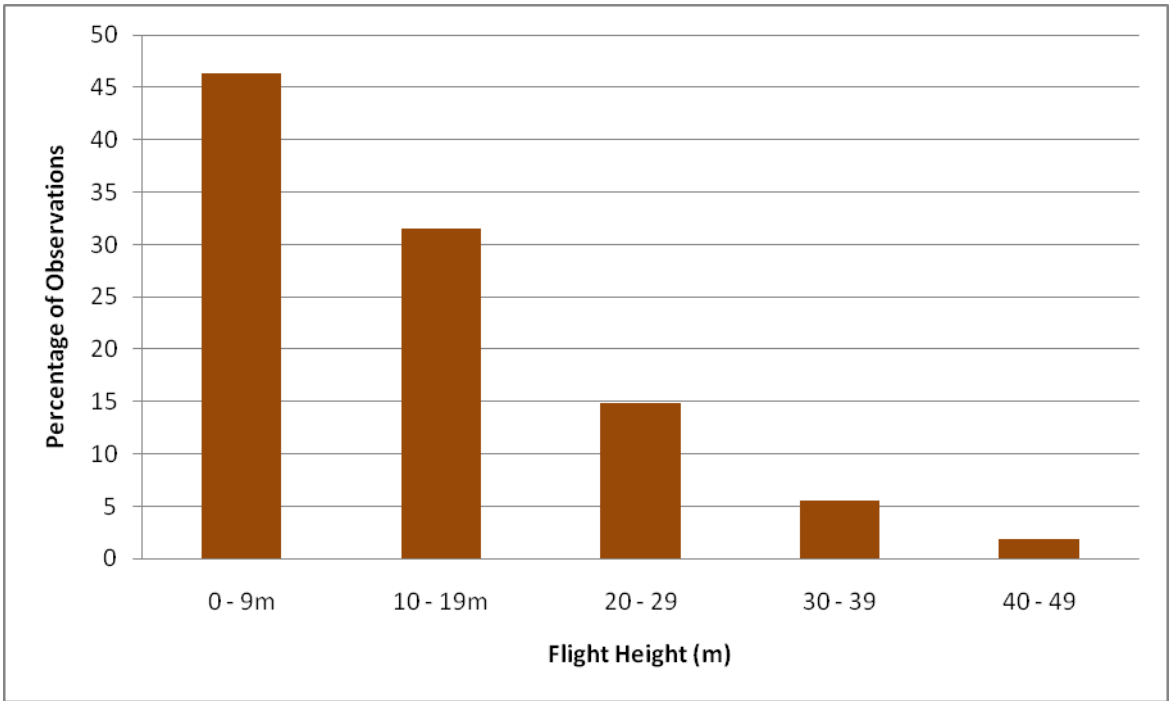
Figure 32: Percentage of Flight Observations at Different Heights (n = 44)



4.4 MIGRATION SEASON

4.4.1.1 Aims

The aims of the study were to:

- Determine the nature of dispersal of Brolgas from breeding sites to flocking sites;
- Determine the potential and actual flocking sites for Brolgas in the region; and
- Collect ancillary information about Brolga flocking behaviour and movements to inform impact assessments and potential mitigation measures.

4.4.1.2 Methods

The study was designed to provide for a rigorous and repeatable approach to observations. Surveys were timed to provide coverage of Brolga movements from their breeding sites to flocking sites. Breeding sites found during the 2007 breeding season were regularly visited from mid-November 2007 each fortnight until mid-February 2008. Potential flocking sites (based on historical flocking season records in the *AVW* and from DSE), such as wetlands and lakes, were also surveyed during this period. The area surveyed was within 20 kilometres of the boundary of the proposed Stockyard Hill Wind Farm and within the proposed wind farm site itself.

All wetlands and previous breeding sites in the survey area were surveyed for Brolgas over three days. Each three day survey was undertaken on seven separate occasions between 19 November 2007 and 14 February 2008, averaging once per fortnight. The total observation period was therefore 21 person-days.

Observers located Brolgas within the known breeding and flocking sites as well as any incidental sightings when travelling between sites. Sites that held more water and those

suspected of providing better habitat for Brolgas were investigated in more detail, and were numbered for ease of identification. Observers stayed inside their cars, wherever possible, to minimise impacts on Brolga behaviour.

The following information was systematically recorded each time Brolgas were sighted:

- Date of observation period;
- Breeding site number, and name and location of lake or wetland;
- Habitat condition, including the presence of surface water, the percentage of the wetland basin that held water, the cover of aquatic vegetation (negligible, some, lots) and the overall quality of the site;
- Additional field observations such as:
  - Whether water levels had risen or fallen since the site was last visited;
  - Sightings of other waterbirds located at the site; and
  - Any movement of stock onto the site for grazing purposes.
- Number of Brolgas present and their age (i.e. adult or chick/young);
- Any behavioural observations (i.e. feeding, resting, drinking etc.);
- Any movement from the location (i.e. either a breeding site or potential flocking site) and the distance of that movement;
- The flight height of any movement;
- The direction of any movement; and
- The habitat to which the bird moved.

Sampling effort in November was lower, involving one survey in the second half of the month, compared with other months, which were surveyed on two separate fortnights.

4.4.1.3 Results

No Brolga flights were observed during the migration season. Observations of Brolga numbers are summarised in Table 31. This shows the numbers of Brolgas at each site surveyed on each fortnight of the survey. Note that as the survey progressed, birds were occasionally found at additional sites, which were added to the list of sites surveyed thereafter.

The majority of sites where pairs had been observed in the breeding season investigations, including wetlands that had active nests, had dried out by mid-November, when the migration season surveys commenced. Therefore, where Brolgas had been commonly encountered during the breeding season, few pairs eventually remained. Most breeding sites had been vacated by late January 2008.

