, they refer to them outside the narrow technical definition of the term 'home range' in ecology. Therefore, the term 'turbine free buffer' is used to avoid erroneous understanding of what is being described.

records – see Appendix 2) have had to be sued to determine the extent of turbine-free buffers for each breeding site and to guide how collision risk at each breeding site can be reduced.

Information on the movements of Brolgas around their breeding sites in Victoria has been obtained from previous investigations of Brolga movements around breeding wetlands from observational studies by BL&A personnel elsewhere in the Brolga's range (Mortlake, Darlington and Skipton regions) (see Appendix 2). This information has been used due to the lack of regular or continued breeding activity within 3.2 km of the proposed wind farm during the Level Two assessment fieldwork that was readily accessible or observable. The key findings from past observations and from Appendix 2 are:

- Areas of pasture within 200 metres of the breeding site and the wetland habitat of the breeding site itself provided the bulk of the foraging resources during breeding as demonstrated by the considerable time spent in this part of the home range.
- The majority of Brolga flights from the breeding wetland (54% of all flights recorded) were within 400 metres of breeding sites and many (86% of all flights recorded) were within 1600m (Appendix 2).
- The greatest distance flown from a breeding site was 3.2 kilometres (Appendix 2).
- Brolgas spend an average of 45 minute per flight away from a breeding site (BL&A, unpubl. data). Usually, one adult at a time makes, on average, one flight per day to and from a foraging site away from the breeding wetland.
- When moving more than 400 m from the breeding site, Brolgas showed a statistically significant preference for wetlands when the area of wetland relative to other habitats was taken into consideration (Binomial Test, $p < 0.001$). This preference became stronger with increasing distance from the breeding site (see Appendix 2).

Collision related impacts have been avoided through the adoption of turbine-free buffers, which are discussed below.

Indirect impacts on Brolgas can arise through disturbance and barrier effects (DSE 2012). This is discussed below.

Information on the impacts of wind turbines on Brolga behaviour from Wood (2014) is informative and was not available at the time the Brolga Guidelines were prepared. This new information indicates that at the Macarthur Wind Farm, Brolgas have successfully raised young within 200 metres of constructed and operating turbines and that they will forage within metres of the base of operating turbines (see Appendix 3). Therefore, turbines are a static form of potential disturbance to which Brolgas appear to habituate. Whereas the Brolga Guidelines provide for a 300-metre additional disturbance buffer between turbines and breeding or flocking site home ranges, findings at Macarthur Wind Farm indicate that this is unlikely to be required as the Brolga is not disturbed by operating wind turbines. It is noteworthy that the latter buffer was based on observations of the distance at which Brolgas react to the presence of people and unfamiliar vehicles not static sources of disturbance like wind turbines.

Notwithstanding this, the required 300 metre disturbance buffer has been used in developing the mitigation strategy for this project, particularly for those breeding sites close to or within the proposed wind farm.

Brolgas belong to the crane family and turbine interactions have been observed for two other crane species: the European Common Crane (*Grus grus*) and the North American Sandhill Crane (*G. canadensis*).

In Germany, Stübing and Korn (2006) observed Cranes near wind farms on 88 occasions over a seven-year period in Rhineland. They found that in-flight Cranes never approached closer than 100 m to turbines, with distances usually between 300 and 700 m. In summer, after breeding, the Cranes approached wind farms to within 150 to 250 m but no closer.

Langgemach (2013) found that avoidance action by Cranes in response to operating wind turbines was observed for individuals and small flocks up to a distance of 750 m from turbines while for larger flocks, turbines were avoided by greater distances, between 1,000 and 1,350 m.

The observations of Gerjets (2006) for European Cranes, again at a wind farm in northern Germany, are summarised below:

- Cranes avoided flying close to wind turbines;
- Cranes have been observed flying within 200 m of operating wind turbines where turbine lines are oriented parallel with the direction of flight;
- The range of distances from turbines that Cranes were observed flying in one systematic study was between 150 m and 670 m, with a median distance of 300 m, where turbines were not parallel with the direction of flight;
- In another, less systematic study, crane flocks flew around operating wind turbines at distances of between 400 and 500 m where turbine lines were not parallel with the flight direction;
- Flocks of Cranes have been observed flying quite close to turbines, in one case about 100 m from one and in another between two operating turbines, quite close to the rotor tips; and
- Another observation involved a “V” formation flock breaking up, possibly due to downwind turbulence from a wind turbine, at a distance of 750 m from the turbine. The flock eventually flew around the turbine and regrouped after 1.5 km.

The reaction of cranes to wind turbines therefore varies but it is clear that they generally avoid wind turbines. The flight response of the flock at 750 metres documented above indicates that a precautionary corridor width to exclude barrier effects would comprise a gap in turbines of 1.5 kilometres. This has been adopted, where required at one of the Brolga breeding sites within the wind farm.

Table 13 summarises the location of each Brolga breeding site in relation to the wind farm and describes the turbine free buffers proposed for the 13 such sites within 3.2 kilometres of the proposed wind farm.

Figure 7 shows the changes that have been made in the layout to accommodate turbine free buffers and corridors for Brolga breeding sites.

A total of 12 turbines have been removed from the proposed wind farm layout to provide turbine-free buffers to Brolga breeding wetlands and the positions of a further five turbines have been adjusted to increase their distance from these wetlands or to provide a turbine free corridor for movement. The difference in modelled impact of this layout and the original assessed layout is described in the next sub-section.

Table 10: Summary of turbine-free buffers used to mitigate impacts on the Brolgas at the GPWF

Wetland number	Breeding site number	Habitat Quality	Confirmed breeding record 2016	Past breeding record (year)	Explanation of buffer
52326	1	NA*	BL&A confirmed from aerial survey Nov 2016		Breeding site more than 3.2 kilometres from nearest turbine.
52289	21		BL&A confirmed from aerial survey Nov 2016		Breeding site more than 3.2 kilometres from nearest turbine.
52316	11	Low		Land holder	Six highest risk turbines removed from south-western edge of wind farm and positions of a further three turbines adjusted to reduce risk. Nearest turbine now 2.7 kilometres away.
52347	9	Moderate		Land holder	Six highest risk turbines removed from south-western edge of wind farm and positions of a further three turbines adjusted to reduce risk. Nearest turbine now 2.9 kilometres away.
52357	8	Moderate	BL&A confirmed Sep 2016	2011	Six highest risk turbines removed from south-western edge of wind farm and positions of a further three turbines adjusted to reduce risk. Nearest turbine now 2.9 kilometres away.
52383	7	Moderate	BL&A confirmed in aerial survey Nov 2016		Breeding site more than 3.2 kilometres from nearest turbine.
52401	2	Moderate	BL&A confirmed from aerial survey Nov 2016		Breeding site more than 3.2 kilometres from nearest turbine.
52410	5	Low		Landowner record, nearby non-wetland VBA record	Breeding site more than 3.2 kilometres from nearest turbine.
52415	3	Low		Landowner record, nearby non-wetland VBA record	Breeding site more than 3.2 kilometres from nearest turbine.
52428	20	Moderate - high		Sheldon database - breeding record	Breeding site more than 3.2 kilometres from nearest turbine.

Wetland number	Breeding site number	Habitat Quality	Confirmed breeding record 2016	Past breeding record (year)	Explanation of buffer
52646	10	Low		1988, 1989, 1990	Six highest risk turbines removed from south-western edge of wind farm and positions of a further three turbines adjusted to reduce risk. Nearest turbine now 2.5 kilometres away. One wetland lies beyond one turbine within 3.2 kilometres of this site.
52659	6	High	BL&A confirmed from aerial survey Nov 2016		Breeding site more than 3.2 kilometres from nearest turbine.
52668	4	Moderate-high		1984	Breeding site more than 3.2 kilometres from nearest turbine.
54009	14	Moderate	BL&A confirmed in aerial survey Nov 2016		Breeding site more than 3.2 kilometres from nearest turbine.
54010	13	Moderate		1983, 1988, 1991, 2008	Breeding site more than 3.2 kilometres from nearest turbine.
54013	12	Moderate-high		Landholder records 1988 1992	Nearest turbine 1.8 kilometres away. One small wetland occurs beyond turbines within 3.2 kilometres of this site.
54031	17	High	BL&A confirmed Nov and Dec 2016	1978, 1979, 1987, 1988, 1991.	Nearest turbine 0.7 kilometres away. No wetlands occur beyond these turbines that would attract Brolgas. Buffer is therefore the minimum required based on Brolga habitat usage (i.e. 400 m plus 300m disturbance buffer)
54037	16	Moderate - high		Landholder records from the 1980's	Three turbines have been removed and turbine positions have been adjusted. Nearest turbine now 0.9 kilometre away. Turbine free area provided between this wetland, wetlands to the south of the site and the edge of wind farm to permit unencumbered movement of Brolgas in these areas.
54088	23	Low		Landholder record	The nearest turbine is 2.4 kilometres away. No wetlands occur within 3.2 kilometres beyond the two turbines that occur within this range.
54103	19	Not assessed - suitable		VBA records 1986, 1988	Breeding site more than 3.2 kilometres from nearest turbine.

Wetland number	Breeding site number	Habitat Quality	Confirmed breeding record 2016	Past breeding record (year)	Explanation of buffer
2	15	High		2000	Two highest-risk turbines removed, nearest turbine now 0.8 kilometres from breeding site. Two further turbines removed and further turbine positions adjusted to provide a 1.5 kilometres wide turbine-free corridor to the south west of this site to facilitate the movement of Brolgas breeding at this site to wetlands to the south west.
3	18	Moderate	BL&A confirmed Sep 2016		Nearest turbine 2.0 kilometres from nearest turbine.
4	22			Geelong FNC record	Nearest turbine is 1.4 kilometres away. One small wetland occurs within 3.2 kilometres inside the wind farm and eight turbines occur within 3.2 kilometres of the site.

*NA = Not assessed

The turbine free buffer distances have been developed by removing the highest risk turbines. The high-risk turbines were determined by considering the flight distance and height data and determining an overall flight probability across the site (considering each breeding site). The turbine risk is, as indicated in the bar-chart attached (the Brolga collision risk). Three factors have contributed to defining site-specific buffers:

1) We have considered the presence of wetlands within 3.2 km of all breeding sites that are within 3.2 km of proposed turbine sites (allowing for blade-tip dimensions) and minimised the number/extent of wetlands within 3.2 km of the breeding site that lie beyond this distance;

2) We have provided for turbine free corridors or zones between the two breeding sites within the wind farm and the edge of the wind farm to permit unobstructed movement of any breeding birds out of the wind farm; and

3) We have ensured that the total collision risk of the project is reduced to a level comparable with previously approved wind farms by removing turbines with the highest collision risk.

The actual collision risk associated with removed turbines is shown in Appendix 6 (see sub-section 4.4.2).

The minimum distance between turbines and breeding sites *within* the wind farm is 700 metres (from the tip of the turbine blades), based on the minimum distance used on other wind farms that captures the 400-metre zone that includes flights from the site where the birds show no habitat preference (i.e. more than 50% of movements) plus a 300-metre disturbance buffer.

The turbine blade length has been considered and all indicated set back distances are the distance from the turbine blade tip when horizontal.

The location of the internal powerlines will be included in the final CRM report overlaid on the 'heat map' (see attached map) and in a project layout map to be included at the beginning of the updated Brolga report.

Turbine free buffers have been identified within the 3.2-kilometre zone for each breeding wetland based on an assessment of risk for each breeding site. This has been made based on the presence of wetlands (a preferred habitat) within this potential zone of movement, the individual collision risk of turbines within this zone (higher risk ones have been removed) and removal of turbines within a minimum 700 metre buffer (i.e. 400 metres encompassing more than 50% of movements where habitat does not determine flight path plus the 300-metre disturbance buffer).

A total of 99 turbines are located with 3.2 km of the breeding sites. Of these, 39 are within 3.2 km of site 15, 28 within 3.2 km of site 16 (15 of these are common to both sites) and 17 are within 3.2 km of site 17. Over two-thirds of turbines within this zone affect these three sites. The balance (30 turbines) occur within 3.2 kilometres of the remaining breeding sites (i.e. eight sites). Notwithstanding this, the collision risk is modelled to be less than for the approved Dundonnell Wind Farm. This is likely due to one of the three sites close to or within the wind farm site being used about once per year on average and two of the six sites being used about once per year on average (i.e. assuming the eight pairs in the RoI use eight of the 23 breeding sites each year *with equal likelihood*). Therefore, in each year, less than 1% of the state population will be affected by turbines constructed within 3.2 km of their nesting site. In this context, it is noteworthy that the two sites within the wind farm have not been used this frequently in the last 20 years.

The residual risk (i.e. the collision risk that will result from the residual predicted number of Brolga movements beyond these turbine free buffers at rotor swept area height (i.e. above 40 metres) for all breeding sites combined) is documented in the following sub-section of this report.

