

Table 24: Three steps in the assessment of impact collision risk from wind farms

Level	Type	Scope	Action
1	Risk Assessment	Review potential species of concern within the possible zone of impact of the proposed wind farm	Review of all potential fauna constraints. See Chapter 3. Brolga identified as potential constraint.
2	Risk Assessment	Assess the likelihood of a significant impact on any species of concern identified in Level 1.	Determined that the Brolga utilised the landscape surrounding the proposed Stockyard Hill Wind Farm and was recorded as breeding in a number of wetlands within a 20 kilometres radius of the proposed wind farm (section 4.2). Fieldwork done in 2007 and 2008.
3	Impact Assessment	Assess the actual impact on the species of concern as accurately as possible	Level 2 assessment concluded need to do more detailed investigation to gain a better understanding of the movements and behaviour of the Brolga population in the region. Work was done to determine the risk that the proposed wind farm may pose to this population. This involved surveys in the breeding, migration and flocking seasons for the species. The results from the detailed Level 3 assessment were used as factors in the collision risk model (section 4.3). Fieldwork done in 2007 and 2008.

4.2 LEVEL TWO RISK ASSESSMENT

This section of the report presents a review of existing information on the status of the Brolga in a region within 20 kilometres of and including the proposed wind farm site. Investigations consider three components of Brolga life history:

1. Breeding season (nesting pairs at wetlands);
2. Flocking season (outside breeding season, when birds congregate); and
3. Migration season (when birds ‘stage’ at locations away from wetlands, enroute to flocking areas).

Note Level 2 and Level 3 assessments were done in both 2007 and 2008. Some detailed Level 3 investigation in 2007 also informed more targeted Level 2 work in 2008.

4.2.1 *Distribution and Movement of Brolgas across Victoria*

In Victoria, the range of the Brolga has contracted over time as a consequence of wetland drainage and loss of habitat due to agricultural development since European settlement. Currently birds have been found in the southwest and in the north of the state along parts of the Murray River (Du Guesclin 2003). Its former range included northeast Victoria, Gippsland and the Melbourne region.

Flocking sites of Brolgas in south western Victoria occur in the following locations:

- Grampians region;
- Strathdownie;

- Cressy;
- Streatham (mainly on Lake Wongan and in the Skipton area);
- Hamilton, Dunkeld and Peshurst areas;
- Edenhope area;
- Toolondo;
- Willaura and Stavely areas; and
- Lake Bernie Bolac, near Darlinghurst.

Approximately 250, or 75% of breeding sites in Victoria, are found on the volcanic plains in the southwest of the state.

Brolga movements in south western Victoria are not completely understood. Regular movements in south eastern Australia occur between flocking and breeding sites. Local movements can also take place when birds are moving between night time roosting sites and feeding sites, in response to rainfall and the availability of food. 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.

4.2.2 Previous Records from the Stockyard Hill Area

Previous records of Brolgas from the search area (within 20 kilometres of the proposed Stockyard Hill Wind Farm) are reported in the AVW. There were 219 records over 30 years from 1970 to 2003. The records were from various wetlands scattered within 20 kilometres from the boundary of and including the proposed wind farm site. Analysis of the records resulted in a final map of breeding sites and sightings based on correcting the position of some breeding records to the nearest wetland and removing duplicates that were obviously the same breeding attempt documented during separate visits.

The number of Brolgas seen in each of the observations listed in the AVW records varied from a single bird to a flock of 77 Brolgas.

Flocking season records from the AVW have been analysed for the period since 1988. For the purpose of analysis, a flocking site was defined as a site that supported five birds or more (i.e. more than the maximum family party, representing sites where more than one family party came together).

Large numbers of Brolgas have been recorded in single sightings, including those at Lake Wongan in 1995 (77 birds), Alexanders Lake in 1991 (60 birds), and St Marnocks Swamp in 1992 (52 birds). These figures may represent the number of Brolgas present during the flocking season, as they were recorded in February and June. The 2006/2007 flocking sites survey in Victoria reported a maximum of 20 birds from the Streatham flocking site and from the area within 20 kilometres of the proposed wind farm (DSE, unpublished records). To summarise, within 20 kilometres of the boundary of the proposed wind farm, there are at least five historically known Brolga flocking sites (AVW records). These include:

- Lake Wongan (seven kilometres to the west of wind farm);

- St Marnocks Swamp (approximately one kilometre from the north-west corner of wind farm);
- Lake Goldsmith (close to the eastern edge of the proposed wind farm);
- Alexanders Lake (seven kilometres to the west of wind farm);
- Horseshoe Swamp (six to eight kilometres to the south and south-west of wind farm; (currently dry); and
- A small number of scattered wetlands north of Skipton.

Records of flocking birds (i.e. > five birds) in the Sheldon (DSE) flocking season database have also been reviewed and the same sites appear in this data set as well. Being a more comprehensive database of flocking season sightings, this includes some additional sites, such as:

- Lake Goldsmith (two records in 1988);
- Pasture west of Lake Goldsmith;
- Slater Lake; and
- Pasture near the southern part of the proposed wind farm (two sites).

These sites did not regularly support Brolgas during the flocking season, and in three cases comprised pasture rather than the larger, permanent wetland usually preferred as flocking sites.

Historical records and current observations suggest that observations of flocking Brolgas (five or more individuals together) fall into two categories:

- Sites where large numbers of Brolgas regularly occur within and between years, exclusively in larger, more reliably full, wetlands (termed ‘traditional’ flocking sites); and
- Sites where large numbers of Brolgas have occurred once or for only one of the last 20 years (termed ‘one-off stopover’ sites).