During the surveys, breeding pairs started appearing at larger lake systems from early December onwards. At these sites, the percentage of the basin that held water was greater than at former breeding sites. Whereas during the breeding season there was a preference to use wetlands of moderate to high habitat quality, after breeding the habitat quality of wetlands used covered the full range, from high to low. In the early parts of the migration season, most Brolgas were found in pairs or small, even-numbered flocks of eight or less birds, suggesting that they moved mostly in pairs. After early December, the

duration of stay at a site varied from less than two weeks to four or more weeks. No Brolgas were found to stay at a site for more than two surveys, suggesting that the maximum stay may be less than six weeks.

No chicks or flying juvenile birds were found during the migration season surveys, suggesting poor breeding success.

The total number of Brolgas detected within the survey area over the course of the migration season is shown in Figure 33. In early December, 27 birds were found in the survey area, compared with up to 38 during the breeding season. Across all sites surveyed, numbers declined to only two in late January, suggesting that birds gradually formed a larger and larger flock in an area that was not visited, or that was outside the survey area. Then in mid-February, a flock of 40 birds was found at Pink Lake, south-east of Streatham. The number subsequently increased to 58 birds as the flocking season progressed; this is described in Section 6.7 of this report.

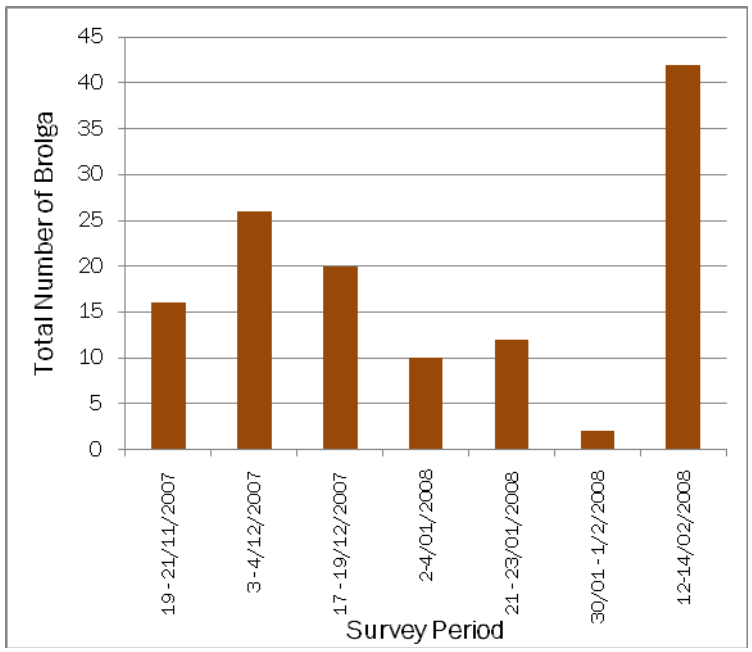
Table 31: Abundance and Distribution of Brolgas Recorded in the Survey Area.

Site	Date						
	19 - 21/11/2007	3 - 4/12/2007	17- 19/12/2007	2 - 4/01/2008	21- 23/01/2008	30/01 - 1/02/2008	12- 14/02/2008
1	2	2	0	0	0	0	0
2	0	0	0	0	0	0	0
3	4	4	0	0	0	0	0
4	-	-	-	2	2	-	0
5	0	0	2	0	2	0	0
6	0	2	0	0	0	0	0
7	-	-	-	0	0	-	0
8	-	-	-	0	0	-	-
9	-	-	-	0	-	-	-
10	-	-	-	0	0	-	-
11 #1	0	0	0	0	-	0	0
11 #2	0	2	0	0	2	0	0
12	0	2	0	0	2	0	0
13	0	0	0	0	0	0	0
14	2	2	0	0	0	0	0
15	4	2	2	0	0	0	0
Lake Goldsmith	2	2	0	0	0	0	0
Black Lake	0	0	0	0	0	0	0
Buln Gherin Swamp	0	0	0	0	0	0	0
Lake Wongan	0	4	0	6	0	2	0
Lake Wongan North #2	0	0	0	2	4	0	2
Black Swamp	0	0	0	0	0	0	0

Site	Date						
	19 - 21/11/2007	3 - 4/12/2007	17- 19/12/2007	2 - 4/01/2008	21- 23/01/2008	30/01 - 1/2/2008	12- 14/02/2008
St. Marnocks Swamp	0	0	0	0	0	0	0
Salt Lake Wongan	0	0	0	0	0	0	0
Stoneleigh #1	0	2	4	0	-	0	0
Stoneleigh #2	0	0	0	0	-	0	0
Chinaman Swamp	0	0	0	0	0	0	0
Holdsworth Swamp #1	0	1	2	0	0	0	0
Holdsworth Swamp #2	0	0	0	0	0	0	0
Horseshoe Swamp	0	2	0	0	0	0	0
Slater Lake	0	0	0	0	0	0	0
Widderin Swamp	0	0	0	0	-	0	-
Lake Burrumbeet	0	0	0	0	0	0	0
Black Swamp (Lake Burrumbeet)	0	0	0	0	0	0	0
Flocking site (north site 7)	0	0	0	0	0	0	0
Alexanders Lake	2	0	8	0	0	0	0
Lake Oundell	0	0	0	0	0	-	0
Nerrin Nerrin Swamp	0	0	0	0	0	0	0
Lake Jollicum	0	0	0	0	-	0	0
Pink Lake	-	-	2	0	0	0	40
Salt Lake	-	-	0	0	0	0	0
Blue Lake	-	-	0	0	0	0	0
TOTAL	16	27	20	10	12	2	42