Figure 7: Turbine layout changes

Project: Golden Plains Wind Farm
Client: WestWind Energy Pty Ltd
Date: 25/05/2017

Legend

- Wind Farm boundary
- Wind Farm
- Turbine layout 30/03/2017

Turbine layout adjustments (based on initial layout)

- Retained
- Adjusted
- Removed

Wetland assessment

- Likely breeding wetlands (numbered 1-23)
- Suitable (Low to High quality)
- Unassessed
- Unsuitable (non-functional)

N

Kilometers
0 2

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4.4.2. Step 2: Collision risk modelling

The Brolga Guidelines indicate that the objective of collision risk modelling is:

> *" ...to estimate the residual number of Brolga movements which have the potential to interact with wind turbines on the proposed site and from this estimate the annual collision risk."*

The way the BL&A turbine bird collision risk model works and a description of how it derives the estimated collision rate is described in detail in Appendix 4 by Symbolix Pty Ltd. The techniques involved are used regularly for the same purposes and have been published and peer reviewed in relevant professional journals. An overview of how the model works and its results are provided here.

In addition, a powerline collision risk has been undertaken by Symbolix (see Appendix 4) for that portion of the internal powerline network that will run above ground on poles.

The BL&A collision risk model used two inputs, described below.

- An estimate of the rate of movement of Brolgas within the site has been generated based on a combination of: a) the predicted activity levels of Brolgas around all breeding sites within 3.2 kilometres of the wind farm (see Appendix 2 for the derivation of this estimate); b) converted using kernel analysis to a probability distribution of Brolga activity across the wind farm site. Appendix 4 provides a full explanation of how this has been done.
- An estimate of the interaction of the Brolgas estimated to fly over the site with turbines using the collision estimation model of Scottish Natural Heritage (Band *et al.* 2007, SNH 2010), given a range of potential avoidance rates (see Appendix 4).

The combination of the spatial probability of occurrence and number of flights across the site, together with a rate of turbine interaction (for a range of avoidance rates) enables the collision risk associated with different wind turbine layouts to be compared.

Model inputs

Details of the turbines to be used were provided by the proponent and factored into the application of the Band *et al.* (2007) model (see Appendix 4). The turbine specifications are summarised below.

- 231 turbines in the final layout (248 turbines in the original, unconstrained layout);
- Rotor swept area (RSA) between 40 and 190 metres above the ground;
- Three blades per turbine;
- Rotor diameter of 150 metres;
- Maximum chord of 4 metres;
- Pitch of 30 degrees;
- Rotation speed of 12 revolutions per minute (actual is 6 – 12 but maximum has been assumed to occur constantly);
- All turbines operating 24 hours per day, 365 days per year, including all daylight hours when Brolgas are active.

The last two assumptions make the model inherently conservative: that is, it has been designed to over-estimate impact.

The inputs for the model are described in Appendix 4. Key inputs in relation to Brolga movements from breeding wetlands are described in Appendix 2 and these have informed the turbine and powerline collision risk modelling.

Notably, the modelling has factored in the movements of Brolgas around breeding sites, as well as a residual level of movement during the non-breeding or flocking season.

The **breeding season** scenario has been developed based on observations at 31 breeding sites by BL&A in the last decade. It involves:

- 23 confirmed breeding sites will be used (see Figure 2);
- 8 pairs of Brolgas (see Section 4.3.3) using each wetland with equal probability each year (this allows for breeding events that have not been documented for each site in the historical record);
- Each member of the breeding pair making a flight into the country around the breeding site once per day (a total therefore of two outward and two inward flights per day), in accordance with the distance and height distributions documented in Appendix 2;
- A proportion of the flights being at a height and distance where turbine interaction is possible (see Appendix 2); and
- An average breeding event of 130 days for each pair comprising 30 days of incubation and 100 days of chick rearing until fledging (Marchant & Higgins 1993).

The final assumption is conservative. The duration of occupation of a breeding site (and therefore the number of assumed flights by that pair from the breeding site) has been estimated by BL&A (unpubl. records) at 50 days as most breeding attempts fail due to predation of eggs or chicks by foxes, or the rapid drying of the breeding wetland.

The **flocking season** scenario was included given that occasional flocks of Brolgas have been observed during the flocking season on and near the wind farm, presumably dispersing each day from the Lake Weering traditional flocking site, or from further afield, or on the move between habitats. The flocking season scenario assumed:

- A flock of 20 birds uses foraging habitats on the wind farm site every two years;
- The flock undertakes four flights per day (i.e. a morning and an afternoon return flight to the traditional flocking site);
- The flock uses the site on average for 15 days per event; and
- Brolgas have an equal likelihood of interacting with any turbine on the proposed wind farm.

Additional inputs that apply to both seasons are discussed below.

Three avoidance rates were modelled and are presented herein: 90%, 95% and 99%. Determining an appropriate wind turbine avoidance rate for the Brolga is challenging given the lack of past interactions between Brolgas and wind turbines. Apart from the Macarthur Wind Farm, there are no operating wind farms in areas where Brolgas could regularly interact with turbines so that avoidance rates could be measured based on behavioural observations. Such rates have not been measured at Macarthur. Therefore, information on the behaviour of other crane species has been referred to.

Before discussing crane avoidance behaviour, it is worth considering definitions of avoidance. Cook *et al.* (2012) highlight the difference between 'macro-avoidance' and 'micro-avoidance'. Macro-avoidance refers to changes in flight behaviour that result in a bird avoiding a wind farm altogether. Micro-avoidance refers to the flight behaviour of a bird to avoid a turbine once within a wind farm. In practice, if birds avoid a turbine at 100

m distance, they could do so at the edge of a wind farm or several turbine 'rows' into a wind farm, where they might come across the first turbine in front of their flight path, so the distinction is not necessarily always useful for collision risk modelling.

In a mathematical sense avoidance is dealt with in the CRM as micro-avoidance and it is assumed that no macro-avoidance occurs. In practice, our only available evidence for similar species combines both forms of avoidance, with an emphasis on macro-avoidance. What these studies show is that cranes can avoid wind turbines at a range of scales. In acknowledgement of the uncertainty of estimating the exact proportion of flights that will avoid turbines, a range of avoidance rates is presented. This is an accepted way of dealing with this uncertainty in Australian wind farm impact assessments, as is discussed in Appendix 4.

The reaction of European Cranes to wind turbines varies, but they generally avoid wind turbines and a high avoidance rate above 90% is likely to be realistic in determining inputs to a collision risk model.

Langgemach (2013) reviewed the impact of wind farms throughout Germany and found that up to 2013 there were seven recorded instances of Cranes colliding fatally with wind turbines, mostly during night-time autumn migration, from a population numbering in the thousands in an area with many more turbines (e.g. in 2000, Germany had around 9,300 operating wind turbines; by 2012 this figure had risen to 23,000). It is noteworthy that, unlike European Cranes, Brolgas do not undertake long-distance night migration. It is well known that night-migrating birds are more susceptible to collision with wind turbines and other structures (Drewitt and Langston 2008, Erickson *et al.* 2001).

Observations of Sandhill Cranes in North America are also informative.[3] Observations at a wind farm in South Dakota showed that out of 66 flocks that approached wind turbines, totalling more than 4,000 individuals, 92 per cent of birds showed an avoidance response (http://aweablog.org/blog/post/windpower-report-whooping-cranes-may-avoid-wind-farms-more-research-ahead, viewed 20th April 2017).

A recent review (Nations *et al.* 2012) suggested a turbine avoidance rate of between 90 and 95 per cent for collision risk modelling for the Whooping Crane.

The true turbine avoidance rate for the Brolga is unlikely to be determined in the near future, given the small number of wind farms operating and being monitored specifically for Brolga impacts in south-western Victoria. An informed assumption is therefore unavoidable and has been used in previous wind farm studies in Victoria (e.g. Stockyard Hill, Mortlake, Yaloak) and been found by decision-makers to be informative. Based on the foregoing information, it was considered appropriate to use avoidance rates of 90%, 95% and 99% and to present the collision risk modelling results for this range of avoidance rates.

Flight speed is another key input to the CRM. A literature review on the flight speed of Cranes showed the average flight speed range is between 48 to 64 km/hour (Table 11). Given that the average weight of Brolgas (6.15 kg) lies between the average weight of Whooping and Common Cranes, a conservative average speed of 60 km/hour was assumed for Brolgas for the purpose of the CRM input.

[3] Note that a recent study of Sandhill Cranes at four Texas wind farms by Navarrete (2011) has not been used, as a review of its statistical design found it to be flawed as it used parametric statistical tests on frequency and category data, thereby violating the assumptions of the statistical methods.

Table 11: Flight speed of Cranes

Species	low weight kg	high weight kg	av. Weight kg	low speed km/h	high speed km/h	av. Speed km/h	Source	estimated speed range	av. Speed/ av. weight
Sandhill Crane	2.7	6.4	4.55	40	56	48	Journey North 2014	40-56km/h	10.5
Sandhill Crane	2.7	6.4	4.55	23	83	53	Melvin & Temple 1982	23-83 km/h	11.6
Whooping Crane	6.4	7.7	7.05	56	72	64	Journey North 2014	56 - 72 km/h	9.1
Common Crane	4	6	5	40	80	60	LPO 2014	40 - 80 km/h	12

To summarise, key model inputs in relation to the Brolga's flight behaviour were:

- Flight speed, 60 kilometres per hour;
- Wind Span, two metres;
- Total length, 1.65 metres;
- Typical flight, flapping.

Model results

The collision risk model has been run on two wind farm layouts: an optimum ('original') layout from a wind energy production viewpoint; and a 'final' layout that integrates all current constraints, including minimisation of native vegetation impacts (4 turbines removed), cultural heritage (1 turbine removed) and geotechnical constraints, and Brolga breeding site turbine free buffers (12 turbines removed). Given the spatial sensitivity of the model, it is possible to compare layouts and adjust them to reduce collision risk.

The final layout incorporates adjustments to reduce the Brolga collision risk of the project, as described in Table 10. The methods and results of the wind farm collision risk modelling are presented in detail in Appendix 4. The results of the powerline collision risk modelling are provided in **Error! Reference source not found.**. The combined results are summarised below in Table 12.

Note that the output of the collision risk model is technically the number of *flights* that results in collision, which is assumed to be equal to the number of individual Brolgas that collide. This assumes that the removal of a small number of individuals will not affect the overall flight rate, which is believed to be valid for Brolgas where a number of individuals are responsible for the flights and not one pair alone producing a large number of flights.

Table 12: Results of Brolga CRM for the GPWF.

	Original Layout			Final Layout		
Avoidance rate	90%	95%	99%	**90%**	**95%**	**99%**
Modelled average long term annual collision rate (breeding season)	0.806	0.403	0.081	0.710	0.355	0.071
Modelled average long term annual collision rate (flocking season)	0.143	0.071	0.014	0.134	0.067	0.013
Modelled annual powerline collision rate	0.001	0.001	0.001	0.001	0.001	0.001
TOTAL	0.950	0.476	0.096	**0.845**	**0.423**	**0.084**

The collision risk modelling predicts that the preferred, final wind farm layout will lead to a long term, annual average of between 0.084 and 0.845 Brolga collisions with wind turbines and powerlines. Over the 25-year life of the project, this amounts to between two (one every 12 years) and 21 birds (less than one every year), slightly less than the predicted impact of the recently approved Dundonnell Wind Farm (BL&A 2014).

It has not been possible to ascertain the number of flights around each breeding site and the proportion that flies beyond each turbine free buffer into areas where turbines are proposed to be located. The model uses mathematical methods that pool all flight and turbine location information across the wind farm layout.

This is within the range of the approved Dundonnell Wind Farm of 0.13 to 0.95 Brolga collisions per year (BL&A 2015), which was assessed as a 104-turbine wind farm (maximum per turbine collision rate [90% avoidance rate]:0.0091) and ultimately approved as a 96-turbine project. The GPWF is a 231-turbine wind farm, yielding an average predicted per turbine Brolga collision rate of 0.0038, or about 41% that predicted for the approved Dundonnell Wind Farm.

4.4.3. Conclusions

Conclusions from the first two steps of the Level Three assessment in accordance with the Brolga Guidelines are presented below.

- Twelve breeding sites are at least 3.2 kilometres from the nearest turbines and for these collision risk is considered negligible.
- Turbine-free buffers have been developed for all Brolga breeding wetlands within 3.2 kilometres of the proposed Golden Plains Wind Farm.
- Buffers of at least two kilometres (between 2.0 and 2.9 kilometres) have been provided for five of the remaining eleven breeding sites within 3.2 kilometres of turbines.
- Buffers of between 0.7 and 1.8 kilometres have been provided for the remaining six breeding sites (c. 25% of sites).
- For the two sites within the wind farm, turbine free buffers include a minimum 1.5-kilometre turbine free corridor to the edge of the windfarm that provides opportunities for movement to nearby wetlands.

