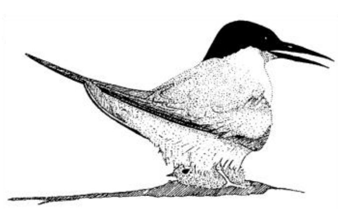
WALKER BAY WIND ENERGY FACILITY

Draft Environmental Impact Assessment: Birds

Prepared by:



Dr Rob Simmons

Birds & Biodiversity Consultant

Rob.Simmons@uct.ac.za

Prepared for:

Jo-Anne Thomas and Ravisha Ajodhapersadh

Savannah Environmental (Pty) Ltd

ravisha@savannahsa.com

EIA report on impact to birds of the proposed Walker Bay Wind Energy Facility on the farm Groot Vlei, near Stanford

1. EXECUTIVE SUMMARY

This study contains a summary of the published literature on wind energy impacts on avifauna, and focuses on potential impacts to birds of the proposed Walker Bay Wind Energy Facility, near Stanford. It incorporates bird atlas data with personal observations on site. The possible impacts are: minimal habitat destruction by the facility itself; disturbance by construction and maintenance activities and possible displacement or disturbance of a suite of raptors and bustards (some red-listed). Collision with blades of the wind turbines is the biggest risk with turbines placed on soaring ridges in pristine Fynbos; electrocution associated with the overhead power line is likely to be of a lesser risk.

The impact zone of the proposed facility features an area of highland fynbos on the farm Groot Vlei that lies about 300 m above the coastal Agulhas plain between Stanford and Gansbaai. The surrounding area is known to support over 177 bird species, including 8 red-listed species, 14 raptor species, 28 waterfowl species and 40 endemics. Those recorded in the wind farm boundary included 4 species that are red-listed species and are considered collision-prone due to their size and use of the habitat and hill tops in the area where the turbines are planned. Potential impacts may occur in terms of both collision and disturbance due to the facility itself, and by the disturbance and mortality risks posed by its peripheral infrastructure. The number of species recorded during the field survey in the study area itself is an under-estimate given the (winter-July) timing of the survey. Nevertheless, three species of concern were recorded in the proposed wind farm site itself. A resident Denham's Bustard was recorded twice as were two species of harrier – African Marsh Harrier and Black Harrier. The latter species was found to be breeding less than 1 km from the western-most proposed turbine. This and the presence of Jackal Buzzards and Verreaux's Eagles require careful mitigation and further investigation as to their presence and movements.

The degree and significance of potential impacts or displacement by turbines will depend largely on the relative abundance and movements of key species. Given that at least 27 of the red-listed, raptorial, wetland or endemics species show high reporting rates in the surrounding area

above 30%, means their relative abundance at times is going to be high. Breeding species will require further study in the pre-construction monitoring phase as some of the proposed wind turbines occur within their likely foraging range and favoured microhabitats. This monitoring is already underway on site. Recommended mitigation measures include re-positioning turbines away from known foraging areas of the harriers and 1 km from the known nests. Additionally I recommend that one blade of each turbine be painted with UV paint. All turbines and all birds, particularly breeding bustards or harriers should also be monitored pre- and post-construction over a minimum 12 months with control areas to determine (i) the effects of painted and un-painted turbines on the species highlighted in this report and (ii) whether placing turbines away from expected high-risk areas reduces any impacts.

2. BACKGROUND AND QUALIFICATIONS OF SPECIALIST CONSULTANT

Dr Rob Simmons was approached to conduct the specialist avifaunal assessments for the Wind Farms proposed by Savannah Environmental (Pty) Ltd. Rob Simmons is responsible for the Scoping and final Environmental Impact Assessment for this site. I am an experienced ornithologists, with over 25 years' experience in avian research and impact assessment work. I have undertaken twenty avian impact assessments (of powerlines, cement factories, mines, golf courses, guano platforms and wind farms) throughout Namibia and South Africa, and undertake research in the Western and Northern Cape on threatened bird species and mammals with students and staff of the FitzPatrick Institute at UCT. I am a Research Associate of the University of Cape Town and of the Institute of Zoology, London.

3. CONSULTANT'S DECLARATION OF INDEPENDENCE

I hereby declare that I have no conflicts of interest related to the work of this report. Specifically, I declare that I have no personal financial interests in the property and/or development being assessed in this report, and that I have no personal or financial connections to the relevant property owners, developers, planners, financiers or consultants of the development. I declare that the opinions expressed in this report are my own and a true reflection of my professional expertise.