Notes: Breeding sites are numbered 1 to 15. **0** = no Brolga found, **-** = site not surveyed

Figure 33: Number of Brolga at Survey Sites during the Migration Season

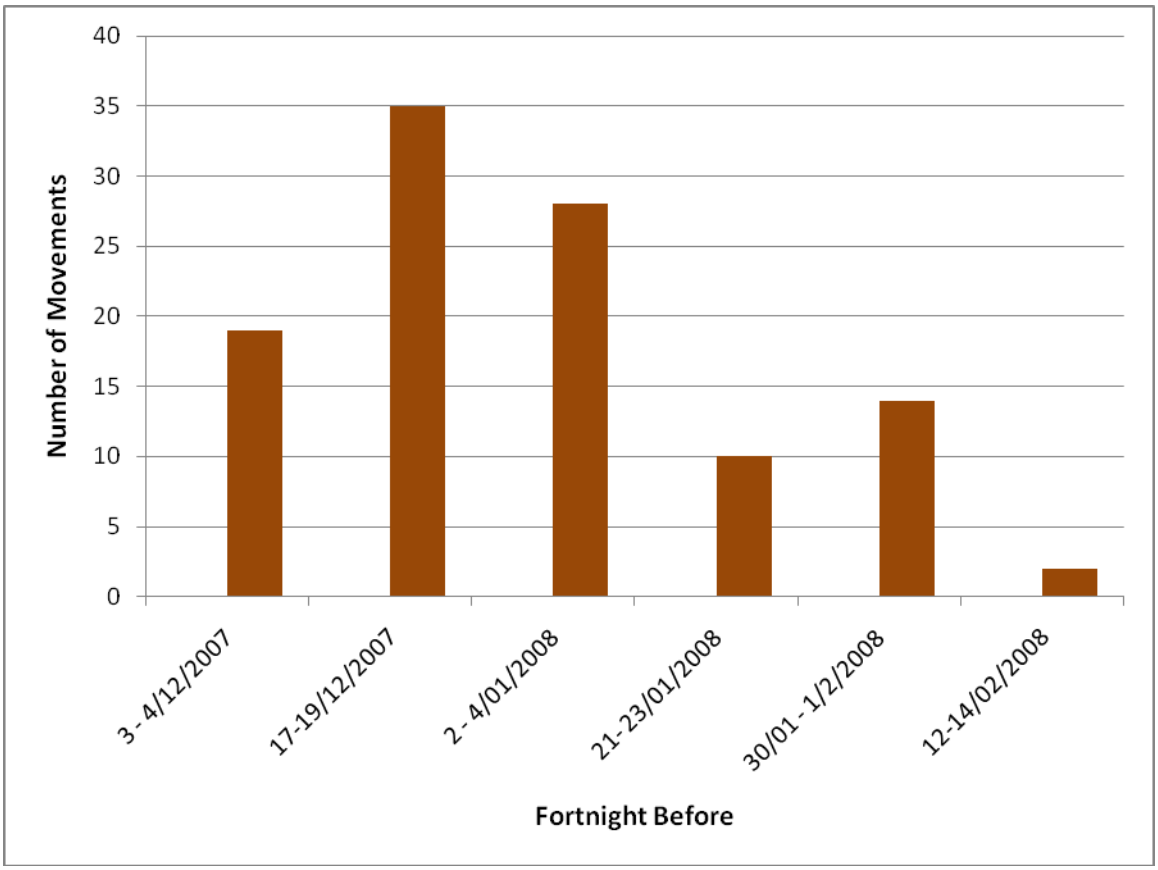


Movement rates of birds within the migration season were estimated. This involved assuming that where Brolgas were found during the migration season, the change in numbers of birds at that site represented a movement into then out of that site by that number of birds. For example, if two birds were found during two concurrent surveys at a site, it was assumed that they stayed at that site and did not move away from it during that period but that two bird-flights (i.e. one by each bird) occurred to bring them there in the first place and that two bird-flights occurred on departure. These flights have been assumed to be long distance flights of several kilometres. It is not known at what height these flights would occur as such observations were not practical within the time frame and numbers of sites surveyed for this investigation.

Over the 12.5 weeks of the migration season investigation, a total of at least 108 Brolga movements occurred. This is considered to be a minimum estimate. The trend in numbers over the survey period is shown in Figure 34.

This analysis shows that the numbers of movements declined over the flocking season. This is most likely due to birds joining then staying with an increasingly large flock at an unknown site in or near the survey area. For the maximum 27 birds responsible for these movements, this corresponds to about four longer-distance movements to new wetlands per bird (i.e. 108 flights/27 birds) during the migration season before birds settled as a large flock at a flocking site.

Figure 34: Minimum Numbers of Bird Movements in the Brolga Migration Season



By May 2008, the flocking site at Pink Lake/Blue Lake supported 58 birds. Allowing for this total number of birds in the region, it has been estimated that a total of 232 movements were made by them during the migration season (i.e. 58 birds making four movements each).

Throughout the survey period, it appeared that Lake Wongan and surrounds could emerge as the main flocking site. By late January, only Lake Wongan, Alexanders Lake, Holdsworth Swamps and the Pink Lake/Blue Lake system held water. All other wetland areas and lakes had dried up completely. In mid-February, a flock of 40 Brolgas was located on the Pink Lake wetland system, which also includes Blue Lake and Salt Lake. During this particular survey, only two other pairs were located throughout the survey area, suggesting that the majority of Brolgas in the area had migrated to Pink Lake to flock via a subsidiary flocking site that was not observed during the current investigation, and that may have been outside the survey area.