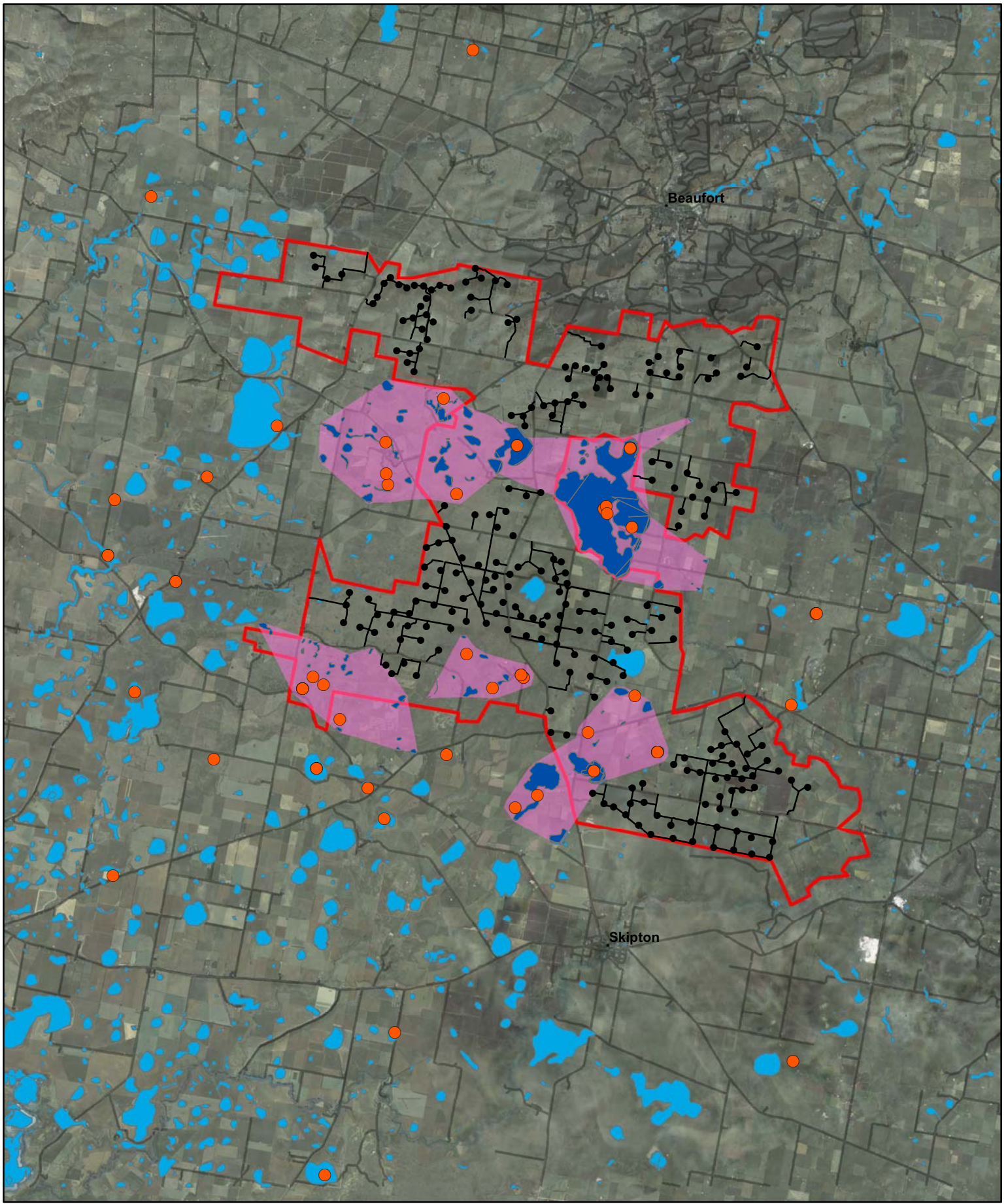
Traditional flocking sites are considered to have much greater value for Brolgas than one-off stopover sites. Movements to and from on-off stopover sites are more likely to resemble the movements Brolgas make in the migration seasons. These two types of flocking sites have been accounted for in the collision risk modelling (Smales 2008a).

4.2.2.1 Breeding Season Records

The AVW records included 60 breeding records from the search area between 1970 and 2003. In addition to the historic records from the AVW database, Philip Du Guesclin of the DSE Warrnambool office kindly provided flocking records for the region for the years 2006–2007 (see Appendix 19) and breeding records for the 2006 breeding season (see Appendix 20). During that season, 14 Brolgas were recorded within 20 kilometres of the boundary of the proposed Stockyard Hill Wind Farm during the flocking season, and no breeding was found in the region during the 2006 breeding season.

The records since 1988 were reviewed and a number of duplicates were identified (e.g. records at the same place a month or so apart, clearly of the same breeding attempt). Furthermore, errors in mapping were rectified by relocating all records to the closest wetland if they were not in such habitat. This resulted in a final set of breeding records

to be used for analysis and impact assessment. A total of 23 of these breeding records were from sites within 3 kilometres of the wind farm site or internal powerline routes (Figure 27).



Legend

- Study Area
- Breeding Records
- Proposed Turbines
- Access Tracks
- Wetlands within Home-range Area
- Home-range
- Wetlands
- Roads

Figure 27: Historical Breeding Records (1988 to 2008) and Broilga Home-range

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Client: Stockyard Hill Wind Farm Pty. Ltd.

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4.2.2.2 Recent Local Records

Recent local records in the Stockyard Hill region were collated through a Brolga Questionnaire for local residents. This survey outlined specific questions on Brolga sightings including the location and habitat of the Brolga sighted and the duration of the sighting. The information gathered from the questionnaire is tabulated in Appendix 21.

A summary of the results is below:

- All local residents surveyed are very confident at identifying the Brolga;
- All local residents surveyed have sighted Brolgas more than once in a year;
- All local residents surveyed have seen Brolgas in the district in the past 12 months except for one resident, who last saw Brolgas between one and five years ago;
- Most Brolga sightings by local residents have been in paddocks, swamps and/or grassland habitat; and
- Some local residents comment that Brolgas frequent their property each year to nest.

All localities of Brolga sightings made by local residents match with records from the AVW database. Several common Brolga locations in the Stockyard Hill area include: Lake Goldsmith, Lake Wongan, Buln Gherin Swamp, St Marnocks Swamp, Slater Lake and Stoneleigh.

No additional Brolga localities were identified from the questionnaire.

4.2.3 Breeding Season Investigation

4.2.3.1 Aims

Investigations of the Brolga were undertaken in the 2007 and 2008 breeding seasons.