- The residual collision risk considering these turbine layout changes varies between 0.084 and 0.845 Brolga collisions with wind turbines and powerlines. Over the 25-year life of the project, this amounts to between two (one every 12 years) and 21 birds (less than one every year), a slightly lesser impact than the recently approved Dundonnell Wind Farm.

5. FURTHER INVESTIGATIONS

This section summarises investigations that remain to be done to address the brolga Guidelines. The results of these investigations will be included in an updated version of this report that will accompany the planning application for the GPWF.

5.1. Population Viability Assessment

Step three of the Level Three assessment in the Brolga Guidelines requires that a Population Viability Assessment (PVA) be undertaken. Dr M. McCarthy of Melbourne University was commissioned by DELWP (then DSE) to develop the PVA for the south-east Australian Brolga population. He will be commissioned to apply this model to determine the impact of the GPWF, without compensation, on the future population size of the Brolga in south eastern Australia.

5.2. Zero Net Impact – the GPWF Brolga compensation plan

The development of the GPWF Brolga Compensation Plan will be done in consultation with DELWP and the Corangamite CMA, as well as participating private landowners. An outline of this plan is provided below. It is anticipated that the plan will have over-arching aim and objectives, as well as a monitoring, evaluation and reporting framework. Sitting under this will be a set of site management plans that will form the basis for agreements with participating landowners.

The compensation plan and the individual site plans will be developed in consultation with the landowner. It is proposed that the proponent establish a small group of experts, including a representative from DELWP to oversee the implementation of the compensation plan.

5.2.1. Aim

The aim of the plan will be to replace the estimated number of Brolgas affected by the GPWF. The collision risk modelling estimated that at 95% avoidance rate, 11 birds would be lost and at 90% avoidance rate, almost 24 birds would be lost. The objective of the compensation plan will therefore be:

> *To replace up to 21 adult birds estimated to be lost to the south east Australian population of the Brolga as a consequence of the GPWF through the restoration of lost breeding habitat so that additional breeding pairs can produce increased numbers of young that survive to become breeding adults.*

It is anticipated that a set of over-arching objectives will be developed, as well as site-specific management objectives for each compensation site.

5.2.2. Criteria for suitable breeding sites

Criteria will be developed for identifying sites suitable for the restoration of Brolga breeding sites. These criteria will be developed in consultation with DELWP and are expected to include but not be limited to criteria that address:

- Past wetland type (i.e. freshwater meadow or shallow freshwater marsh);
- History of drainage and alteration (with an emphasis on cost-effective restoration options);
- History of Brolga breeding activity on or near the compensation site (with sites having a track record in the last 50 years of Brolga breeding activity within several kilometres or, ideally, at the site itself);

- Adequate catchment water yield to ensure regular (at least one in every three years) substantial filling given expected annual differences in future rainfall (to take account of future climate change projections);
- The availability of any artificial top-up water supplies;
- The compatibility of land uses surrounding the wetlands with requirements for Brolga breeding, including water supply, catchment inputs and disturbance levels;
- Landholder considerations, such as willingness to set aside wetland and water for conservation purposes, and to provide on-title security (e.g. s. 69 agreement) for the life of the project; and
- Cost.

5.2.3. Hydrological considerations

Water security is a significant consideration in selecting future restored Brolga breeding sites. It is important that the catchment of a restored breeding site delivers sufficient water to substantially fill the wetland in as many years as possible, in accordance with the criteria agreed above.

To this end, West Wind Pty Ltd proposes to retain the services of a hydrologist to evaluate the catchment yield and likely future fill extent and level of the wetland to test if it meets the required criteria. This analysis will take into consideration annual rainfall variability and the impact of future climate change on this.

5.2.4. Land tenure and security

In line with current environmental offset policies at Commonwealth and state levels, all private land compensation sites will need to be protected for the duration of the impact (i.e. the project life) through on-title security, such as an agreement between the landholder and DELWP under section 69 of the *Conservation Forests and Lands Act 1986* (CFL Act) or section 173 of the *Planning and Environment Act 1987* (P&E Act).

This agreement will include a site-specific management plan (see below) agreed by all parties. It will require any future owner of the property to continue implementing the plan for the required period.

5.2.5. Monitoring, evaluation and reporting

A framework for periodic monitoring, evaluation and reporting (MER) of the compensation plan will be developed in consultation with DELWP. DELWP has well-developed systems for MER for its environmental management activities and it is anticipated that a suitable model can be developed in consultation with DELWP for the proposed compensation plan. This will be vital to ensure the plan achieves its aim and objectives.

The MER framework will ensure that each site management plan will be managed adaptively to achieve its objectives.

It is anticipated after 10 years that a significant review of the compensation plan will be undertaken to ascertain progress in meeting the plan aim of replacing the estimated number of Brolgas.

5.2.6. Feasibility

In 2010 and 2011 a long drought broke in south western Victoria, filling many seasonal wetlands that had been dry for many years. In the subsequent (2012 and 2013) flocking season surveys, a higher than usual percentage of young birds were found in non-breeding

flocks. This indicates that expanding the availability of breeding habitat will result in better breeding by Brolgas and the production of more young. This increase occurred without any widespread targeted management to enhance the chances of successful Brolga breeding. It is anticipated that the targeted site management that the compensation plan will require will expand breeding opportunities for the Brolga permanently and more reliably that currently occurs during above average rainfall years.

A test of the feasibility of the compensation plan is provided in Table 13. This is based on a mix of sites of varying capacity to produce young Brolgas, as follows:

- No Brolgas breed successfully in the first three years of the program as wetland habitat is still being restored and Brolgas are still finding the new breeding sites;
- High capacity sites produce young every second year from the fourth year, with one being produced in one successful breeding year and two being produced in the second successful breeding year;
- Moderate capacity sites produce young every second year from the fourth year, with one young being produced in three successful breeding attempts then two young being produced on the fourth breeding attempt; and
- Low production sites produce one young every third year from the fourth year.

These are shown in Table 13.

As some fledged young will not survive to breeding age, it is expected that the plan will define an objective for fledged young that is higher than the required maximum number of 21 adult birds to replace those affected by the GPWF.

This table shows that by managing between two and three sites, it would be possible to generate a surplus of fledged young to replace affected Brolgas, assuming the rate each site produces young is correct. It is known that pro-actively managed wetlands regularly produces young Brolgas that successfully fledge. The number of sites that the plan ultimately includes will be a matter for agreement between the proponent and DELWP and the proposed oversight group of experts will assist in reviewing plan objectives and outcomes.

Table 13: Compensation site numbers versus filling frequencies and breeding success rates.

Sites	Duration of Plan																									Total young	Plan Total	Surplus
Year - >	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25			
Scenario 1																												
Site 1 (high capacity)			1		2		1		2		1		2		1		2		1		2		1		2	18		
Site 2 (high capacity)			1		2		1		2		1		2		1		2		1		2		1		2	18	36	14
Scenario 2																												
Site 1 (moderate capacity)			1		1		1		2		1		1		1		2		1		1		1		2	15		
Site 2 (moderate capacity)			1		1		1		2		1		1		1		2		1		1		1		2	15	30	8
Scenario 3																												
Site 1 (low capacity)			1			1			1			1			1			1			1			1		8		
Site 2 (low capacity)			1			1			1			1			1			1			1			1		8		
Site 3 (low capacity)			1			1			1			1			1			1			1			1		8	24	2
Scenario 4																												
Site 1 (high capacity)			1		2		1		2		1		2		1		2		1		2		1		2	18		
Site 2 (low capacity)			1			1			1			1			1			1			1			1		8	26	4
Scenario 5																												
Site 1 (moderate capacity)			1		1		1		2		1		1		1		2		1		1		1		2	15		
Site 2 (low capacity)			1			1			1			1			1			1			1			1		8	23	1

6. OVERVIEW OF FINDINGS

This section provides an overview of the findings of the Brolga investigations for the Golden Plains Wind Farm undertaken so far. The full investigations will be documented in the development application.

The findings arising from the application of the methods and techniques of the Victorian Brolga Guidelines (DEPI 2012) are summarised below. The adoption of this approach is required whether the project is assessed through a planning permit or Environment Effects Statement (EES) process.

The findings to date from this investigation are summarised below.

- A significant proportion of the wetlands in the RoI have been permanently drained and are no longer considered suitable for future use by Brolgas.
- A significant proportion of the RoI, in particular the western and northern portions lack wetlands and the Brolga has not historically been recorded there.
- An estimated population of eight pairs of Brolgas occurs in the southern and eastern parts of the RoI, representing less than two percent of the Victorian population of the species (estimated at between 800 and 900 birds);
- Suitable breeding wetlands in the RoI occur mostly to the south of the proposed GPWF, with a small number of sites within and to the north of the southern section of the proposed wind farm. Brolgas have bred in 23 of these wetlands.
- Two of these breeding wetlands occur within the southern section of the proposed wind farm.
- Brolgas have been recorded during the flocking season within the RoI, most regularly at Lake Weering, about 9 kilometres south of the proposed wind farm. Six flocking season records of 10 or more birds elsewhere in the RoI were found to be one-off flocking records and did not involve regular use of a wetland for overnight roosting purposes.
- Based on the activity of the Brolga in the RoI, the focus of assessment and mitigation has been on the use of the area for breeding. Much less risk is considered to arise from the sue of the area during the flocking season.
- Mitigation of risks to the Brolga involves the establishment of turbine free buffers around breeding sites on and near the wind farm. As no site-specific studies could be undertaken, it has been assumed that Brolgas move up to 3.2 kilometres from their breeding wetland. Turbine-free buffers have been developed by removing 12 turbines and adjusting the positions of five turbines at Brolga breeding sites within or closest to the wind farm. For remaining sites, the risks associated with the 99 turbines that remain within 3.2 kilometres of breeding wetlands have been considered based on the presence of wetland habitat (preferred by the Brolga beyond 400 metres from breeding wetlands) within this movement zone. In all cases this involves a very limited number of small wetlands.
- The impacts of the project on the Brolga have been assessed through the development of a collision risk model that integrates spatial modelling of the probability of occurrence of the Brolga at RSA height across the landscape and the Scottish Natural Heritage turbine collision risk model.
- Model inputs have been developed from available information on the movements of Brolgas around breeding sites elsewhere in its Victorian range.

- The collision risk model results indicate that between two and 21 Brolgas may be lost from the population as a consequence of the Golden Plains Wind Farm.
- The Brolga Guidelines require that any Brolgas impacted by a wind farm are replaced through the implementation of a Brolga Compensation Plan. For the proposed project, this will focus on producing more young Brolgas by effectively managing additional breeding sites in cooperation with private landholders for the life of the project.

The Population Viability Assessment, together with the full Brolga Compensation Plan will be presented in the final development application.

This impact assessment has relied upon a combination of empirical and modelled results. The modelled results have been based on conservative assumptions, including:

- The wind turbines will operate 24 hours per day;
- They will operate at their maximum rotation speed (12 revolutions per minute) all the time;
- The maximum likely number of eight breeding pairs occurs in the RoI every year, as occurred in 2016, a year of above average rainfall and breeding habitat availability.
- There is an equal likelihood that the 23 breeding wetlands will be used by the eight pairs each year. It is noteworthy that landowners indicated that the wetlands within the wind farm and some of those to the north east were used rarely, and much less frequently than assumed.

These conservative assumptions ensure that the modelled results used to assess the impacts of the wind farm on the Brolga are more likely to over-estimate impact than under-estimate it.

The Brolga Guidelines are designed to prevent the Victorian wind energy industry from having a cumulative, unacceptable impact on the Victorian Brolga population by requiring Zero Net Impact from each project. This assessment has demonstrated that this is feasible for the Golden Plains Wind Farm.

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APPENDICES

Appendix 1: Landholder questionnaire (used to guide interviews)

Community Survey Questionnaire

Date:_____

Landholder's Name:_____

Property Address:_____

The aim of the following survey is to establish a broad-scale understanding of the environment on and around local landholder properties in the region through acquiring information such as; land use, historical land use, management practices, habitats and what flora and fauna are present. This information will inform the design and operation of Barunah Park Wind Farm.

LAND USE

What is the primary use for your land? E.g. cropping, grazing, mixed, alternating (indicate areas on map) – use attached spreadsheet

What broad land types exist on your property? E.g. arable, stony, aquatic, mixed, cleared (indicate on map) – use attached spreadsheet

How long have you been on the property?

_____

History / previous land use? – use attached spreadsheet

(If sheep grazing) When and where does lambing typically occur?

_____

_____

Do you remove the carcasses of dead stock? If so, what is the process?

_____

_____

Do you artificially feed stock on your property? - use attached spreadsheet

FLORA

Are there native plant communities / habitats on your property you are aware of?

Yes / No

What type? E.g. wetlands, woodlands, grasslands, rocky outcrops (indicate on map)

_____

How do you manage these areas? (i.e. fencing stock, weed control)

_____

_____

Has there been changes to wetland in and around your property? When, what caused this? (i.e. drainage for cropping purposes)

_____

_____

_____

_____

Are you aware of any of the following threatened flora species on your property?