Pink and Blue Lake basin water levels were relatively stable and the quality of habitat was high, despite sheep being present at Pink and Blue Lakes. This large flock formed the basis for the subsequent flocking season investigation, described in the next section of this report.

4.5 FLOCKING SEASON

4.5.1.1 Aims

The aims of the investigation were to:

- Determine how Brolgas move in and around their flocking site; and
- Collect information about Brolga behaviour during the flocking season that might inform impact assessments and mitigation strategies.

The study was undertaken at the Pink Lake/Blue Lake/Salt Lake complex of lakes south-south east of Streatham. Fifty-eight birds were observed here during this investigation.

4.5.1.2 Methods

The study was been designed to provide for a rigorous and repeatable approach to observations.

It was designed to provide coverage of Brolga behaviour and movements at and from their flocking site to nearby foraging areas and back during daylight hours. At night, Brolgas were observed to remain at their flocking site and not move away until mid-morning.

Observation Schedule

Observations of flocking behaviour started after the large flock of 40 Brolgas were discovered at Pink Lake on 14 February 2008. The number of Brolgas initially recorded at the lakes was 40, gradually increasing to 58 birds by the end of observations on 7 May, 2008.

The flock was observed by a single observer for a total of 20 days (totalling 205 hours) according to the schedule listed in Table 32.

Table 32: Observation Schedule of Brolga Flocking Sites - Pink and Blue Lakes

Date	Time of Obs.	Total hrs (approx.)
18/02/08	Midday-sunset	8
19/02/08	Sunrise-sunset	13
20/02/08	Sunrise-sunset	13
21/02/08	Sunrise-sunset	13
22/02/08	Sunrise-midday	8
25/02/08	Midday-sunset	8
26/02/08	Sunrise-sunset	13
27/02/08	Sunrise-sunset	13
28/02/08	Sunrise-sunset	13
29/02/08	Sunrise-midday	8
17/03/08	Midday-sunset	8
18/03/08	Sunrise-sunset	13
19/03/08	Sunrise-sunset	13
20/03/08	Sunrise-midday	8
15/04/08	Midday-sunset	7
16/04/08	Sunrise-sunset	12
17/04/08	Sunrise-midday	8
5/05/08	Midday-sunset	7
6/05/08	Sunrise-sunset	12
7/05/08	Sunrise-midday	8

Observations Recorded

Observation stations were located at vantage points near the flocking site to maximise the visibility of the birds and of the area around the site to which birds might move. Observers were stationed no closer than 300 metres from the birds so that their behaviour was not modified by the presence of the observer.

The following information was systematically recorded:

- Date and time (beginning and end) of observation period;
- Number of Brolgas present at the flocking site and their age (i.e. adult or chick/young);
- Habitat type and quality at the flocking site and habitat type at nearby foraging sites;
- The weather (including temperature, wind direction and strength, and rainfall) for the observation period;
- Dominant behaviour of the flock of Brolgas at the flocking site (resting, feeding, preening, displaying, walking) and while on the foraging sites;
- Any movement from the flocking site and the distance of that movement;
- The flight height of any movement;
- The direction of any movement; and
- The habitat to which the bird moved.

4.5.1.3 Results

The results of the flocking site investigation are summarised under the following headings:

- General observations;
- Distance of movements and habitat at destination; and
- Flight heights.

General Observations

Over the more than 200 hours of observations, a total of 1700 bird-flights were observed. Many of these flights involved the entire flock, but the numbers reported here refer to individual bird movements. The flocking site was located on the north shore of Pink Lake. Habitat at the flocking site comprised a brackish wetland and consisted of a large expanse of saltmarsh (Beaded Glasswort, *Sarcocornia quinqueflora*) mixed with sedges, rushes and various native and pasture grasses. The Brolgas spent the day within this habitat, except when foraging in paddocks, usually spread over a distance of approximately 100 – 200 metres of the north shore of the lake.

This same area formed the main roosting site, where Brolgas roosted on every night of observations (14 nights).

Brolga behaviour at the flocking site followed a similar pattern each day. The birds confined themselves to the northern shore of Blue Lake, where they spent most of the day resting, preening and walking. Usually twice during the day, the whole flock, or occasionally part of the flock, flew to a nearby foraging area where the birds fed

intensively for up to three hours in the morning and about two hours in the late afternoon. The foraging areas were mainly grazed paddocks, stubble, patches of native grass or a mixture of all three. During the 20 days of observations, three foraging areas were used (see Figure 35). These were:

- A grazing paddock approximately 2 to 2.5 kilometres south of the flocking site (foraging area 1);
- Another large paddock (stubble) approximately 3.5 kilometres east of the flocking site (foraging area 2); and
- A smaller paddock approximately 150 – 300 metres north of the flocking site (foraging area 3).

Legend

- Flocking Area
- Foraging Area
- 1 Foraging Site Number

Figure 35: FLocking Core Area and Associated Foraging Sites

Project: Proposed Stockyard Hill Wind Farm

Client: Stockyard Hill Wind Farm Pty. Ltd.

Project No.: 7132	Date: 23/09/2009	Created by: Inga Kulik / Syahrudin

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Distance of Movements and Habitat at Destination

The percentage of Brolga flights of various distances recorded to and from the core flocking area to foraging areas is presented in Figure 36 and the cumulative percentage of flights to different distances from the flocking site is summarised in Table 33.

The movements (flights) and distances travelled during observations were of two types (Figure 36):

- Short distance flights within the core flocking area, mostly involving changes in position among the flock or display flights. Such flights covered less than 100 metres; and
- Longer distance flights to and from foraging areas. The distance of these flights varied depending on the position of the foraging paddock-stubble in relation to the main core flocking area. During the observations, the distance varied between 150 to 300 metres (foraging area 3) to a maximum of 3500 metres (foraging area 2).

