Pre-construction Avian Basic Assessment for the proposed grid connection infrastructure for the Zonnequa Wind Farm, Kleinzee, Northern Cape

May 2017 to February 2018

Prepared for: **A joint venture between**

genesis eco-energy DEVELOPMENTS

ATLANTIC ENERGY PARTNERS

Prepared by:

BIRDS & BATS UNLIMITED

Environmental Consultants

www.birds-and-bats-unlimited.com

TABLE OF CONTENTS

1 SUMMARY

Genesis Zonnequa Wind (Pty) Limited have proposed the development of a Wind Energy Facility (WEF) in the Renewable Energy Zone (REDZ 8) near Kleinsee, South Africa, part of the arid Namaqualand Strandveld. The proposed Zonnequa Wind Farm requires the construction and operation of a grid connection solution. The grid connection solution will include the development of a double-circuit 132kV power line (known as the Strandveld-Gromis 132kV double-circuit power line) and collector substation (known as the Strandveld Substation) to connect the proposed Zonnequa Wind Farm to the national grid. Other associated infrastructure will also be required for the grid connection solution, including access tracks/roads, administrative buildings and laydown areas.

A corridor 300m wide and 22km long is being assessed to allow for the optimisation of the grid and associated infrastructure and to accommodate environmental sensitivities. The grid infrastructure will be developed within the 300m corridor. The height of the power line pylons will be up to 32m and the servitude width of the power line will be 31m[1]. The extent of the Strandveld Substation will be 100m x 200m and the capacity of the substation will be 132kV. Two grid connection options exist within the 300m corridor (Figure 1), namely:

- A direct connection from the Strandveld Substation to the existing Gromis Substation located ~18km from the northern boundary of the Zonnequa Wind Farm project site. This is the preferred option from a technical perspective because the Gromis Substation already exists.
- A loop-in loop-out connection from the Strandveld Substation to the proposed Rooivlei-Gromis 132kV double-circuit power line. This forms part of the Namas Wind Farm grid connection solution, lies ~800m to the east of the Strandveld substation, and is only viable should the Namas Wind Farm be developed.

The construction and operation of the proposed grid connection for the Zonnequa Wind Farm may pose threats to the priority avifauna in the area, therefore the avifauna were monitored over 12 months to determine the possible impacts. Kleinsee lies in the Succulent Karoo Biome of the Northern Cape and this report details the number of priority species (including all threatened and collision-prone birds) and their Passage Rates through the proposed 44.2-km^2 wind farm area and the 300m power line corridor in spring, summer, autumn and winter seasons of 2017-2018. This assessment quantifies and predicts

[1] The Strandveld-Gromis 132kV double-circuit power line will be located parallel to the Eskom Gromis Juno 400kV power line.

possible threats from the development of grid connection infrastructure within the 300m power line corridor, and maps high- and medium-risk areas along its length to reduce future impacts.

The possible impacts for any power line include:

- Mortality arising from priority bird species impacting the lines directly;
- Electrocution on the infrastructure;
- Loss of habitat for such species due to direct habitat destruction under the lines; and
- Disturbance during construction.

The impact zone of the proposed power lines and substation lie within the coastal area of the Succulent Karoo biome. Dry and uniform grazed habitats within this undulating area allows a small suite of arid-adapted and nomadic bird species to exist. Up-to-date (SABAP2) bird atlas data of the broader region indicates that the area proposed for the development of the grid infrastructure supports a low diversity of 48 bird species. Our own records, focussed on the proposed Zonnequa Wind Farm and the 300m grid infrastructure corridor and a Control site in a particularly dry period, found only 45 species in 12 months of monitoring. Allowance for this was made based on our experience of bird diversity and abundance in arid areas to give a more realistic assessment of avian diversity at other times. More birds (31.3 per kilometre) and a higher species richness (26) were present in spring (August), than in any other month. This included 9 highly collision-prone species of which 3 were red-listed: Ludwig's Bustard *Neotis ludwigii* (ranked 10th in the top 100), Secretarybird *Sagittarius serpentarius* (ranked 12th) and Kori Bustard *Ardeotis kori* (ranked 37th).

In the larger area around the proposed grid connection infrastructure (i.e. 300m corridor) and wind farm covered by bird atlas cards, 9 collision-prone species were recorded, and the power line may, therefore, impact some birds negatively. Power lines that kill, on average, 1.05 birds per kilometre of line per year in South Africa, particularly bustards (Shaw 2015) could, thus, impact the raptors and bustards that frequent the area. Fortunately, both the annual passage rate of the collision-prone species on the WEF and within the 300m corridor (0.36 birds per hour), and the Red Data birds alone (0.09 birds per hour) was so low, that the probability of impacts or avoidance are also likely to be low in dry conditions. One area of high-risk is likely within the 300m corridor proposed for the development of the grid infrastructure where it crosses the Buffels River. This section of the double-circuit 132kV power line will require bird diverters along its entire span, and the proposed line must be constructed as closely as possible to the existing line where it spans the river. Further impacts expected to occur with the development of the proposed double-circuit 132kV power line and collector substation for the Zonnequa Wind Farm, should be mitigated through:

- mitigation in high- and medium-risk avian areas;
- aligning the two lines (132 kV and 400 kV) and **staggering the pylons** of the two adjacent lines (i.e. the proposed Strandveld-Gromis 132kV double-circuit power line and the 400kV Eskom power line to be constructed in the near future) to reduce bustard fatalities (Simmons, Pallett and Brown in prep);
- all on-site electrical connections should be buried underground;
- all new overhead pylons must be made bird-friendly to reduce electrocutions; and
- construction and post-construction monitoring must take place to ensure that any line-related fatalities are documented and addressed immediately (the monitoring can be undertaken simultaneously with the monitoring required for the Zonnequa Wind Farm).

The cumulative impacts of other power line connections within 30-km of the Zonnequa Wind Farm were assessed, based on the length and voltage of about 158km of power lines. Based on estimated rates of about 1.05 bustards/km/year for transmission lines and 0.37 bustards/km/ year for distribution-66 kV-lines (Shaw 2015), we estimate about 100 bustards are likely to be killed on the lines annually.

Because the 300m corridor of the grid connection falls within a low impact site with few areas of high avian sensitivity, we recommend that, with the mitigations above considered, the preferred routing be allowed to proceed with a construction and systematic post-construction monitoring programme in place. This should be undertaken by competent ornithologists familiar with the area's threatened species to monitor fatalities or problems in the construction and post-construction phases. Solutions and mitigations can then be suggested and implemented if challenges arise.

1.1 Consultant's Declaration of Independence

Birds & Bats Unlimited are independent consultants to Genesis Zonnequa Wind (Pty) Limited. They have no business interest - financial, personal or other - in the activity, application or appeal other than fair remuneration for work performed in connection with the activity, application or appeal. There are no circumstances that compromise the objectivity of the specialists performing such work.

1.2 Qualifications of Specialist Consultant

Birds & Bats Unlimited (www.birds-and-bats-unlimited.com/) were approached to undertake the specialist avifaunal assessment for the pre-construction phase of the proposed grid connection of the Zonnequa Wind Farm near Kleinsee. Dr Rob Simmons is an ornithologist, with 35 years' experience in avian research and impact assessment work. He has published over 100 peer-reviewed papers and 2 books, (see www.fitzpatrick.uct.ac.za/fitz/staff/research/simmons for details). More than 60 projects and assessments over 23 habitats have been undertaken throughout Namibia, (where he was the State Ornithologist for 14 years), Angola, Lesotho and South Africa. He also undertakes long-term research on threatened species (raptors, vultures, flamingos and terns) and the impacts of predatory domestic cats on biodiversity around Cape Town, at the FitzPatrick Institute, UCT where he has been an Honorary Research Associate for 17 years.

Marlei Martins, co-director of Birds & Bats Unlimited, has over 7 years' consultancy experience in avian power line and wind farm impacts in South Africa, Lesotho and Tristan da Cunha, as well as 20 years in environmental issues and rehabilitation. She has been employed by several consultancy companies throughout South Africa, because of her expertise in this field. She has published papers on her observations, including a new species of raptor to South Africa (http://www.birds-and-bats-unlimited.com/).

2 TERMS OF REFERENCE

The terms of reference for the final Pre-construction Avian Assessment Report for the grid infrastructure for the Zonnequa Wind Farm, based on the EIA regulations, are as follows:

- To provide a list of the occurrence and passage rates of priority species, particularly the priority Red Data and collision-prone species [CPS], along the 300m corridor from the Zonnequa Wind Farm to the Gromis substation (~22 km);
- To provide details of any medium- and high-risk avian areas along the proposed corridor, based on the occurrence of priority species found throughout the year;
- To provide a semi-quantitative assessment of impacts, before and after the proposed mitigations;

- To provide recommendations for mitigating the possible impacts identified;
- To provide an assessment of the Cumulative Impacts for other grid connections for proposed and approved renewable energy facilities with a current Environmental Authorisation within 30-km to determine possible wide-scale mortalities or displacement; and
- To provide an Environmental Management Plan to implement during construction and post-construction monitoring and to ensure that the recommended mitigations are implemented to reduce potential impacts to the priority avifauna of the area.

2.1 Need for Proposed Avian Assessment

Birds are known to be impacted directly and indirectly by power lines and their support structures, and the Department of Environmental Affairs (DEA) mandates that all proposed lines require an avian impact assessment to determine the abundance and diversity of collision-prone species, particularly threatened Red Data species. Such species may be at risk, and the impacts and should be mitigated and alternatives provided (where applicable) during the construction and operation phases. The recommendations are guided by the Birds and Renewable Energy Specialist Group (BARESG). This advisory group produced monitoring guidelines for birds and power lines (Jenkins et al. 2014). This study arises from this need for an impact assessment of the grid connection.

3 BACKGROUND

Genesis Zonnequa Wind (Pty) Limited has proposed a Wind Energy Facility (WEF) in the Renewable Energy Zone (REDZ 8) near Kleinsee, South Africa in the arid Namaqualand Strandveld. The wind farm will be sited on slightly raised ground on portion 1 of the farm Zonnekwa 328 and the remaining extent of the farm Zonnekwa 326, 22.5-km south-east of Kleinsee. To export the energy produced two grid connection solutions are being considered and will include the development of a double-circuit 132kV power line (known as the Strandveld-Gromis 132kV double-circuit power line) and collector substation (known as the Strandveld Substation) to connect the proposed WEF to the national grid. Other associated infrastructure will also be required for the grid connection solution, including access tracks/roads, administrative buildings and laydown areas.