Spiny Rice Flower Yes / No

Matted Flax Lily Yes / No

Others?

_____

FAUNA

Are you aware of feral animals on your property? E.g. Rabbits and warrens, foxes, deer etc...

_____

_____

Do you manage feral animals on your property?

Yes / No

Are you aware of any of the following species on your property?

Wedge-tailed Eagle	Yes / No	Nests present?	Yes / No
Fat-tailed Dunnart	Yes / No		
Striped Legless Lizard	Yes / No		
Growling Grass Frog	Yes / No		
Golden Sun Moth	Yes / No		
Brolga	Yes / No	Nests present?	Yes / No
Owl Species	Yes / No		

BROLGA SPECIFIC

Have Brolgas occurred on your property? Yes /no

Explain _____

_____

For each sub-area (paddock) of your property subject to different land use histories, how often and in what numbers have you seen Brolgas?

Area No (see map)	1	2	3	4	5	6	7
>10 birds*							
5-10 birds							
3-5 birds							
1-2 birds							
None							
Never							
>20 yrs ago							
10-20 yrs ago							
<10 yrs ago							

* If more than 10, estimate actual observed numbers or range of numbers.

If yes to the above - locate areas on maps

Have there been changes in the wetlands in and around your property?

When ? What was the cause ?

_____

_____

_____

Additional Comments on Brolgas

_____

_____

_____

Appendix 2: Summary of Brolga flight behaviour observations at breeding sites (BL&A, unpubl. data)

Appendix 2: Flight height and distance data used for developing collision risk model inputs.

The application of the BL&A collision risk model to the Golden Plains Wind Farm (GPWF) relies on estimating the probability of occurrence at any point on the wind farm site of a Brolga at turbine height. This has been determined based on site-specific investigations of where Brolgas breed on and around the GPWF, as well as from extensive behavioural investigations undertaken by BL&A in the last decade within the Brolga's breeding range in Victoria. This appendix describes the scope of the latter investigations and the data that have been used to inform the inputs to the spatial probability component of the collision risk model.

GPWF Brolga movement data

The observations that were used are presented below. Symbolix Pty Ltd requested that only data on flights where both distance and height could be related should be used as it is known that Brolgas fly at different distances depending on how far they fly.

BL&A analysed data obtained during previous breeding surveys undertaken from 2007 to 2014 within the Brolga's range, but principally around the Mortlake, Darlington and Skipton-Beaufort regions of south western Victoria. Some 163 flights were observed by breeding Brolgas from 24 separate breeding wetlands. Of these, flight height and distance were recorded in a manner that could be correlated at 13 sites, totalling 67 flights (from 2007 – 2009). These 67 flights were all greater than 100 metres and flights less than this were deemed not to have left the breeding wetland. It is this sub-set of observations that were used to develop the input to the collision risk model. These data are presented in Table 1 below.

The field investigations involved equal observational effort and the integration of observations over part or all of four days (consistently) at each breeding wetland. Given this, it has been assumed that the pooled data are representative of the behaviour of Brolgas at their breeding sites in Victoria.

Table 1: Distance and height of 67 flights of Brolgas from breeding sites in south western Victoria.

Site	Distance (m)	Height (m)
11	3000	20
11	100	15
11	3000	20
11	100	15
6	400	10
6	400	5
6	300	10
6	300	10
6	200	15
6	250	15
6	1500	50
6	1500	10
5	100	10
5	100	10

Site	Distance (m)	Height (m)
5	150	15
5	150	10
10	100	10
10	100	10
12	1500	30
12	500	10
12	200	5
12	500	10
12	1500	30
12	500	10
12	200	10
12	500	10
15	400	10
15	200	10
13	2000	25
13	2000	25
13	500	20
13	500	20
13	3000	25
13	3000	25
13	500	20
13	500	20
6	1000	30
6	1000	30
2	2000	90
2	2000	90
2	300	10
2	2000	40
2	400	30
2	300	10
2	2000	40
2	400	30
2	250	10
2	250	10
2	250	10
2	300	10
2	250	10
3	300	15
3	300	15
9	800	30
9	800	30
9	600	10
9	600	10

Site	Distance (m)	Height (m)
8	100	5
8	1500	25
8	1500	15
8	1000	15
8	1000	25
8	1500	10
8	1500	10
8	1500	10
11	1500	50
11	150	10

On pages 2 and 3 of Appendix 4, the model 'inputs summary table' describes how these data were used.

- Flight distance was modelled from these data by applying a gamma distribution to estimate the probability that a flight from a wetland will travel (at least) to the distance of a given turbine. This probability was generated for each breeding wetland and each turbine location. The total probability is the sum of these values.
- For height versus distance, a generalised linear (log-log) model was used to predict the expected height for a given flight distance. The proportion of flights within rotor swept area (RSA) height (40 – 190 metres) was calculated by the proportion of the residuals within this height range for a given distance. A value was calculated for each turbine/wetland combination.

The shaded 'heatmap' that underlies the two scenarios modelled for the GPWF (the original layout and a revised layout of lower risk to the Brolga) has been derived from the above two inputs and shows the probability of a Brolga flying at varying distances around each breeding site at RSA height, summed at each point for each breeding site. The other inputs and assumptions of this aspect of the model are described in the body of the report.

Further information

DELWP have asked for more information on the flight behaviour of Brolgas to inform its consideration of the flight behaviour of Brolgas around breeding sites and, therefore of the proposed turbine free buffers. This is provided below for the pooled data from all 24 sites investigated, totalling 163 flights. Information such as the proportion of flights to particular distances and at different heights, as well as the habitat at the destination, are provided.

Flight distance

The majority of Brolga movements observed were within 400 metres of breeding sites and many (86% of all flights recorded) occurred within 1600m (Figure 1). The greatest distance flown from a breeding site was 3.2 kilometres.

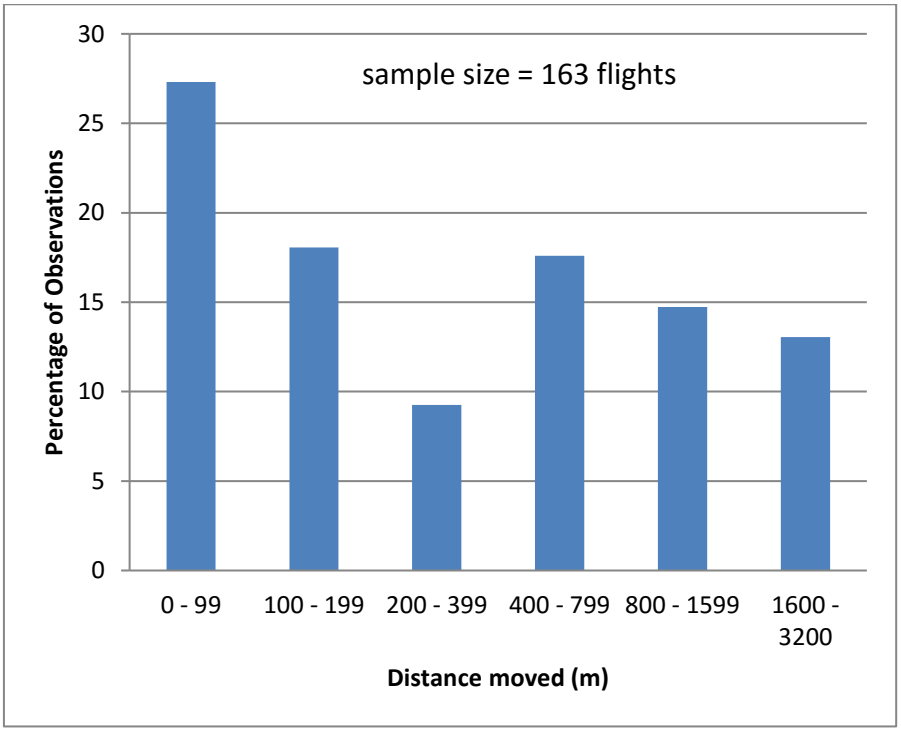


Figure 1: Observed Brolga movement distance from breeding sites

Habitat used

Areas of pasture within 200 metres of the breeding site and the wetland habitat of the breeding site itself provided the bulk of the foraging resources during breeding as demonstrated by the considerable time spent in this part of the home range. Flights from breeding sites and the time spent at the location flown to averaged 45 minutes out of the approximately 12 hour period from sunrise to sunset at the time of the observations. On average, one such flight was made from the breeding site per day. The rest of the time was spent close to (within 200 metres) and in the breeding site wetland.

Brolgas showed no preference for a particular habitat when flying up to 400 metres from their breeding site. Figure 2 illustrates that Brolga's use wetlands as well as other habitats which includes pasture, grassland and crop. This is based on observations from 105 flights in 2007 – 2009.

Observations indicated that the Brolga when moving over 400 m from the breeding site showed a statistically significant preference for wetlands when the area of wetland relative to other habitats was taken into consideration (Binomial Test, p <0.001). The preference became stronger with increasing distance from the breeding site (see Figure 2).

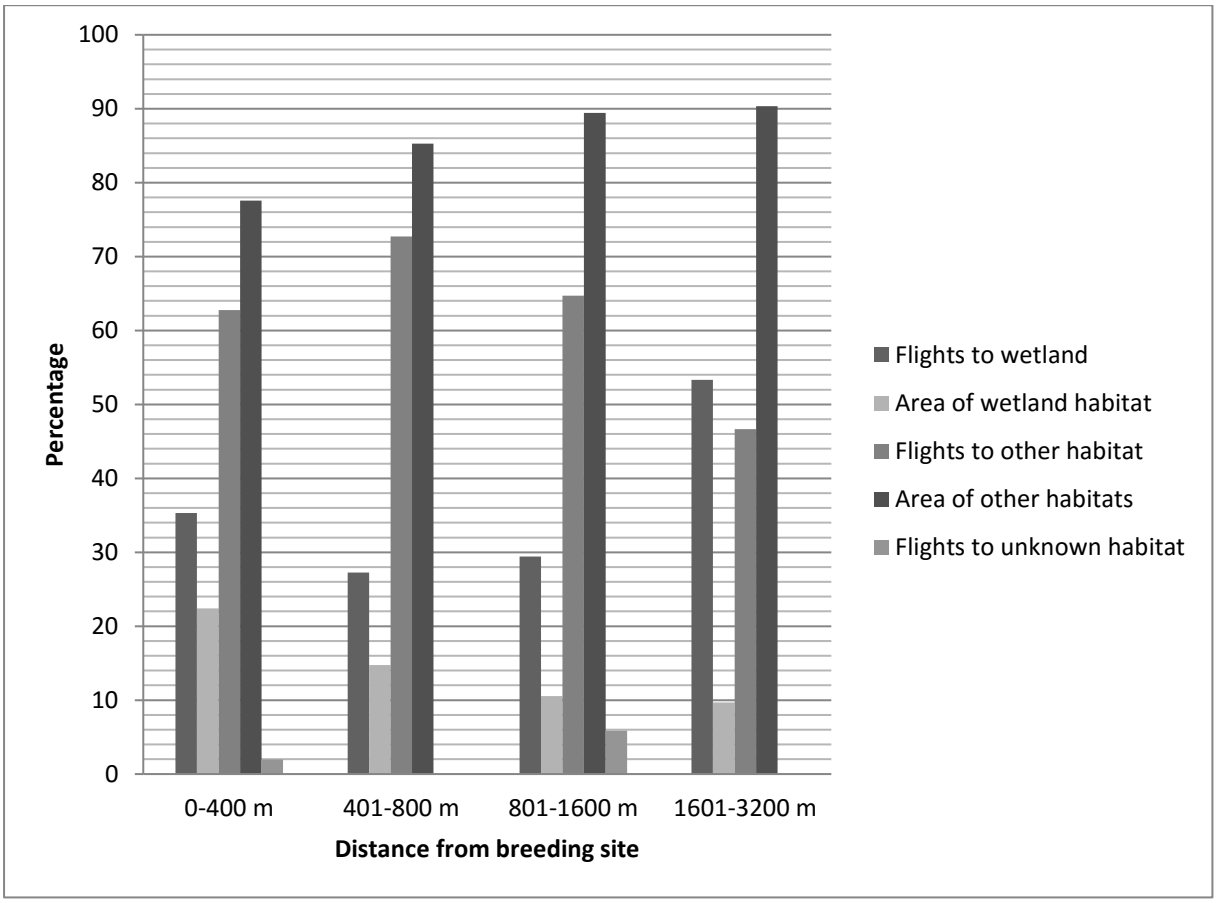


Figure 2: Percentage of flights to habitats and area of habitats from breeding sites (n = 105)

In conclusion, the data demonstrates that during the breeding season, Brolgas spend the majority of time foraging within the nesting site wetland and the immediately adjacent pasture. The majority of flights occurred within 400m of the site. The longer distance flights observed (400 metres to 3.2 kilometres) showed a preference for wetland habitat.