Movements and distances travelled within the flocking site were short and limited; they constituted only 3% of all recorded movements. The main purpose of flying was therefore to access foraging areas nearby.

The maximum distance travelled in the current investigation was 3.5 kilometres. This distance was confirmed by referring to aerial photography during flight observations. Flights to and from the foraging areas comprised 97% of all movements.

The data in Table 33 and Figure 36 show the most frequent movements were of distances between 200 and 300 metres from the flocking site (39%), and 1600 to 3500 metres (30%) from the flocking site. This reflects the frequency with which the Brolga flock used foraging area 3 compared with foraging areas 1 and 2. The flight distances between 400 metres and 1599 metres were less frequent as no established foraging areas occurred at such distances; however, pairs of Brolgas occasionally flew independently of the flock and foraged at such distances from the flocking site.

Figure 36: Observed Brolga Movements to and from the Flocking Site (n = 1700)

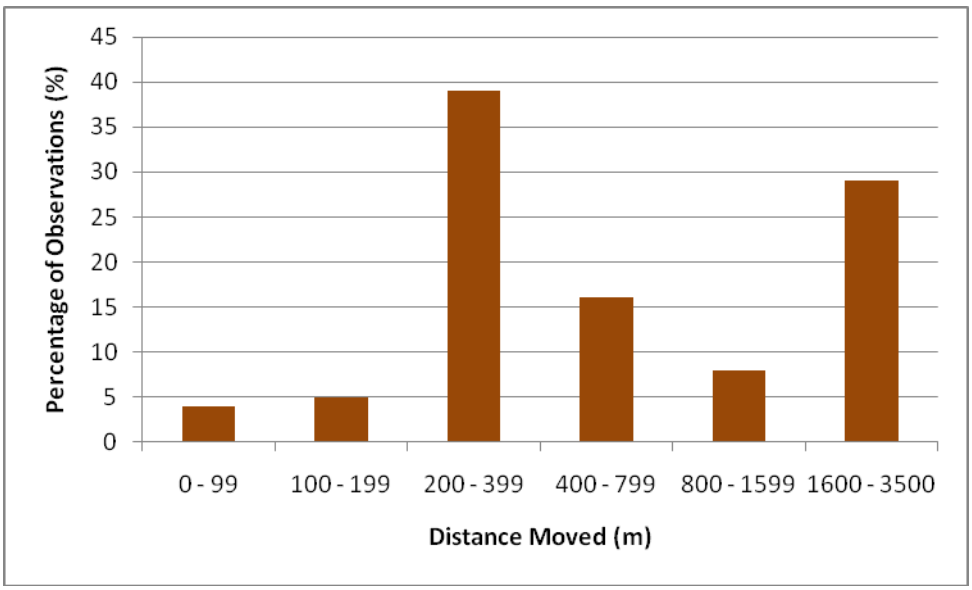

Table 33: Distance of Brolga Flights from the Flocking Site - Cumulative Percentage

Flight Distance (m)	Cumulative %
0 - 99	3.1
100 - 199	7.5
200 - 399	46.7
400 - 799	62.5
800 - 1599	70.5
1600 - 3500	100.0

Flight Height

The percentage of Brolga flights by heights is presented in Figure 37 and Table 34.

Observations showed that most flights (63%) occurred at heights less than 30 metres above the ground. However, a considerable proportion of flights (>30%) were above 50 metres, usually between 60 metres and 80 metres above ground. Flight height was found to be strongly correlated with flight distance (see Figure 38); the further the distance travelled the higher the flight (correlation coefficient of 0.7665; P> 0.001). Most flights beyond 1000 metres were to heights of more than 50 metres above the ground to a maximum height of 100 metres.

Figure 37: Percentage of Brolga flights at different heights (n = 1700)

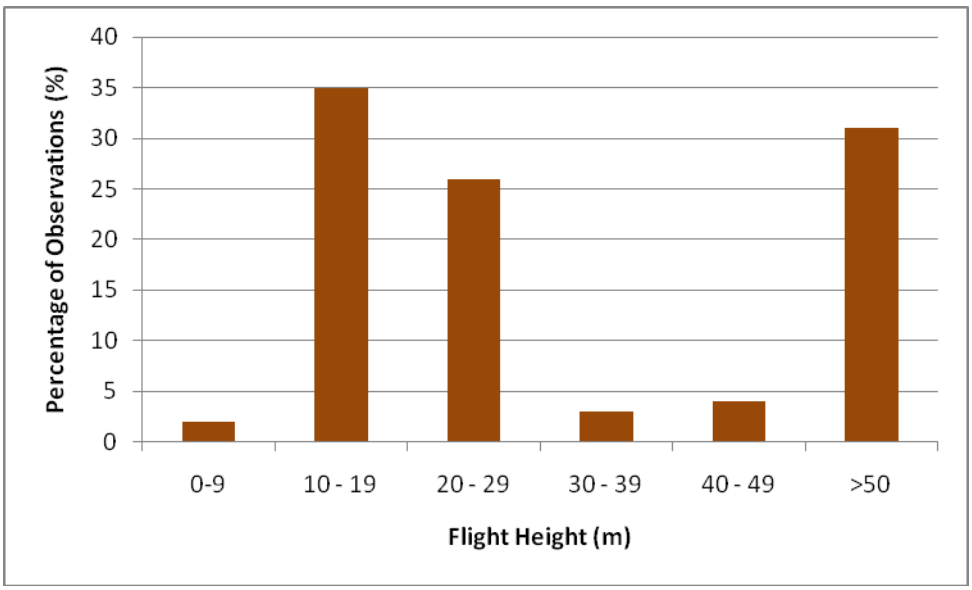

Figure 38: Correlation between flight height and flight distance during the flocking season