The aims of the 2007 breeding season investigations were to:

- Provide data to be used as factors in the model of collision risk;
- Identify the number and quality of wetlands known to be frequented regularly by Brolgas;
- Determine how Brolgas may use the proposed wind farm site and surrounding areas (within 20 kilometres of the wind farm boundary); and
- Identify known and potential breeding sites on the proposed wind farm site and surrounding areas (within 20 kilometres of the wind farm boundary).

During the 2007 surveys, not all wetlands could be visited due to private property access limitations. This was remedied in 2008 by a more thorough survey of wetlands within 3 kilometres of the wind farm boundary. The three kilometre range was chosen based on behavioural observations (Level Three risk assessment) in the 2007 breeding season. The aims of this more thorough survey were to:

- Identify the number and quality of additional wetlands known to be frequented regularly by Brolgas; and
- Identify potential breeding sites on and within 3 kilometres of the proposed wind farm site.

4.2.4 *Field Methodology*

To provide detailed information on the status, distribution and possible breeding of the Brolga on wetlands in the vicinity of the proposed Stockyard Hill Wind Farm, a targeted field survey was undertaken in the 2007 and 2008 breeding seasons.

The field survey was undertaken by two observers from 6 to 10 August 2007, followed by a second survey on 27 and 28 August 2007. The surveys covered the area within 20 kilometres of the boundary of the proposed wind farm site, including the proposed wind farm site itself. Surveys began at sunrise and finished after sunset each day. The wetlands were surveyed at a time when Brolgas usually breed, namely between July and November.

An additional targeted field survey was undertaken by two observers on 21 and 22 August 2008 and from 25 to 27 of August 2008. This survey focussed on filling gaps in coverage due to property access issues in 2007 close to the proposed wind farm. As many wetlands as possible within three kilometres of the development footprint were visited. Three kilometres was chosen based on the observed movement distance of breeding Brolgas from their nest site in the detailed 2007 behavioural studies (see Section 6.4).

Rainfall in this part of south western Victoria was below average in the winter of the 2008, but considered to be average in the winter and early spring of 2007 (A. Pritchard, DSE, pers. comm.). This meant that many small seasonal wetlands filled before the 2007 Brolga breeding season. For this reason, the current survey is considered to be representative of a year of average to above average breeding habitat availability and the survey results can therefore be considered representative.

As far as possible, all wetlands (not subject to private land access limitations) were visited and surveyed. Wetlands were targeted if they were previous breeding sites in the AVW data or if they were designated as past breeding sites in the 2006 breeding season survey results (see Appendix 20). The surveyed sites included the following wetlands:

- Lake Goldsmith;
- Black Lake;
- Buln Gherin Swamp;
- St. Marnocks Swamp;
- Slater Lake;
- Lake Wongan;
- Salt Lake Wongan;
- Lake McLaren;
- Alexanders Lake;
- Stoneleigh Lake and Swamp;
- Chinaman Swamp;
- Holdsworth Swamp;
- Horseshoe Swamp;

- Lake Burrumbeet;
- Several creek valleys that traversed the wind farm site, including: Mt Emu Creek, Blacks Creek, Wongan Creek, and other smaller creeks; and
- Many unnamed wetlands of various sizes scattered within the survey area, including: freshwater meadows, shallow freshwater marshes, permanent and semi-permanent saline water bodies, sewage ponds and water logged or grass paddocks inundated with water following the recent rains in the region.

The wetlands surveyed in 2007 are shown in Figure 28 and those in 2008 in Figure 29. All of the wetlands surveyed are shown in Figure 30.

Many wetlands which were marked on the 1:50 000 topographic map sheets were dry during the surveys, or had been dry for many years, as they had previously been converted to 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.

Notes were recorded on the habitat quality, and aquatic and emergent vegetation present. The wetland habitats were assessed for their suitability as breeding habitat for Brolga. The quality of these habitats was assessed using the criteria detailed below. These criteria were based on current information on Brolga breeding habitat requirements in western Victoria (Marchant and Higgins 1993, Du Guesclin 2003). Three main habitat quality categories were used.

High: Habitat components listed below are usually all present:

- Shallow freshwater marsh or shallow freshwater meadow less than 0.5 metres deep;
- Wetlands with large areas of aquatic and emergent vegetation (e.g. annual herbs, rushes (*Carex* spp. or *Juncus* spp.) or Tussock Grass (*Poa* spp.);
- Little or no signs of changed water regimes (e.g. drained wetlands); and
- 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 nesting opportunities:

- Water body likely to hold water throughout breeding season (July-December) (i.e. permanent, or largely permanent);
- Water body with some aquatic and emergent vegetation (e.g. annual herbs, rushes (*Carex* spp. or *Juncus* spp.) or Tussock Grass (*Poa* spp.));
- Some changes to water regime may have occurred (drainage lines); and
- Wetland shows some signs of disturbance (e.g. due to access to stock, cultivation, feral predators).

Low: Many habitat elements have been lost. Wetland habitats that can be described as follows:

- Likely to be ephemeral or drained (only hold water for limited time of the year);
- Little or no aquatic or emergent vegetation;
- Changed water regime, little water present; and

- Showing signs of disturbance (such as heavily grazed by stock, cultivated, feral predators).

4.2.4.1 Limitations

The Brolga breeds from July to November. The timing of the breeding Brolga survey during August was deemed acceptable for the purposes of this assessment. Breeding behaviour had commenced at the time of the 2007 investigation and nests were being attended by Brolgas.

During the 2008 survey, the majority of wetlands assessed were dry and no Brolga breeding behaviour was observed. In some cases, access to some potential breeding sites on private land was limited. The number of confirmed breeding pairs of Brolga is likely to be the minimum number in the search area. Some breeding pairs may have been missed due to access and sight-line difficulties from public roads in areas where private land access was restricted.

Adopting a precautionary approach, any impact assessments will be based on the number of breeding pairs identified in the current surveys (including in Section 6.5), grossed up to account for the estimated 29 breeding pairs assumed to make up the Blue Lake flock observed during the 2008 flocking season (see Section 6.7).