Breeding stage

It has been suggested that brolgas fly further from their breeding wetland when they have chicks (DELWP, pers. comm.). Analysis of the 67 flights in the first part of this appendix indicates that flights by adult birds without chicks (n = 51) averaged 880 metres, and with chicks (n = 16) averaged 720 metres. When chicks are about to fledge, movements for a short period before birds depart the breeding territory are thought to be further than this but no data are available to test this hypothesis.

Appendix 3: Maps from Wood (2014) showing locations of Brolga observations at nest sites within the Macarthur Wind Farm.

Figure 8. Locations of Brolga pair 5 observations

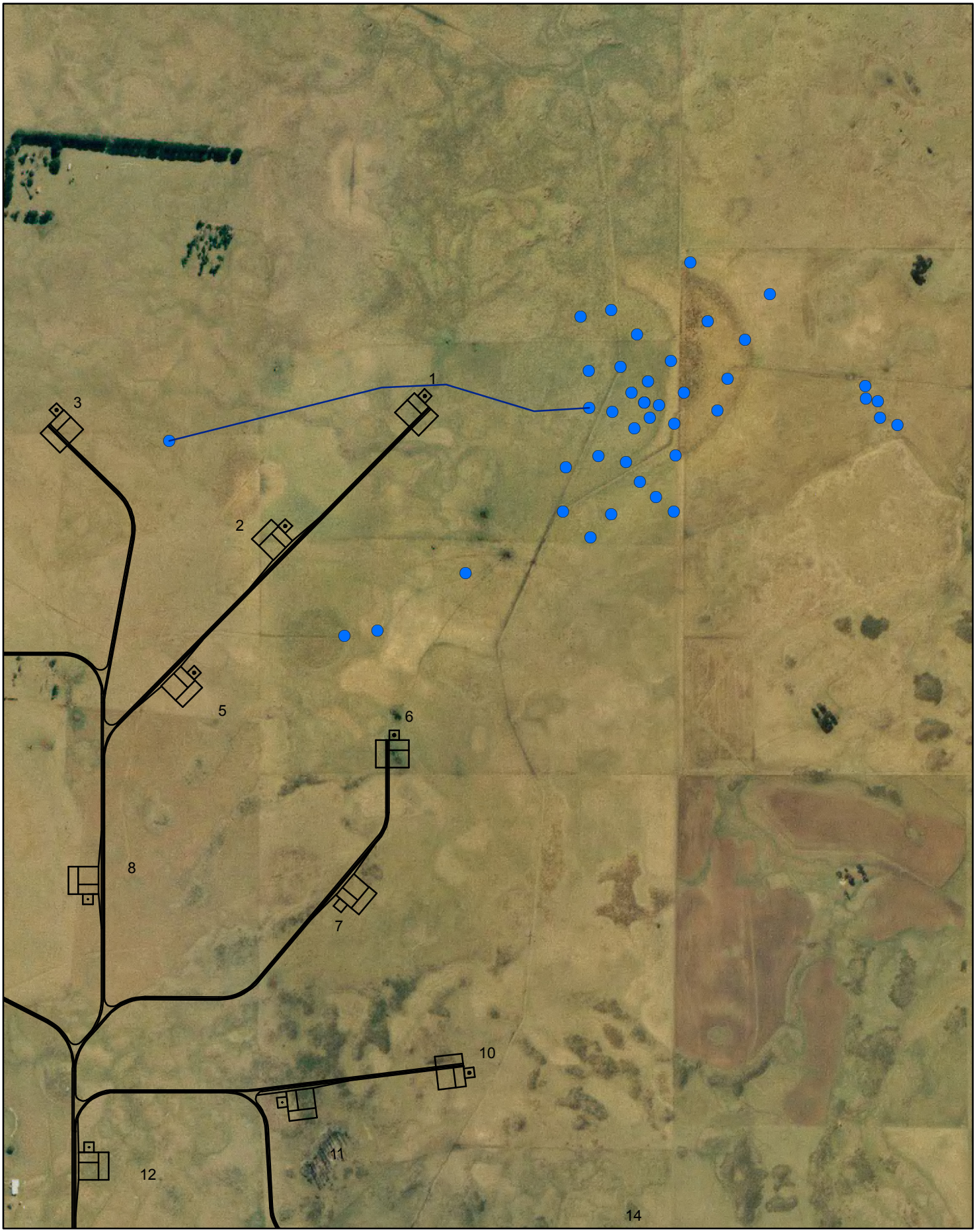


Figure 4. Locations of Brolga pair 1 observations (northern section)

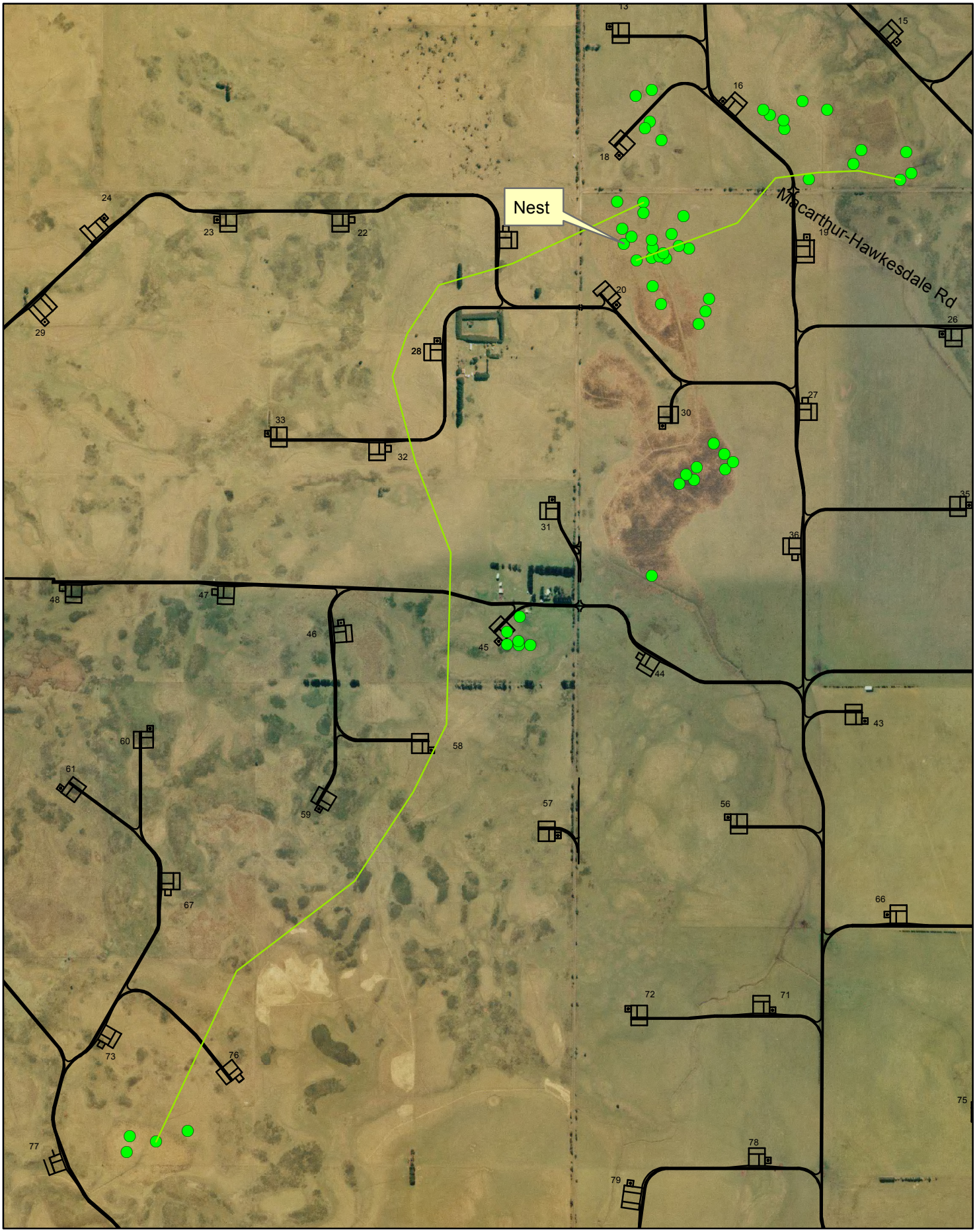
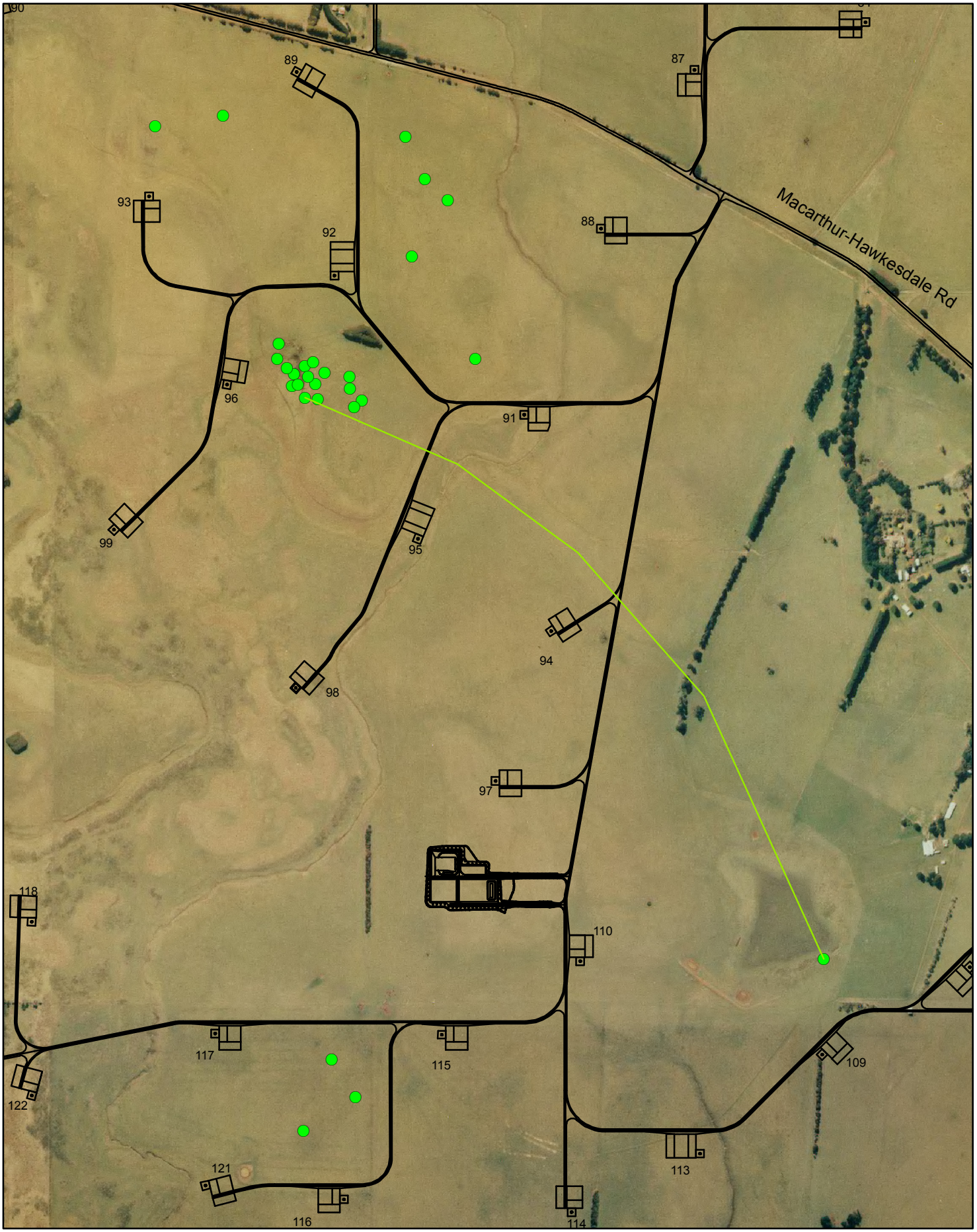


Figure 3. Locations of Brolga pair 1 observations (southern section)



Appendix 4: Golden Plains Wind Farm: Brolga turbine collision risk modelling

Brolga collision risk at Golden Plains Wind Farm

Version 2.0

26 May 2017

Submitted to

Bret Lane & Associates

symbolix

making your data work harder

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Version Control

Doc ID: **BLABPWF20170525**

Main Author: **Elizabeth Stark**

Version	Status	Date	Approved for release	Issued to	Comments
1.0	For review	21/4/17	E. Stark	B.Lane, I.Kulik	Short results summarising turbine collision risk (BLABPWF20170405) and powerline collision risk (BLABPWF20170412)
2.0	For review	26/5/17	S.Muir	B.Lane, I.Kulik	Consolidated both models into one report and added scenarios and content in response to DEWLP review.

Approved for Release:

26/5/17

Signed Date

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1 Executive summary

This document summarises the estimated annual collision rate of brolgas at the proposed Golden Plains Wind Farm. The model results rely on the methods and brolga activity inputs outlined in the following sections.