A corridor 300m wide and 22km long is being assessed to allow for the optimisation of the grid and associated infrastructure and to accommodate environmental sensitivities. The pylons will be up to 32m high and the servitude will be 31m[2]. Two grid connection options are being considered within the 300m corridor (Figure 1):

- A direct connection from the Strandveld Substation to the existing Gromis Substation located ~18 km from the northern boundary of the Zonnequa Wind Farm project site. This is the preferred option from a technical perspective because the Gromis Substation already exists (Fig 1);
- A loop-in loop-out connection from the Strandveld Substation to the proposed Rooivlei-Gromis 132kV double-circuit power line. This forms part of the Namas Wind Farm grid connection solution, lies ~800m to the east of the Strandveld substation, and is only viable if the Namas Wind Farm is developed;

Pre-construction avian monitoring was undertaken for the Zonnequa Wind Farm and the 300m corridor in line with the international best-practice guidelines of the Birds and Renewable Energy Specialist Group (BARESG) (Jenkins et al. 2014). Passage rates (number of priority collision-prone birds [CPB] per hour) through the proposed wind farm (including the 300m corridor) are given as an indication of the risk to priority birds from impacting the power lines.

4 STUDY METHODOLOGY

The avian monitoring reported here covered 12-months and all seasons. Priority species, defined as the top 100 collision-prone species (CPS) and red-listed species that pass through the 44.2-km^2 area and along the 22 km power line (i.e. to be located within the 300m corridor), were documented in winter (May 2017), spring (August 2017), summer (November 2017) and autumn (February 2018), to help quantify, predict and reduce future impacts. This covers all the bird-active months for migrants and residents. We report on (i) the presence and passage rates of all larger CPS passing through the wind farm site and 300m corridor (and the Control area) from Vantage Point (VP) surveys; and (ii) breeding species throughout the area. We use the presence of birds in the WEF area and the 300m corridor and in bird atlas data from the area to the existing Gromis substation to determine the birds at risk along the corridor. We conclude by identifying the impacts and the high- and medium-risk sensitivity areas within the corridor, based on the presence and number of priority species using the area. The possible Cumulative impacts were also assessed and provided, as required by the DEA.

[2] The Strandveld-Gromis 132kV double-circuit power line will be located parallel to the Eskom Gromis Juno 400kV power line.

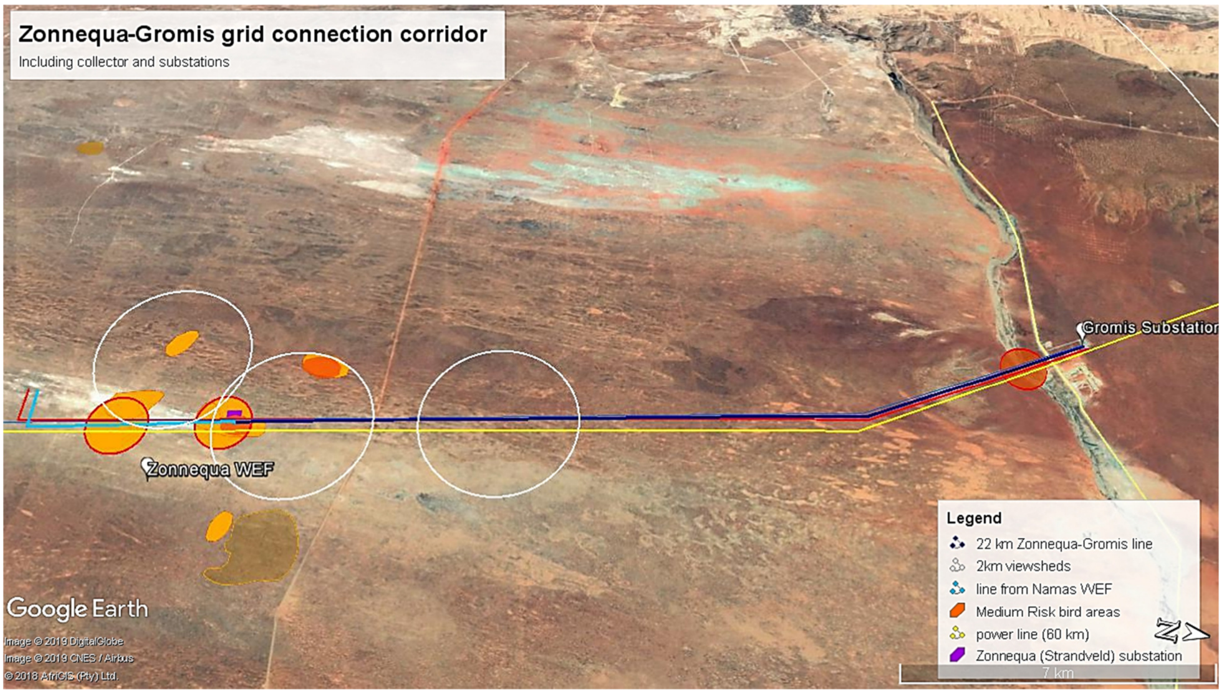

Figure 1: The 22 km long grid connection corridor (dark blue line) from the Strandveld Substation on the proposed Zonnequa Wind Farm and its route north to the existing Gromis substation. Bird surveys were undertaken within the white circles (2 km radius) viewsheds, along ~12 km of the 22 km x 300m corridor, north of the Zonnequa Wind Farm project site. North is to the right.

Vantage Point (VP) monitoring is the most important aspect of such site surveys (BARESG 2015). They comprised 6-hours observations for each VP on two separate days, for a total of 12-hours to record passage rates of the larger CPB (i.e. large raptors and bustards) from equally-spaced vantage points throughout the WEF and Control areas (one control area traversed the 300m corridor just north of the Zonnequa Wind Farm project site). These were undertaken from hills and other raised points, and allowed uninterrupted views of about 2-km. At 2-km it becomes more difficult to identify each species and their positions, but the presence and identity of larger birds is still possible over these distances with 8.5x or 10x Swarovski binoculars. The VPs were sited to cover the entire study area (including sections of the corridor) equally. For areas where the viewshed was obstructed, we undertook additional observations from a second VP in those obstructed areas. For identified birds, their flight height and behaviour was estimated every 15-seconds and recorded directly onto laminated Google Earth maps in the field, and then transferred to a digital Google Earth image of the area. These are combined and presented here for May 2017 to February 2018 (Figures 5-6). Flight height is a difficult parameter to measure but we used the presence of the 99-m wind mast on the adjacent property and our previous expertise with estimating height in a drone experiment in similar terrain in which our average error was about 10 m (Figure 2).

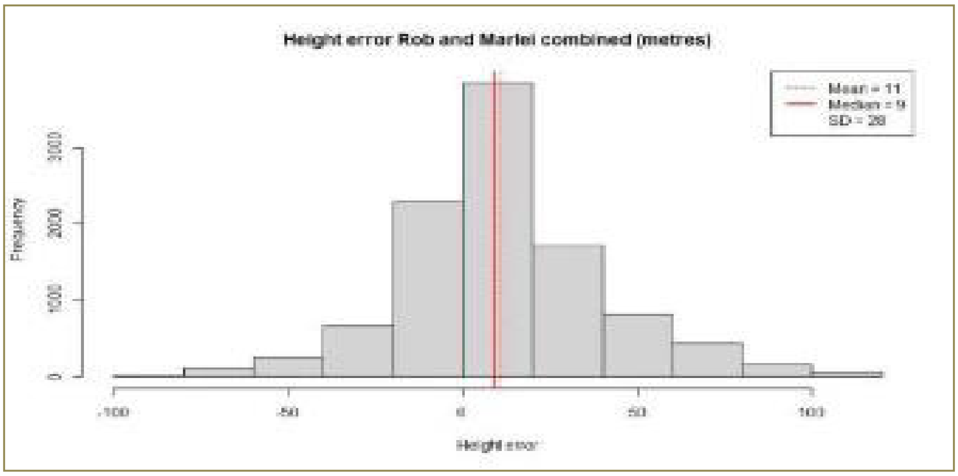

Figure 2: The error in estimating height of a GPS-fitted drone under field conditions by M Martins and R Simmons, based on over 3000 observations at a west-coast site. The median error was under 10m. Unpubl data of F Cervantes-Peralta.

4.1 Data Sources Used

The following data sources and reports were consulted in the compilation of this report:

- Data on the biology (Hockey et al 2005), distribution (Harrison et al. 1997) and conservation status (Taylor et al. 2015) of South African birds was consulted. Up-to-date data were extracted from the Southern African Bird Atlas Projects (SABAP) which were obtained from the Animal Demography Unit website (http://sabap2.adu.org.za/index.php) for the relevant "pentads" of 5' x 5' (from SABAP 2: Appendix 1). From these data, we compiled a list of the avifauna likely to occur within the impact zone of the proposed grid connection infrastructure. These data were augmented and constantly updated from our four visits over the period May 2017 to February 2018;
- The ranking of collision-prone species (CPS) was drawn from the updated BARESG tabulation of 2014. We considered only the Top 100 collision-prone species as priority species. We consider this as a fair proxy for the birds likely to fly into the area of the 300m corridor of the double-circuit 132kV power line. This was sourced from the Birdlife South Africa website at www.birdlife.org.za/conservation/terrestrial-bird-conservation/birds-and-renewable-energy. Among these CPS are Red Data species that require special attention;
- Red Data species conservation status, and the Red Data classification in South Africa, was sourced from Taylor et al. (2015);

- Important Bird Area (IBA) data were collated from Barnes (1998) and the updated layers provided by D Marnewick (Birdlife SA) and available at http://www.birdlife.org.za/conservation/important-bird-areas/documents-and-downloads

4.2 Limitations and Assumptions

Inaccuracies in the above sources of information can limit this study. The SABAP1 national data set is now over 20-years old (Harrison et al. 1997) and it is likely that bird distributions have since altered under the effects of climate change in South Africa (Simmons et al. 2004). Therefore, we have used only the more recent SABAP2 data set. This has a higher spatial resolution and is up to date (2007 to 2018). There were 18 full-protocol cards in the pentads that cover the 300m corridor and together they help to give a picture of the overall species richness that single site visits would not achieve.

We used the birds occurring in the WEF incorporating about 12 km of the proposed line as a proxy for the birds likely to occur along the entire 22 km-long 300m corridor within which the double-circuit 132kV power line and collector substation will be located. To increase the accuracy of the avian survey we chose a Control site north of the Zonnequa WEF that the 300m power line corridor will bisect (Figure 1).

