INYANDA ROODEPLAAT WIND FARM, EASTERN CAPE, SOUTH AFRICA: BIRD SURVEYS UPDATE AUGUST 2015 – JULY 2016

Black Harrier © Steve Percival

Report to Newcombe Wind Developments

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INYANDA ROODEPLAAT WIND FARM: BIRD SURVEYS AUGUST 2015-JULY 2016

Introduction

1. This work was commissioned by Newcombe Wind Developments, to undertake baseline bird survey work at Inyanda Roodeplaat for the proposed wind farm, updating the previous bird survey work to address concerns with the existing data. This report provides a further update incorporating data collected during February - July 2016, bringing the recent baseline surveys (started in August 2015) to a full year. Its purpose was not to undertake a full baseline survey but rather to focus on the key issues, data gaps and ornithological sensitivities already identified, specifically:

   - Eagle breeding status and distribution (particularly Verreaux's Eagle and Martial Eagle).
   - Eagle and other large raptor flight activity within and around the proposed wind farm site (particularly Verreaux's Eagle and Martial Eagle).
   - Species vulnerable to collision with overhead wires along the proposed grid connection route (particularly Blue Crane, and Ludwig's and Denham's Bustards)

2. The surveys were designed to take into account BirdLife South Africa emerging guidance (Jenkins et al. 2015) and other international guidance on bird surveys for wind farms (including Natural England, Drewitt 2010 and Scottish Natural Heritage, SNH 2014). The initial August surveys were undertaken by Mike Hoit and Keith Langdon, during which the local surveyor, Adri Barkhuysen (a local raptor expert) was trained to Ecology Consulting wind farm survey standards. Adri Barkhuysen then undertook the September to July surveys, with all of the data checking and processing undertaken by Ecology Consulting, who also carryied out all of the data analysis and reporting.

3. This report includes an update to the assessment presented in the project Environmental Statement (ES) Ornithological Impact Assessment (OIA) that was undertaken for the EIA, incorporating the new February - July 2016 data. The assessment methodology used in this report follows the same as that used in our previous report (Percival et al. 2015), and in the ES OIA. It draws on the methodology developed by SNH and the British Wind Energy Association [BWEA] (Percival et al. 1999) and updated by Percival (2007), and with SNH (2006) guidance on assessing the impacts from onshore wind farms on birds in the wider countryside.

Bird Survey Methods

4. The surveys during the August 2015 – July 2016 period were carried out on the following dates

   - Visit 1: 25-31 August;
   - Visit 2: 22 September – 1 October;
   - Visit 3: 19 – 27 October;
   - Visit 4: 17-24 November;
   - Visit 5: 12-19 December;
   - Visit 6: 21-27 January and 1-2 February;
   - Visit 7: 18-25 February;
   - Visit 8: 12-18 and 22-24 March;
   - Visit 9: 17-24 April;

- Visit 10: 16-19 and 23-31 May;
- Visit 11: 21 June - 3 July;
- Visit 12: 25-30 July, 4 August.

Breeding eagle surveys

5. Two previous breeding eagle surveys have been undertaken as part of the baseline survey work at this site, in 2013 (by Adri Barkhuysen) and in 2014 (by Avisense Consulting). Further breeding eagle surveys were carried out in 2015 and 2016, checking all known and other possible raptor nest sites within a 6km buffer of the wind farm site (plus some additional sites more distant from the site). In addition to the previous surveys, repeat visits are being made to monitor range occupancy and breeding success. The following visit protocol for each range is being implemented through the breeding period: visit 1 to check for occupancy of the range, visit 2 to locate active nests, visit 3 to check for young, and visit 4 to check for fledged young. This includes surveys for all raptors that could use the survey area, but with particular focus on Verreaux's and Martial Eagle.

6. The locations of the surveyed sites in relation to the proposed wind farm are shown in Figure 1.

Vantage point surveys

7. Previous vantage point surveys of the site carried out in 2013-14 were incomplete and there were substantial gaps in coverage of the wind farm site. Only minimum survey time was undertaken, so, given the presence of key species potentially vulnerable to wind farm development (notably Verreaux's Eagle), this has been increased. The 2015-16 surveys have filled these gaps by extending the numbers of vantage points, ensuring that they cover the site to BLSA guidance (minimum 75% of turbines), extending survey time above the minimum (and spreading it over a wider survey period) and using a survey method that increases detectability and viewing distance (using binoculars and telescopes to assist in scanning for target species rather than relying on naked eye).

8. Vantage point surveys monitored flight lines of target species to quantify the numbers that could potentially be at risk of collision. The specific aim of the surveys was to collect data on key species flight activity that enabled estimates to be made of:

   - The time each species spends flying over the survey area
   - The relative use each species makes of different parts of the survey area
   - The proportion of flying time each species spends at different elevations above the ground.

9. All flight lines of target species were mapped, and the flight height of each flock recorded. Six vantage points were used for the surveys, four overlooking the wind farm site, and an additional two to view the area between the site and the two nearest Verreaux's Eagle nests (Holbak and Perdehoek). In the initial August 2015 surveys nine hours of surveys were undertaken from each VP, then six hours per month thereafter (exceeding the BLSA minimum value and in line with current UK/SNH guidance), from September 2015 through to July 2016 (giving 75 hours total survey time from each of the 6 VPs during this period). As 360° viewing was not required at any VP, a single observer was considered sufficient at each.

10. The location of the vantage points and the computer-generated prediction of viewsheds from those VPs (showing the areas visible at 20m above the ground, the lowest point that the rotor sweep of the current proposed turbines would reach, from each VP) are shown in Figure 2, in relation to the proposed 52-turbine layout. The VP locations were chosen on the basis of the best locations irrespective of location within wind farm (VPs would normally be located outside the wind farm but it is not possible to achieve this at this site while maintaining optimal visibility).

11. The following species were recorded as target species:
    - All birds of prey and owls
    - All cranes and bustards
    - Large flocks (>100 birds) of other species
    - Other species/sightings considered of note.
12. All target birds were recorded, irrespective of their distance from the vantage point. Observations were carried out throughout daylight hours (to cover the full daylight period over the survey visits) but not in periods of severely reduced visibility (<3km).
13. Vantage point surveys were usually carried out for a 3-hour block, with a gap of at least 30 minutes for a rest period between surveys to avoid observer fatigue. When more than one surveyor was active at any one time, VP surveys were not carried out at the same time as any walkover survey of the site.
14. During the observation periods all target species flights were mapped and cross-referenced to a standard recording form using a numbering system, and the flight height of each recorded. To estimate flight height as accurately as possible, available reference features (e.g. met masts, summit/ridgelines) were used. Flight heights were estimated as accurately as possible and recorded on the form, i.e. not summarised to height classes. Below 10m it was possible to estimate to 1m, between 10 and 20m to 2m, between 20m and 50m to 5m, and above 50m to 10m. In any case of uncertainty an estimate of the upper and lower range of height were recorded. When birds were observed over an extended period, estimates of flight height were recorded every 30 seconds. The activity during each flight (e.g. striking prey, displaying, food passing) was also recorded. Particular attention was paid to any observations of birds at rotor height crossing the proposed wind farm site that would be at risk of collision.

Grid connection route surveys

15. Vehicle transects were driven along the proposed route of the grid connection, recording all target species but particularly focusing on Blue Crane, Ludwig's Bustard and Denham's Bustard. Two repeat transects were driven each month through the year (with 24 completed during August 2015 – July 2016), mapping the location of all target species encountered, and with additional stops at strategic viewpoints along the route overlooking potentially suitable crane/bustard habitat to scan with binoculars/telescope.
16. The grid connection transect survey routes are shown in Figure 3. The 2015-16 grid connection transect surveys covered the main part of each potential route where access for the surveys was possible and where the surveys could be carried out safely. This did not include the full route but did cover a representative range of the habitats through which the route would pass.

Bird Surveys August 2015 – July 2016: Results

Breeding Eagle Survey Results

17. The results of the Verreaux's Eagle breeding surveys are summarised in Table 1. The breeding site locations are shown in Figure 1. Overall it was clear that 2015 was a very poor breeding year for this species, with no successful breeding at any of these sites. The previous surveys in 2013 and 2014 found a much higher success rate, so more successful breeding would be expected in the future. The results from 2016 indicated a more typical year.

Table 1. Verreaux's Eagle nest site survey results, August 2015-July 2016.

Eagle range name	Distance from proposed wind farm in km (52T layout)	Status Aug- 2015 - Jan 2016	Status Feb - Jul 2016
Perdehoek	1.4	Pair seen daily flying in vicinity of nest kloof during August visit, showing territory occupied. No sign of breeding success – failure confirmed on September visit. Pair seen over nest site during October VP survey, and in January.	Active May 2016, no eggs but lots of green leaves/branches. No eggs in June or July but pair present still.
Holbak	2.3	Breeding failure confirmed on September survey. Single seen 3.6km N from site on 22/9/15.	Active May 2016, female incubating 2 eggs on new nest on the west side of the kloof.
February	3.3	Breeding failure confirmed on September survey.	No access possible in May 2016 but female on 2 eggs in June.
Tiptree, Zunga	4.0	Pair seen flying in vicinity of nest site during August VP survey. Nest site located on a cliff facing SW in the Zungarivier valley on October survey. No eagles were seen then and no chick on the nest, but it appeared to have been active (from the white defecation marks and greenery that was laid some time ago).	Active May 2016 (female incubating) but failed by June visit.
Tygerberg	5.0	Pair flying around the nest kloof during September visit but no sign of active nest	Active May 2016, female incubating on the old 'regular' nest. Chick there in July.
Guntia	8.5	No chick was seen on either nest during the October survey, and no adults were seen. Some white defecation marks on the smaller nest but no greenery could be seen.	No activity in May 2016, pair present in June and July but no nest located.
Krompoort	12	No chick on the nest and no adult eagles were seen during the October visit. This nest had active white defecation marks but otherwise it appeared inactive. Single seen near the site on 27/9/15.	Active May 2016 (female incubating).

18. The records obtained of other breeding raptors during these surveys are summarised below:

- Martial Eagle – there was no sign of any activity in the 2014 nesting area (2.6km SW from proposed wind farm) during the Aug 2015 - Jan 2016 surveys, with the only records of this species at that time being occasional over-flying birds seen during the VP surveys (Figure 4) and a single incidental sighting near Perdehoek in August. The Feb-July 2016 surveys, however, found a pair nest-building in April 2016 (in the same area where breeding had been thought to occur in 2014), with a single egg in the nest in May, and a 4-5 week old chick observed there during the June survey.
- Booted Eagle - a pale phase bird was seen twice in the Perdehoek kloof during the September surveys, suggesting possible breeding at this location.
- African Harrier-hawk – seen in the February kloof during the September survey, with several further sightings over the lower ground mainly to the north-west of the proposed wind farm site.
- Black Harrier – this species was confirmed nesting within the proposed wind farm site, above and very close to the track near the higher of the two meteorological masts. There were a minimum of three adults present, likely to have been a polygamous male with two females (two nests). Breeding was successful, with sightings of fledged juveniles during October and November. Two sightings in the Zunga valley suggested potential nesting there too.

Vantage Point Survey Results

19. The rates of bird flight movement observed across the study area during the vantage point observations are summarised in Table 2. This gives the mean over-flying rate per hour from each VP. Table 2 also gives the percentage of flights of each species that were recorded at rotor height (taking rotor height conservatively as between 16m and 180m above ground level, to allow for errors in flight height estimation, particularly at greater heights, as in the ES OIA). The two most frequently encountered target species were Black Harrier and Jackal Buzzard, with regular sightings also of Verreaux's Eagle, Rock Kestrel and White-necked Raven.

Table 2. Bird flight rates (number of birds per hour) recorded over the VP survey area during August 2015-July 2016 vantage point surveys. N = 75 hours total observation from each of six VPs.

	Flight rate (number of birds per hour)						Total number of flights observed	% flights at rotor height
Species	**VP5**	**VP6**	**VP7**	**VP8**	**VP9**	**VP10**		
Alpine Swift	0	0	0	0	0.53	0	40	100%
African Swift	0.27	0.20	0.20	0	0.60	0	95	100%
Blue Crane	0	0.03	0	0	0	0.03	4	100%
Black Stork	0	0	0.03	0	0	0.01	3	100%
White Stork	0	0	0	0	0.04	0.24	21	100%
African Harrier-hawk	0	0	0	0.01	0.01	0.01	3	100%
Crowned Eagle	0	0.01	0.01	0	0	0	2	100%
Martial Eagle	0.04	0.01	0.01	0	0.04	0.01	9	100%
Verreaux's Eagle	0.27	0.32	0.19	0.21	0.36	0.25	120	95%
Booted Eagle	0.01	0.01	0	0	0.05	0.01	7	86%
Black Harrier	0.59	0.83	0.37	0.21	0.07	0.05	159	82%
African Goshawk	0	0	0.01	0	0	0	1	100%
Rufous-breasted Sparrowhawk	0.01	0	0.03	0	0.01	0.01	5	80%

Species	Flight rate (number of birds per hour)						Total number of flights observed	% flights at rotor height
	VP5	VP6	VP7	VP8	VP9	VP10		
African Fish-eagle	0	0	0.01	0	0	0	1	100%
Jackal Buzzard	0.71	0.55	0.40	0.39	0.66	0.57	247	95%
Steppe Buzzard	0.19	0.03	0.12	0.04	0.11	0.04	39	100%
Rock Kestrel	1.01	0.24	0.19	0.58	0.58	0.23	213	86%
Lanner Falcon	0.01	0	0.03	0.01	0.03	0	6	67%
Peregrine Falcon	0.11	0	0	0	0.01	0	9	100%
White-necked Raven	1.43	0.88	0.71	0.58	1.38	0.85	438	50%

20. The monthly breakdown of the flight rates recorded is summarised in Table 3. Black Harrier flight rates were higher during August-October than later in the survey period, though others, including Verreaux's Eagle, were more similar across the whole survey period.