4.2.5 Results

This sub-section presents the results of the Level Two breeding season survey undertaken in 2007 and 2008. Confirmed breeding attempts were reported from some of the wetlands visited in the survey area.

4.2.5.1 Habitat Assessment

2007 Survey

A total of 258 wetlands were assessed during the 2007 investigation. A total of 170 wetlands were visited and assessed during the first field trip from 6 to 10 August and another 88 sites were visited in the second field trip on 27 and 28 August, 2007.

The majority of the wetlands surveyed were of low quality and did not contain habitat characteristics that make them suitable for Brolga breeding. Of the 258 wetlands, 18 sites (c. 7%) were considered of high habitat quality, 18 of moderate–high habitat quality (c. 7%) and 30 (c. 12%) of moderate habitat quality (Figure 28).

Table 25 summarises the numbers of wetlands in each habitat quality class and the numbers of pairs of Brolgas observed in each quality class. These findings show that the Brolga preferred to feed and breed in higher quality wetlands; however, selection of feeding or nesting habitats did not always follow the criteria used to assess higher quality habitats. That is, Brolgas did not build nests only in high quality habitats; in fact, most nests in this survey were found to be built in moderate quality habitats. Brolgas are known to rely primarily on shallow wetlands areas that have low vegetation cover, allowing them to maintain a panoramic view of their surroundings. This is thought to maximise the detectability of predators, enabling defensive action, if possible.

Table 25: Wetlands Visited - 2007 Breeding Season

Habitat quality	No. of wetlands	Active nests	No. Brolga confirmed with nest	Brolga observed at a wetland but without nest
Low	165	0	0	1
Low-moderate	27	0	0	0
Moderate	30	3	6	10
Moderate-high	18	2	4	3
High	18	2	4	5
Total	258	7	14	24

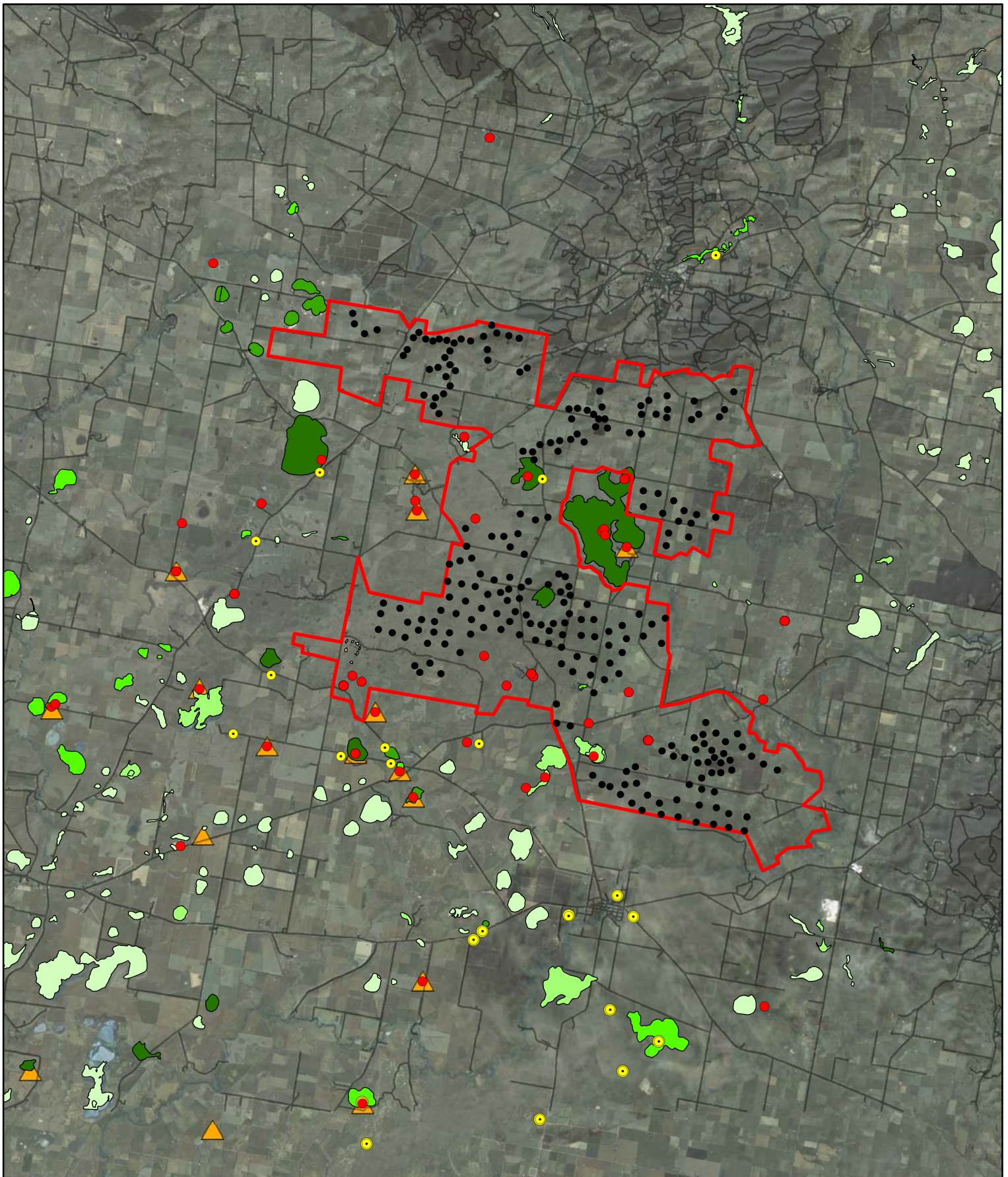
2008 Survey

There were 126 wetlands within the survey area within three kilometres of the development footprint during the 2008 investigation. Of these, 89 wetlands were assessed. Wetlands not assessed included sites which could not be accessed at the request of the land owners (9.5%), and farm dams (20%). Details surveyed wetlands, including their habitat quality and site descriptions are presented in Appendix 22 and Figure 29. The majority of the wetlands surveyed were of low quality and did not contain habitat characteristics that made them suitable for Brolga breeding. All dams were of low habitat quality, with the exception of one dam that was of moderate habitat quality which was included in the analysis. Of the 89 wetlands, five sites (6%) were considered of high habitat quality, three of moderate-high habitat quality (3%) and 10 (11%) of moderate habitat quality.