Any site visits to record birds, even over a 12-month period, may not provide a complete picture of all species likely to occur in an arid region. Rainfall is the chief limiting factor as it dictates if birds occur, species diversity and when, and if they breed (Lloyd 1999, Dean 2004, Seymour et al. 2015). Rainfall was scarce throughout most visits to the site, and this may reduce the overall numbers and diversity of birds occurring. We used our experience from years of surveying bird communities in arid areas (Seymour et al. 2015) to extrapolate more normal diversity conditions and thus impacts at times of typical rainfall.

5 BRIEF REVIEW OF AVIAN-POWER LINE IMPACTS

Birds are known to be impacted directly and indirectly by power lines. But which birds are susceptible and why?

5.1 Collision prone birds

Collision prone birds (CPBs) generally include:

- large species, or those with high wing-loading (i.e. the ratio of body weight to wing surface area), and with low manoeuvrability (cranes, bustards, vultures, gamebirds, waterfowl, falcons);
- species which fly at high speed (gamebirds, pigeons and sandgrouse, swifts, falcons);
- species which are distracted in flight – predators, or species with aerial displays (many raptors, aerial insectivores, some open country passerines);
- species which habitually fly in low light conditions (flamingos);
- species with narrow field, or no, binocular vision (cranes and bustards) (Drewitt & Langston 2006, 2008, Jenkins et al. 2010, Martin & Shaw 2010).

To these we can add those species that more frequently fly at power line heights and are more likely to impact power lines.

Recent studies by Martin and Shaw (2010) indicate that, particularly, collision-prone species such as bustards and cranes do not see ahead of them due to skull morphology and have a blind region that prevents them from seeing directly ahead. This is one reason why they hit overhead lines so regularly (Shaw et al. 2015).

These traits confer high levels of susceptibility, which may be compounded by high levels of exposure to man-made obstacles such as overhead power lines and wind turbine areas (Jenkins et al. 2010). Exposure is greatest in (i) highly aerial species; (ii) species that make regular and/or long-distance movements (migrants or any species with widely-separated resources – food, water, roost and nest sites); and (iii) species that fly in flocks (increasing the chances of incurring multiple fatalities in single collision incidents). Fast-flying species may be particularly prone to colliding with power lines where this infrastructure is placed along migration routes or corridors to roosts or feeding stations for vultures. Storks, cranes, and most raptors are particularly susceptible (Erickson et al. 2001, Kerlinger & Dowdell 2003, Drewitt & Langston 2006, 2008, Jenkins et al. 2010, Katzner et al. 2012).

5.2 Habitat destruction during construction and maintenance of power lines

Some habitat destruction and alteration inevitably takes place during the construction of power lines, substations and associated roadways. These activities have an impact on birds breeding, foraging and roosting in or close to the servitude, and retention of cleared servitudes can have the effect of altering bird community structure along the length of any given power line (e.g. King & Byers 2002).

MITIGATING COLLISION AND ELECTROCUTION WITH POWER LINES

Power lines and wind turbines pose equal collision risks to birds, affecting the same suite of collision prone species (Bevanger 1994, 1995, 1998, Janss 2000b, Anderson 2001, van Rooyen 2004a, Drewitt & Langston 2008, Jenkins et al. 2010, Shaw et al. 2015).

Mitigation of this risk involves

- the careful selection of low impact alignments for new power lines relative to bird movements and avoiding concentrations (roosts) of high-risk species. This applies to turbine placements too.
- The use of static or dynamic marking devices can make the lines more conspicuous (particularly earth-wires). Various marking devices (spirals, bird flappers) have been used globally, and those tested have reduced collisions between 40% and 60% relative to un-mitigated controls (Jenkins et al. 2010).
- No known mitigation, however, has reduced bustard mortalities (C Hoogstad, EWT pers comm), thus a Namibian solution suggests **staggering the pylons** of adjacent lines. Bustards more often hit the mid-span (89%) than they do the supporting pylon towers (11%) so by aligning the pylons of one line with the mid-span of the adjacent line, bustard deaths could be reduced > 50% (Simmons, Pallett and Brown in prep.).

Avian electrocutions occur when a bird perches, or attempts to perch, on an electrical structure and causes a short-circuit by physically bridging the air gap between live components, or earthed, components (Lehman et al. 2007). Electrocution risk is strongly influenced by the voltage and design of the power lines erected – increasing where air gaps are relatively small on low voltage lines. They mainly affect larger, perching species, such as vultures, eagles and storks, capable of spanning the spaces between “live” components.

This can be mitigated with the use of bird-safe structures (with critical air gaps >2-m), the physical exclusion of birds from high-risk areas of live wires, and insulation of all exposed electrical conductors.

Photo 1: Example of dangerous power line configurations that should be avoided on any low-voltage overhead lines. A Pale Chanting Goshawk (right) perch-hunts inside a live loop – if the birds' wings touch the wire while it's perched it will be electrocuted.

5.3 Benefits of wind farms and the associated infrastructure

While this review focuses on the negative impacts of wind farms, and power lines, and reducing those impacts to birds, it is important to give the positive side of such energy production. As a green, sustainable form of energy production, with no green-house gas emissions, wind farms have huge benefits over traditional fossil-fuel or nuclear energy production. At present, over 80% of South Africa's energy is derived from coal, oil or gas that increases South Africa's carbon-footprint. From an environmental point of view, wind farms create sustainable energy, do not emit green-house gases, and can be built on otherwise productive land without altering the land-use practises. Wind farms are one of the most cost-effective sources of energy and provide energy at night when other renewable energy sources are dormant (https://energy.gov/eere/wind/advantages-and-challenges-wind-energy).

The impacts to the environment, while highlighted by environmentalists, are relatively negligible when compared with other forms of energy that we take for granted in our homes. Most of South Africa's energy is produced by coal-fired power stations (69%), crude oil (15%) or natural gas (~3%). Renewables accounted for ~0.2% of all energy production in 2012 (www.zapmeta.co.za/wiki/page/Energy_in_South_Africa). This will have increased since 2012 when these statistics where compiled.

6 STUDY AREA AND HABITAT

The placement of the proposed grid infrastructure will be located within a 300 m corridor which runs from the wind farm, via a proposed collector substation north to the Gromis substation, crossing the Buffels River just before the existing substation (Figure 3). The facility will be connected to the national grid via a double-circuit 132kV power line. The land undulates from 163 m asl at the WEF to 216 m asl 10 km north of the WEF and thereafter descends slowly to 49 m asl where it crosses the river. The land is primarily deep sand with calcrete outcrops in some areas. The only naturally occurring water is in the ephemeral Buffels River after the rains. Land-use is predominantly sheep grazing.

6.1 Vegetation of the study area

The study area (i.e. 22 km x 300 m corridor) occurs at the north-west end of the Nama Karoo biome (Mucina and Rutherford 2006, p264) and is designated as Namaqualand Strandveld. It is dominated by low species-rich shrubland (Photo 2-3) of erect and creeping succulents on nutrient-poor sand and heavily grazed in places. The sheep are moved off the land in the summer when temperatures increase, and rainfall decreases.

The study area experiences winter rainfall averaging a low 112-mm per annum, with high variability. Most falls in June-July-August (winter). In our 12-month visit, little rain had fallen and by the summer and autumn visits the veld was dry and moribund. While this will reduce avian diversity indices (Seymour et al. 2015), we have used our experience at other wind farm projects in the area to account for this in more typical years. Maximum day time temperatures average about 10-20°C from winter to summer. Minimum temperatures average ~7-15°C. Minimum night-time temperatures rarely dip below zero for the winter months (Mucina & Rutherford 2006).

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Photos 2-3: Coastal shrubs, bulbs and other plants found on the Zonnequa Wind Farm project site and within the 300m corridor during our site visits

6.2 Avian microhabitats

Bird habitat in the region and along the power line corridor consist of fairly uniform vegetation types of coastal shrubs and succulent plants (Photos 2-4). The vegetation includes succulents such as *Tertragonia, Cephalophyllum* and *Didelta* and non-succulents such as *Eriocephalus, Pteronia* and *Salvia*. There are a few alien trees on site (Eucalyptus), found around the farmsteads, and some artificial farm dams and water points for sheep. Water in the Buffels River occurs seasonally and only after good rains. Thus, for the majority of the year it is dry. Few grasses are found, making the lark species diversity rather slim within the site. Power poles along the existing road provides some perch sites for raptors but no nesting sites.

Photos 5-6: Raptors and bustards were the main species seen on the WEF site (and along the 300m corridor1), including this Least Concern Booted Eagle *Aquila pennatus* (left). Highly collision-prone Red Data bustards (right) were apparent in the control area that is bisected by the 300m corridor.

7 RESULTS

7.1 Species diversity

Over the course of 12-months only 45 avian species were recorded in the WEF site (including the 300m corridor) in four equally-spaced site visits over the year (Simmons & Martins 2018). This is a very low total compared with other arid areas in the Northern and Western Capes that we have sampled. Species richness varied over the seasons with higher totals recorded in Spring (26 species) and the lowest in summer (12 species: Table 1). All were typical residents of the arid Karoo landscape including chats, prinias, cisticolas, titbabblers, warblers, flycatchers, Karoo Larks and Tits.

The average number of species per kilometre was higher in the WEF (7.5 species per km) than in the Control site bisected by the 300m corridor (4.5 species per km) (Table 1). Similarly, the average number of individual birds per kilometre found in the WEF (21.3 birds per km) was higher than in the Control site and corridor (10.0 birds per km). Bird abundance indices were higher in the spring (August) than any other month (Table 1). Bird species richness on site stayed relatively constant throughout the year but reduced as the drought intensified in autumn (February).

Table 1: Summary of bird species richness and number of birds/km recorded in 1 km transects in the proposed WEF and Control areas (bisected by power line corridor), from May 2017 through Feb 2018. Overall means are given in bold.