Table 3. Bird flight rates (number of birds per hour) recorded over the VP survey area during August 2015-July 2016 vantage point surveys. N = 9 hours observation from each of six VPs in August, and 6 hours in September - July.

Species	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
Alpine Swift	0.70	0	0	0	0	0	0	0	0	0	0	0
African Swift	0	0.50	0.34	0	0.83	0	0.48	0.42	0	0	0	0
Blue Crane	0.04	0	0.05	0	0	0	0	0	0	0	0	0
Black Stork	0	0.07	0	0	0	0	0.02	0	0	0	0	0
White Stork	0	0	0	0	0.58	0	0	0	0	0	0	0
African Harrier-hawk	0.02	0	0	0	0	0	0	0	0	0.05	0	0
Crowned Eagle	0	0	0	0	0	0	0.05	0	0	0	0	0
Martial Eagle	0.04	0.03	0.05	0	0	0	0	0	0	0	0.10	0.04
Verreaux's Eagle	0.37	0.53	0.21	0.03	0.11	0.20	0.29	0.14	0.40	0.24	0.36	0.34
Booted Eagle	0.04	0.03	0.05	0	0.03	0	0.02	0	0	0	0	0
Black Harrier	1.58	0.70	0.57	0.11	0	0.07	0.12	0	0.17	0.17	0	0
African Goshawk	0	0.03	0	0	0	0	0	0	0	0	0	0
Rufous-breasted Sparrowhawk	0.02	0	0	0.06	0	0	0	0	0	0.05	0	0
African Fish-eagle	0	0.03	0	0	0	0	0	0	0	0	0	0
Jackal Buzzard	1.40	0.80	0.46	0.75	0.36	0.83	0.52	0.36	0.30	0.07	0.15	0.16
Steppe Buzzard	0.07	0	0	0.14	0.28	0.30	0.21	0.06	0	0	0	0
Rock Kestrel	0.86	0.43	0.11	0.36	0.19	1.23	1.21	0.36	0.17	0.31	0.05	0.12
Lanner Falcon	0.04	0	0.02	0.03	0.03	0	0	0	0	0.02	0	0
Peregrine Falcon	0	0	0	0	0	0	0	0	0.30	0	0	0
White-necked Raven	-	1.30	1.06	1.42	0.86	1.47	1.81	1.00	1.00	0.62	1.08	0.72

Note: white-necked ravens were not recorded as a target species during the August surveys.

21. Maps of the flight activity of the key species recorded during the August 2015-July 2016 VP surveys are shown for Martial Eagle (Figure 4), Verreaux's Eagle (Figure 5), Booted Eagle (Figure 6), Black Harrier (Figure 7), Jackal Buzzard (Figure 8) and Rock Kestrel (Figure 9). Flights from the

previously reported surveys in Aug 2015 - Jan 2016 are shown in red, and the new flights from Feb-July 2016 are shown in blue for each species.

- Martial Eagles (Figure 4) were seen on only nine occasions, seven of which involved flights through the collision risk zone. No areas of more concentrated flight activity were apparent. Flight activity through the collision risk zone remained low in April-July 2016, even though a pair was nesting 2.2km SW from the wind farm site.
- Verreaux's Eagles (Figure 5) were recorded widely but at relatively low frequency over most of the survey area. Flight activity patterns were similar during Feb-July 2016 as they had been in the previous Aug 2015-Jan 2016 surveys. As for the Martial Eagle, no areas of more concentrated flight activity were apparent. The two VPs over-looking the two closest breeding sites revealed more connectivity with the wind farm site during the Feb-July surveys that they had done previously.
- Booted Eagle (Figure 6) was only occasionally recorded, with six flights in total over the August 2015 – January 2016 survey period, and only one further flight during Feb-July 2016. Again, no areas of more concentrated flight activity were apparent.
- Black Harrier (Figure 7) was the most frequently observed target species, with a total of 144 flights logged in total. Activity was greatest around the nesting sites near to the upper met mast, but also further to the east and west along the main ridge running through the wind farm site, and over the ridge south from the nesting area. Activity declined markedly after breeding in October (as found in the previous 2013-14 surveys).
- Jackal Buzzard (Figure 8) was frequently recorded, particularly along the main ridge running east-west through the wind farm site (especially at its western end). This species was less frequently seen over the lower ground. Flight activity patterns were similar during Feb-July 2016 as they had been in the previous Aug 2015-Jan 2016 surveys.
- Rock Kestrel was seen widely over the survey area, with several scattered areas of more concentrated activity, as shown on Figure 9. Flight activity patterns were similar during Feb-July 2016 as they had been in the previous Aug 2015-Jan 2016 surveys.

Grid Connection Route Transect Survey Results

22. The results of the grid connection route transect surveys are summarised in Table 4a (Transect 1 - main gravel road) and Table 4b (Transect 2 - Glen Connor road); see Figure 3. This gives the peak transect count for each target species for each month during August 2015 – July 2016. Table 4c gives the peak count recorded of incidental ad hoc sightings of each species.

23. Distribution maps for each key species recorded during the transect surveys are shown in Figures 10-13. The records of the key species initially identified as being at particular risk of collision with overhead wires are shown in Figure 10. Blue Cranes were widely distributed over the more open habitat, particularly at the western end of the main grid connection route (transect 1). That area was also where most of the Ludwig's Bustards were seen, as well as further to the north along the Glen Connor Road (transect 2). There was only a single record of the third key risk species, Denham's Bustard (Figure 10).

24. The most frequently recorded raptor species was Pale Chanting-goshawk (Figure 11). It was seen regularly along the both the preferred grid connection route (transect 1) and along the Glen Connor Road (transect 2).

25. Less frequently-encountered raptors included African Harrier-hawk, Verreaux's Eagle, Booted Eagle, Crowned Eagle, Black Harrier, Jackal Buzzard, Forest Buzzard, Steppe Buzzard, Lesser Kestrel, Rock Kestrel, Lanner Falcon and Peregrine Falcon – their locations are shown in Figure 12. There was a single incidental record of an African Fish-eagle seen during the surveys, 8km SW from the wind farm site.

26. Other species potentially at risk of collision with overhead wires seen during these surveys included Southern Black Korhaan, Kori Bustard, Secretarybird, African Wood-owl, Barn Owl and Spotted Eagle-owl – their locations are shown in Figure 13 (mostly at the western end of the main route (transect 1) and along the Glen Connor Road (transect 2).

Table 4a. Grid Connection Route Transect 1 (main gravel road) survey results – peak counts per month, August 2015 – July 2016.

Species	Aug	Sep	Oct	Nov	Dec	Jan	Aug	Sep	Oct	Nov	Dec	Jan
Blue Crane	4	4	11	0	2	0	3	0	0	0	0	0
Ludwig's Bustard	2	0	0	0	0	0	1	0	0	0	0	3
African Spoonbill	1	0	0	0	0	0	0	0	0	0	0	0
Sacred Ibis	0	4	0	0	0	0	0	0	0	0	0	0
Black-headed Heron	0	1	0	3	2	0	0	0	0	0	0	0
Hamerkop	0	1	0	0	2	0	0	0	0	0	0	0
Secretarybird	1	0	0	0	0	0	0	0	0	0	0	0
Verreaux's Eagle	0	2	0	0	0	0	0	0	0	0	0	0
Booted Eagle	1	1	0	0	1	0	0	0	0	0	0	0
Pale Chanting-Goshawk	5	2	3	2	3	2	0	1	2	2	2	1
Jackal Buzzard	1	1	1	1	1	0	0	0	1	0	0	0
Steppe Buzzard	0	0	1	2	0	3	1	0	0	0	0	0
Forest Buzzard	0	0	0	0	1	0	0	0	0	0	0	0
Rock Kestrel	0	1	2	0	0	0	0	0	0	0	0	0

Table 4b. Grid Connection Route Transect 2 (Glen Connor road) survey results – peak counts per month, August 2015 – July 2016.

Species	Aug	Sep	Oct	Nov	Dec	Jan	Aug	Sep	Oct	Nov	Dec	Jan
South African Shelduck	0	0	0	3	0	0	0	0	0	0	0	0
Blue Crane	0	1	0	2	0	0	0	0	0	0	0	0
Ludwig's Bustard	15	0	0	2	0	0	1	0	0	0	0	3
Kori Bustard	0	0	0	0	2	0	1	0	0	2	6	0
Southern Black Korhaan	1	1	0	0	0	0	0	0	0	0	0	0
Black-headed heron	0	1	1	0	0	1	0	0	0	0	0	0
Secretarybird	0	2	0	1	0	1	0	0	0	0	0	0
Black-shouldered kite	1	1	2	2	2	1	0	1	0	0	0	0
Martial Eagle	0	0	0	0	0	0	0	0	0	1	0	1
Booted Eagle	0	0	0	1	0	0	0	0	0	0	0	0
Pale Chanting-Goshawk	2	1	0	1	2	2	2	1	1	0	4	2
Jackal Buzzard	0	0	0	0	0	0	0	0	0	0	0	1
Steppe Buzzard	0	0	0	2	1	0	1	0	0	0	0	0
Lesser Kestrel	0	0	0	0	0	5	0	0	0	0	0	0
Peregrine Falcon	0	0	0	0	0	0	0	0	0	0	1	0

Table 4c. Grid Connection Route Transect survey additional incidental records - peak counts per month, August 2015 – July 2016.

Species	Aug	Sep	Oct	Nov	Dec	Jan	Aug	Sep	Oct	Nov	Dec	Jan
Blue Crane	2	0	2	2	2	0	0	2	2	0	0	2
Ludwig's Bustard	0	1	4	2	3	0	1	0	0	0	0	0
Denham's Bustard	0	0	0	0	0	0	0	0	1	0	0	0
Black Stork	0	0	0	0	0	0	0	0	3	0	0	0
White Stork	0	0	0	0	18	0	0	0	0	0	0	0
Barn Owl	0	0	0	0	0	1	0	0	0	0	0	0
African Wood-owl	0	0	0	0	0	1	2	0	0	0	0	0
Spotted Eagle-Owl	1	0	0	0	0	0	2	0	0	0	0	1
Secretarybird	0	0	1	0	1	0	1	0	0	2	0	0
Black-shouldered kite	0	0	0	0	1	0	0	0	0	0	0	0
African Harrier-Hawk	1	0	1	1	0	0	1	0	0	0	0	1
Crowned Eagle	0	0	0	0	0	0	0	0	1	0	1	0
Martial Eagle	0	0	0	0	0	0	0	0	1	1	0	0
Verreaux's Eagle	2	0	0	0	1	0	2	0	0	1	1	2
Booted Eagle	1	0	0	1	0	0	0	0	0	0	0	1
Pale Chanting-Goshawk	0	0	0	2	1	0	0	0	0	0	0	0
Black Harrier	0	0	1	1	1	1	0	0	1	1	0	0
Rufous-breasted Sparrowhawk	0	0	1	0	1	0	0	0	0	0	0	0
African Fish-Eagle	0	0	0	0	0	0	0	0	0	1	0	0
Jackal Buzzard	0	0	0	1	0	0	0	0	0	0	1	0
Steppe Buzzard	0	0	1	0	1	0	0	0	0	0	0	0
Forest Buzzard	0	0	0	0	0	0	0	0	0	1	0	0
Lanner Falcon	0	0	1	0	0	0	1	0	0	0	0	0
Peregrine Falcon	0	1	0	0	0	0	0	0	2	0	0	0

Ornithological Assessment Update

Collision Risk Modelling

27. One of the main potential ornithological impacts of concern for the Inyanda Roodeplaat wind farm is collision with the operational turbines. Collision risk modelling (CRM) was undertaken for a previous report (Percival et al. 2015) and for the ES OIA, following the method of Band et al. (2007), as extensively used in the UK. Details of the original SNH guidance on this model (Band 2000) are available from the SNH web site at <www.snh.gov.uk/docs/C205425.pdf>. The model runs as a two-stage process. Firstly, the risk is calculated making the assumption that flight patterns are unaffected by the presence of the wind turbines, i.e. that no avoidance action is taken. This is essentially a mechanistic calculation, with the collision risk calculated as the product of (i) the probability of a bird flying through the rotor swept area, and (ii) the probability of a bird colliding if it does so. This probability is then multiplied by the estimated numbers of bird movements through the wind farm rotors at the risk height (i.e. the height of the rotating

rotor blades) in order to estimate the theoretical numbers at risk of collision if they take no avoiding action.

28. The second stage then incorporates the probability that the birds, rather than flying blindly into the turbines, will actually take a degree of avoiding action, as has been shown to occur in all studies of birds at existing wind farms (Urquhart 2010[1]). Discussion as to the most appropriate avoidance rates to apply is included in the following section.

29. The results presented in this report update those previously that were based mainly on the Aug-Jan surveys, using the full year of baseline data (Aug 2015-Jul 2016). The CRM was carried out on the four key raptor species of concern that were observed flying within the collision risk zone at rotor height; Verreaux's Eagle, Booted Eagle, Martial Eagle and Black Harrier, as in the previous report. The same model structure and basic input data were used as in the previous modelling, but updated to include the February-July 2016 VP survey data.

30. The collision model requires data on bird body size and flight speed. Body sizes and baseline mortality rates were taken from Roberts Birds of South Africa (Hockey et al. 2005). Flight speeds were taken from Alerstam et al. (2007)) for ecologically similar species, as none were available for any of the four key species (Golden Eagle for Verreaux’s Eagle, the mean of all of the available *Aquila* eagle species for Martial Eagle, the mean of all of the available *Buteo* species for the smaller Booted Eagle and the mean of all *Circus* harrier species for Black Harrier). The data used in the collision risk modelling are shown in Table 5.