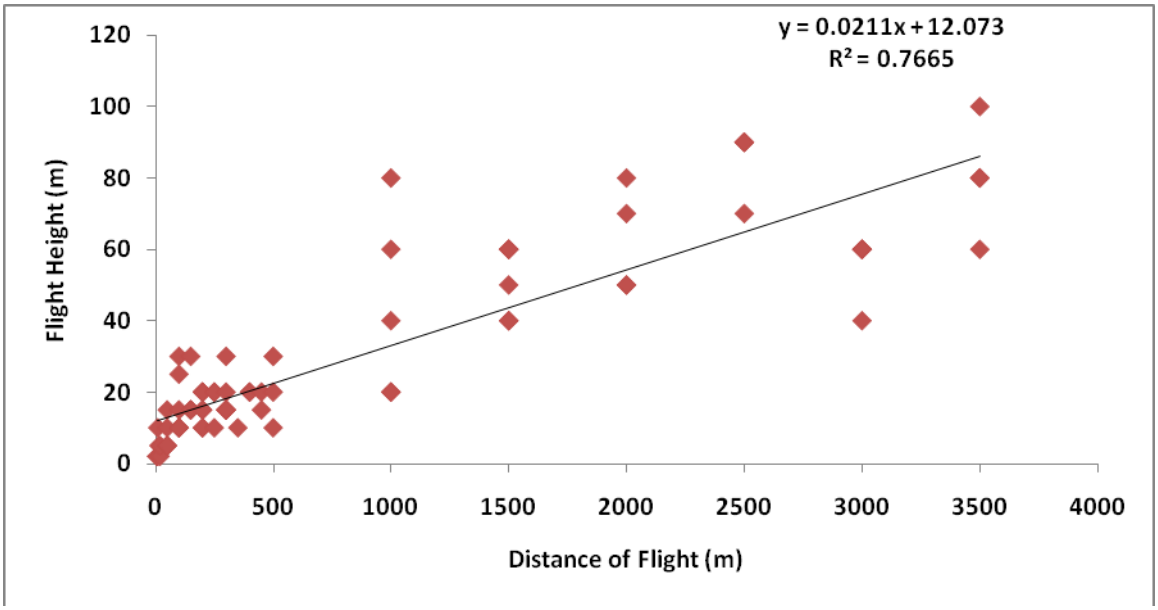

Table 34: Height of Brolga flights from the flocking site - cumulative percentage

Flight height (m)	Cumulative %
0 - 9	1.8
10 - 19	36.2
20 - 29	63.0
30 - 39	65.8
40 - 49	69.9
> 50	100

4.6 Conclusions

The following conclusions are drawn from information gathered during Level 2 and Level 3 assessments in 2007 and 2008. These data have been used to understand more about the vulnerability of Brolga to impacts from the wind farm. They also feed directly into the collision risk model (Smales 2008a).

Breeding season

- It is unlikely that more than six pairs of Brolga regularly use the area within 3.5 kilometres of the proposed wind farm area to breed. In exceptional years, this number could be higher but is very unlikely to be above about eight pairs.
- More than 50% of Brolga movements were within 200 metres of the breeding wetland and less than 14% more than 1600m from the breeding wetland;
- Movements within 200 metres of the breeding wetland were to both wetlands and pasture;
- Movements beyond 400 metres from the breeding wetland showed a strong bias towards wetlands, the species' preferred foraging habitat; and
- Almost all flights (>90%) were at a height of 30 metres or less above the ground.

Flocking season:

- Brolga flights were within 3500 metres of the flocking site;
- 97% of Brolga movements were to and from foraging areas;
- Movements of less than 100 metres involved display or position changes within the flock while on the flocking site;
- Flight height was found to be directly correlated to flight distance: the further the distance, the greater the height;
- The maximum distance travelled and maximum height attained during flights in the flocking season investigation were 3500 metres and 100 metres, respectively; and
- During the 20 days of observation, Brolgas exhibited a strong daily routine, spending most of the day at the flocking site and moving limited distances to nearby foraging areas, usually twice a day: in the mid-morning and late afternoon.

Migration season

- Most Brolgas moved from breeding sites between early December 2007 and late January 2008 to larger wetlands with more reliable water;
- Throughout the duration of the survey, most breeding and flocking sites dried up;
- Brolgas were located in all wetland quality classes;
- Pink Lake, south-east of Streatham, contained 40 Brolgas by mid-February, by which time there were very few Brolgas elsewhere in the search area;
- No chicks or juvenile birds were found during the migration season;

- It was estimated that, over the migration season, Brolgas make an average of four longer-distance flights each within the search area between wetlands to reach their principal flocking site; and
- The regional population of 58 birds probably made a total of approximately 232 longer-distance flights within the region during this migration season.
- Observations elsewhere indicate that Brolgas fly up to 5 kilometres from their flocking sites on a routine basis (R. Hill, DSE, pers. comm.).

4.7 IMPACTS OF THE PROPOSED WIND FARM ON THE BROLGA

4.7.1 Introduction

Potential impacts fall into the following categories:

- Collision risk (with turbines or powerlines);
- Habitat removal;
- Indirect disturbance (including barrier effects); and
- Habitat exclusion.

Collision risk refers to a direct impact on the Brolga from collision with operating turbines, leading to mortality.

Habitat removal is concerned with the removal of wetland and nearby pasture habitats for wind turbines and other fixed infrastructure, such as access tracks, substation(s) and underground power cable routes.