1-km Transects in WEF Site	**SPECIES per km**					**BIRDS per km**				
(region of the WEF)	**May**	**Aug**	**Nov**	**Feb**	**MEAN**	**May**	**Aug**	**Nov**	**Feb**	**MEAN**
Transect ZT1 (centrally placed at VP1)	6	9	8	8	7.8	19	22	22	30	23.3
Transect ZT2 (centrally placed at VP2)	6	9	10	6	7.8	12	39	28	12	22.8
Transect ZT3 (centrally placed at VP3)	5	11	9	3	7.0	17	33	17	5	18.0
Means	5.7	9.7	9.0	5.7	**7.5 Species/km**	16.0	31.3	22.3	15.7	**21.3 Birds/km**
Seasonal occurrence of all species:	25.0	26.0	22.0	12.0						
Overall totals	45 Species in WEF/Control									

1-km Transects in Control Site	**SPECIES per km**					**BIRDS per km**				
	May	**Aug**	**Nov**	**Feb**	**MEAN**	**May**	**Aug**	**Nov**	**Feb**	**MEAN**
Transect ZT1 (centrally placed at VP1)	4.0	10.0	2.0	2.0	4.5	4.0	25.0	3.0	8.0	10.0
Means	4.0	10.0	2.0	2.0	**4.5 Species/km**	4.0	25.0	3.0	8.0	**10.0 Birds/km**
Seasonal occurrence of all species:	**25.0**	**26.0**	**22.0**	**12.0**						
Overall totals	45 Species in WEF/ Control									

7.2 Collision-prone and red-listed species

Among the 50-species recorded on the 19 SABAP bird atlas cards for the power line corridor (Appendix 1) were 8 priority collision-prone species (CPS). We recorded nine collision-prone species from our Vantage Point surveys (Kori Bustards *Neotis ludwigii* were missed by the SABAP data set) over the course of the year (Table 2). These included three Red Data species (Ludwig's and Kori Bustards and Secretarybird), all of which head the list of collision victims in South Africa (Jenkins et al. 2010). The Ludwig's Bustards were recorded in August and November, as was the Kori Bustard. The Secretarybirds were only recorded in August 2017 when a pair were observed in flight together over the Zonnequa Wind Farm. A red-listed Lanner Falcon was also seen as an incidental in May 2017, but not seen again.

Secretarybirds made use of many areas within the proposed WEF. The proposed grid infrastructure for the WEF will require careful siting given that the flights recorded were located over the power line corridor (Figure 4).

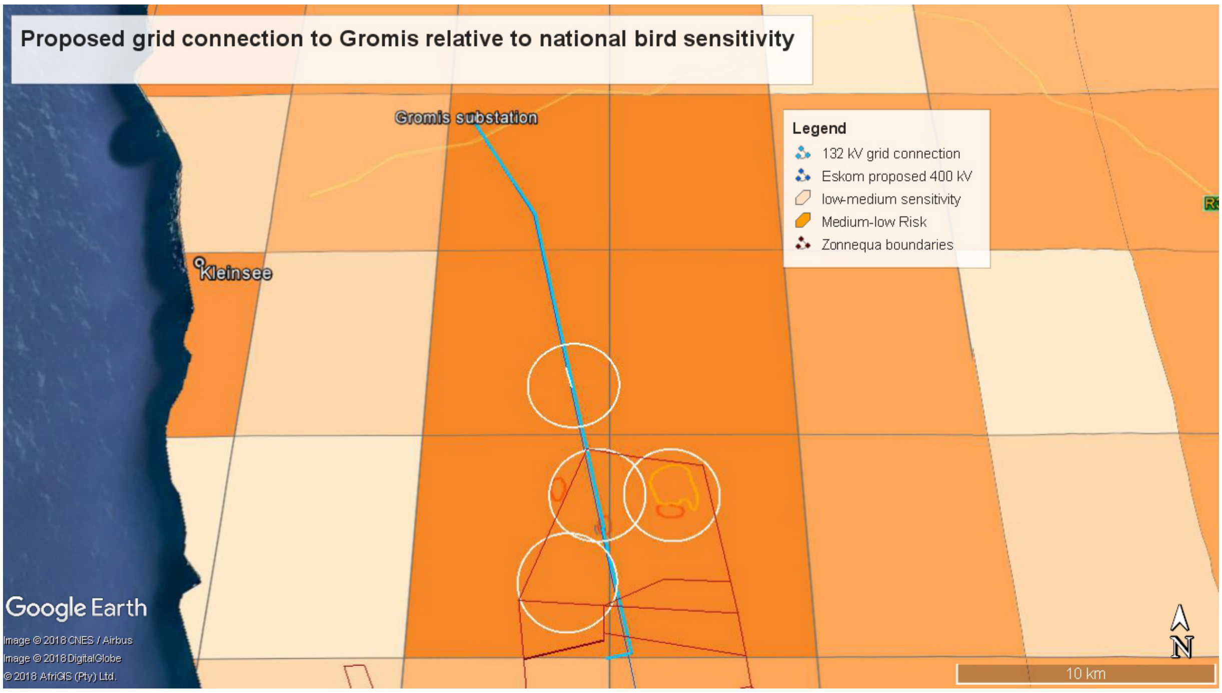

Figure 3: The Zonnequa WEF and grid infrastructure 300m corridor (light blue line) in relation to the national bird sensitivity map of Birdlife South Africa. Light squares depict low-bird sensitivity (score ~50-100) and darker squares higher bird sensitivity (scores 800-1000). The proposed grid infrastructure and WEF all lie in an area of medium bird sensitivity (scored 601). For details see:http://www.birdlife.org.za/conservation/terrestrial-bird-conservation/birds-and-renewable-energy/wind-farm-map

Table 2. Red-listed bird species (in red) and collision-prone species recorded on 18 cards by SABAP2 in the 8 pentads that cover the power line corridor (Appendix 2). Shaded species were recorded over the corridor and WEF site during our 4 site visits (16 field-days) May 2017 to February 2018. SABAP2 Reporting Rate is given in brackets. Black Harriers and Kori Bustard were only recorded by us.

Common Name	Scientific Name	Red-list status	Reporting Rate *	Collision (Rank **)	Susceptibility to: Disturbance
Black Harrier	*Circus maurus*	Endangered	None[a]	6	High
Ludwig's Bustard	*Neotis ludwigii*	Endangered	3/16 = 19% (28%)	10	Medium
Secretarybird	*Sagittarius serpentarius*	Vulnerable	2/16 = 13% (11%)	12	High
Lanner Falcon	*Falco biarmicus*	Vulnerable	1/16 = 6% (6%)	22	Medium
Kori Bustard	*Ardeotis kori*	Near Threatened	2/16 = 13% (0%)	37	High
Southern Black Korhaan	*Afrotis afra*	-	1/16 = 6% (17%)	35	Low
Booted Eagle	*Aquila pennatus*	-	3/16=19% (22%)	55	Medium
Black-chested Snake Eagl	*Circaetus cinerescens*	-	2/16 = 13% (22%)	56	Medium
Pale Chanting Goshawk	*Melierax canorus*	-	8/16 = 50% (50%)	73	Low
Greater Kestrel	*Falco rupicolloides*		3/16 = 19% (33%)	97	low

* Reporting rate is a measure of the likelihood of occurrence and is based on the number of times seen in 20 days field work over 4 seasons. We compare this with the number of times it was recorded/in 18 atlas cards (on SABAP2 cards).

** Collision rank derived from the BARESG 2014 guidelines. Smaller numbers denote higher collision-risk.

a. Black Harriers were not recorded on the atlas cards but are known to breed in the Buffels River (R.E. Simmons Unpubl data).

7.2.1 Passage Rates of collision-prone species (CPSs)

Records from four Vantage Points (VPs) of the airspace above the proposed grid infrastructure (Figure 1), indicated that 9 collision-prone species (Table 1) traversed the corridor in 144-hours of observations. 66 individual flights of these species in 192-hours over one year, gave a low Passage Rate of 0.34 birds/ hour (Table 3).

Summary of Passage Rates for all seasons and all collision-prone birds over the 300m corridor of the grid infrastructure for the Zonnequa Wind Farm							
Passage rate:						Season	Collision-prone species
WEF+Control	48.0	hr	3 birds	0.06	birds / hr	February 2018	Black-chested Snake Eagle, S Black Korhaan
WEF+Control	48.0	hr	32 birds	0.67	birds / hr	November 2017	Pale Chanting Goshawk, Greater Kestrel, Jackal Buzzard, Booted Eagle, Ludwig's Bustard, Kori Bustard

WEF+Control 48.0 hr 29 birds 0.60 birds / hr	August 2017	Pale Chanting Goshawk, Greater Kestrel, Jackal Buzzard, Booted Eagle, Snake Eagle, Ludwig's Bustard, Kori Bustard, Secretarybird
WEF+Control 48.0 hr 2 birds 0.04 birds / hr	May 2017	Pale chanting Goshawk,
Summary: 192 h 66 birds 0.34 birds / hr	**4 seasons**	**9 species of Collision-prone birds**

Table 3. Passage Rates of all (9) collision-prone species recorded in the WEF site and the Control site (bisected by the 300m corridor) over all seasons in 2017-2018. Red Data species (3) are included and their combined passage rate was very low at 0.34 birds/hour.

For the priority Red Data species alone (comprising the Secretarybird and Kori and Ludwig's Bustards) the Passage Rates were very low, averaging just 0.07 birds per hour over the 300m corridor. Thus, while three Red Data species were present on site, their Passage Rates (Tables 3 and 4) and their likelihood of occurrence (Table 1) were both low, making the risk of collision low. These data were collected at a time of drought (reducing the passage rates by an estimated 50%) and this has been taken into account in the scoring of impacts below.

Table 4. Passage Rates of the three Red Data collision-prone species recorded in the Zonnequa WEF site and over the 300m corridor over all seasons in 2017-2018. The Red Data species combined passage rate was very low at 0.07 birds per hour.

WEF & corridor - Month	Hours	No. of Collision-prone Red Data birds	Passage Rate (birds/h) Red Data birds	Season
May 2017	48.0	0	0.00	Spring
August 2017	48.0	1	0.02	Summer
November 2017	48.0	13	0.27	Autumn
February 2018	48.0	0	0.00	Winter
TOTALS	**192.0**	**14**	**0.07**	**All seasons**

7.2.2 Flying heights and risk

Flying heights are possibly a better estimate than Passage Rate of the risk that the collision-prone species face from proposed grid infrastructure (Whitfield & Madders 2006, Band et al. 2007). This arises because any species flying for large proportions of time at power line (pylon) heights up to 50-m are more likely to be at risk of hitting the earth wires than if it is simply passing through the site at higher altitudes (Smallwood et al. 2009). We have also included the flight band down to 1-m because Secretarybirds are known to collide with farm fences too (E Retief pers. comm). By recording flight height every 15-seconds for focal birds, we assessed the proportion of time spent at pylon height.

Of the three Red Data species recorded, all flew more often at pylon heights (50-m or less), with the Kori Bustard flying 100% of the time at this height (Table 5) and Ludwig's Bustards at 84% of the time. If Kori and Ludwig's Bustards occurred around the double-circuit 132kV power line they would probably suffer a high risk of impact. Since their passage rates were low in this time of drought (0.07 birds/h) the probability is very low. If rains occur, however, this can change rapidly as bustards are attracted in to exploit the flush of resources and mitigation measures are therefore required.