Table 26 summarises the numbers of wetlands in each habitat quality class and the numbers of Brolgas observed in each quality class. Some Brolgas observed during this survey were foraging in pasture within 200 metres of wetlands and the quality of these wetlands is indicated. Three Brolgas were seen further than this from a wetland are not included in Table 26. No Brolgas were confirmed with a nest.

Table 26: Wetlands Visited - 2008 Breeding Season

Habitat quality	No. of wetlands	Brolga observed at a wetland but without nest
Low	56	0
Low-Moderate	15	0
Moderate	10	4
Moderate-High	3	2
High	5	2
Total	89	8

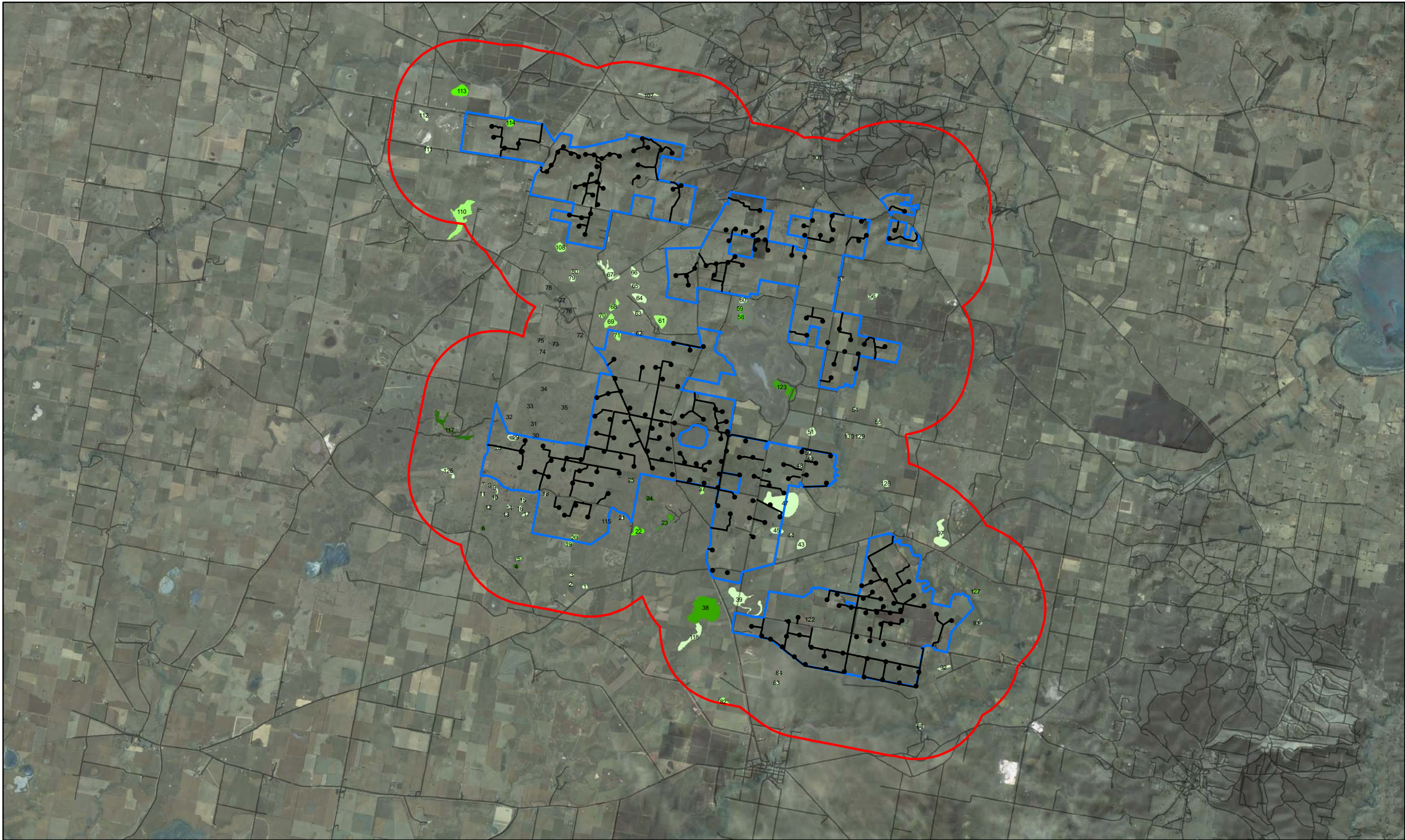


Legend

- | | |
|----------------------|-------------------------|
| Study Area | Low & Very Low Quality |
| AVW Sighting Records | Low - Moderate Quality |
| AVW Breeding Records | Moderate Quality |
| Brolga Survey Site | Moderate - High Quality |
| Proposed Turbines | High Quality |
| Roads | |

0 2.5 5 10 Kilometers

Figure 28: Wetlands Surveyed in 2007, Habitat Quality and Survey Results		
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Legend

- Wind Farm Boundary
- 3KM Buffer Area
- Proposed Turbines
- Access Tracks
- Roads
- Habitat Quality**
- High Quality
- Moderate - High Quality
- Moderate Quality
- Low - Moderate Quality
- Low & Very Low Quality
- 12 Wetland Number



Figure 29: Wetlands Surveyed in 2008, Habitat Quality and Survey Results

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4.2.5.2 Brolga Sightings

2007 Survey

During the 2007 assessment, 38 Brolgas were seen within the survey area. The number included seven confirmed nesting pairs. The locations of these sightings and the nesting sites are presented in Figure 28.

The 38 Brolgas were recorded from 21 sites. These sightings were mainly from areas outside the proposed wind farm site boundary, except for a pair of Brolgas seen on Buln Gherin swamp within the boundary of the proposed wind farm site. There were four other sightings about 0.5 to 1 kilometre from the boundary of the proposed wind farm site. All other records were between approximately 3 kilometres and 20 kilometres from the proposed site boundary (see Figure 28).