Table 5. Key species body size and flight speed data used in the collision risk modelling

Species	Body length (m)	Wing span (m)	Flight speed (m/s)
Verreaux’s Eagle	0.88	2.4	11.9
Booted Eagle	0.50	1.23	11.5
Martial Eagle	0.81	2.15	10.4
Black Harrier	0.51	1.0	9.7

31. The collision modelling requires a range of input data on the wind turbine specifications, which were provided by the client and the turbine manufacturers (Table 6). This modelling has taken a reasonable worst-case approach, running the model for the turbine likely to give the highest collision risk of the options being considered. The model was run for this report on the current proposed 52-turbine layout that was assessed for the EIA. It is likely that the number of turbines will be reduced further, but this has been assessed as a worst case at this stage.

Table 6. Wind turbine data used in the collision risk modelling.

Specification	52-turbine input data
Number of turbines	52
Hub height	85m
Rotor diameter	130m

[1] See SNH web site: www.snh.gov.uk/docs/B721137.pdf

Specification	52-turbine input data
Height to blade tip	150m
Minimum height of blade above ground	20m
Rotational speed (variable – mean of range used)	9.5 rpm
Blade maximum chord	4.2m
Blade pitch (variable – mean value used)	6°
Turbine operation time (when not constrained by high/low wind speed or maintenance activity)	90%

32. Data from the VP surveys were used to determine the proportion of flights at rotor height, with all flights between 16m and 180m treated (conservatively to take into account the difficulty of accurately estimating flight heights, as in the ES OIA) as being at rotor height.

33. The collision risk zone was defined, as per Band et al (2007) and SNH guidance (Whitfield et al. 2010) as a 500m zone around the proposed wind turbine locations.

34. The improved VP survey protocol enabled viewing to 2km and, in combination with more VPs, enabled a high coverage of this zone (including viewing of the full risk volume of 46 of the 52 turbine locations, in comparison with only 27 turbines within the effective viewing zone for the 2013-14 data).

35. In the previous analysis presented in the OIA, recent data were only available for the six months of August 2015 -January 2016. Some assumptions were needed, therefore, to convert the modelling predictions to give an annual total and compare with the previous results. For the three species resident in the area year-round, Verreaux's Eagle, Martial Eagle and Booted Eagle, it was assumed, that the same level of flight activity in the collision risk zone will occur through the remainder of the year, so the August-January flight activity was doubled to give an initial annual estimate. Black Harrier, however, was only present in the survey area during the breeding period in the previous 2013-14 surveys, so it was assumed that there would not be any further flight activity of this species in the February-July period.

36. As can be seen in Table 3, these assumptions were largely upheld by the Feb-July 2016 data. There was some black harrier activity in the survey area but this was much reduced from that observed in the previous period, whilst activity levels of Martial Eagle and Verreaux's Eagle were similar to those recorded in Aug-Jan. Booted Eagle activity was, however, lower in Feb-Jul than had been anticipated.

37. The results of any collision risk modelling using the Band et al. (2007) approach is highly sensitive to the avoidance rate used (Chamberlain et al. 2006). Application of an appropriate rate is therefore of fundamental importance in undertaking such modelling. However, there are very few studies at existing wind farms where avoidance rates have been fully determined, comparing pre-construction flight activity with the actual numbers of collisions post-construction (Urquhart 2010). The approach generally used to address this is to apply a precautionary rate based on the available data, such that any collision prediction is unlikely to be exceeded (i.e. represents a reasonable worst case). Where data on actual avoidance rates of particular species/groups have been established, then this has usually enabled a higher rate to be safely applied. For example, SNH has recently recommended a move from a 99% rate to 99.8% for geese based on recent research (Douse 2013). SNH now recommends using a value of 99.8% as an avoidance rate for geese (Douse 2013), 99% for several birds of prey (including Golden Eagle and Hen Harrier), and 98% for most other species (Urquhart 2010).

38. There is a lack of specific avoidance rate data from South Africa and on the species of concern at Inyanda Roodeplaat. As collision avoidance rates are not yet known for the species of concern, suitable overseas species have been used as proxies, following the same assumptions as made for the previous CRM. The selection of appropriate rates followed SNH guidance and with reference to the bird-wind farm literature. As recommended in SNH guidance, a precautionary 98% was adopted as the default value (Urquhart 2010) but the work has also explored whether particular species exhibit similar behaviour to more vulnerable species such as White-tailed Sea Eagle and Kestrel, or such behaviour that would reduce risk (and hence allow higher rates to be used as is recommended by SNH for Golden Eagle and Hen Harrier for example). The collision risk modelling results have been presented for each layout for a range of avoidance rates to inform the assessment but the most appropriate rate to apply in each specific case is also indicated. Most weight has been given to the precautionary SNH position of applying a 98%, though Verreaux's Eagle in particular shares an ecological similarity with Golden Eagle (albeit at a generally higher breeding density), for which SNH recommends a 99% avoidance rate, so applying that rate could be justified (particularly in relation to adult birds). The Golden Eagle is recognised as the Verreaux's Eagle's closest relative (Wink and Sauer-Gürth 2000). However, a more precautionary approach has been adopted in this assessment, as previously. Given that the Inyanda Roodeplaat eagles occur at a much lower density (approximately 2.4/100km^2) than the white-tailed eagles at Smøla where a density of 73/100km^2 has been recorded with 13 pairs of white-tailed eagle nesting in the wind farm which extends over 17.3km^2, Bevanger et al. 2009) and that the eagle core ranges have been buffered, it is not considered appropriate to apply as low a rate as 95% to the Verreaux's Eagle or for any other modelled species at Inyanda Roodeplaat.

Collision Modelling Results

39. The results of the updated collision risk modelling for the proposed 52-turbine layout, incorporating the Feb-July 2016 data, are summarised in Table 7 (for each of the four key species). This Table gives the number of collisions predicted per year based on a range of avoidance rates (95% - 99%). Verreaux's and Martial Eagle are both large non-colonial eagles, and the area in proximity to their nest sites has been avoided in the design process (so 'riskier' display flights and early juvenile flights would be less likely to occur in the wind farm). As a result, 99% should be a suitable precautionary avoidance rate to apply (as is used in the UK for Golden Eagle, an ecologically similar species), though as discussed above a more precautionary 98% has been adopted for the purpose of this assessment. Booted Eagle is more ecologically similar to buzzard species, so on the basis of the information currently available, the possibility of lower avoidance cannot be excluded so the SNH default 98% value has been applied. SNH has recommended the use of 99% avoidance rate for harriers, so that value is the primary one used for Black Harriers.

Table 7. Updated collision risk modelling predictions based on Aug 2015-July 2016 data for the Inyanda Roodeplaat wind farm 52-turbine layout, applying a range of avoidance rates. Predictions in bold represent the precautionary result used in the further assessment.

Species	**Precautionary predicted number of collisions per year**			
Avoidance Rate	**95%**	**98%**	**99%**	**99.5%**
Verreaux's Eagle	8.22	**3.29**	1.64	0.82
Martial Eagle	0.88	**0.35**	0.18	0.09
Booted Eagle	0.33	**0.13**	0.07	0.03
Black Harrier	9.10	3.64	**1.82**	0.91

40. The predicted risks for all three eagle species using the recent data were broadly similar to those produced previously, with no major differences from the previous assessments. Table 8 shows a comparison of the predicted collision risks, for the same 52-turbine layout, based on the 2013-14 data, the Aug 2015 - Jan 2016 data (adjusted for a full year, as presented in the ES OIA) and the Aug 2015 - Jul 2016 data. These results show that the incorporation of the Feb-July 2016 data has resulted in small increases over the previous predicted collision rates for Verreaux's Eagle, Martial Eagle and Black Harrier, and a slightly reduced risk for Booted Eagle.

Table 8. Comparison of collision risk modelling predictions for the Inyanda Roodeplaat wind farm 52-turbine layout based on 2013-14 data, Aug 2015 - Jan 206 (adjusted for a full year) and Aug 2015 - Jul 2016 data.

Species	**Primary Precautionary Avoidance Rate**	**2013-14 data**	**Aug 2015 - Jan 2016 data (adjusted for a full year)**	**Aug 2015 - Jul 2016 data**
Verreaux's Eagle	98%	1.72	2.64	3.29
Martial Eagle	98%	0.21	0.29	0.35
Booted Eagle	98%	0.08	0.21	0.13
Black Harrier	99%	0.17	1.47	1.82

Collision Modelling Interpretation

41. Whilst the Band collision model produces a quantitative estimate of the numbers of birds that might collide with the wind turbines, those numbers need to be put into the context of the existing mortality to enable their significance to be assessed. The same level of additional mortality on a population that has a low level of background mortality could potentially have a much more important effect than on a population with a higher level of existing mortality. The collision mortality needs to be assessed in the context of each species population dynamics. In the UK a 1% increase over the baseline mortality is now frequently being used as an initial filter

threshold above which there may be a concern with the predicted collision mortality (and hence requiring further investigation). Collision risks below this level are usually considered not to be significant.

42. In the context of the Inyanda Roodeplaat site, the predicted collision mortality has been set against the regional background mortality for each of the four key species at risk of collision. The population data used in this analysis are summarised in Table 9. The region has been taken as the Karoo biome (Mucina and Rutherford 2006, and with reference to the WWF Karoo eco-region).

Table 9. Background population data for Verreaux's Eagle, Booted Eagle and Martial Eagle. Source: Roberts VII (Hockey et al. 2005) and Gargett (1990).

Species	Regional population	Adult mortality rate	Immature mortality rate	Annual productivity (chicks/pair /year)	Age at first breeding	Baseline mortality
Verreaux's Eagle	940 pairs	5%	20%	0.5	5	94 (adult)
Martial Eagle	300 pairs	7%	20%	0.6	5	150
Booted Eagle	700 pairs	10%	20%	1.0	3	500
Black Harrier	150 pairs	20%	50%	1.9	2	330 (all) 60 (adult)

43. The Verreaux's Eagle baseline population has been estimated in the same way as the previous report. This gave a conservative estimate of 600 pairs of Verreaux's Eagle for the Karoo escarpment (Roggeveld, Nuweveld, Sneeuberge and Winterberge) plus a further 100 pairs for the smaller inselbergs outside of the main mountain ranges was produced by Rob Simmons for the Witberg wind farm project (Percival 2013). These numbers were derived primarily from information collected by Rob Davies for his PhD work (together with other published population density estimates; Simmons in Hockey et al. 2005) and since then the population is thought to have declined by about 15% on the basis of recent field surveys carried out by Rob Davies. This would therefore give a current populations estimate for the escarpment plus the inselbergs of about 600 pairs. The area on which this estimate is based does not include approximately 24,000km^2 of other Karoo mountain ranges that would provide suitable habitat Verreaux's Eagle habitat. Using a very conservative nesting density of 1 pair per 60km^2 (the lowest recorded according to Davies 1994, densities at the Karoo National Park and around the Inyanda Roodeplaat site are considerably higher than this) over this entire area, this gives a further 400 pairs over this area. That too should be scaled down from the 1994 density by 15%, giving an estimated 340 additional pairs, and hence a more realistic total of about 940 pairs for the Karoo.

44. Tables 10a-c shows the predicted collision risk and associated impact significance for each of the four species in the context of their background mortality and the % increase over the baseline that each risk represents, for the 2013-14 data, the Aug 2015 - Jan 2016 data (adjusted for a full year, as presented in the ES OIA) and the Aug 2015 - Jul 2016 data respectively. For Verreaux's Eagle, the assessment summarised in these Tables assesses the collision risk against the adult population, as the large majority of records from the site related to adult birds.

Table 10a. Collision risk for Verreaux's Eagle, Martial Eagle, Booted Eagle and Black Harrier and the increases that these represent over baseline mortality, for the 52-turbine layout based on Aug 2015-Jul 2016 data.

Species	Precautionary avoidance rate	Predicted collision risk	% increase over baseline mortality	Magnitude of effect	Likely significant effect?
Verreaux's Eagle	98%	3.29	3.5%	Low	Possible, but could be mitigated
Martial Eagle	98%	0.35	0.24%	Negligible	No
Booted Eagle	98%	0.13	0.03%	Negligible	No
Black Harrier	99%	1.82	0.56% (all) 3.0% (adult only)	Negligible/Low	Possible, but could be mitigated

Table 10b. Collision risk for Verreaux's Eagle, Martial Eagle, Booted Eagle and Black Harrier and the increases that these represent over baseline mortality, for the 52-turbine layout based on Aug 2015-Jan 2016 data (adjusted for full year prediction).

Species	Precautionary avoidance rate	Predicted collision risk	% increase over baseline mortality	Magnitude of effect	Likely significant effect?
Verreaux's Eagle	98%	2.64	2.8%	Low	Possible, but could be mitigated
Martial Eagle	98%	0.29	0.19%	Negligible	No
Booted Eagle	98%	0.21	0.04%	Negligible	No
Black Harrier	99%	1.47	0.45% (all) 2.5% (adult only)	Negligible/Low	Possible, but could be mitigated

Table 10c. Collision risk for Verreaux's Eagle, Martial Eagle, Booted Eagle and Black Harrier and the increases that these represent over baseline mortality, for the 52-turbine layout based on 2013-14 data.

Species	Precautionary avoidance rate	Predicted collision risk	% increase over baseline mortality	Magnitude of effect	Likely significant effect?
Verreaux's Eagle	98%	1.72	1.8%	Low	Possible, but could be mitigated
Martial Eagle	98%	0.21	0.14%	Negligible	No
Booted Eagle	98%	0.08	0.02%	Negligible	No
Black Harrier	99%	0.17	0.05%	Negligible	No

45. Overall, updating of the collision risk predictions with the new data collected during February - July 2016 has not made any material difference to the conclusions reached in the assessment.