This report documents two specific collision risk models:

1. Turbine collision risk was estimated using an avian collision risk model, based directly on Band (2001,2007). The Brett Lane & Associates (BLA-BAND) application updates the model to accept spatial data inputs. This model has previously been applied to assess collision risk for Moorabool Wind Farm and Dundonnell Wind Farm (Victoria). For full details see Section 3.
2. The number of powerline crossings was estimated using a geometric model and data on flight heights and distance from multiple south-west Victorian sites. This model has been previously applied for Stockyard Hill Wind Farm and Dundonnell Wind Farm. For full details see Section 4.

The models were used to assess the interactions between brolgas breeding at the 23 identified breeding wetlands and wind farm infrastructure. The occurrence of small flocks during non-breeding season is also modelled (based on historical sightings).

This document presents a short overview of the model methodology, the inputs used, and scenario results.

1.1 Summary of results

1.1.1 Turbine collision risk model

The following table summarises the output of the turbine collision risk model for the final layout. Scenarios were built using avoidance rates of 90%-99%.

Two turbine layouts were considered.

1. The original layout had 248 turbines. This model was used to assess areas of high brolga utilisation and inform turbine layout at a workshop held between Symbolix, Brett Lane & Associates and West Wind on Thursday 2nd February, 2017. During that workshop, the group modified the turbine placement and number to reduce the brolga collision risk.
2. The revised layout consists of 231 turbines. The turbine collision risk for the revised layout is summarised in Table 1 and a range of scenarios are considered in section 3.2.

Table 1: Long-term annual average collision risk estimates by time of year, and annually.

Avoidance rate	Breeding season (130 days)	Flocking/non-breeding season	Annual total
0.9	0.710	0.134	0.844
0.95	0.355	0.067	0.422
0.99	0.071	0.013	0.084

In a given year the annual rate (assuming 90% avoidance) translates to between zero and three brolga collisions (to 95% confidence); or between eight and 20 in the life of the wind farm (20 years).

If we assume a 95% avoidance, this could manifest as zero – two brolga in a given year, or between four and 13 over 20 years. All numbers represent 95% confidence bounds.

These counts represent the potential yearly manifestation of the long-term rate in Table 1[1]. This does not mean that one should expect three brolgas struck every year. Over time, the long-term rate should regress to the values in Table 1.

1.2 Powerline collision risk model

Annual powerline crossings were also estimated. The model is also a simple projection of activity across the landscape and is very similar in structure and inputs to the turbine collision risk model.

Under the assumption that there are no flocking sites at risk of powerline collision, the breeding season represents the entire annual collision estimate.

Table 2: Results from powerline model. Estimated collisions based on empirical assumption of 1 collision per 10,000 crossings.

Number of Sites	Number of breeding pairs	Total number of crossings at height per year	Estimated average annual collisions
23	8	7	0.001

This suggests (to 95% confidence) that less than one brolga will be lost to powerline collision over the 20-year lifetime of the farm.

[1] Technically, the range represents the distribution of a Poisson variable with expectation value given by the rate in Table 1.

2 Methodology

2.1 Overview

Collision risk modelling (CRM) requires a step-wise risk model (Reason 1997), where the total risk is the probabilistic combination of the risk of each step in the process. The process can be summarised by the equation:

$$N_{collisions} = n * P(I) * P(C \mid I) \quad (1)$$

where:

- $N_{collisions}$ is the estimated number of flights ending in collision
- n is the estimated number of flights in the region
- $P(I)$ is the probability of a flight interacting with a turbine or powerline (given a flight in the region)
- $P(C \mid I)$ is the probability of collision, given an interaction occurs.

The probability of collision given interaction is generated using the exact model published by Band et al. (2007 and updated in 2012).

If survey data were available we would generate the probability of interaction, and flight density using a field survey program. However, when a species is rare in a region it becomes very difficult to physically generate enough survey hours for a statistically robust sample of flights (at rotor swept height or powerline height) across a wind farm and surrounding area.

The alternative approach (applied here) is to use ecological inputs and data on flight heights and distances to generate scenarios that represent a potential usage pattern. For brolgas this requires us to apply different scenarios to the breeding season and non-breeding season. We refer to the non-breeding season as the flocking season but recognise it may include activity of birds moving from nests to flocking sites and other background activity.

2.2 Probability of interaction of a flight with infrastructure (breeding)

For the breeding season we assumed that flights are centred on wetlands and can radiate from there in any direction. The **Probability of interaction (*P(I)*)** equals

$P(I) = P(wetland\ occupation) * P(flight\ distance) * P(direction) * P(flight\ height \mid distance)$, where

- $P(wetland\ occupation)$ is the probability that a given wetland will be occupied in a given year.
- $P(flight\ distance)$ is the probability that a flight will travel far enough to reach a turbine/powerline from any wetland.
- $P(direction)$ is simply the proportion of flights that are traveling in the right direction to interact with a turbine/powerline. This is a geometric calculation of the ratio between the angle subtended by the infrastructure and the 360 degree circle around the wetland (assuming that brolga might fly in any direction).

- $P(flight\ height\ |distance)$ is the probability that the flight will be at rotor swept height/powerline height, given that it travelled the requisite distance.

In addition:

- We assume mutually exclusive (individual) use of wetlands (i.e. each pair breeds at one site only).
- The distribution of flight distance is taken from combined BL&A breeding data from a range of sites through south-west Victoria (*BL&A, in litt. to DELWP*)
- The distribution of flight height at a given distance is taken from combined breeding and flocking season data (BL&A) from sites in south-west Victoria (*BL&A, in litt. to DELWP*). Breeding/flocking season was not a significant factor in the relationship between flight height and distance so the data sets were combined to increase the size of the dataset.

2.2.1 Probability of distance

The distribution of flight distance is taken from combined BL&A breeding data from a range of sites through south-west Victoria (*BL&A, in litt. to DELWP*). The dataset was small (66 records) but demonstrates a clear preference for shorter flights (up to one kilometre).

We fit a gamma distribution to the data which allowed us to infer the probability that a flight would travel a given distance ($P(flight\ distance)$), even if no observations were recorded at that distance.

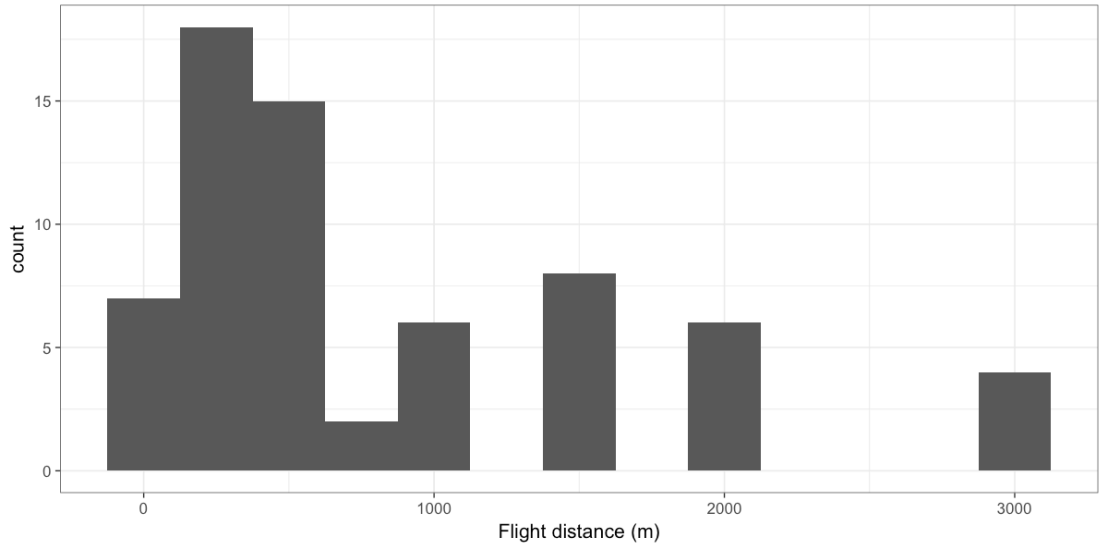

Figure 1: Distribution of flight distances used as input to the collision risk models.

2.2.2 Probability of height given distance

The dataset of breeding season observations used in the previous section also contains flight height data. It was also used as a basis for fitting the model to predict flight height

given distance. We also made use of flocking season flight height and distance data from the same sites, also provided by BL&A.

As seen in Figure 2 there is a clear linear relationship between flight height and distance (if we pre-transform both variables using the natural log function). We fit linear models to quantify this relationship. Testing breeding/non-breeding as a factor showed no significant difference between the two seasons (thereby justifying our combination of the data).

The linear model allowed us to predict the expected height at a given flight distance, but to estimate the probability that a flight will occur in the rotor swept height range (or powerline height range) we need to know more than the average height. We also need to consider the **variability** of the data around this expected value (i.e. we want to know the distribution of model residuals).

At any given distance, the probability of seeing a given flight height is described by the percentiles of the distribution of the residuals around the modelled value. $P(flight\ height\ |distance)$ is the proportion of this distribution that falls in the height range of the infrastructure being modelled.

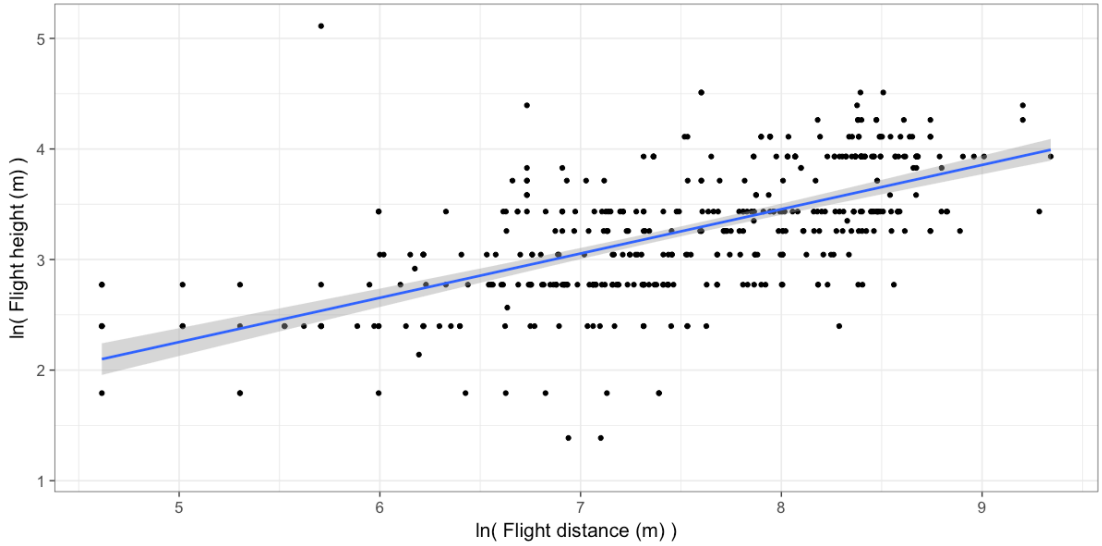

Figure 2: Log - log relationship between slight height and distance. This shows the linear nature of the relationship and the spread of model residuals.

2.2.3 Mapping the probability of interaction

Combining the results from Section 2.2.1 and Section 2.2.2 allows us to generate a probability distribution function for each wetland that describes the probability of a flight at the required height for any distance from that wetland. For each wetland this distribution is simply $P(direction) * P(flight\ height\ |distance)$.

Each wetland has a distribution representing the probability that a flight will occur at rotor swept/powerline height for a given distance.

The total probability of interaction at a given point in the landscape is simply the sum of the value of these distributions at that point.

This interaction probability can be viewed as a heatmap (Figure 3, Figure 5).

2.3 Probability of interaction of a flight with infrastructure (non-breeding)

There are no flocking sites within range for this wind farm but there exist a small number of historical non-breeding records. These account for small brolga groups in paddocks and/or brolgas moving from breeding sites to flocking sites.

The frequency of these events was estimated (by BL&A) based on historical data and provided to us as scenario inputs. The model assumes an occurrence somewhere on the wind farm sites every two year on average, lasting 15 days each time, with flock size of 20 birds.

Because there is no information to guide a spatial model for the probability of interaction, we have assumed that every turbine is equally likely to interact with a flight.

3 Results: turbine collision risk

3.1.1 Inputs summary table

The following table summarises the data inputs. All data was provided by Brett Lane & Associates and is used 'as is'.