Indirect disturbance involves a reaction by birds to the presence of operating wind turbines and associated infrastructure, as well as the movements of vehicles and personnel on site during construction and operational phases of the wind farm, leading to a significant change in Brolga behaviour.

Habitat exclusion is not unrelated to the previous impact and refers to the avoidance of a zone near wind turbines where productive habitat is present and the effects of the effective removal of this habitat from access by the Brolga.

There is currently no existing information on the impacts of operating wind farms in south western Victoria on the Brolga. No wind farms have yet been constructed within the species' usual range in the state. In the absence of locally available information, examining analogous species and situations from overseas is potentially informative.

Although not exactly comparable, existing information on the impacts of wind farms on the European Crane (*Grus grus*) in Germany could form one set of information that informs the impact assessment. In Germany, there is a well-developed wind industry of many thousands of turbines, and several thousand European Cranes move about the northern part of the country during the migration and non-breeding seasons. Information on the impacts of wind farms on cranes in Germany is summarised below, together with other information on wind farm impacts that assists the impact assessment. The principal source of information is Gerjets (2006) and results are summarised below:

- Cranes avoided flying close to wind turbines;

- Cranes have been observed flying within 200 metres 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 metres and 670 metres, with a median distance of 300 metres, where turbines were not parallel with the direction of flight;
- In another, less systematic study, flying crane flocks flew around operating wind turbines at distances of between 400 and 500 metres 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 metres 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 metres from the turbine. The flock eventually flew around the turbine and regrouped after 1.5 kilometres.

The reaction of cranes to wind turbines therefore varies but it is clear that they generally avoid wind turbines. However, further investigations are warranted to determine whether the proposed Stockyard Hill Wind Farm will significant impact Brolga populations. Results are provided below.

4.7.1.1 Wind Turbine Collision Risk Analysis

Collision with wind turbines has the potential to occur as Brolga are moving throughout the wind farm site. The risk of this occurring was analysed by Biosis Research Pty. Ltd. (Smales 2008) using the results from the assessments presented in this report. Full details of the model are provided in Smales (2008). A summary, prepared by Biosis Research Pty Ltd is provided below.

> *"Assessment of the potential for Brolga mortalities to occur as a result of collisions with wind turbines and powerlines proposed for the Stockyard Hill Wind Farm, and of the consequent potential effect on the Victorian Brolga population, has been a collaborative process requiring a number of steps as outlined below.*
>
> *Draft Guidelines for evaluation of the possible effects of wind farms in south-western Victoria have been under development by the Victorian Brolga Wind Farm Scientific Panel led by DSE, whilst the assessment for the proposed Stockyard Hill Wind Farm project has been underway. The assessment for Stockyard Hill has entailed liaison throughout with DSE and has followed the processes outlined in the Draft Guidelines.*
>
> *The Victorian Brolga population is estimated at between 400 and 600 birds with the great majority of the population centred on the south-western volcanic plains. Habitat suitable for Brolgas has quite specific characteristics including shallow wetlands and meadows traditionally used for breeding and flocking. The birds also forage out from wetlands into low-lying pasture and cropped agricultural land. Availability of suitable wetlands is heavily influenced by drought and, more permanently, by drainage works. Outside of the flocking season pairs of Brolgas are territorial and do not tolerant close proximity of other Brolgas. As a result of*

these factors Brolgas are relatively scarce and widely dispersed even in suitable areas of their range for much of the year. During the annual flocking season they congregate at a few key sites. As a consequence, there is limited capacity for ornithologists to obtain a large body of numerical data for Brolga utilisation from field observations.

Brolgas spend significant portions of their time on the ground. They obtain their food whilst walking and this activity occupies a large part of their activity cycle. Flights are relatively infrequent and are undertaken primarily when moving between locations of concentrated terrestrial activity, such as between a nest site and preferred foraging areas, between foraging areas and during displays. Thus long periods of field observation generally document few flights.

Records of Brolgas were obtained from the area encompassed by the proposed Stockyard Hill Wind Farm and adjacent areas during fieldwork undertaken by Brett Lane & Associates Pty. Ltd. From early in the assessment program it was recognised by DSE that collection of a large body of empirical data for Brolgas was not feasible. Thus field data collected for the project was obtained with the primary purpose of providing information about current Brolga use of the area as an adjunct to pre-existing records for the area. It also obtained some key information, such as records of Brolga flight heights, for which no previous information existed. Monitoring of Brolgas was naturally concentrated on areas used by the birds. Its results apply only to areas of habitat for the birds and are not indicative of their use of the great majority of the landscape of the proposed wind farm which is not suitable habitat for them.

Collision risk assessments for Brolgas have been undertaken on the basis of informed scenario modelling. The scenarios have been informed by general ornithological knowledge and published information about the biology of the south-western Victorian Brolga population; previous database records of Brolgas from the relevant area; and specific information obtained from the field by Brett Lane & Associates.

Algorithms and mathematical computations for some key inputs to collision risk modelling, such as for the lengths and heights of Brolga flights, were determined by Symbolix on the basis of data provided by Brett Lane & Associates Pty. Ltd.. Due to uncertainties and the likelihood of variables that were not encompassed by the available field data, a level of conservatism was introduced by the use of an 80 percentile confidence boundary on values derived from the field data.

The rationale, parameters and values used for various scenarios for the different seasonal activities of Brolgas are described in turbine and powerline collision assessment reports prepared by Biosis Research. Predictions of mean annual numbers of Brolga fatalities that might occur under the scenarios modelled were calculated using the Biosis Research deterministic collision risk model.

Potential numbers of Brolga mortalities predicted by the model were provided to Dr Michael McCarthy of Melbourne University and input into a Brolga Population

Viability Analysis model. This demographic model evaluated the effect of predicted mortalities on extinction risk for the Victorian Brolga population.