46. For Martial Eagle and Booted Eagle, the predicted collision risks from the full year's 2015-16 data continued as previously to be very small both numerically and in a population context. Those increases were considerably less than 1% when assessing the collision risk against the regional population. With such a negligible magnitude risk, there would not be likely to be any regionally significant population impact for either of these species for any of the layouts.

47. For Verreaux's Eagle, the predicted collision risk of 3.3 collisions per year was a slight increase from the previous ES OIA prediction. This did not though make any material difference to the assessment. It was still assessed as a low magnitude effect, which would be considered to be of low significance on a high sensitivity species, and hence strictly not a significant impact (see Avifaunal Impact Assessment Report for more details of the assessment methodology). However, it is above the 1% increase in the baseline mortality, and therefore requires careful consideration as to whether on the information currently available a significant effect on Verreaux's Eagle can be ruled out.

48. It was recommended previously that mitigation measures should be implemented to reduce the collision risk to Verreaux's Eagle, and this remains the case from the further year of baseline data collected during 2015-16. As previously, it should be noted that the collision risk results presented here are from a precautionary assessment, not the most likely outcome. The analysis has adopted a precautionary approach, including:

- Use of a precautionary 98% avoidance rate rather than the more evidence-based 99% for the closely related Golden Eagle;
- Use of a conservative regional population estimate against which to assess the predicted wind farm mortality;
- Assessment of mortality has been made against only the existing adult mortality rather than the usual assessment against all of the predicted mortality;
- Assuming that flight activity through the wind farm will continue at the same rate after construction. Given that mitigation measures have been recommended to improve the food resource within nest buffers away from the wind farm (see next section) and the observed behavior of Golden Eagles at existing wind farms (e.g. Walker et al. 2005), some reduction in risky flight activity is more likely.

49. The predicted collision risk for Black Harriers (1.8 collisions per year) is higher than that predicted from the 2013-14 data (0.2 per year) and slightly higher than that predicted in the ES OIA (1.5

per year), reflecting this species' higher use of the wind farm site in August 2015-January 2016 than had been recorded previously (including two nests). Set against the overall regional mortality this would be an increase of only about 0.6% over the existing baseline mortality, which would be a negligible magnitude effect (and not significant). However, focusing on adult mortality (most of the flights within the risk zone were of adult birds) this increases to a 3% increase over the baseline, a low magnitude effect. This species is globally 'vulnerable' (on the 2015 IUCN red list) and is listed as 'endangered' on the BirdLife South Africa red list and is a near-endemic to South Africa (SA holds >70% world population), so that has the potential to be a significant impact. Potential mitigation measures for this species should be developed with Black Harrier as a specific target species to benefit from a conservation management plan, as they are likely to be required to ensure that this species is not adversely affected by the development.

Disturbance Effects

50. The loss of key species' foraging range that could result from wind farm disturbance was assessed previously (Percival et al. 2015) in an analysis based on theoretical range modelling, so that is unaffected by the new field data. The new VP data do, however, confirm the previous finding that the wind farm site itself is not a particularly important foraging area for either Verreaux's or Martial Eagle.

51. The 2015-16 data have shown that the wind farm site can be important for Black Harrier, with breeding birds nesting there and a high level of use of the site for foraging as well. This was in contrast to previous surveys, which had shown that this species made only occasional use of the site. Population fluctuations in this species are well-documented (Simmons et al. in Hockey et al. 2005), so the breeding as in 2015-16 is not an event that is certain to be repeated in future years. As noted above in the discussion of collision risk, Black Harrier is a species of particular conservation importance, being an IUCN globally vulnerable and a South African endangered red list species. With two nests within the wind farm site, disturbance to breeding birds does have the potential to be significant, so mitigation measures should be developed to ensure that any net adverse effect on this species is avoided.

Effects of Grid Connection

52. The potential collision risk posed by the overhead lines required to connect the wind farm into the grid was identified by Jon Smallie as an impact that would require mitigation. He advised that all overhead power line should be on 'bird friendly' pole design as per Eskom Standard, and that high risk sections to be marked with 'bird flappers'. There was though no field survey as part of that work to enable those higher risk sections to be defined.

53. The 2015-16 surveys have shown that several species prone to collision with overhead wires (including Blue Crane, Ludwig's Bustard and Denham's Bustard) are present in the area through which the overhead lines would pass. It will be important therefore to ensure that suitable mitigation is put in place. The 2015-16 surveys have also informed where those species occur and hence the higher collision risk areas where those measures would need to be applied. It was not possible to obtain access to survey the full routes of all three possible grid connection routes, so a further survey should be undertaken once the final route is confirmed to identify the locations where these measures will be needed (in combination with the 2015-16 data).

Conclusions and Recommendations

54. A full year's additional baseline survey of the Inyanda Roodeplaat wind farm site has been successfully completed during August 2015-July 2016. A local surveyor, Adri Barkhuysen, has

been trained to undertake vantage point surveys to international standards, and a high quality field dataset has been collected.

55. Breeding Verreaux's Eagle were active in most of the known ranges around the wind farm site, but all of these birds failed to breed successfully in 2015 (though they had bred successfully at many of these sites in 2013 and 2014, and several did so again in 2016). There was no evidence of any breeding Martial Eagles within the survey area in 2015 but a pair nested successfully 2.2km SW from the wind farm site in 2016. Use of the wind farm site by these species during August 2015-July 2016 was at a similar level to that recorded previously, and as a result the predicted collision risks were similar too.

56. Breeding black harriers had not been previously noted in the survey area in the 2013-14 surveys, but at least two females were nesting within the wind farm site in 2015-16. They made extensive use of the wind farm site, being the most frequently recorded raptor species during the VP surveys.

57. Mitigation measures for Verreaux's Eagle were suggested previously (Percival et al. 2015), that had two specific aims (a) to ensure that the relative attractiveness of the wind farm site for this species was not increased following construction of the wind farm, and (b) to improve nesting/foraging habitat further away from wind farm (to encourage birds to move away from the wind farm). Additionally, a programme of post-construction studies was recommended to understand interaction with wind farm and provide more information on their basic ecology. Given the increased use of the site by Black Harriers in 2015, and the conservation status of this species (globally 'Vulnerable' and nationally 'Endangered'), similar measures should be developed for this species as well.

58. Proposed mitigation measures were set out in the ES OIA. They included on-site habitat management to ensure that the wind farm site does not attract foraging raptors, off-site habitat management to enhance raptor food resources away from the wind farm, and a backup scheme for targeted turbine shutdown, as well as the implementation of a programme of post-construction bird monitoring. The data collected during 2015-16 has further supported the need for these measure to be implemented.

Habitat Management (on-site)

59. The raptor food resource must not become more attractive within the wind farm site, drawing foraging birds into the site, as this would increase collision risk. For instance, during access track construction, there may be periods of time where imported or excavated aggregate is stockpiled forming potentially attractive habitat for Rock Hyrax. During construction of the wind farm all mounds of aggregate or rocks which could serve as hyrax habitat should be removed prior to the commencement of operation of the turbines and through the operational phase of the wind farm.

60. In addition, the proposed turbine bases should not serve as a refuge for small mammals, and thus the turbines themselves will not create attractive habitat for potential prey species such a hyrax.

61. As none of key species are predominantly carrion-feeders it is not considered necessary to have a programme of carrion removal from the wind farm site, though this should be reviewed in light of the results of the post-construction monitoring programme.

Habitat management (off-site)

62. A management programme will be implemented within the Verreaux's Eagle nest buffers to enhance the food resources away from the wind farm, and hence reduce eagle flight activity within the wind farm.

63. The wind farm landowner plans to put 16,000 ha within his ownership into stewardship as part of the mitigation programme. This will include management measures that could improve raptor prey populations and habitat over a large area that, if managed appropriately, could deliver a net gain to the local raptor populations. A specific management plan will be drawn up and

implemented to integrate the ecological requirements of the local raptors into the management of this area.

Turbine shutdown on demand

64. Curtailment of the operation of wind turbines could potentially be a useful mitigation measure to reduce collision risk, but is often uneconomic. Recent developments of schemes that have very limited shutdown over short periods has made the implementation of such schemes more viable, and there are now several in operation globally (mainly in southern Europe). These rely either on direct human observers at key risk periods and/or automated detection systems based on radar or video monitoring. Such a system should be implemented at Inyanda Roodeplaat, if required, to provide a back-up response should the number of collisions actually approach the worst-case predictions.

Post-construction Ornithological Monitoring

65. Post-construction bird monitoring should be undertaken to better understand the impacts that actually occur and inform future wind farm design. This has the potential to make a significant contribution to the understanding of bird-wind farm interactions in this area and specifically about the key species at risk at this site, Verreaux's Eagle and Black Harrier.

66. The post-construction bird monitoring should include continuation, for a period of at least three years, of the raptor surveys and vantage point surveys, to compare bird distribution, abundance and behaviour before and after construction, and a programme to monitor the actual collisions that occur.

67. A programme of tagging Verreaux's Eagles and Black Harriers should also be undertaken to provide further information on how these species behave in and around wind farms. Sample individuals (ideally young and adult birds) from the local population should be tagged with GPS/satellite tags to enable their detailed movement patterns to be determined. The VP surveys provide data on the use of the wind farm site but the tagging would provide more comprehensive data on how these birds are using their whole ranges and on how they respond to the presence of the wind turbines. Data from such a study could also be used to inform range modelling for this species (similar to that undertaken for the golden eagle in the UK, McLeod et al 2002, which has been widely applied to better assess the effects of wind farms on this species). Funding of a project that combines tagging and range modelling could make a significant contribution to the future conservation management of these species.

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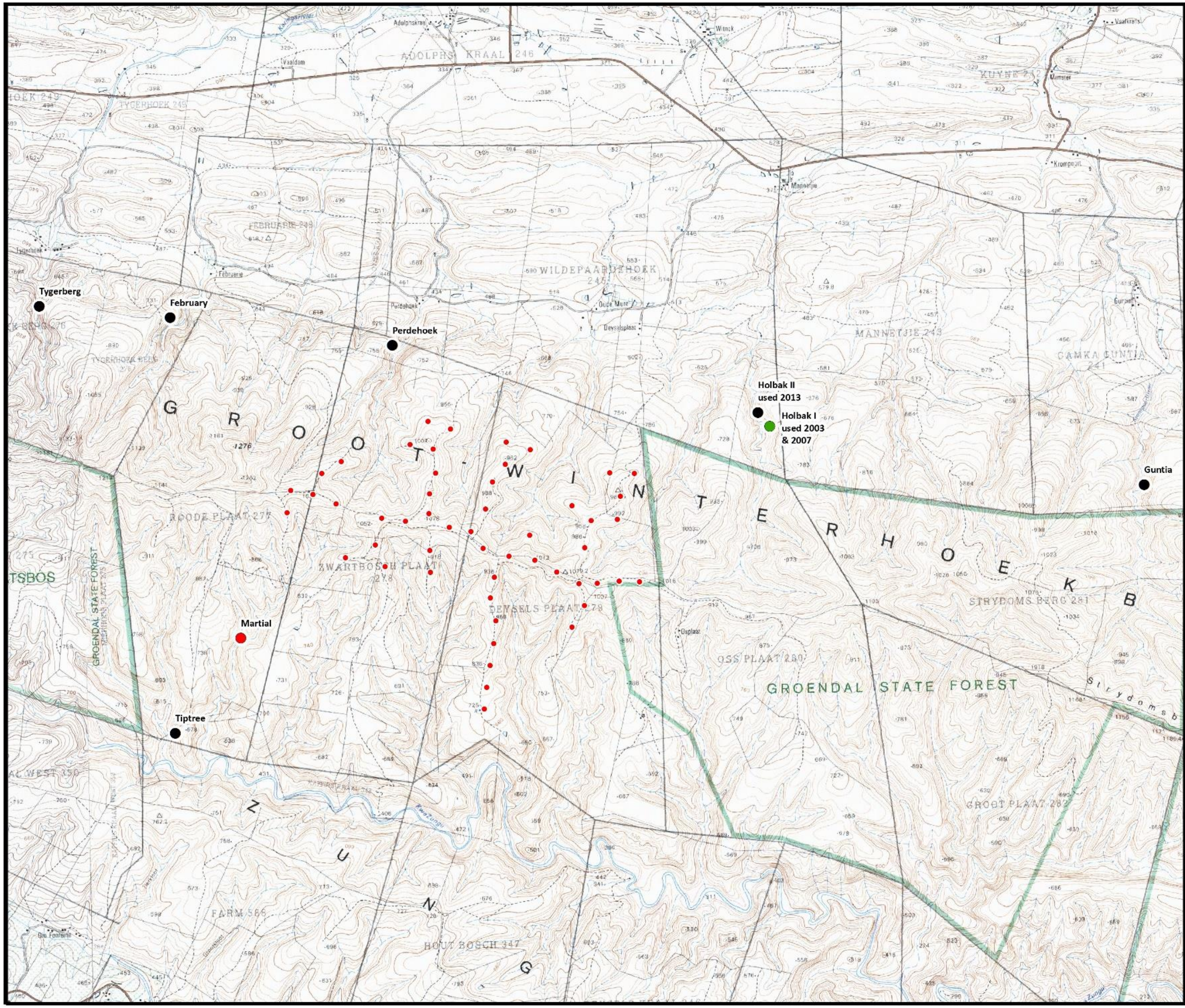


NEWCOMBE WIND DEVELOPMENTS

Inyanda Roodeplaat Wind Farm

FIGURE 1

Breeding Eagle Survey 2015-16 - locations of sites checked

KEY:

- 52-turbine layout

Eagle nest sites

- Martial Eagle
- Verreaux's Eagle
- Verreaux's old site

ECOLOGY CONSULTING

N

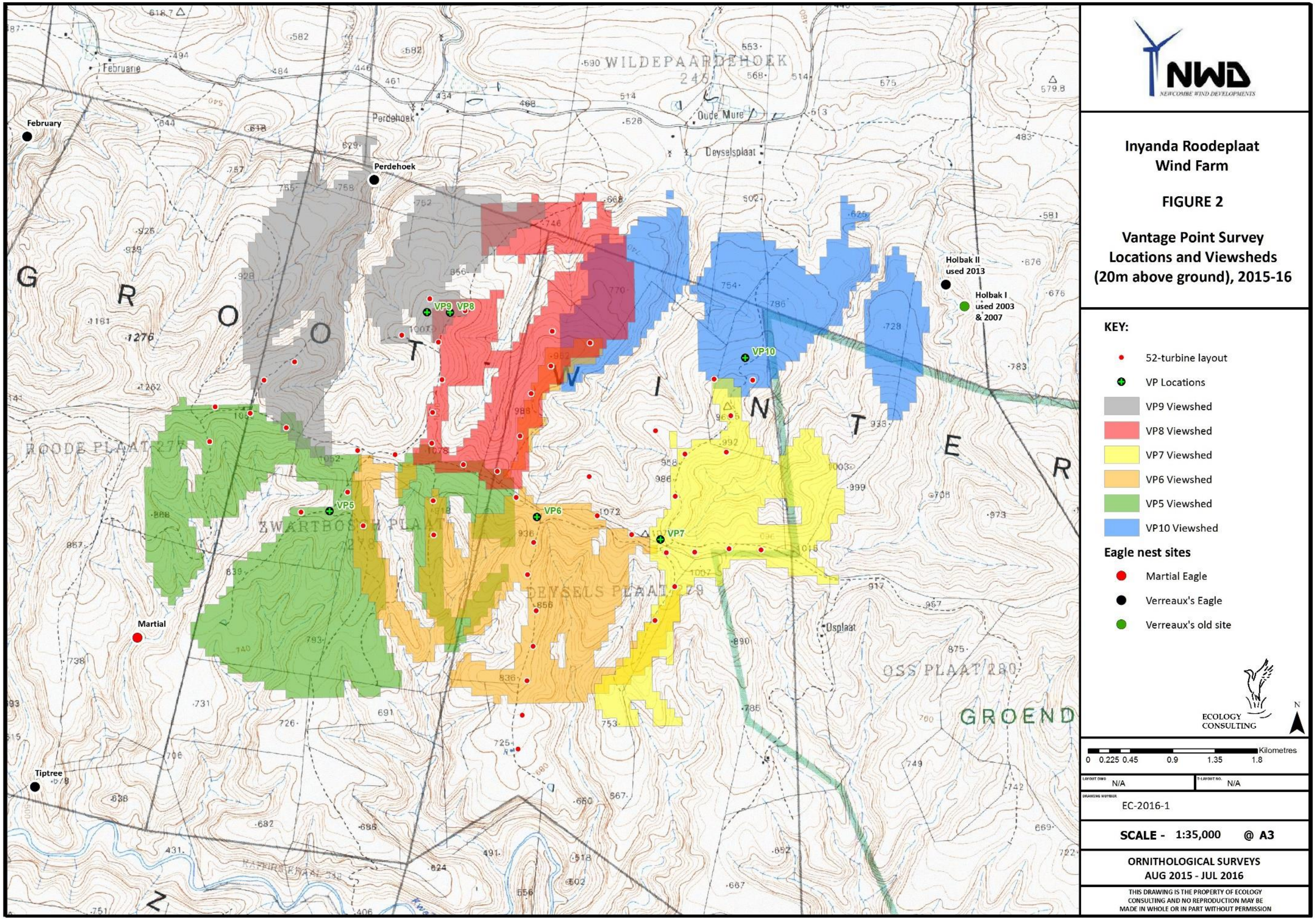
Kilometres: 0, 0.4, 0.8, 1.6, 2.4, 3.2

LAYOUT DWG	N/A	T-LAYOUT NO.	N/A

DRAWING NUMBER: EC-2016-1

SCALE - 1:60,000 @ A3

ORNITHOLOGICAL SURVEYS AUG 2015 - JUL 2016


NWD
NEWCOMBE WIND DEVELOPMENTS
Inyanda Roodeplaat
Wind Farm
FIGURE 2
Vantage Point Survey
Locations and Viewsheds
(20m above ground), 2015-16
KEY:
52-turbine layout
VP Locations
VP9 Viewshed
VP8 Viewshed
VP7 Viewshed
VP6 Viewshed
VP5 Viewshed
VP10 Viewshed
Eagle nest sites
Martial Eagle
Verreaux's Eagle
Verreaux's old site
ECOLOGY
CONSULTING
N
0 0.225 0.45 0.9 1.35 1.8 Kilometres
N/A
N/A
EC-2016-1
SCALE - 1:35,000 @ A3
ORNITHOLOGICAL SURVEYS
AUG 2015 - JUL 2016
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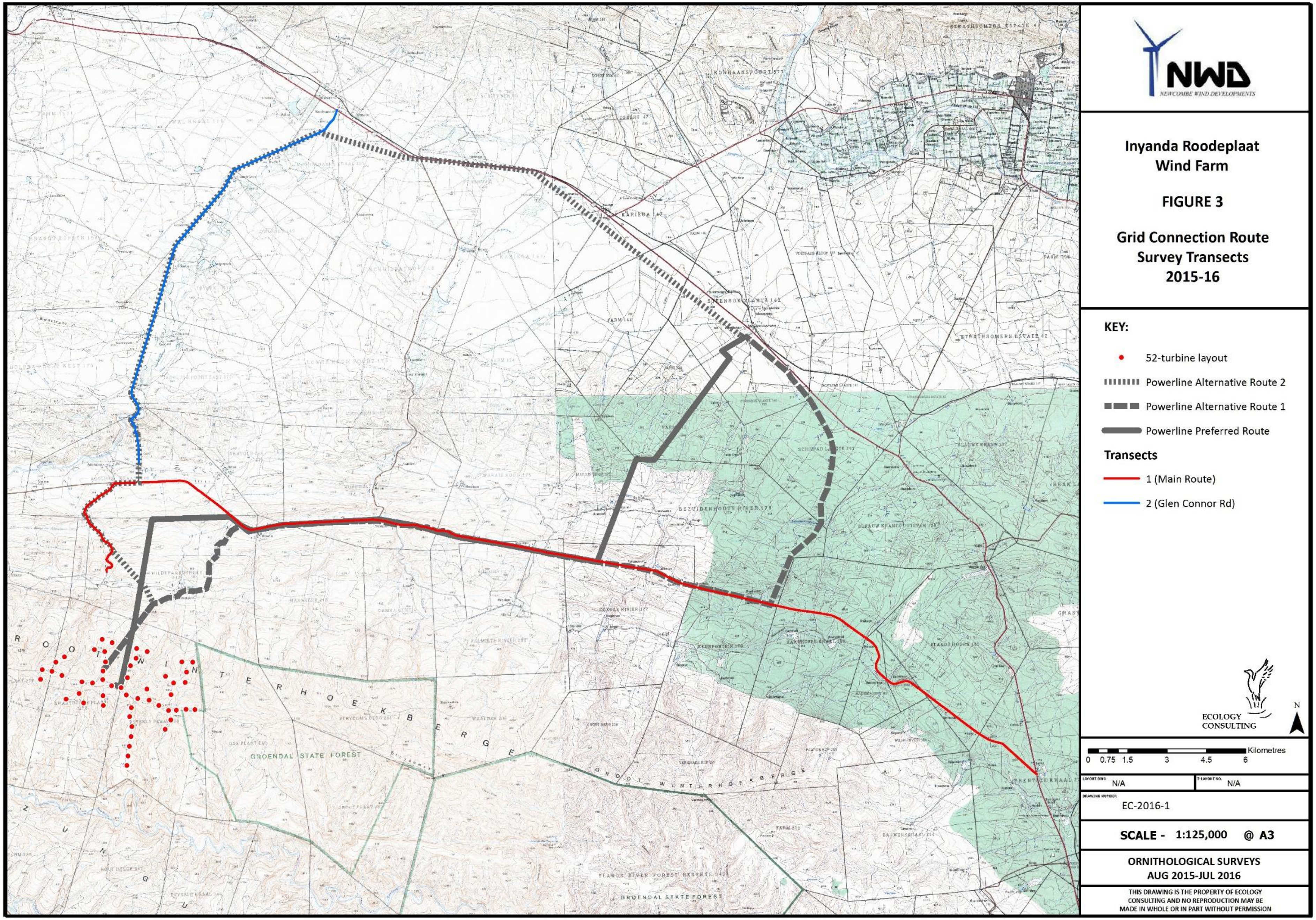
February
Perdehoek
Holbak II
used 2013
Holbak I
used 2003
& 2007
Martial
Tiptree
VP9
VP8
VP10
VP5
VP6
VP7
WILDEPAARDEHOEK
ROODE PLAAT
DEYSELS PLAAT
OSS PLAAT 280
GROEND


NWD
NEWCOMBE WIND DEVELOPMENTS
Inyanda Roodeplaat
Wind Farm
FIGURE 3
Grid Connection Route
Survey Transects
2015-16
KEY:
52-turbine layout
Powerline Alternative Route 2
Powerline Alternative Route 1
Powerline Preferred Route
Transects
1 (Main Route)
2 (Glen Connor Rd)
ECOLOGY
CONSULTING
N
Kilometres
0 0.75 1.5 3 4.5 6
LAYOUT DWG N/A
T-LAYOUT NO. N/A
DRAWING NUMBER EC-2016-1
SCALE - 1:125,000 @ A3
ORNITHOLOGICAL SURVEYS
AUG 2015-JUL 2016
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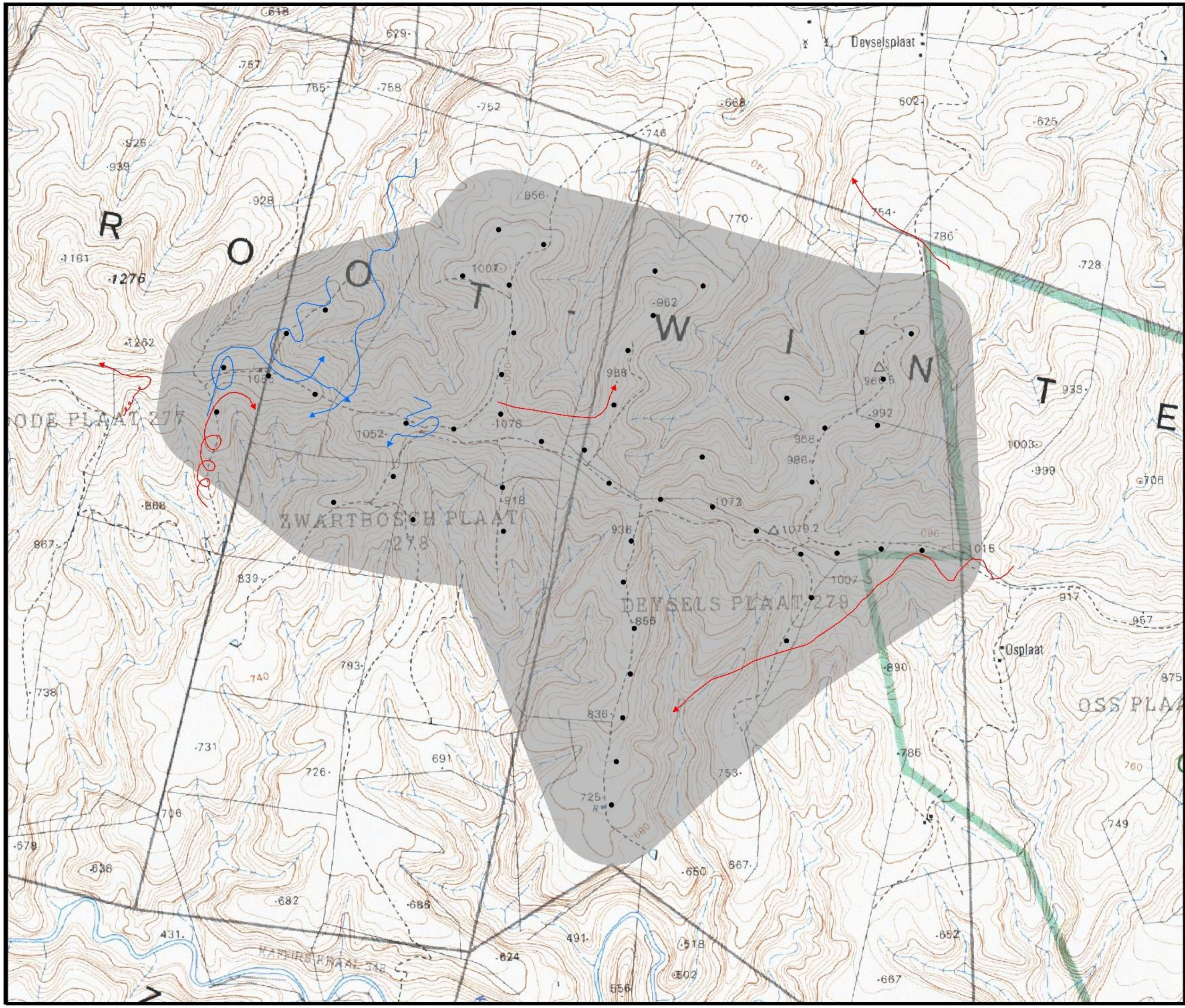
GROENDAL STATE FOREST
GROOT WINTERHOEKBERGE



NWD
NEWCOMBE WIND DEVELOPMENTS

Inyanda Roodeplaat Wind Farm

FIGURE 4

VP Survey Flight Lines Aug 2015 - Jul 2016: Martial Eagle

KEY:

- 52-turbine layout
- Collision Risk Zone (52T)