Table 5: Flying heights of all collision-prone species observed over the proposed grid infrastructure recorded every fifteen seconds. Data were collected throughout the year – May, August, November 2017 and February 2018 from focal birds over the southern section of the WEF and 300 m corridor. The height of 32 m was taken as the tallest pylons likely to occur.

Species	Flight heights	Number of observations	Proportion of observations at highest tower height
Ludwig's Bustard	**1-32 m (danger zone)**	**32**	**84%**
N= 38	32+ m	6	16%
Kori Bustard	**1 -32 m (danger zone)**	**14**	**100%**
N = 14	32+ m	0	0%
Secretarybird	**1 -32 m (danger zone)**	**37**	**58%**
N = 64	32+ m	27	42%
Booted Eagle	**1 -32 m (danger zone)**	**106**	**29%**
N = 368	32+ m	262	71%
Jackal Buzzard	**1 -32 m (danger zone)**	**3**	**15%**
N = 20	32+ m	17	85%
Pale chanting Goshawk	**1 -32 m (danger zone)**	**40**	**77%**
N = 52	32+ m	12	23%
Greater Kestrel	**1 -32m (danger zone)**	**42**	**89%**
N = 47	32+ m	5	11%
Black-chested Snake Eagle	**1 -32 m (Danger zone)**	**31**	**41%**
N = 76	32+ m	45	59%
Southern Black Korhaan	**1 -32 m (danger area)**	**7**	**100%**
N = 7	32+ m	0	0%

Six other collision-prone species (CPS) were recorded and, of these, three flew more often above the maximum pylon height than below it (Jackal Buzzard: 85%, Booted Eagle: 71% and Black-chested Snake Eagle: 59%). Three others flew more often within the heights of the pylons (Table 5).

In summary, the Red Data Ludwig's and Kori Bustards and Secretarybirds all flew often within the power line heights, but exhibited low Passage Rates, and are therefore at low risk of colliding with the lines when populations are low. However, this may change when rains bring them into an area.

All flight tracks of all collision-prone species in the proposed Zonnequa WEF project site and over the 300m corridor are shown in Figures 5-6. Areas where two or more of the Red Data species overlap are designated as medium- or high-risk areas where grid connection corridor mitigations need to be strictly enforced. Locations of nests of Red Data species are also to be avoided.

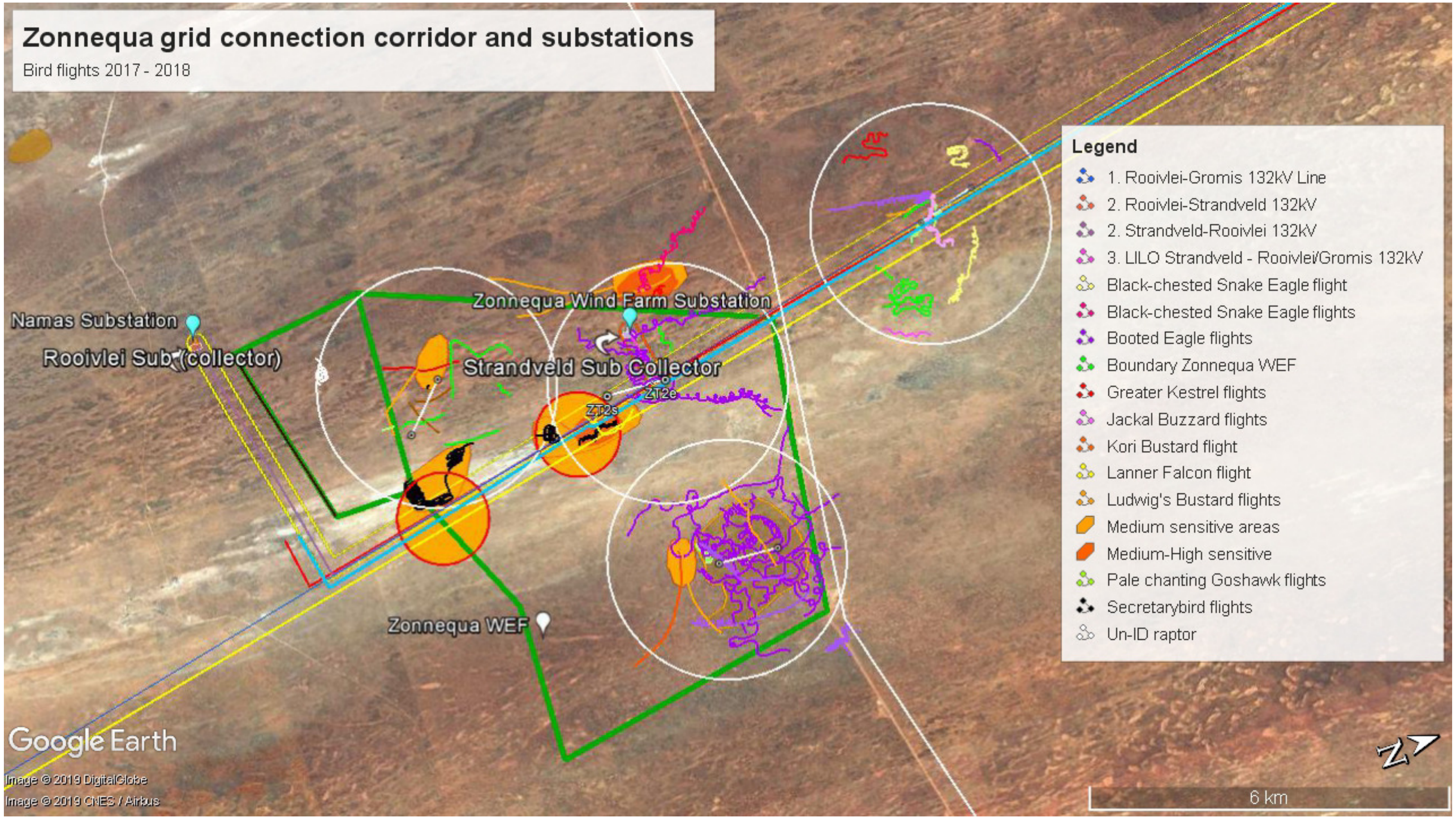

Figure 5: All flights of collision-prone birds over ~10 km of the proposed grid infrastructure for the Zonnequa Wind Farm (= light green line) from May 2017 to February 2018. Our 2-km viewsheds (=white circles) are shown. Three Red Data species - Secretarybird (=black line), and Ludwig's and Kori Bustards (= orange lines) were found over or near the 300m corridor. Non-threatened CPS included several Pale Chanting Goshawks (=PCG, green lines), Greater Kestrels (=red lines), Southern Black Korhaan (=brown lines), Black-chested Snake Eagle (=magenta line) and Booted Eagle (=mauve line) were recorded in flight over the corridor or WEF site. A Lanner Falcon (=yellow line) was recorded as an incidental but did not occur in timed VP observations. Medium-risk zones (=orange circles) indicate where Red Data Secretarybirds were recorded.

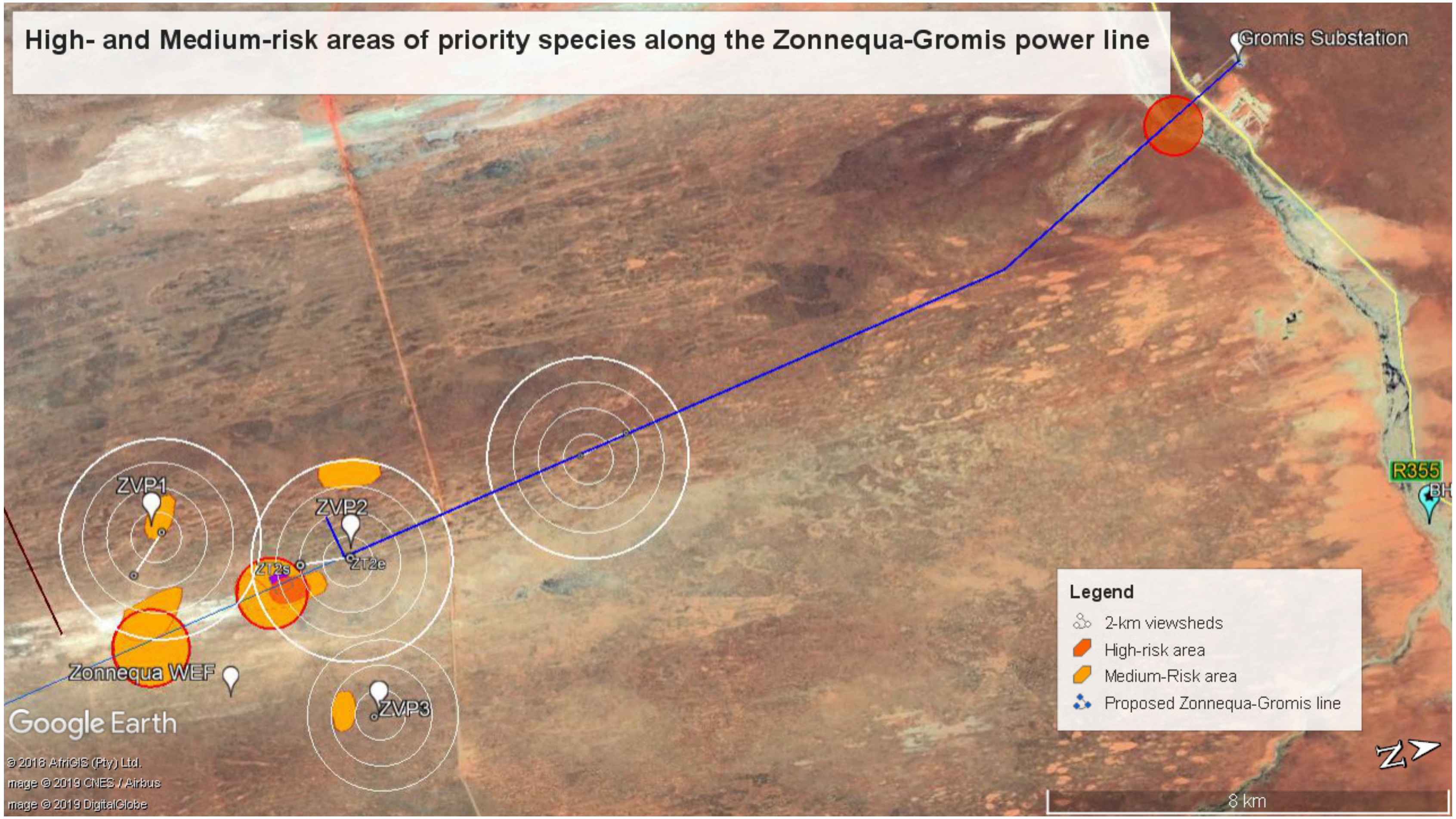

Figure 6: High- and Medium-risk areas identified along the 300m corridor based on flight data from May 2017 to February 2018. Three areas are identified – based on the presence of Red Data species in the area. The high-risk areas (red-filled circle) indicate where raptors such as Black Harriers may occur and additional work indicates Lanner Falcons and other raptors, while the two medium-risk areas (orange-filled circles) indicate presence of Secretarybirds. Black Harriers breed in the river as shown = BHBUFL306. Wetland birds are also likely to commute along the river and strike any lines crossing it.