Most of the seven nesting sites were also outside the wind farm boundaries; however, the nest on Lake Goldsmith was within 500 metres of the nearest wind turbine (Figure 28). All other six confirmed nesting sites during this current survey were approximately two to 20 kilometres away from the wind farm site.

It is worth mentioning that several other nesting sites were discovered during additional surveys in September and October 2007 in the areas surrounding the wind farm, but none were within the wind farm site boundary. These sites and Brolga behaviour and movements will be discussed later in this chapter.

2008 Survey

During the 2008 wetland assessment, 11 Brolgas were seen within three kilometres of the wind farm site, including one juvenile; however no pairs had established nests during this time (Figure 29). Of these, three were not seen near a wetland. The dominant behaviour observed among Brolga pairs was foraging in wetland and grassland habitat.

Concluding Summary

No pairs of Brolgas were found breeding within the boundaries of the proposed Stockyard Hill Wind Farm site during the 2007 and 2008 surveys. However, one pair of Brolgas nested on the edge of Lake Goldsmith during the 2007 survey (c. 500 metres away from the nearest part of the proposed wind farm). Sites where Brolgas have been observed in the past (AVW, DSE data), such as Buln Gherin Swamp and Black Lake, did not support Brolgas in those breeding seasons. Six other confirmed breeding sites during the 2007 survey were located west and south of the wind farm.

Since 1970, there have been 60 breeding records from within the search area. At least 23 of these breeding records were from sites within 3 kilometres of the wind farm site or internal powerlines.

The Brolga is well known from the Streatham–Skipton area and breeds in smaller, seasonal and permanent wetlands throughout this area. Within 20 kilometres of the boundary of the proposed wind farm, there are at least five historically known Brolga flocking sites (AVW records). These include:

- Lake Wongan (7 kilometres west of the wind farm site);
- St Marnocks Swamp (approximately 1 kilometre from the north-west corner of the wind farm site);
- Alexanders Lake (7 kilometres west of wind farm site);
- Horseshoe Swamp (6–8 kilometres south and south-west of the wind farm site (currently dry); and
- Scattered wetlands north of Skipton.

The number of Brolgas seen in the past on these sites ranged between 14 and 77 birds, with the maximum flocking observed on Lake Wongan. It is likely that some Brolgas in this region would fly across the proposed Stockyard Hill Wind Farm site when moving from flocking to breeding sites and back again. This issue is explored in more detail later in this report (Section 6.5).

As mentioned in the results section above, 38 Brolgas were sighted in the search region within 20 kilometres of the wind farm during the 2007 breeding season, which comprised seven nesting pairs. The Victorian population of Brolgas is currently estimated at approximately 650 individuals (Du Guesclin 2003). During the 2007 survey, at least 6% of the population was observed in the search region. In the 2008 investigation, 11 Brolgas were sighted within 3 kilometres of the wind farm boundary, based on a more comprehensive search of wetlands in this project impact zone, including one juvenile. Based on this, it is estimated that up to six pairs may occur within 3 kilometres of the wind farm boundary in an average or above average rainfall breeding season. In an exceptional year, it would be highly unlikely that any more than about eight pairs could exist within the wind farm boundary, based on knowledge of available habitat and historic records.

The historical and current regular occurrence of significant numbers of Brolgas in the search region warranted a Level Three risk assessment, which is presented in the following sections of this chapter.

4.3 LEVEL THREE IMPACT ASSESSMENT

4.3.1 *Breeding Season*

4.3.1.1 Aims

The aims of the study were to:

- Provide data to be used as factors in the model of collision risk;
- Determine a reasonable buffer distance between Brolga breeding sites and wind turbines;
- Determine how Brolgas move about their breeding range; and
- Collect ancillary information about Brolga behaviour that might inform impact assessments and mitigation measures.

The study was designed to ensure randomisation, where possible, of data collection, and to provide for a rigorous and repeatable approach to observations. It aimed to generate information on the likely number of flights by Brolga across the wind farm site to inform collision risk modelling and application of a Population Viability Assessment (PVA) model that predicts population impacts at a state scale.

4.3.1.2 Methods

The study was designed to provide coverage of Brolga behaviour and movements from their breeding sites during daylight hours. Coverage of each site was spread evenly across times of day and across the study period. Randomisation was introduced through the numbering of sites and order in which sites were visited. At each site, the Brolga were observed from a vantage point. The site was selected to maximise the observable distance. The majority of the time, the Brolga could be seen, even when flying to another habitat. When the Brolga flew out of site, it was followed where possible. When this was not possible, a record was made of where these were lost from sight.

Observation Schedule

Pairs at each site were observed for a total of two person-days each (total observation time of 24 hours). At each Brolga breeding site there were three observation periods of one-third of a day (morning, early afternoon, late afternoon), and one observation period of one whole day (sunrise to sunset) spread over the study period. Days of full-day observations were alternated with days of part-day observations.