Period

- Aug 2015 - Jan 2016
- Feb - Jul 2016

ECOLOGY CONSULTING

N

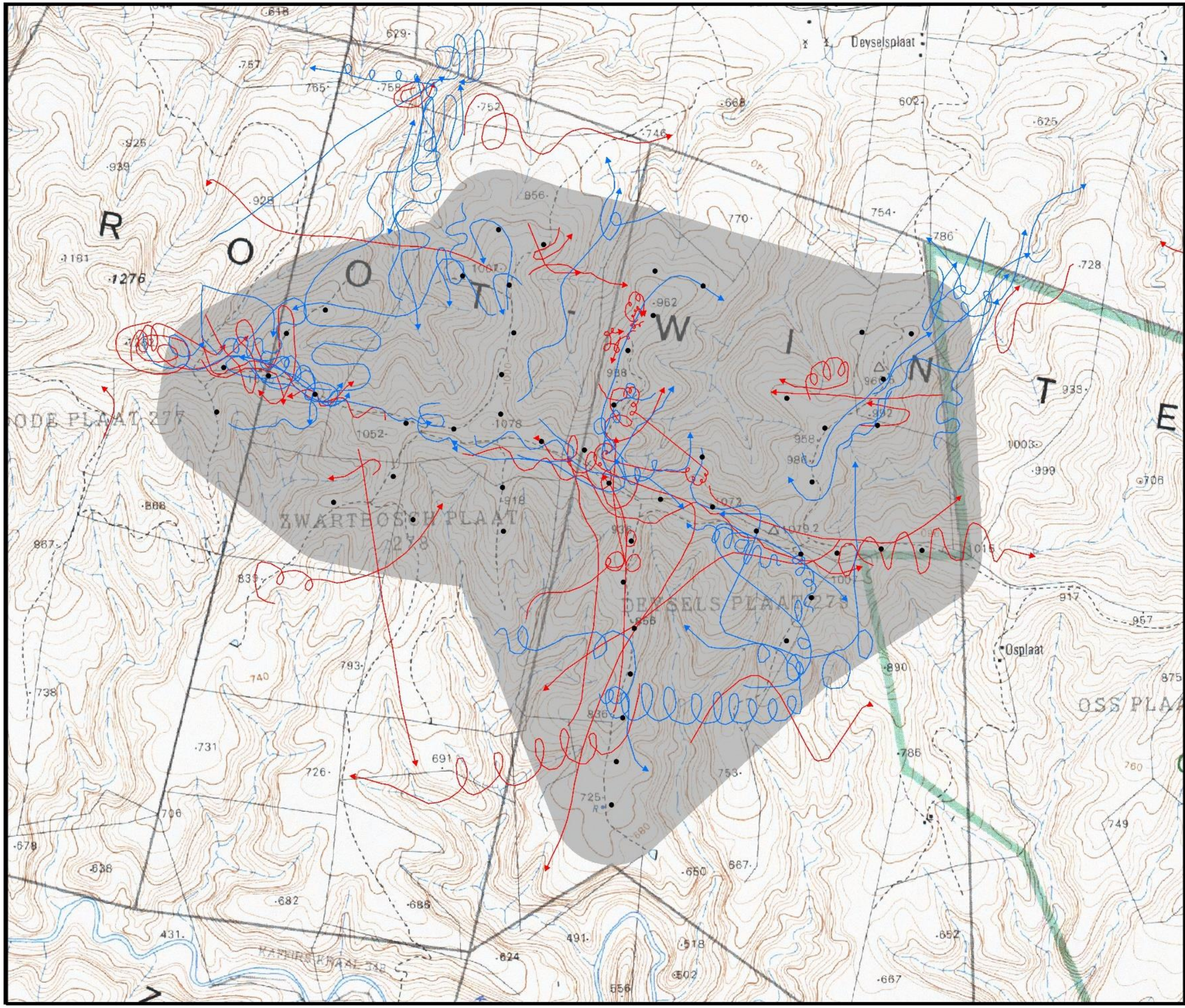
Kilometres
0 0.2 0.4 0.8 1.2 1.6

LAYOUT DWG N/A
T-LAYOUT NO. N/A

DRAWING NUMBER
EC-2016-1

SCALE - 1:30,000 @ A3

ORNITHOLOGICAL SURVEYS AUG 2015-JUL 2016



NEWCOMBE WIND DEVELOPMENTS

Inyanda Roodeplaat Wind Farm

FIGURE 5

VP Survey Flight Lines Aug 2015 - Jul 2016: Verreaux's Eagle

KEY:

- 52-turbine layout
- Collision Risk Zone (52T)

Period

- Aug 2015 - Jan 2016
- Feb - Jul 2016

ECOLOGY CONSULTING

N

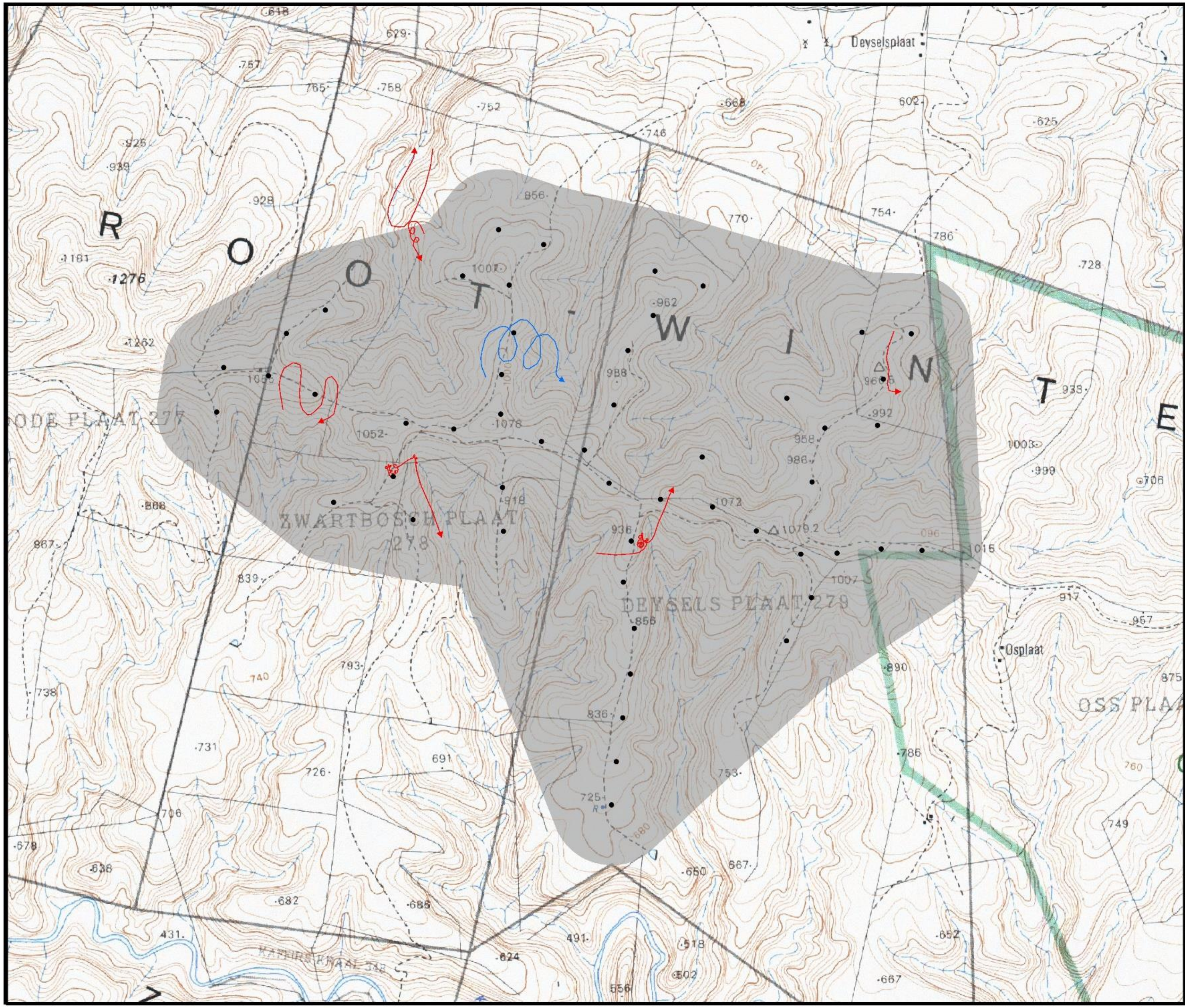
0 0.2 0.4 0.8 1.2 1.6 Kilometres

LAYOUT DWG N/A	T-LAYOUT NO. N/A

DRAWING NUMBER EC-2016-1

SCALE - 1:30,000 @ A3

ORNITHOLOGICAL SURVEYS AUG 2015-JUL 2016



NWD
NEWCOMBE WIND DEVELOPMENTS

Inyanda Roodeplaat Wind Farm

FIGURE 6

VP Survey Flight Lines Aug 2015 - Jul 2016: Booted Eagle

KEY:

- 52-turbine layout
- Collision Risk Zone (52T)

Period

- Aug 2015 - Jan 2016
- Feb - Jul 2016

ECOLOGY CONSULTING

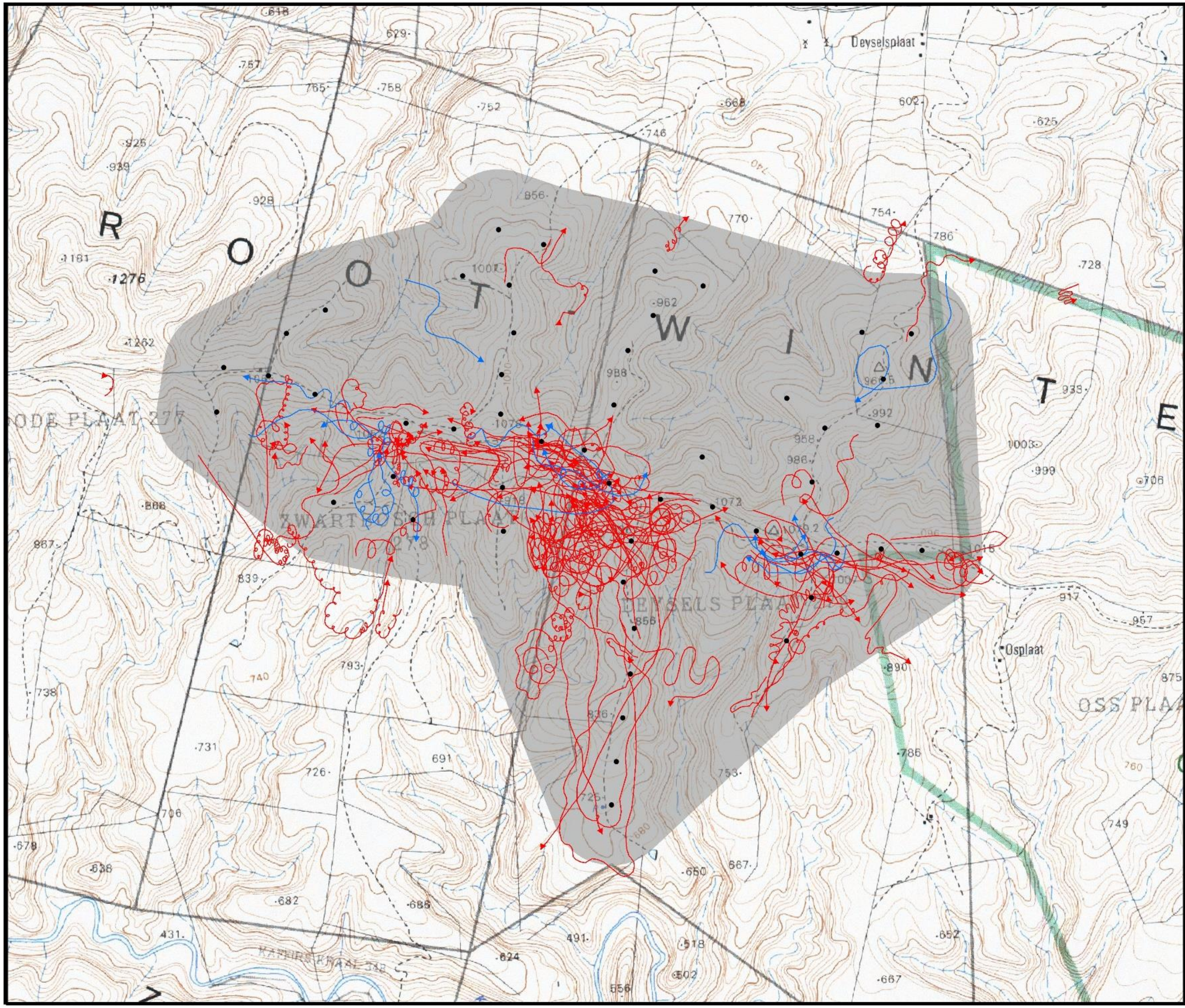
N

Kilometres: 0, 0.2, 0.4, 0.8, 1.2, 1.6

LAYOUT DWG	N/A	T-LAYOUT NO.	N/A
DRAWING NUMBER	EC-2016-1		

SCALE - 1:30,000 @ A3

ORNITHOLOGICAL SURVEYS AUG 2015-JUL 2016



NEWCOMBE WIND DEVELOPMENTS

Inyanda Roodeplaat Wind Farm

FIGURE 7

VP Survey Flight Lines Aug 2015 - Jul 2016: Black Harrier

KEY:

- 52-turbine layout
- Collision Risk Zone (52T)