The **High-risk** areas identified on Figure 6 encompassed the following areas (red-filled circles):

a. Black Harriers occur and breed along the Buffels River and birds probably forage along the river margins. A harrier nest occurs at S29°34'21.44" E17°17'39.63", 11 km east of the proposed crossing corridor. Wetland birds typically fly along river-lines and, thus, may impact lines strung across them. Subsequent work (April 2019) indicated Red Data Lanner Flacons and collision-prone Harrier-Hawks in this area too. Thus, the crossing here is deemed a high-risk area and must be mitigated.

Two **Medium-risk** areas were identified within the wind farm and along the 300m-wide corridor:

b. Secretarybirds were observed circling and a red-data Lanner Falcon was also recorded over the previous site of the substation (note that this substation has now been moved to a low sensitivity site, so the recommendations have been followed); and
c. Further south along the corridor a pair of Secretarybirds were also observed in courtship flight. Note that this does not pose a problem given that the proposed 132kV line will parallel a proposed 400 kV line, and they will thus increase the visibility of both lines.

7.3 Level of risk and recommended mitigation

All of these risk areas are designed to highlight areas where disturbance to priority species must be minimised during construction or operation. The level of risk signifies the level of mitigation. This varies from mitigations essential in any High Risk areas, to power lines constructed with mitigation measures installed as the line goes up within the medium-risk areas. The following mitigations in the two Medium-Risk areas are recommended:

a. The lines within these areas must all have bird spirals or dynamic bird diverters/flappers on the earth wires to reduce the risk of Endangered Black Harriers or wetland birds impacting them. If the development of the proposed Strandveld-Gromis double-circuit 132kV power line and the approved (to still be constructed) Eskom Gromis-Juno 400 kV line also occurs here, then the two lines should be aligned and the pylons staggered as proposed by Simmons, Pallett and Brown in prep.

b. We recommend that the collector substation here is re-positioned outside the medium-risk area. The lines leading in and out of it will also have to be re-aligned outside any high-risk area.

For the High-risk area we recommend :

c. that the power lines here is aligned as close to the existing line as possible where it spans the river and the new line has diverters and spirals on the earth wire.

All are designed to reduce the possibility of direct impacts for priority species to a minimum. This applies to the construction of roads, substations or the power lines themselves.

8 QUANTIFYING THE IMPACTS

Below, we semi-quantify the impacts and evaluate the advantages of various forms of mitigation to reduce expected impacts.

Nature: The impact of the proposed grid infrastructure will generally be negative for birds given the certainty that priority birds (particularly the bustards and Secretarybirds that occur) may be killed directly if they fly into the power line.

The Extent (**E**, from 1-5) of the impact will be local along the 22-km-line = **(1)**

The Duration (**D**, from 1-5) will be long-term **(4)** for the lifetime of the power lines that are required. This is so for all collision-prone species.

The Magnitude (**M**, from 0-10) of the proposed grid infrastructure is expected to cause a medium-high impact **(8)** for the bustards and raptors.

The Probability of occurrence (**P**, from 1-5) of the raptors (Secretarybird) and bustards having some sort of interaction with the grid infrastructure is ranked as probable **(4)** because of their passage rates and occurrence along the 300m corridor. This was justified above for three Red Data species (Secretarybird and two bustards) which frequently fly between 1 and 50 m.

The Significance S, [calculated as S = (E+D+M)P], is as follows (Table 7) for the species identified at risk for the proposed grid infrastructure associated with the Zonnequa Wind Farm.

The scale varies from:

- 0 (no significance), to
- < 30 Low (this impact would not have a direct influence on the decision to develop in the area), to
- 30-60 (the impact could influence the decision to develop in the area unless it is effectively mitigated), to
- >60 (the impact must have an influence on the decision process to develop in the area).

Table 7. A quantification of impacts to the three, main, collision-prone Red Data species and other priority raptors likely to be impacted by the **proposed grid infrastructure (specifically the double-circuit 132kV power line), operational phase and construction phase.**

Double-circuit 132kV power line and collector substation to export generated power from the wind farm to the national grid.
Operational Phase

Nature: Negative impact due to direct impact mortality (or avoidance of area) around any new power line for the Red-listed bird groups identified as at risk above.

The nomadic Ludwig's and Kori Bustards (**BS**) are the most likely to be impacted by overhead power lines, while the Secretarybird and possibly other collision-prone raptors such Black Harriers (**RA**) may be impacted, however more due to the disturbance caused on the ground during the construction phase of the grid infrastructure.

	Without mitigation	**With mitigation**
Extent	**1**	**1**
Duration	**4**	**4**
Magnitude	**8**	6
Probability	**4**	**4**
Significance (E+D+M)P	**52 (Medium-high)**	**44 (Medium)**
Status (+ve or –ve)	Negative	Negative
Reversibility	Medium for raptors High for collision-prone bustards	Medium for all raptors Medium for collision-prone bustards because of their propensity for impacting even marked power lines
Irreplaceable loss of species?	No, the raptors are infrequent in this area and rarely hit power lines. Thousands of bustards are killed on power lines per year in South Africa (Shaw et al, 2015) so every effort must be made to reduce this high	Bustards need more attention to reduce fatalities, or a local loss of species could occur. Mitigations are therefore essential.

	mortality.	
Can impacts be mitigated?	Yes, by marking all future power lines constructed. Also, by staggering the position of pylon towers of adjacent or parallel power lines could reduce bustard mortality by > 50%	Yes, by marking all future lines as they are constructed, and staggering adjacent power line towers

Mitigation for power lines:

There are four classes of mitigation for birds in terms of the grid infrastructure development at the Zonnequa Wind Farm:

(i) re-position the lines to avoid medium risk areas for birds on Zonnequa;

(ii) add bird diverters or spirals (diurnal and nocturnal) to all new lines, as they are constructed;

(iii) where existing lines occur (or are planned e.g. Gromis-Juno 400 kV from the south), construct the proposed double-circuit 132kV power line adjacent to the lines and stagger the pylons to reduce bustard deaths; and

(iv) bury the lines internally within the WEF site. This would be preferable outside the site too but we understand this is potentially too expensive.

Residual impacts:

After mitigation, direct mortality may still occur through collision or area avoidance by the species identified above, and further research and mitigation for the high-risk sections of the double-circuit 132kV power line will be needed.

Double-circuit 132kV power line and collector substation to export generated power from the wind farm to the national grid, **Construction phase**

Nature: Negative impact due to avoidance of the area (due to human activity, noise, predation threat) due to construction of the new power line for the Red-listed bird groups identified as at risk above.

The nomadic Ludwig's and Kori Bustards (**BS**) and Secretarybird and possibly other collision-prone raptors such as Black Harriers (**RA**) may be disturbed due to anthropogenic disturbance caused on the ground during the construction phase of the grid infrastructure.

	Without mitigation	**With mitigation**
Extent	**1**	**1**
Duration	**4**	**4**
Magnitude	**6**	5
Probability	**4**	**3**

Significance (E+D+M)P	**44 (Medium)**	**30 (Low)**
Status (+ve or –ve)	Negative	Negative
Reversibility	Medium for the bustards and the raptors	Medium for all raptors Some raptors are attracted to sites by new perching and nesting sites so this will be reversible
Irreplaceable loss of species?	No, the raptors are infrequent in this area and are likely to be attracted back into the area post-disturbance Bustards will return once the disturbance is gone depending on the background level of disturbance	Once human disturbance is removed, as long as the habitat remains relatively un-altered then the raptors and bustards will return.
Can impacts be mitigated?	Yes,	Yes, by reducing the extent of construction disturbance in the areas of high- and medium-sensitivity identified. For bustards this occurs shortly after the winter rains (July-September) and for raptors this is also likely shortly after the winter rains.

Mitigation for disturbance during construction:

There are several classes of mitigation for birds in terms of the construction disturbance for the proposed grid connection through and from the Zonnequa Wind Farm:

(i) reduce the extent of the human disturbance to around the line itself (ie. within the 300 m corridor allocated);

(ii) avoid the areas identified as high-risk wherever possible; (If not possible then all other mitigations must be enacted)

(iii) avoid any nests that are active (some ground-nesters may be found if rainfall is high);

(iv) avoid polluting the area with plastics or human waste of any kind – all material to be disposed of in suitable sites.

Residual impacts:

After mitigation, direct mortality may still occur through collision or area avoidance by the species identified above, and further research and mitigation for the high-risk sections of the double-circuit 132kV power line will be needed.

8.1 Cumulative Impacts

Cumulative impacts are defined as "impacts that result from incremental changes caused by either past, present or reasonably foreseeable actions together with the project" (Hyder, 1999, in Masden et al. 2010).

Thus, in this context, cumulative impacts are those that will impact the general avian communities in and around the Zonnequa Wind Farm development and the associated grid infrastructure, mainly by other wind and solar farms and their associated infrastructure in the Nama Karoo. This will happen via the same factors identified here viz: collision, avoidance and displacement. As a starting point, the number of renewable energy developments (proposed and approved and developed) around the region within a 30-km radius of the site needs to be determined, and secondly, to know their impact on avifauna.

Given the general assumption that power line length and bird impacts are linearly related, a starting point in determining cumulative impacts is to determine:

- the number of birds killed by collision with the new power lines surrounding the site; and
- the length and size of the existing power lines within 30 km.

The number of lines, and their length, are shown in Figure 7.

Given that

- transmission lines (> 220 kV) kill ~ 1.05 bustards/ km/ yr (Shaw 2013), and
- distribution lines of 66 kV kill ~0.37 bustards/km/yr (Shaw 2013),

A cumulative total of 99 Red Data bustards per year are expected to be killed by these power lines per year.

Table 8: All power lines within 30 km of the Zonnequa Wind Farm and associated (adjusted) bustard fatalities from similar size power lines (Shaw 2015). Estimated fatalities for the 22 km 300m corridor is shaded.