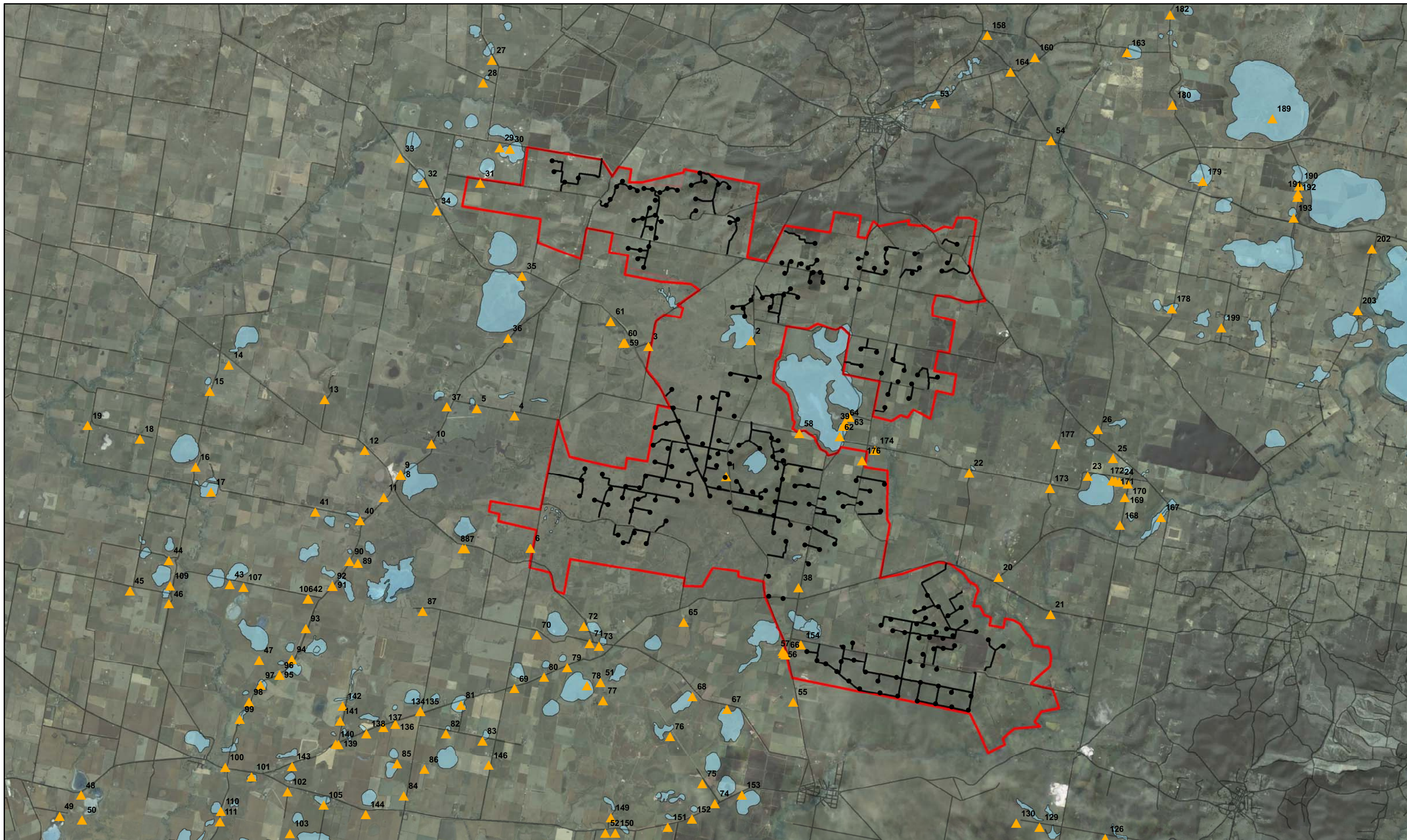
An initial investigation at Stockyard Hill discovered 13 breeding sites for Brolga within a 20 kilometres radius of the wind farm centre. Observations commenced on 25 September 2007 and were completed on 23 October 2007. The total observation period was 26 person-days, or 312 person-hours (Table 27).

The schedule used for observations is provided in Table 32 below. Numbers in the body of the table refer to breeding site numbers (see Figure 30). Note that not all sites where pairs were found in August held birds during the behavioural study. Furthermore, if pairs disappeared from their sites before all observation periods could be covered then the schedule below was adjusted accordingly, but the overall total number of hours of observations was maintained.

Table 27: Observation Schedule of Brolga Breeding Sites - within 20 kilometres Radius of Wind Farm Site

Person-day	Sunrise to 10 am	10 am to 2 pm	2 PM to Sunset
1	1	2	3
2	13	13	13
3	4	5	6
4	1	1	1
5	7	8	9
6	12	12	12
7	10	11	12
8	2	2	2
9	13	1	2
10	11	11	11
11	3	4	5
12	3	3	3
13	6	7	8
14	10	10	10
15	9	10	11
16	4	4	4
17	12	13	1
18	9	9	9
19	2	3	4
20	5	5	5
21	5	6	7
22	8	8	8
23	8	9	10
24	6	6	6
25	11	12	13
26	7	7	7

Numbers refer to site numbers



Legend

- Study Area
 - ▲ Brolga Survey Site
 - Wetlands
 - Roads
- 100 Brolga Survey Site Number



Figure 30: Brolga Breeding Site Survey Locations

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Observations Recorded

Observation posts were located at vantage points near breeding sites, 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 200 metres from the birds, so that bird behaviour was not modified by the presence of the observer. Observers stayed inside their cars, wherever possible, to minimise impacts on Brolga behaviour.

The following information was systematically recorded:

- Date and time (beginning and end) of observation period;
- Site number;
- Position and direction of the observer from the site;
- Number of Brolgas present and their age (i.e. adult or chick/young);
- Habitat condition, including the presence of surface water, the percentage of the wetland basin that held water and the cover of aquatic vegetation (negligible, some, lots);
- Whether water level had risen or fallen since the wetland was last visited;
- The weather (including temperature, wind direction and strength, and rainfall) for the observation period;
- Dominant behaviour of each Brolga at the site (resting, feeding, preening, displaying, walking, incubating etc.) every 15 minutes over the observation period;
- Any movement (and the age of the bird concerned) from the breeding site (i.e. from the edge of the wetland in which it was) 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.