Period

- Aug 2015 - Jan 2016
- Feb - Jul 2016

ECOLOGY CONSULTING

N

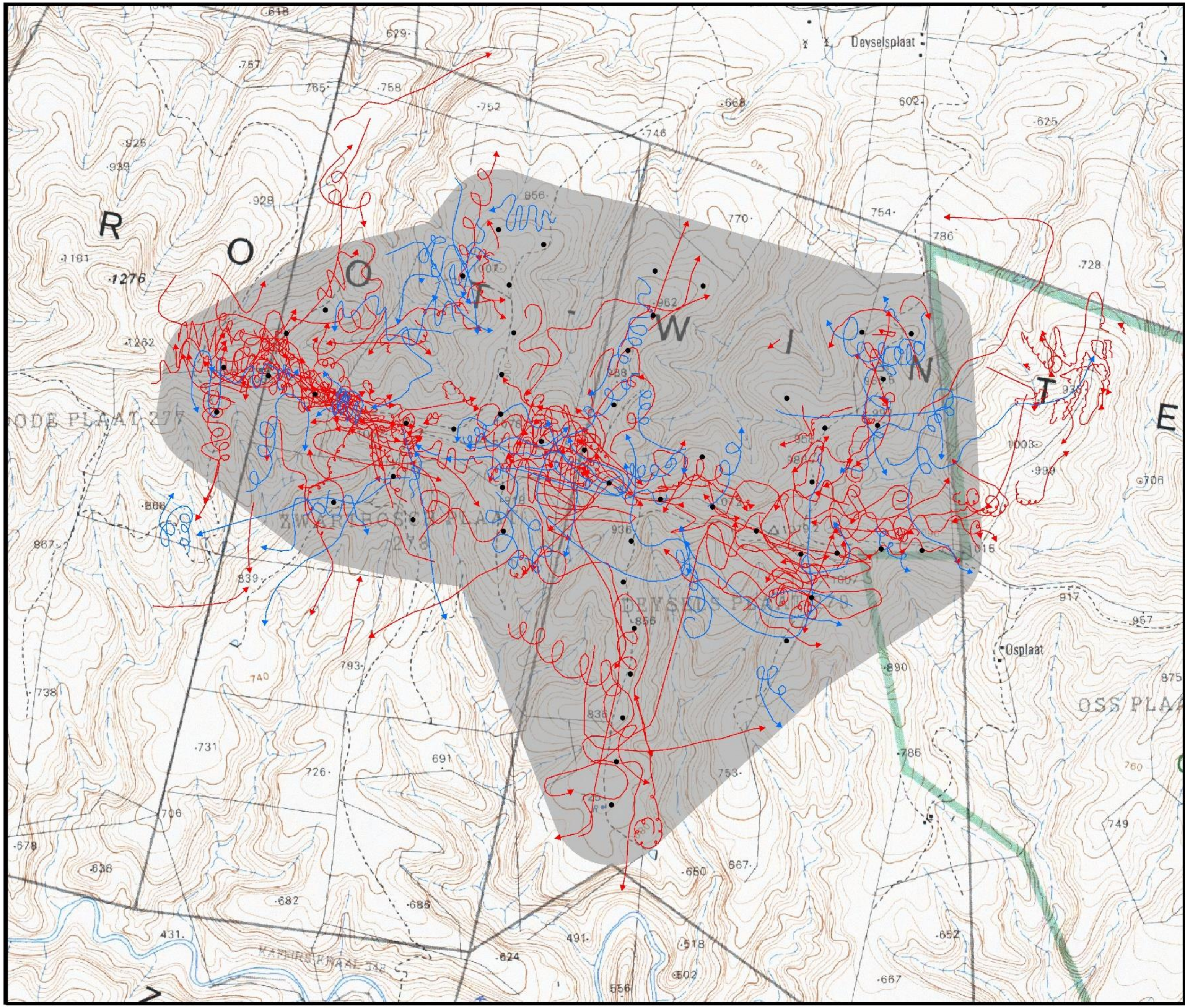
0 0.2 0.4 0.8 1.2 1.6 Kilometres

LAYOUT DWG N/A | T-LAYOUT NO. N/A

DRAWING NUMBER EC-2016-1

SCALE - 1:30,000 @ A3

ORNITHOLOGICAL SURVEYS AUG 2015-JUL 2016



NWD
NEWCOMBE WIND DEVELOPMENTS

Inyanda Roodeplaat Wind Farm

FIGURE 8

VP Survey Flight Lines Aug 2015 - Jul 2016: Jackal Buzzard

KEY:

- 52-turbine layout
- Collision Risk Zone (52T)

Period

- Aug 2015 - Jan 2016
- Feb - Jul 2016

ECOLOGY CONSULTING

N

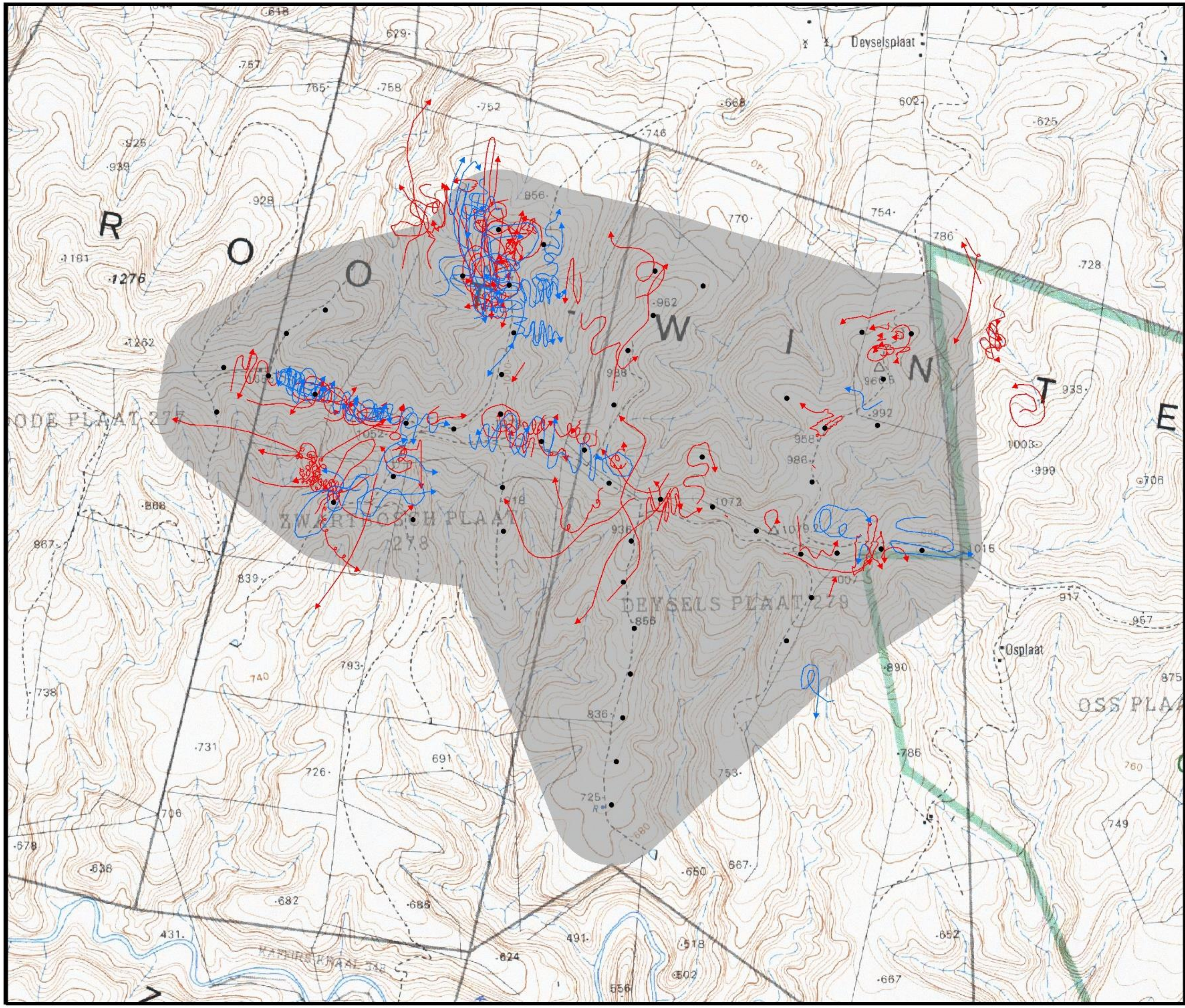
0 0.2 0.4 0.8 1.2 1.6 Kilometres

LAYOUT DWG	T-LAYOUT NO.
N/A	N/A

DRAWING NUMBER: EC-2016-1

SCALE - 1:30,000 @ A3

ORNITHOLOGICAL SURVEYS AUG 2015-JUL 2016



NEWCOMBE WIND DEVELOPMENTS

Inyanda Roodeplaat Wind Farm

FIGURE 9

VP Survey Flight Lines Aug 2015 - Jul 2016: Rock Kestrel

KEY:

- 52-turbine layout
- Collision Risk Zone (52T)