	Power line	Voltage	Length within the 30 km radius (km)	Rate of bustard deaths from same-size power lines	Estimated number of bustard deaths/ yr
1	Koingnaas / Sandveld	66 kV	36.0 km	0.37 b/km/yr	13.3
2	Gromis / Koingnaas	66 kV	62.4 km	0.37 b /km/yr	23.1
3	Gromis/Juno	400 kV	60.0 km	1.05 b /km/yr	63.0
4	Strandveld-Gromis	132 kV	28.0 km	0.37 b/km/yr	10.4

Totals: 3 lines (66 kV and 400 kV) of 158 km	**99.4 bustards/yr***

*excluding the Strandveld-Gromis double-circuit 132kV power line.

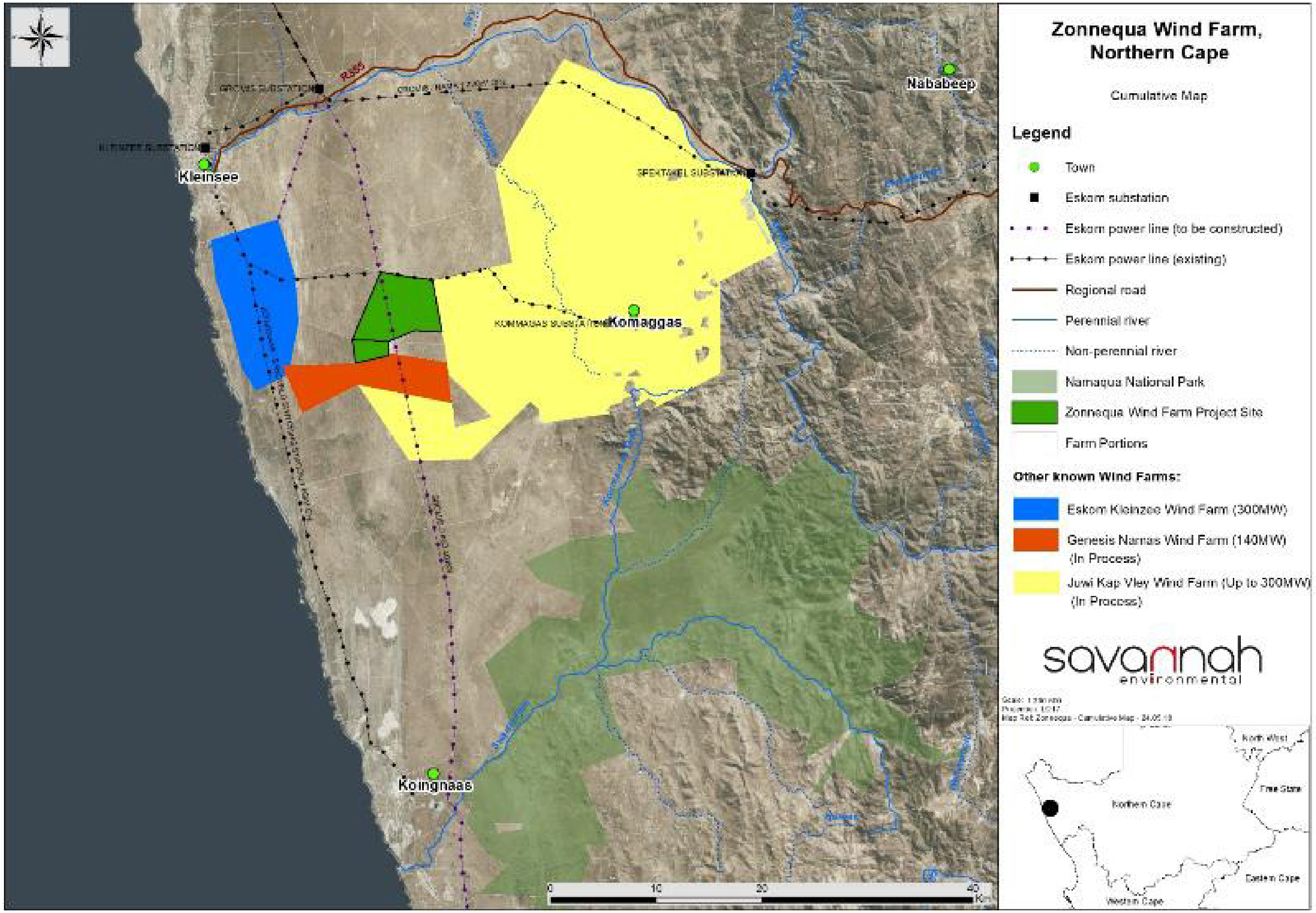

Figure 7: All power lines and proposed renewable energy (RE) developments within a 30-km radius of the Zonnequa Wind Farm. About 158 km of power line occur (= black dotted lines), and the Strandveld-Gromis double-circuit 132kV power line will add ~22 km of 132 kV line (not shown).

Table 9: Cumulative impacts of the Strandveld- Gromis double-circuit 132kV power line, relative to other power lines of facilities within 30-km of the Zonnequa Wind Farm project site.

Nature: The impact of the grid infrastructure (including a double-circuit 132kV power line and collector substation) in the coastal Nama Karoo is expected to be generally negative and arise from disturbance, and collision for birds around the power lines. The associated infrastructure will also affect species in the form of impacts with un-marked power lines. It will simultaneously provide nesting sites for some avian species (crows, kestrels and Pale Chanting Goshawks).

The direct impact of the 158 km of three main lines (Table 7) was gauged using empirical data from Shaw (2015) on bustard mortalities on South African power lines of different sizes. An estimated 99 bustards are expected to be killed annually on the lines (raptor fatalities could not be gauged).

Careful mitigation can reduce this high mortality to low levels.

	Contribution of the proposed grid infrastructure for the proposed Zonnequa Wind Farm *	**Cumulative Impact of all projects within 30 km**
Extent	Low (1)	Medium (3)
Duration	Long-term (4)	Long-term (4)
Magnitude	High (8)	High (9)
Probability	Probable (4)	Likely (4)
Significance	**Medium-High (52)**	**High (64)**
Status (positive/negative)	Negative	Negative
Reversibility	Medium	Medium
Loss of resources/species?	Likely	Likely
Can impacts be mitigated?	Probably, Yes	Yes

*with mitigation

Confidence in findings:

High: the mortality data on bustards (Shaw 2015) is based on a large data set across different lines in South Africa. When rains bring bustards to the relevant areas these rates can be 2.7-fold higher than indicated here (Simmons and Martins unpubl. data). The mitigation measures suggested to avoid major bustard fatalities (and agreed to by the developer) include aligning the proposed Strandveld-Gromis double circuit 132kV power line with the new Gromis/Juno 400 kV line and staggering the pylons. Without mitigation measures (including the avoidance of medium-risk areas) the chances of bustard mortality will increase greatly. However, given that the developer has agreed to implement the staggered pylon mitigation measures, the cumulative impact is expected to be acceptable.

Mitigation:

Reducing avian impacts at power lines can be achieved several ways. The recommended measures include:

- aligning the proposed line with the existing line where it spans the Buffels River and affixing bird diverters to earth wires in the high-risk area;
- avoiding all medium risk areas revealed in this report wherever possible, or
- marking all new overhead power lines with bird diverters, and

- staggering the pylons, along parallel lines to increase visibility to reduce the risk of large birds colliding with them.

Ideally, development should avoid these risk areas. However, to do so may increase the length of the line (and the risk) so we recommend instead that:

- Throughout the length of the proposed line, it should be aligned with the Gromis/Juno 400 kV line and the pylons staggered along its entire length. Bustards can occur throughout this area and this may reduce collisions by 50%. This has been agreed to by the client.
- In the medium-risk areas the lines should additionally be fitted with dynamic bird diverters to reduce further the risk to priority species.

By implementing these measures to mitigate possible impacts for these collision-prone Red Data species, risks and mortality can be reduced to acceptable levels. Therefore, the development of the grid connection infrastructure for the Zonnequa Wind Farm should be authorised, subject to the implementation of the recommended mitigation measures.

We define **acceptable levels** as less than one bustard (or raptor) fatality for every kilometre of power line per year. If these levels are exceeded, with the current level of mitigation implemented, then additional mitigation measures as itemised in Table 7 must be implemented.

Cumulative impacts are greater for the existing power lines within 30-km of the Zonnequa Wind Farm site, and we estimate that in high rainfall years about 100 bustard fatalities may occur annually based on average South African fatality rates. Nevertheless, where adjacent power lines can be aligned and the pylons staggered to reduce avian mortalities, we see no reason why the development should not be allowed to proceed. This must be accompanied by a full 12-24 months of systematic post-construction monitoring by competent ornithologists familiar with the area. The monitoring must include the grid infrastructure and the Zonnequa Wind Farm. This will determine the efficacy of the mitigations and provide input to any further mitigations required if problems arise on site.

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Dr R.E. Simmons / M Martins
Birds & Bats Unlimited
www.birds-and-bats-unlimited.com
rob.simmons@uct.ac.za

2 April 2018, Revised : 13 April 2018; 2nd revision: 27 June 2018 ; 3rd revision: 22 Aug 2018; 4th revision 24 Sept 2018; Final revision 7 March 2019.
Last revision 22 April 2019

Appendix 1

All Bird species recorded on SABAP2 bird atlas cards in the pentads (2935_1710, 2935_1715, 2940_1710, 2940_1715, 2945_1710, 2945_1715, 2950_1710, 2950_1715) from the Zonnequa wind farm north to Buffels River. N = 18 cards from February 2012 to August 2018 for the Gromis Grid line option.