Variable	Input data	Data source	Model input value
	Breeding season		
Number of flights	Scenario for brolga breeding flights, based on estimate of 8 breeding pairs (16.8 individuals) in the region, with an average of two flights daily. Breeding attempts were assumed to last an average of 130 days.	Regional population and activity estimates provided by BL&A based on breeding season surveys and historical records at Golden Plains Wind Farm. The number of birds per breeding pair uses the juvenile to adult ratio of 0.05 (Herring 2001 (in McCarthy 2008)).	4,368 flights annually
P(wetland occupation)	Any wetland with a historical breeding record (that has not since been assessed as permanently unsuitable) was assumed to be equally likely of occupation in a given year.	Spatial layer provided by BL&A	23 suitable wetlands.
P(flight distance)	A gamma distribution was fit to breeding season flight distance data to estimate the probability that a flight from a wetland will travel (at least) the distance to a given turbine.	Survey data provided by BL&A	A probability was generated for each suitable wetland and each turbine location. The total probability is the sum of these values.
P(height | distance)	We fit a generalised linear (log-log) model to predict the expected height for a given flight distance. The proportion of flights within rotor swept height was then calculated by the proportion of the residuals within this range at the given distance.	BL&A provided regional breeding and flocking season flight data with both heights and distances from other Victorian sites. The rotor swept height was assumed to be 40m to 190m (provided by West-Wind)	A value was calculated for each turbine/wetland combination.

Flocking season			
Number of flights	Scenario values provided by BL&A. Assumed: • Four flights per day • Events last 15 days on average • One event every two years (on average)	As there are no recognised flocking wetlands within the study region, the scenario activity was based on historical records of flocks in and around the wind farm. This included one-off flocks in paddocks and migration of pairs between the breeding and flocking season. (*BL&A, in litt to DELWP*)	600 flights per year
P(I)		There is not sufficient certainty about the future location of one off flocking events or flights heights associates with them so we assumed any flight is equally likely to interact with any turbine and all flights could be within rotor swept height.	Value for each turbine
Probability of collision (given a flight and turbine have interacted)			
Pr(C|I) – turbine parameters	Mechanical turbine specifications.	Data from West Wind	Blades: 3 Rotor Diameter: 150m Maximum chord: 4 Pitch: 30°
Pr(C|I) – brolga parameters	Brolga size and indicative flight speed	Provided by BL&A. Flight speed based on data for whooping and common crane, which are similar mass to the brolga.	Flight speed: 60kph Wing span: 2m Total length: 1.65m Typical flight: Flapping
Pr(C|I) – avoidance rate	Avoidance Rate		90%, 95%, 98%, 99%

3.2 Scenario results

3.2.1 Scenario 1: Original layout

Figure 3 and Table 3 summarise the risk of (breeding season) interaction and the annual collision estimate respectively. The highest density of flights occurs around the chain of wetlands to the south and west of the site. There is some activity likely around the isolated wetlands within the site and to the north. But in any given year there are more potential breeding sites in the south-west so we would expect this region to see the most activity (over the long term).

The majority of the flights (and risk) occur within 3.2 km around the wetland. By directly calculating the probability we allow for flexibility in the activity patterns to (e.g. between wetlands).

This scenario predicts a long term average annual brolga loss to collision of 0.95 at the 90% avoidance rate (around 0.5 allowing 95% avoidance).

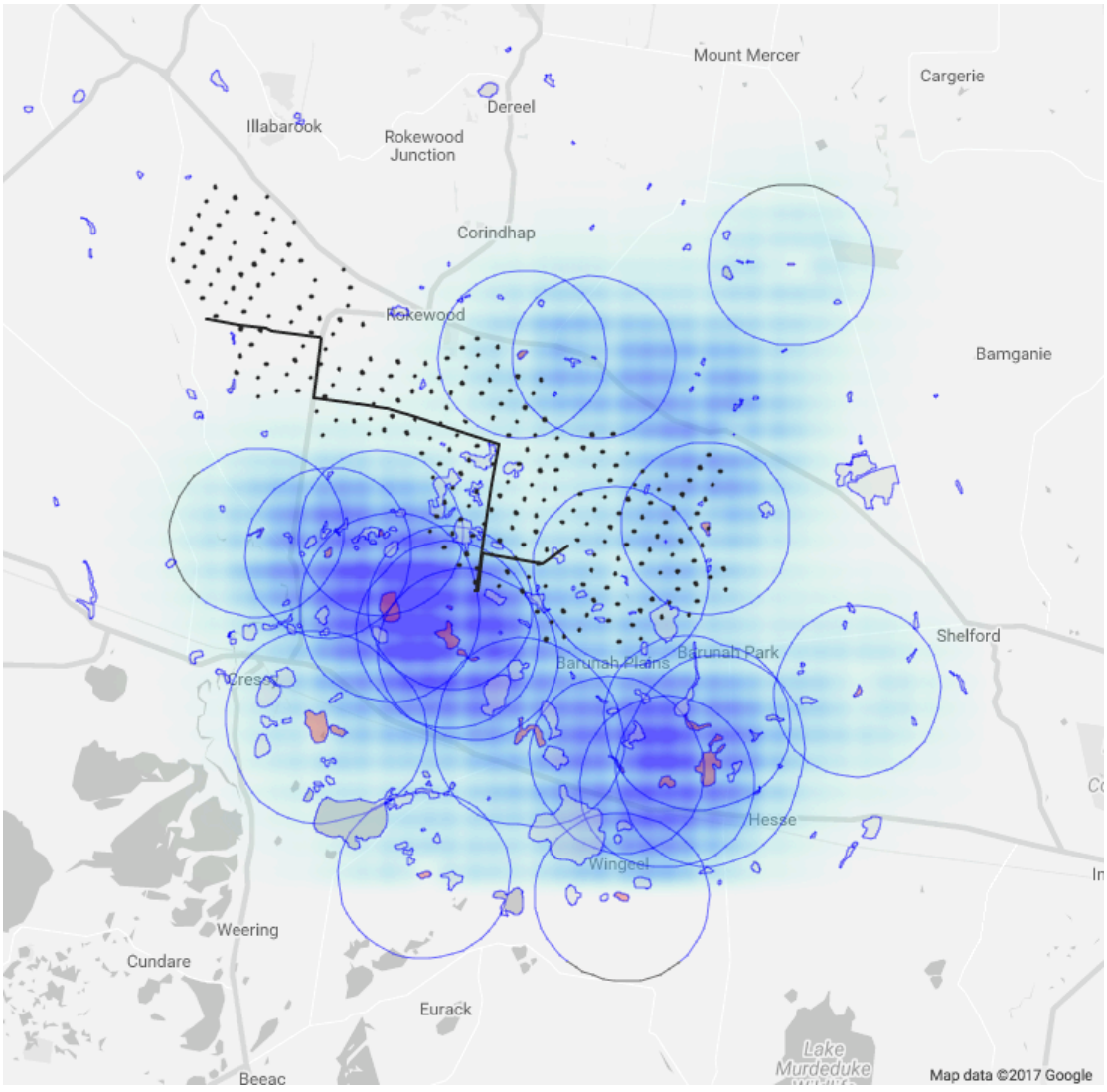

Figure 3: Map showing relative placement and risk profile of wetlands and turbines. Includes powerline (thick black line), wetlands (red indicates potential breeding), turbines (black circles) and heatmap showing the relative probability of interaction (flight at rotor swept height) at each point in the landscape. For reference we also include the nominal 3.2km breeding home range around each potential breeding wetland.

Table 3: Original layout (248 turbines): long-term annual average collision risk estimate by time of year, and annually.

Avoidance rate	Breeding season (130 days)	Flocking/non-breeding season	Annual total
0.9	0.806	0.143	0.949
0.95	0.403	0.072	0.475
0.99	0.081	0.014	0.095

Figure 4 shows the annual collision rate associated with each turbine (only the highest risk turbines are shown. This data was used to facilitate a workshop where different turbine scenarios were trialled to reduce the overall collision risk.

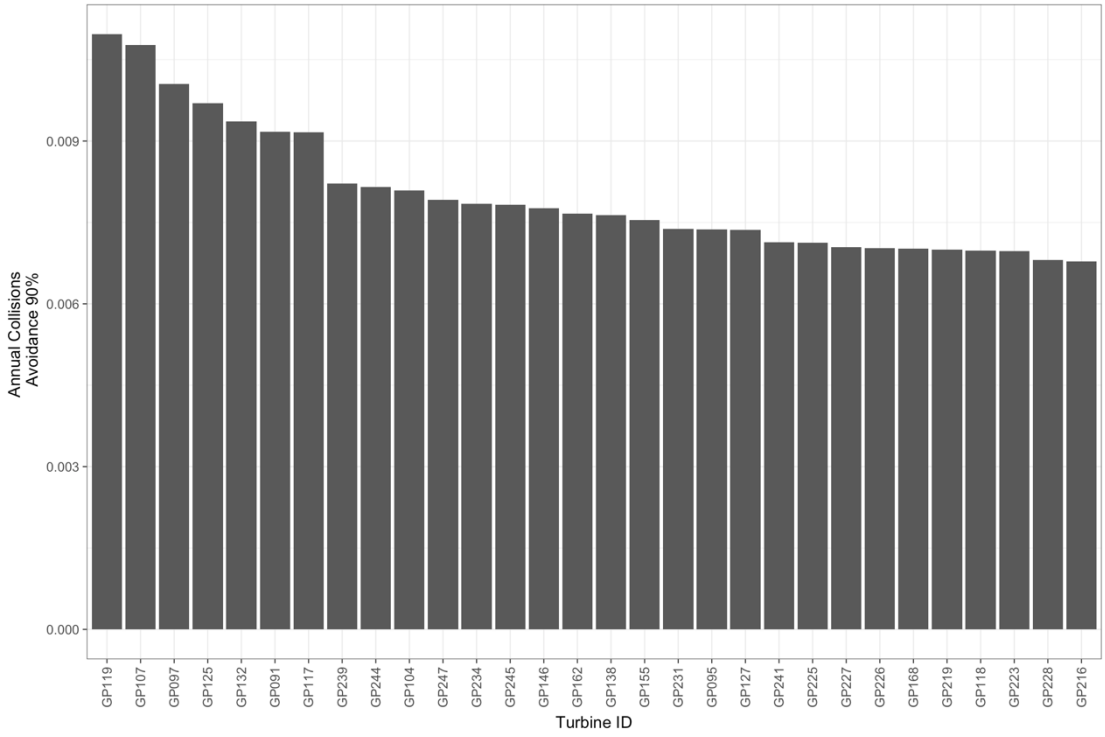

Figure 4: Estimated annual collision loss associated with each turbine, for the 30 highest risk turbines.

3.2.2 Scenario 2: Revised layout

The workshop held between Symbolix, Brett Lane & Associates and West Wind investigated the impact of adjusting the turbine layout to avoid areas of higher brolga flight risk. In terms of the model, we sought to reduce $P(I)_{breeding}$ (the probability of a flight interacting with a turbine in the breeding season). Because we have assumed a flat probability of interaction for the flocking season changing the position of turbines will not change the risk (though removing them will).

The turbine placement considered the flight distribution prediction (Figure 3) and also the desire to clear areas around isolated wetlands on site.

The amended layout was modified to change the placement of some turbines and to remove 17 units, particularly those close to the high-density flight zone in the south west and around the potential sites in and near the site boundary.

The revised turbine layout is shown in Figure 5.

The revised collision risk estimate is shown in Table 4. This scenario predicts a long-term average annual brolga loss to collision of 0.85 at the 90% avoidance rate (around 0.4 allowing 95% avoidance).

Comparison of Figure 6 and Figure 4 highlight the reduction in collision prediction for the highest risk turbines as a result of this process.