Period

- 1
- 2

ECOLOGY CONSULTING

N

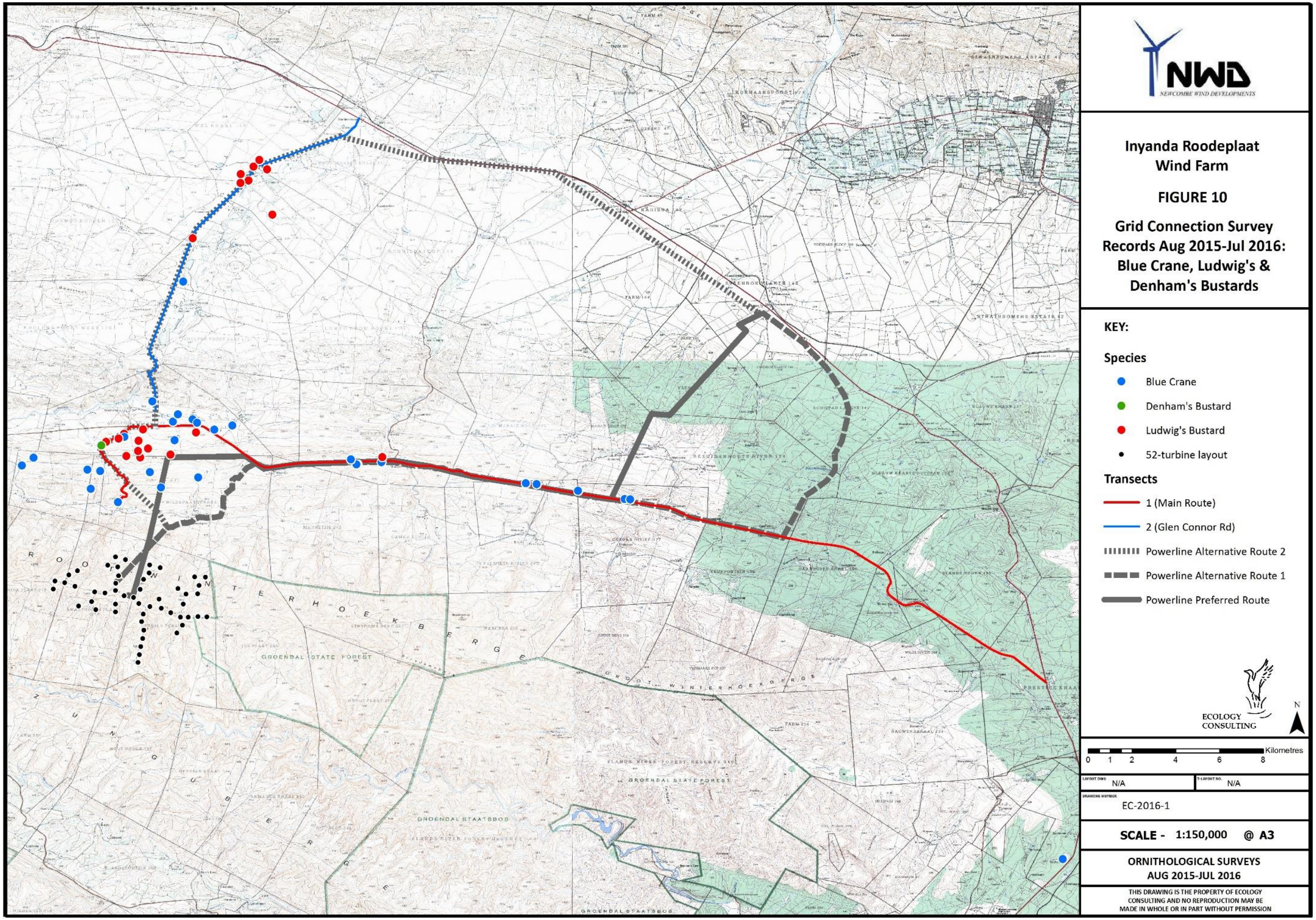
0 0.2 0.4 0.8 1.2 1.6 Kilometres

LAYOUT DWG	T-LAYOUT NO.
N/A	N/A

DRAWING NUMBER
EC-2016-1

SCALE - 1:30,000 @ A3

ORNITHOLOGICAL SURVEYS
AUG 2015-JUL 2016


NWD
NEWCOMBE WIND DEVELOPMENTS
Inyanda Roodeplaat Wind Farm
FIGURE 10
Grid Connection Survey Records Aug 2015-Jul 2016: Blue Crane, Ludwig's & Denham's Bustards
KEY:
Species
Blue Crane
Denham's Bustard
Ludwig's Bustard
52-turbine layout
Transects
1 (Main Route)
2 (Glen Connor Rd)
Powerline Alternative Route 2
Powerline Alternative Route 1
Powerline Preferred Route
ECOLOGY CONSULTING
N
Kilometres
0 1 2 4 6 8
N/A
N/A
EC-2016-1
SCALE - 1:150,000 @ A3
ORNITHOLOGICAL SURVEYS
AUG 2015-JUL 2016
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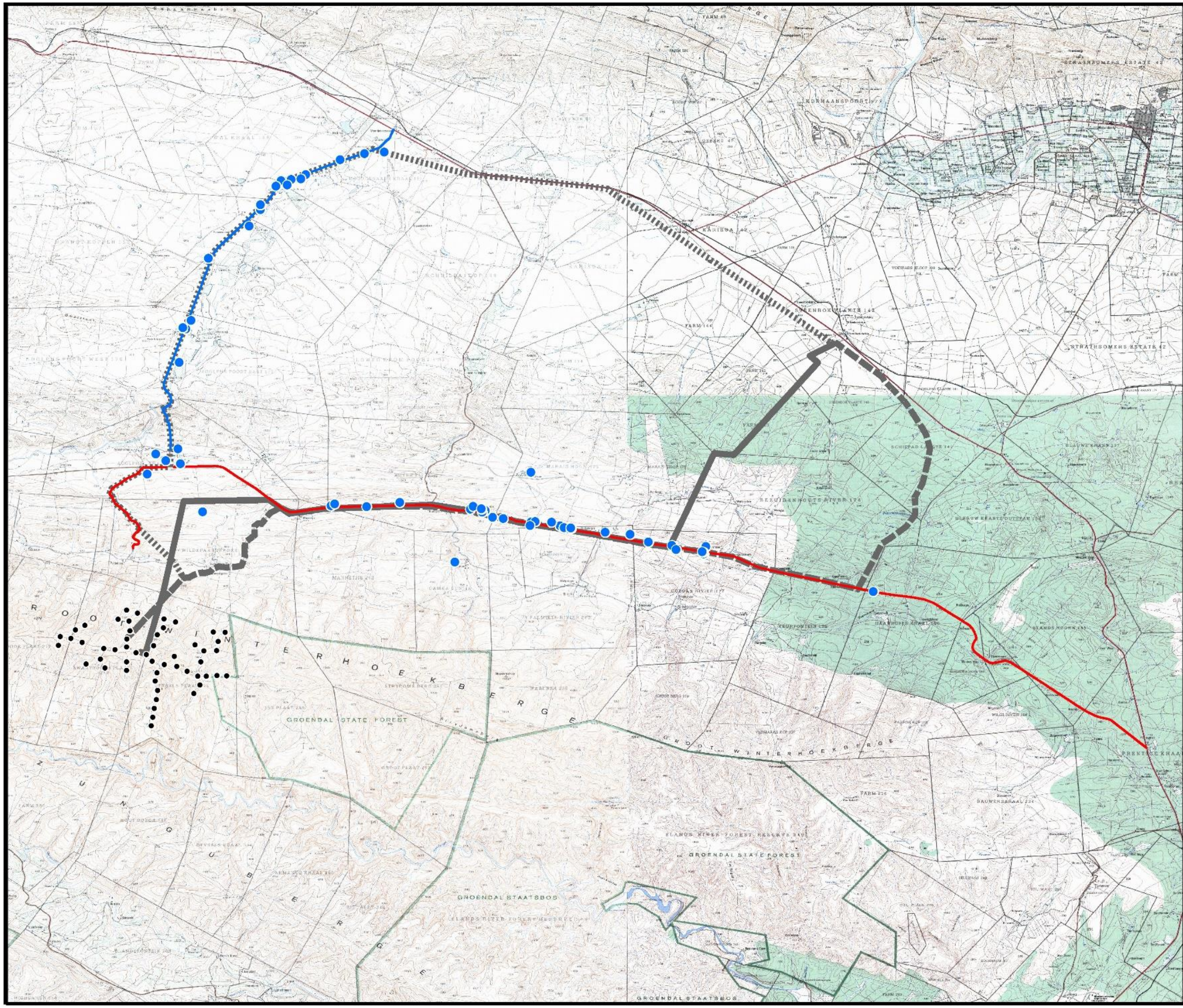


NWD
NEWCOMBE WIND DEVELOPMENTS

Inyanda Roodeplaat Wind Farm

FIGURE 11

Grid Connection Survey Records Aug 2015-Jul 2016: Pale Chanting-goshawk

KEY:

- Pale Chanting-goshawk
- 52-turbine layout

Transects

- 1 (Main Route)
- 2 (Glen Connor Rd)
- Powerline Alternative Route 2
- Powerline Alternative Route 1
- Powerline Preferred Route

ECOLOGY CONSULTING

N

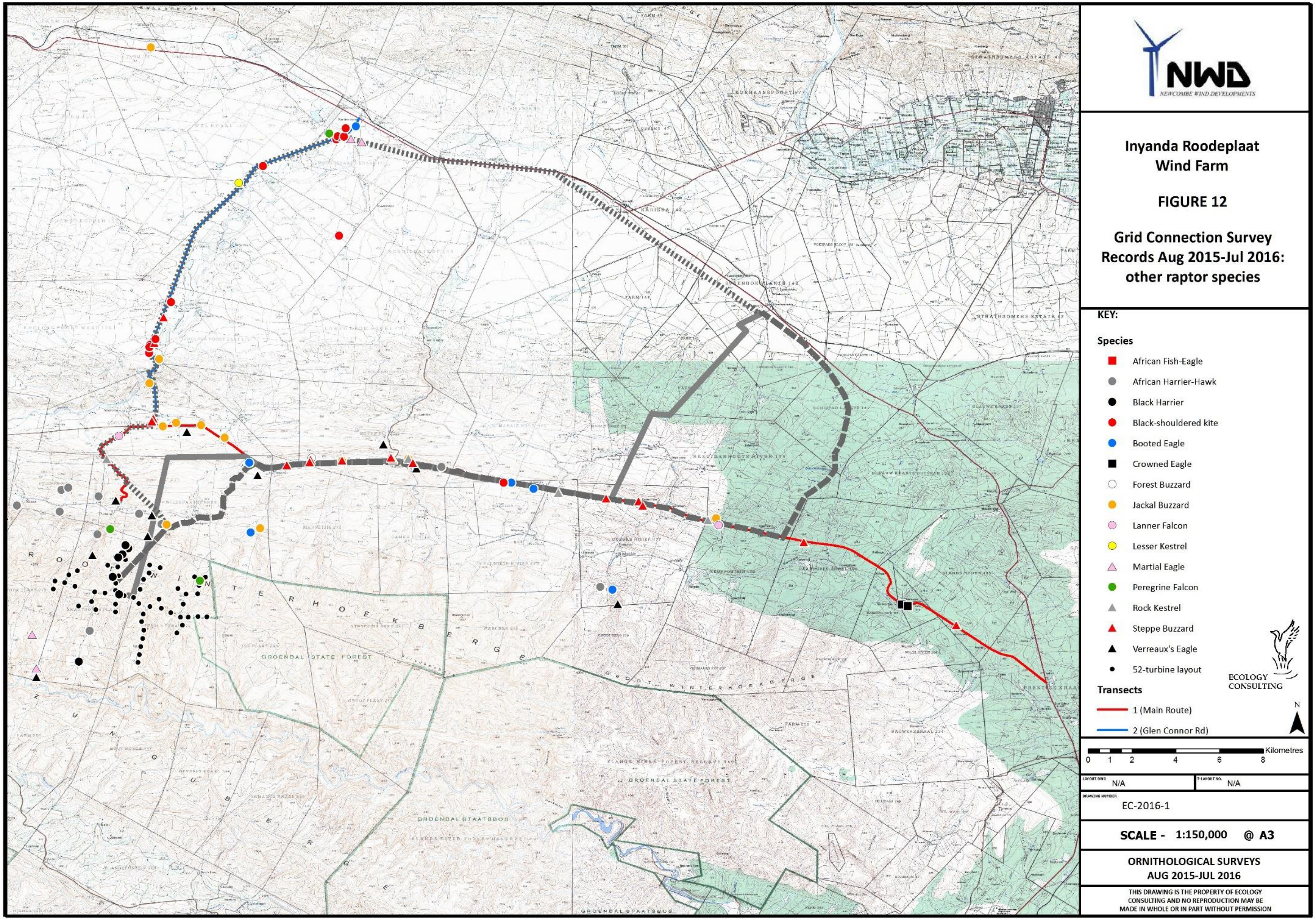
0 1 2 4 6 8 Kilometres

LAYOUT DWG N/A | T-LAYOUT NO. N/A

DRAWING NUMBER EC-2016-1

SCALE - 1:150,000 @ A3

ORNITHOLOGICAL SURVEYS AUG 2015-JUL 2016


NWD
NEWCOMBE WIND DEVELOPMENTS
Inyanda Roodeplaat Wind Farm
FIGURE 12
Grid Connection Survey Records Aug 2015-Jul 2016: other raptor species
KEY:
Species
African Fish-Eagle
African Harrier-Hawk
Black Harrier
Black-shouldered kite
Booted Eagle
Crowned Eagle
Forest Buzzard
Jackal Buzzard
Lanner Falcon
Lesser Kestrel
Martial Eagle
Peregrine Falcon
Rock Kestrel
Steppe Buzzard
Verreaux's Eagle
52-turbine layout
Transects
1 (Main Route)
2 (Glen Connor Rd)
ECOLOGY CONSULTING
N
0 1 2 4 6 8 Kilometres
LAYOUT DWG N/A
T-LAYOUT NO. N/A
DRAWING NUMBER EC-2016-1
SCALE - 1:150,000 @ A3
ORNITHOLOGICAL SURVEYS AUG 2015-JUL 2016
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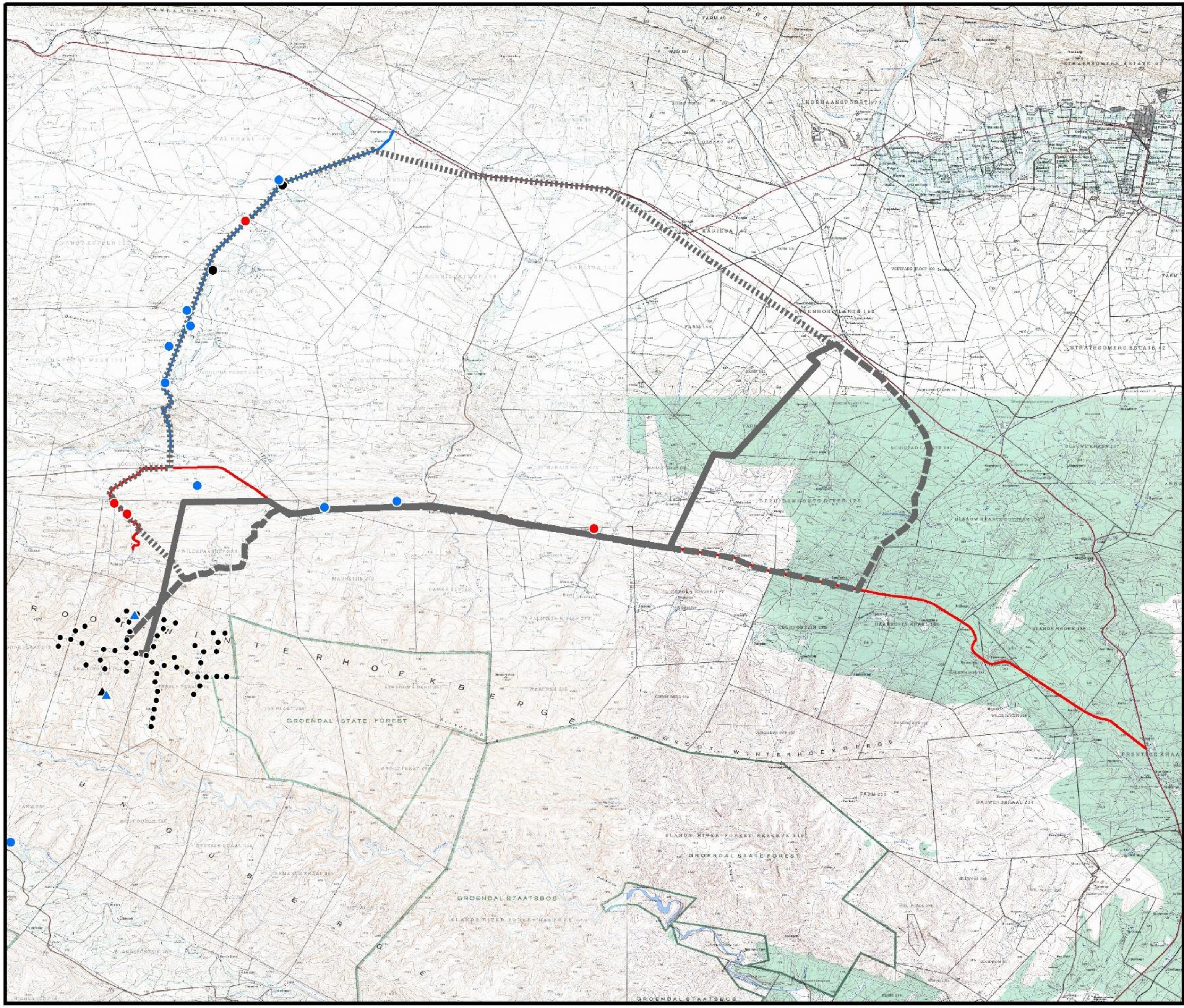

NWD
NEWCOMBE WIND DEVELOPMENTS

Inyanda Roodeplaat Wind Farm

FIGURE 13

Grid Connection Survey Records Aug 2015-Jul 2016: other species

KEY:

Species

- ▲ African Wood-Owl
- ▲ Barn Owl
- ▲ Kori Bustard
- ● Secretarybird
- ● Southern Black Korhaan
- ● Spotted Eagle-Owl

Transects

- 1 (Main Route)
- 2 (Glen Connor Rd)
- Powerline Alternative Route 2
- Powerline Alternative Route 1
- Powerline Preferred Route
- • 52-turbine layout

ECOLOGY CONSULTING

N

0 1 2 4 6 8 Kilometres

LAYOUT DWG	T-LAYOUT NO.
N/A	N/A

DRAWING NUMBER
EC-2016-1

SCALE - 1:150,000 @ A3

ORNITHOLOGICAL SURVEYS AUG 2015-JUL 2016