4.3.1.3 Results

The results of the investigation are summarised below:

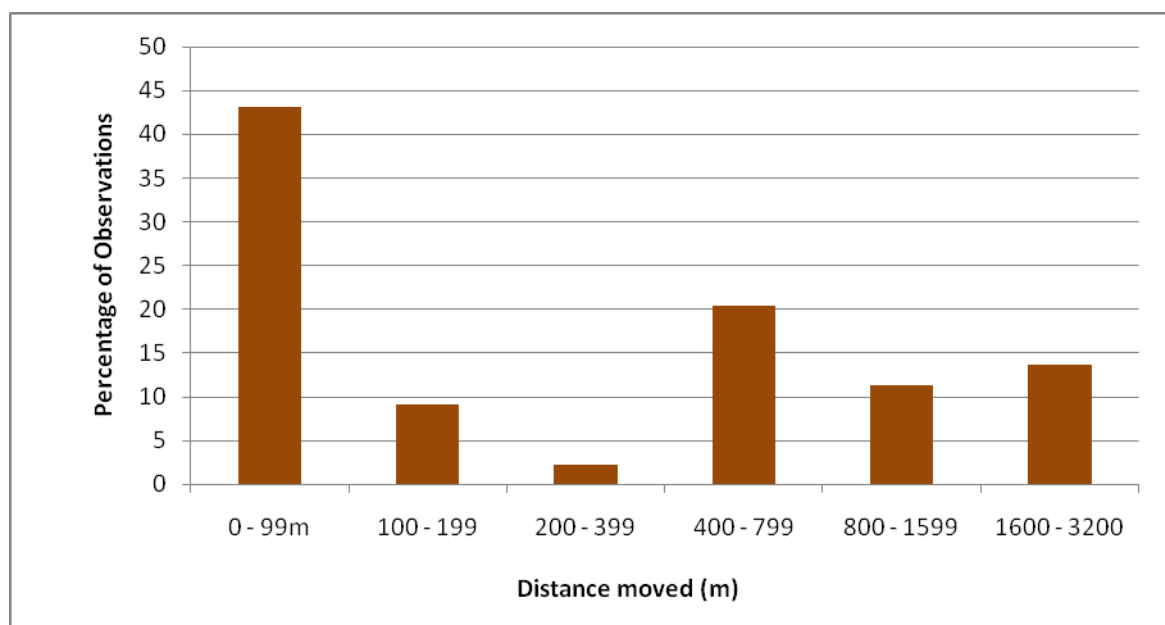
- Distance of movements and habitat at destination; and
- Flight heights.

Over the 312 hours of observations, 44 Brolga flights were observed.

Distance of Movements and Habitat at Destination

The total percentage of Brolga flights recorded is presented in Figure 31.

Figure 31: Observed Brolga Flight Distance from Breeding Sites (n = 44).



The cumulative percentage of flights to different distances from the breeding site is summarised in Table 28.

Table 28: Distance of Brolga Flights from Breeding Sites - Cumulative Percentage

Flight Distance (m)	Cumulative %
0 - 99	43.18
100 - 199	52.27
200 - 399	54.55
400 - 799	75.00
800 - 1599	86.36
1600 - 3200	100.00

The majority of Brolga flights (c. 52%) recorded were less than 200 metres from the breeding site. All walking movements recorded were also less than 100 metres from the breeding site, with the exception of one pair (Lake Goldsmith).

Some 45% of movements were 400 metres or further from the breeding site, with almost 14% being greater than 1.6 kilometres.

The habitat to which these movements occurred is summarised in Table 29 below.

Table 29: Summary of Habitat to which Brolgas Flew from Breeding Sites

Flight Distance	Pasture	Wetlands
<200 metres	13	9
>400 metres	7	13

Notes: Two flights (of 44 flights) were to unknown habitats, so this table shows 42 flights only.

More flights of greater than 400 metres were to wetlands rather than pasture. Note that no flights were observed between 200 and 400 metres from the breeding site.

This suggests that areas of pasture within 200 metres of the breeding site, and the wetland habitat of the breeding site itself, provide the bulk of the foraging resources during breeding. During longer-distance movements, Brolgas visited other wetlands more frequently than pasture. The limited extent of wetlands compared with pasture indicates that the location of wetlands noticeably influences the direction of movements greater than 400 metres. The implications of this for wind farm layout design are discussed in Section 6.8.

Based on these findings, a Brolga ‘breeding home range’ has been defined as:

- A 400 metre zone around the nesting site including both pasture and wetlands; and
- A zone which includes all intact wetlands within a 3.2 kilometre radius of the nesting site.

The selection of foraging sites during the breeding season is assumed to be dependent on the availability of habitats within home ranges. Based on the information collected during the field surveys, and GIS information, it was possible to calculate the percentage of home ranges occupied by wetlands. This equates to an average of 28% (ranging between 0.7% and 89.4%, with 15 of the 18 home ranges studied supporting less than 50% wetlands by area) (Table 30). Taking into consideration that more than 50% of observed Brolga flights occurred towards wetlands, and the significantly lower proportion of home ranges occupied by wetlands, this data indicates a preference by Brolgas for flying towards wetlands when foraging from breeding sites.

Table 30: Percentage of Wetlands in Brolga Home Ranges

Home Range ID	Home Range Area (ha)	Wetland Area (ha)	Percentage of Wetlands in Home Range (%)
1	1.2	0.04	3.6
2	1.0	0.05	4.6
3	0.9	0.04	4.5
4	0.9	0.12	13.6
5	1.1	0.25	22.1
6	0.8	0.25	31.2
7	0.8	0.25	29.1
8	0.9	0.12	13.7
9	1.5	0.95	63.3
10	1.9	0.95	50.6
11	1.8	0.95	52.8
12	1.4	0.94	69.8
13	1.3	1.14	89.4
14	1.3	0.24	18.4
15	1.2	0.01	0.8
16	1.8	0.17	9.7
17	1.2	0.28	23.2
18	0.6	0.03	5.0

Additionally, it is well known that Brolgas are primarily a wetland-dependent species and that they rely on food resources obtained from wetlands for their survival (Marchant & Higgins 1993). Furthermore, during observations for this investigation, Brolgas spent most of their time foraging within the wetland in which they built their nest. Flights away from this 'home' wetland were limited to up to an hour or so; the remainder of their time was spent in the 'home' wetland.

Taking into consideration that the data suggesting Brolga prefer foraging in wetlands within their home ranges is not statistically robust, this has not been assumed as part of the collision risk modelling.

Flight Heights

The total percentage of Brolga flight heights recorded is presented in Figure 32.

Observations showed that most flights occurred at heights of less than 30 metres above the ground. The majority of flights (more than 45%) were less than 10 metres above the ground. Greater than 30% were between 10 and 20 metres above the ground while approximately 15% were between 20 and 30 metres above the ground. Approximately 7% of flights were between 30 and 40 metres above the ground and one flight (2% of observations) was observed between 40 and 49 metres above the ground.