Species name Full protocol	Reporting Rate (%)
Bee-eater, European	11.11
Bokmakierie,	38.89
Bulbul, Cape	5.56
Bunting, Cape	5.56
Bustard, Ludwig's	27.78
Canary, White-throated	22.22
Canary, Yellow	50.00
Chat, Ant-eating	11.11
Chat, Familiar	16.67
Chat, Tractrac	11.11
Cisticola, Grey-backed	61.11
Crombec, Long-billed	27.78
Crow, Cape	55.56
Crow, Pied	61.11
Eagle, Booted	22.22
Falcon, Lanner	5.56
Fiscal, Common (Southern)	16.67
Flycatcher, Chat	72.22
Goshawk, Southern Pale Chanting	50.00
Kestrel, Greater	33.33
Kestrel, Rock	5.56
Korhaan, Southern Black	16.67
Lapwing, Crowned	5.56
Lark, Cape Long-billed	16.67
Lark, Karoo	83.33

Species name	Full protocol	Reporting Rate (%)
Lark, Karoo Long-billed		66.67
Lark, Red-capped		11.11
Lark, Spike-heeled		27.78
Martin, Rock		44.44
Penduline-tit, Cape		16.67
Prinia, Karoo		77.78
Sandgrouse, Namaqua		11.11
Scrub-robin, Karoo		94.44
Secretarybird		11.11
Snake-eagle, Black-chested		22.22
Sparrow, Cape		27.78
Stonechat, African		5.56
Sunbird, Malachite		16.67
Sunbird, Southern Double-collared		61.11
Swallow, Barn		22.22
Swallow, White-throated		5.56
Swift, Alpine		22.22
Swift, Common		5.56
Swift, Little		27.78
Thick-knee, Spotted		5.56
Tit, Grey		5.56
Tit-babbler, Layard's		22.22
Turtle-dove, Cape		11.11
Warbler, Rufous-eared		61.11
Wheatear, Capped		11.11
TOTAL: 50 species, **8 collision-prone species** 4 Red Data species		

APPENDIX 2

ALL COLLISION-PRONE BIRD SPECIES RECORDED IN THE PROPOSED ZONNEQUA WIND FARM FROM MAY 2013 TO FEBRUARY 2018.

ZONNEQUA WEF Passage Rates – May 2017

Date	Time	Obs period	Hrs	VP	No	Species	Height	Seconds	Ref on Map
29/05/2017		08h30-14h30	6.00	**ZVP1**		**No Birds**		-	
31/05/2017		11h55-17h55	6.00	**ZVP1**		**No Birds**		-	
29/05/2017		08h53-14h53	6.00	**ZVP2**		**No Birds**			
31/05/2017		12h00-18h00	6.00	**ZVP2**		**No Birds**		-	
30/05/2017		08h00-14h00	6.00	**ZVP3**	1	Pale Chanting Goshawk	0m perched	0	PCG1
01/06/2017	12h20	12h00-18h00	6.00	**ZVP3**	1	Pale Chanting Goshawk	0m perched	0	PCG2

		36.00	Hrs	2	Birds			
WEF	Passage rate:	36.00	Hr	2		0.06	Birds / hr	
Red Data	Passage rate:	36.00	Hr	0		0.00	Birds / hr	May 2017

ZONNEQUA WEF Passage Rates – August 2017

Date	Time	Obs period	Hrs	VP	No	Species	Age	Sex	Height	Seconds
28/8/2017	8h39	8h15-14h15	6.00	**ZVP1**	1	**Ludwig's Bustard**	Ad	Unkn	15,20,10,20,25,25	75
29/8/2017	11:07	10h40-16h40	6.00	**ZVP1**	1	Unidentified raptor	Unkn	Unkn	130,140,140	40
	12:01				2	**Secretarybird**	Ad	M/F	60,60,80,80,80,60	85
	12:26				2	**Secretarybird**	Ad	M/F	0m	54
	13:01				1	**Secretarybird**	Ad	Unkn	50,50,50,80,100,100,100,120, 130,140,140, 150,160,160,170,170,150,150 ,150,150,170,170,170,170	346
					1	Pale Chanting Goshawk	Imm	Unkn	5,5,5	42
28/8/2017	8:46	7h45-13h45	6.00	**ZVP2**	1	**Ludwig's Bustard**	Ad	Unkn	10,10,8,12,12,12	80
	12:55				1	Pale Chanting Goshawk	Ad	Unkn	15,8,0	40
29/8/2017	10:55	10h15-16h15	6.00	**ZVP2**	**1**	**Ludwig's Bustard**	Ad	Unkn	30,30,30,30,35,35,50,50,55,5 5,60,70,65,60,65,60	225
	10:55				1	Greater Kestrel	Ad	Unkn	25,25,25	30
	11:58				1	**Secretarybird**	Ad	F	10,10,20,25,10,10,10,15,20,2 0,30,30,35,40,40,40,40,40,20	270
	11:59				1	**Secretarybird**	Ad	M	50,40,10,10,15,20,30,30,35,4 0,40,40,40,40,20	210
30/8/2017		7h30-13h30	6.00	**ZVP3**		No Birds				
31/8/2017	11:00	11h00-17h30	6.00	**ZVP3**	1	**Ludwig's Bustard**	Ad	Unkn	7,7,7,5,2	60
					1	**Kori Bustard**	Ad	Unkn	7,7,7,10,15,20,25,30,35,5	135
	12:55				2	Pale Chanting Goshawk	Ad	M/F	45,45,60,60,60,65,70	90
	12:55				1	Booted Eagle	Ad	Unkn	50,50,60,65,70,80,85,80,80,1 00,110,110,110,105,150,150, 150,100,100,105,110	300
					1	Booted Eagle	Ad	Unkn	40,50,50,70,95,110,110,120,1 30,100,110,115,130,130,130, 130,130	240
	14:11				1	Booted Eagle	Ad	Unkn	20,40,50,60,85,95,100,100,10 0,40,10,0	150
	14:13				1	Booted Eagle	Ad	Unkn	15,20,30,40,45,35,35,30,30,3 0,25,29,40,50,50,40,59,50,50, 30,10	285
WEF	**Passage rate:**		**36.0**	**Hr**	**22**	**0.61**	**Birds / hr**			
Red Data	**Passage rate:**		**36.0**	**Hr**	**12**	**0.33**	**Birds / hr**		**August 2017**	

ZONNEQUA WEF Passage Rates – November 2017

Date	Time	Obs period	Hrs	VP	No	Species	Age	Sex	Height	Seconds
26/11/2017	11:29	8h15-14h15	6.00	**ZVP1**	1	Greater Kestrel	Ad	U	20,40,40,40,40,40,45,45,40,43, 15,20,15,20,25,25,20,30,5,15,2 0,5,5,13,17,10,10,7,10,10,20,5, 5,12,5	510
	12:49				1	Pale Chanting Goshawk	Ad	U	35,35,35	30

27/11/2017	11:05	11:00-17:00	6.00	**ZVP1**	1	Pale Chanting Goshawk	Ad	U		62
	15:28				1	Pale Chanting Goshawk	Ad	U		27
	16:19				1	Pale Chanting Goshawk	Ad	U		42
26/11/2017	8:19	8h45-14h45	6.00	**ZVP2**	1	Pale Chanting Goshawk	Ad	U	30,30,20,10	44
	11:27				1	Booted Eagle	Ad	U	60,60,80,80,100,120,140,140,150,160	136
	13:06				1	Booted Eagle	Ad	U	5,5,5,10,15,80,50,60,80,100,100,100,120,120,120,150,180,180,200,240,240,260,300,300,320,320,280,260,220,180,160,140	482
27/11/2017	10:28	10h30-16h30	6.00	**ZVP2**	**1**	Booted Eagle	Ad	U	20,30,35,40,40	60
	12:45				**1**	Booted Eagle	Ad	U	70,75,90,95,90,90,90,90,100,110,110,120,130,130,130,130,130,130,150,160,190,190	315
	12:49				**1**	Booted Eagle	Ad	U	135,135,135,145,160,180,200,210,230,260	135
24/11/2017	8:19	8h15-14h15	6.00	**ZVP3**	1	**Ludwig's Bustard**	Ad	U	20,20,20,10,10	56
	8:44				2	Booted Eagle (pale)			15,30,40,70,80,100,120,140,100,160,180,200,200,200,200,220,220,220,220,220,240,240	197
	9:16				1	Booted Eagle (pale)	Ad	U	40,40,60,60,50,40	76
	10:23				1	Booted Eagle (pale)	Ad	U	80,80,100,120,100	59
	10:51				1	Booted Eagle (dark)	Ad	U	70,70,70,80,80,80,100,100,100,80,80,80,120,120,120,160,160,200,200,200,240,200,200,180,180,150,150,130,130,120,100,90,90	482
	10:56				1	Booted Eagle (pale)	Ad	U	80,80,90,100,80,70,50,50	107
	11:55				1	Booted Eagle (pale)	Ad	U	180,180,180,180,160,160,150,150,150,130,130,130,120,120,100,100,100,80,80,70,60,60,50,50,50	362
	12:13				1	Booted Eagle (pale)	Ad	U	20,20,30,40,50,30,40,40,80,80,30,20,20	183
	12:26				1	Booted Eagle (pale)	Ad	U	50,50,30,30,30,40,50,70,70,100,100,100,80,80,60,60,40	237
	12:50				1	Booted Eagle (pale)	Ad	U	70,70,80,80,100,100,100,90,90,80	131
	14:05				1	Booted Eagle (pale)	Ad	U	50,50,60,60,80,80,90,90,100,100,100,80,80,60,50,50,50	236
25/11/2017	11:15	9:20-15:20	6.00	**ZVP3**	1	Booted Eagle (pale)	Ad	U	40,45,45,45,50,55,65,75,80,85,90,105,120,115,110,120,130,130,125,125,135,140,150,155,155,150,145,140,145,160,150,145,145,135,120,120,120	555
	13:14				1	Booted Eagle (pale)	Ad	U	70,75,75,80,85,80,75,75,75,80,80,75	180
WEF	**Passage rate:**		**36.0**	**hr**	**25**	**0.69**	**Birds / hr**			
Red Data	**Passage rate:**		**36.0**	**hr**	**1**	**0.03**	**Birds / hr**		**November 2017**	

ZONNEQUA WEF Passage Rates – February 2017

Date	Time	Obs period	Hrs	VP	No	Species	Age	Sex	Height	Seconds
2018/02/28	7:11	7h10-14h10	7.00	**ZVP1**	1	Southern Black Korhaan	A	M	5;7;7;7	45
	7:44				1	Southern Black Korhaan	A	M	10;10;10	30
2018/03/01		8h00-13h00	5.00	**ZVP1**		No birds			-	

2018/02/28		7h30-14h30	7.00	**ZVP2**		No birds			-	
2018/03/01	10:40	7h10-12h10	5.00	**ZVP2**	**1**	**Black-chested Snake Eagle**			20,25,30,90,110,125,130,130,130,110,110,110,110,20,down,down,35,35,40,40,40,45,45,50,50,55,60,65,70,70,70,70,80,85,105,105	510
2018/02/26		8h00-12h00	4.00	**ZVP3**		No birds			-	
2018/02/27		7h00-15h00	8.00	**ZVP3**		No birds			-	
WEF	**Passage rate:**	**36.0**	**Hr**	**3**	**0.08**	**Birds / hr**				
Red Data	**Passage rate:**	**36.0**	**Hr**	**0**	**0.00**	**Birds / hr**	**February 2018**