The collision risk model and population viability analysis are predictive mathematical models. All such models are mathematical representations designed to represent what might occur in reality. They are transparent in that every parameter and values used as inputs to the models are defined and explicit.

Collision risk modelling accounts for a range of factors that describe how wind turbines will function based on multiple specifications of their physical dimensions, geometry, movements and positioning in the landscape. It also accounts for the expected flights of Brolgas in the area of the wind farm including their frequency, heights and distance according to the birds' seasonal behaviours. Using this information the model provides forecasts for an annual average number of interactions between Brolgas and turbines that pose a risk of collision. A similar process has been applied to model risk of collisions with a powerline proposed to transfer electricity from the wind farm to the power grid.

Population viability analysis uses information about the demographic functioning of a wildlife population, including rates of survival, mortality, fecundity, immigration and emigration to evaluate the threats faced by the species in terms of its risks of extinction or decline. In the present case it has been used to evaluate the potential influence of mortalities that might occur due to the wind farm on extinction risk for the Victorian Brolga population."

4.7.1.2 Powerline Collision Risk

Powerline collision has been recorded for the Brolga, with at least five known occurrences (Goldstraw & Du Guesclin 1991; A. Pritchard, DSE, pers. comm.). Potentially, the construction of powerlines may represent the greatest likely collision risk to Brolgas from the proposed wind farm. An external powerline route away from the wind farm has been adopted and will have limited potential impact on Brolga. Furthermore, the impact of powerlines associated with the project has been subject to a separate collision risk modelling exercise (Smales 2009). In summary, the collision risk of Brolga to the powerlines was calculated for the breeding and flocking season. The data presented in this report was used for this analysis and included:

- Annual average total of Brolga flights per breeding season;
- Average annual population which has the potential to encounter the powerline;
- Average number of flights during a breeding season; and
- Percentage of Brolga flights that may reach or cross the powerline for each territory;

The collision risk for the flocking season was assessed for the one-off flocking events observed within the wind farm boundary. The data used for this analysis included data recorded at traditional flocking sites, as no records were available for one-off flocking sites. The frequency and duration of flocking events was modelled on those observed at Lake Goldsmith over the past 20 years.

At risk flights were calculated as below:

- Total number of flights during breeding / flocking season x % flights of sufficient length to cross powerline = Average annual number of flights likely to cross powerline
- Average annual number of flights likely to cross powerline x Proportion of flights likely result in collision = At risk flights

Following this analysis a PVA model was completed, as above.

4.7.1.3 Habitat Removal

The removal of significant habitats and native vegetation has been avoided at most Australian wind farms. This is because the layout usually occupies less than 2% of the land area within a wind farm site and micrositing is used to ensure that turbines and infrastructure are located so as to avoid impacts on significant habitats.

At the proposed Stockyard Hill Wind Farm site, most Brolga breeding habitat is wetlands that lie in the lowest part of the landscape, generally more than 800 metres from proposed turbine locations. Therefore, wetlands will not be directly removed by the proposed wind farm.

Brolgas utilise pasture near their breeding wetlands for foraging and therefore may occasionally move into areas where turbines might be located. However, as the total area occupied by the turbines and associated infrastructure is a very small proportion of the available pasture, impacts on the availability of pasture habitat are not considered to be significant. Additionally, Brolgas showed a preference for flying to wetlands at distances greater than 400 metres from their breeding sites. Given that a 400 metres turbine exclusion buffer is to apply to all breeding sites known around the proposed Stockyard Hill Wind Farm, removal of a small proportion of pasture habitat is not considered to represent a significant impact on breeding season foraging habitat availability.

During the flocking season, birds confined their foraging activities to within 4 kilometres of their core flocking site. As no known traditional flocking sites lie closer than 3 kilometres to the proposed wind farm boundary, removal of flocking season foraging habitat will not occur.

4.7.1.4 Indirect Disturbance

Wind farms can potentially affect birds through displacement from an area around the wind turbines, effectively resulting in habitat loss. There is no information available on the effect on European Crane habitat usage near wind turbines. However, discussion outlined in Section 4.7 indicates that the effect of disturbance is relatively low. Whilst the tolerance of Brolgas for nearby wind turbines is not known the observations on site indicate that the use of habitats in the proposed wind farm is relatively low. A precautionary exclusion zone around the turbines have been incorporated to minimise potential risk to Brolga.

4.7.1.5 Barrier Effect

Brolgas may be indirectly affected by a wind farm when attempting to move between roosting and foraging habitats, if adjacent turbines are too close together for cranes to fly between them. Based on observed disturbance of flying birds at distances of between 300 metres and 670 metres, Gerjets (2006) recommended a 1.5 kilometres gap

between groups of turbines to permit undisturbed crane flight between nearby habitats. This would maintain a useable 'airway' for cranes to use when moving between habitats.

4.7.2 Breeding Season Impacts and Mitigation

4.7.2.1 Potential Impacts

Table 35 summarises the number of Brolga breeding sites active during this investigation at different distances from the proposed wind farm boundary but within 3.2 kilometres of the wind farm site boundary (i.e. the maximum flight distance observed from a breeding site).

Table 35: Number of breeding sites active in 2007 within three kilometres of the Stockyard Wind Farm site

Distance range (m)	Number of breeding sites (2007)
0 - 99	0
100 - 199	0
200 - 399	0
400 - 799	1
800 - 1599	1
1600 - 3200	1
Total	3

Based on the frequency of movements, it is possible to estimate the number of Brolga flights that occur in an average 12 hour day during the breeding season (see Table 36).