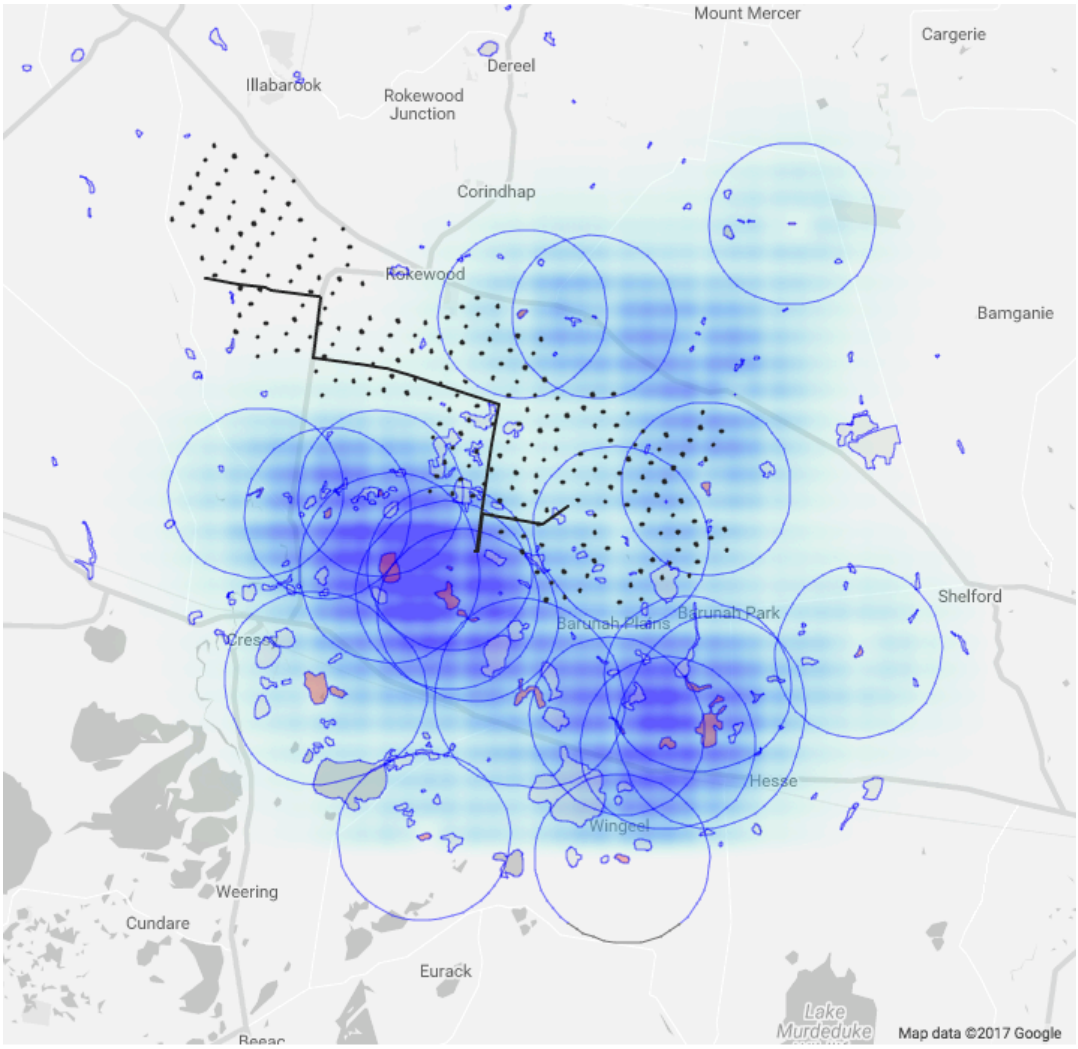

Figure 5: Map showing relative placement and risk profile of wetlands and turbines. Includes powerline (thick black line), wetlands (red indicate potential breeding), turbines (black circles) and heatmap showing the relative probability of interaction (flight at rotor swept height) at each point in the landscape. For reference we also include the nominal 3.2km breeding home range around each potential breeding wetland.

Table 4: Revised layout (231 turbines) Long-term annual average collision risk estimate by time of year, and annually.

Avoidance rate	Breeding season (130 days)	Flocking/non-breeding season	Annual total
0.9	0.710	0.134	0.844
0.95	0.355	0.067	0.422
0.99	0.071	0.013	0.084

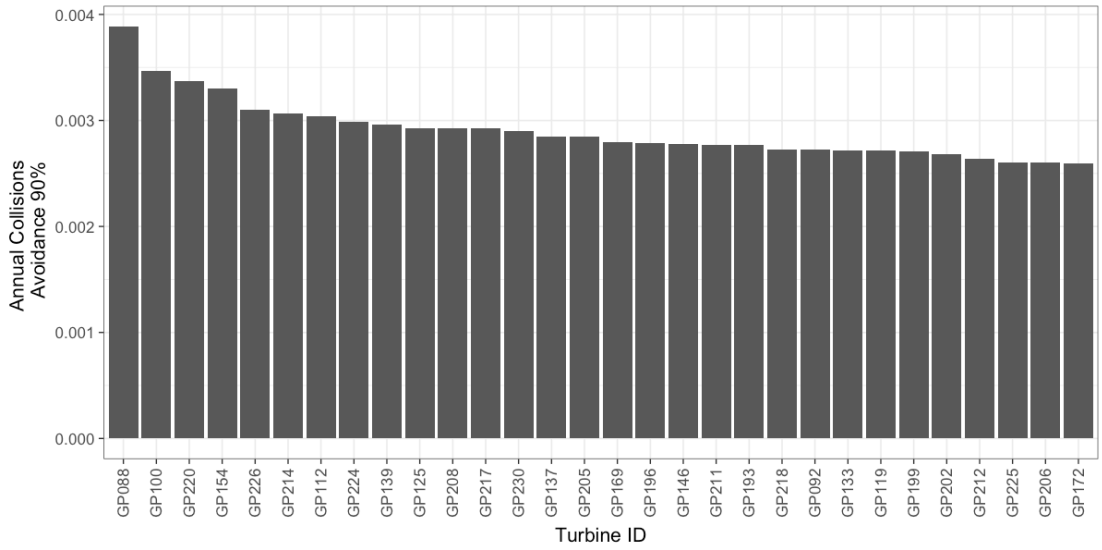

Figure 6 Estimated annual collision loss associated with each turbine, for the 30 highest risk turbines.

3.3 Additional scenarios

All model inputs are chosen to use the best data available and/or make conservative assumptions where model inputs are uncertain. For example, the breeding counts that lead to the assumption of eight breeding pairs were carried out in the most recent season, which was considered wet and hence good conditions for breeding (Brett Lane, *pers comms.*).

The breeding season length was set at 130 days, though not all individual pairs are recorded at breeding sites for that whole time.

To better understand variability, we modelled additional scenarios (again, all model inputs provided by BL&A).
Table 5 presents the annual total collision risk with the following for the following model adjustments:

- Assume a non-wet/wet year breeding scenario of five pairs in one year followed by eight in the next.
- Assume a dry/non-wet/wet year breeding scenario of three pairs in one year followed by five, then eight.
- Also allow for adjustment in the breeding season length of 50 days.

Table 5: Long-term annual average collision risk estimates by time of year, and annually for a range of breeding season model adjustments.

Avoidance rate	Breeding pairs	Breeding season length (days)	Annual total
0.9	8	130	0.844
0.9	8/5	130	0.716
0.9	8/5/3	130	0.617
0.95	8	130	0.422
0.95	8/5	130	0.358
0.95	8/5/3	130	0.309
0.9	8	50	0.407
0.9	8/5	50	0.358
0.9	8/5/3	50	0.320
0.95	8	50	0.204
0.95	8/5	50	0.179
0.95	8/5/3	50	0.160

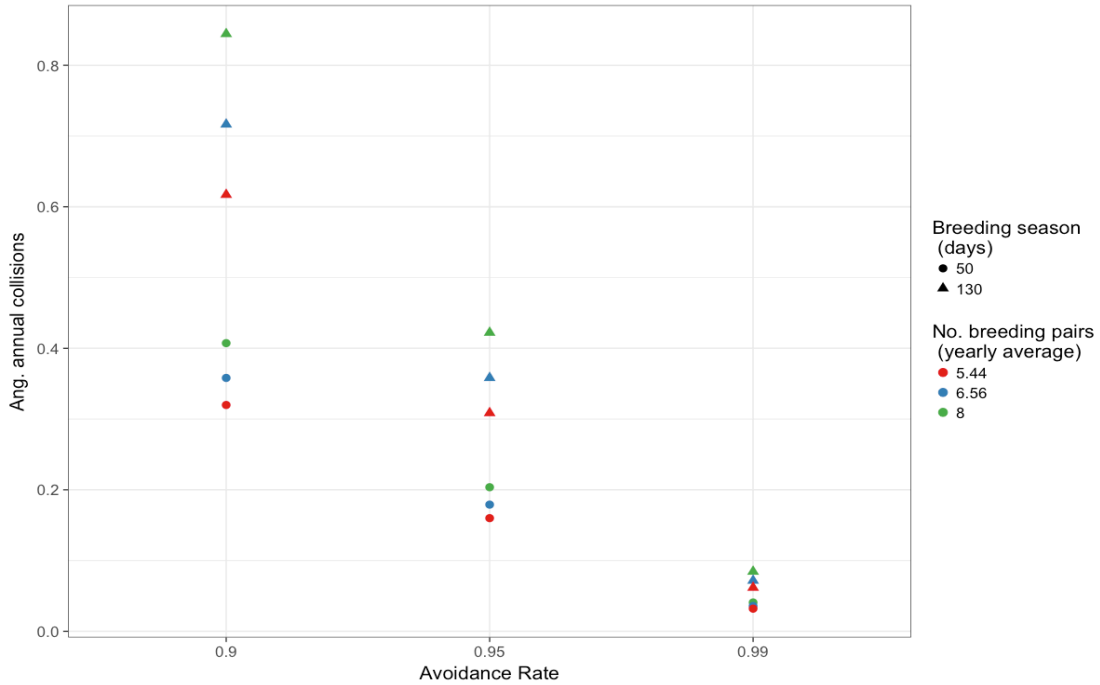

Figure 7: Long-term annual average collision risk estimates by time of year, and annually for a range of breeding season model adjustments.

4 Results: powerline collision risk

4.1.1 Inputs summary table

Error! Reference source not found. summarises the data inputs for the interaction component. All data was provided by Brett Lane & Associates and is used 'as is'.

Table 6:Model inputs for the interaction component

Variable	Input data	Data source	Model input value
	Breeding season		
Number of flights	Scenario for brolga breeding flights, based on estimate of eight breeding pairs (16.8 individuals) in the region, with an average of two flights daily. Breeding attempts were assumed to last an average of 130 days.	Regional population and activity estimates provided by BL&A based on breeding season surveys and historical records at Golden Plains Wind Farm. The number of birds per breeding pair uses the juvenile to adult ratio of 0.05 (Herring 2001 (in McCarthy 2008)).	4,368 flights annually
Distances	Shortest distance from each wetland to the powerline or shortest distances from each wetland to each powerline segment	Survey data provided by BL&A	23 distances
Wetlands	Any wetland with a historical breeding record (that has not since been assessed as permanently unsuitable) was assumed to be equally likely of occupation in a given year.	Spatial layer provided by BL&A	23 suitable wetlands.
P(flight distance)	A gamma distribution was fit to breeding season flight distance data to estimate the probability that a flight from a wetland will travel (at least) the shortest distance to the powerline	Survey data provided by BL&A	A probability was generated for each suitable wetland. The total probability is the sum of these values.
P(height | distance)	We fit a generalised linear (log-log) model to predict the expected height for a given flight distance. The proportion of flights at powerline height was then calculated by the proportion of the residuals within this range at the given distance.	BL&A provided regional breeding and flocking season flight data with both heights and distances from other Victorian sites. Powerline height was deemed to be between 15-22 m.	A value was calculated for each wetland.

4.2 Scenario results

Annual powerline crossings were estimated with two different approaches. The first (Model Type 1) predicts the heights through a linear fit based on the shortest distances between wetland and power line. The second (Model Type 2) uses an adjusted distance to account for the fact that a flight could start from the source (wetland) or from the destination (e.g. beyond the powerline). This correction tends to generate more credible flight heights predictions in case of two-way movements.

The total number of estimated, annual power line crossings are provided in **Error! Reference source not found.**. In this case there is no practical difference in the predictions of the two methods.

Table 7 Results from the power line model

	Model Type 1	Model Type 2
Total number of crossings at height	7	7
Estimated Average of Collisions	0.001	0.001

The model results per wetland are provided in **Error! Reference source not found.**. For a visual representation of the risk see Figure 5.

Table 8: Power line model results per wetland

Wetland ID	Distance (m)	Type	Flights that cross power line	
			Model Type 1	Model Type 2
52646	1106	Breeding	2.00%	2.00%
52347	1623	Breeding	0.53%	0.53%
2	1983	Breeding	0.51%	0.51%
52357	2393	Breeding	0.36%	0.36%
52316	3113	Breeding	0.09%	0.09%
54031	3558	Breeding	0.05%	0.07%
54013	4025	Breeding	0.02%	0.04%
54037	5444	Breeding	0.002%	0.005%
3	5166	Breeding	0.002%	0.003%
54009	5622	Breeding	0.002%	0.005%
52383	5375	Breeding	0.001%	0.002%
54010	5849	Breeding	0.001%	0.003%
52289	7675	Breeding	<0.001%	<0.001%
54088	7972	Breeding	<0.001%	<0.001%
4	8106	Breeding	<0.001%	<0.001%
52668	8283	Breeding	<0.001%	<0.001%
52659	8198	Breeding	<0.001%	<0.001%

52415	9690	Breeding	<0.001%	<0.001%
52410	9880	Breeding	<0.001%	<0.001%
54103	13747	Breeding	<0.001%	<0.001%
52428	13008	Breeding	<0.001%	<0.001%
52326	11461	Breeding	<0.001%	<0.001%
52401	13389	Breeding	<0.001%	<0.001%

5 References

Band, W., Madders, M., & Whitfield, D.P. 2007. Developing field and analytical methods to assess avian collision risk at wind farms. In: de Lucas, M., Janss, G.F.E. & Ferrer, M. (eds.) *Birds and Wind Farms: Risk Assessment and Mitigation*, pp. 259-275. Quercus Books: Madrid.

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BL&A, 2017. *Letter to DELWP 3/3/2017 addressing detailed questions about collision risk modelling inputs.*

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