R.E. Simmons

____

Signature

4. TERMS OF REFERENCE –SCOPE AND PURPOSE OF THE REPORT

The terms of reference and the purpose of this full EIA report are to:

- Describe the existing avifaunal environment at the appropriate scale (local and regional);
- Determine the importance and conservation value of the existing avian communities;
- Determine and assess the potential direct, indirect and cumulative avian impacts associated with the proposed development;
- Suggest mitigation measures that will reduce the impact of the wind farm on the avian community in terms of reduced collisions, reduced habitat loss and reduced avoidance of the wind farm;
- Rank impacts in terms of their (i) nature (ii) **E**xtent, (iii) **D**uration (iv) **M**agnitude (v) **P**robability and (vi) from these rank the overall **S**ignificance of the impact S = (E + D + M)P;
- Provide a management plan for the future assessment of the wind farm and the reduction of the possible impacts.

5. LIMITATIONS AND ASSUMPTIONS OF THE STUDY

Limitations and assumptions of this approach include:

Species recorded within the two bird atlas periods are assumed to cover the majority of birds likely to occur in the impact area. However, rarer and possibly migratory species will remain under-recorded and may be impacted as they pass through the area under investigation. The number of atlas cards available for the 9 km x 7.5 km area (one pentad) in which the study area occurs was a relative healthy 110 cards, but the SABAP1 atlas period represents data that is now almost 20 years old (Harrison et al. 1997). Bird distributions under climate change may have changed and the present atlas period contributing only 3 cards is a limitation of the study. Our own bird assessments on site occurred in winter (July-August) - the low season for bird activity (little breeding, no migrants and no nomadic species on the move) - and so this period under-recorded species in this region. Further assessments are therefore required to determine all species likely to occur in the area.

Given that there are currently only three small wind energy facilities operative in South Africa (totaling 8 turbines), data on the environmental effects of South African wind energy facilities is very limited (Jenkins unpubl. Simmons et al. in press). However, numerous studies are emerging from such facilities internationally. General principles can be gleaned from them, although care is taken in adapting international knowledge and experience to uniquely South African birds and conditions.

In the UK, Europe, Australia, USA and Canada, there is universal consensus (reviewed by Jenkins et al. 2011) that any bird-wind farm assessment can only be carried out over a minimum of 12 months with all seasons covered (breeding seasons, migrations seasons, non-breeding). And a minimum of ~36 hours per site where turbines are due to be erected is the recommended time given. An EIA such as this can only offer a snap shot of the birds in the area, and further data are required from additional monitoring to fully assess all possible scenarios of impacts to birds in the area.

6. ASSUMPTIONS

Any inaccuracies in the above sources of information could limit this study. The SABAP1 data for this area is now almost 20 years old (Harrison *et al.* 1997), but is based on a set of 110 cards. However, more recent data from SABAP2 relies on only 3 cards for the relevant pentads. More reliable or more recent data on bird species is unavailable other than what was recorded in the 2 days of monitoring and transects counts (see Figure 1) on site. This can only be rectified during further visits in spring, summer and autumn (August through February) to record breeders, migrants and nomads. Three of the four site visits will be completed by then adding to our knowledge of the species occurring there.

Furthermore, climate change is known to alter bird distributions (Simmons et al. 2004), pushing birds southwards or up slope where cooler climates are found. This means older data on species distributions could be inaccurate.

7. METHODOLOGY AND DATA SOURCES

The following data sources and reports were used in compiling this report:

- Information on the biology (Hockey et al 2005), distribution (Harrison et al. 1997) and conservation status (Barnes 2000) of southern 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 quarter-degree square (SABAP 1, 3419BC) and the "pentads" of 5′ x 5′ from (SABAP 2: 3425_1930 and 3430_1930). On account of the remote area there were only 3 cards from these pentads, so all of my own observations were also added together with my assistant (P. E. Barnard). From these sources I compiled a list of the avifauna likely to occur within the broader impact zone of the proposed wind farm. This also allowed an index of the likelihood of occurrence (reporting rate) to be given. I combined these data with my own from July and August 2011.

- Conservation status and endemicity of all species considered likely to occur in the area was determined from the national Red-list for birds (Barnes 2000), and the most recent comprehensive summary of southern African bird biology (Hockey *et al.* 2005).
- EIA reports and subsequent monitoring reports on the potential impacts on birds of other wind energy facilities in South Africa were also consulted (van Rooyen 2001, Jenkins 2001, 2003, Küyler 2004, Jenkins 2008, 2009).

METHODOLOGY AND APPROACH

Approach

I undertook the following steps:

- A review of available published and unpublished literature on bird interactions with wind energy facilities summarising the issues involved and the current level of knowledge in this field. Data sources examined included atlas data on avifauna of the area and previous studies of bird interactions with wind energy facilities and electrical infrastructures associated with them.
- An inclusive list of the avifauna likely to occur within the impact zone of the proposed wind energy facility was compiled using a combination of the existing distributional data from published atlases and our experience of the avifauna of the general area.
- A short-list of priority bird species (defined in terms of conservation status and endemicity) which could be impacted by the proposed wind energy facility was extracted from the total bird list. These species were considered as adequate surrogates for the local avifauna generally, and mitigation of impacts on these species was considered likely to accommodate any less important bird species that may be affected.
- On-site monitoring in both the wind farm site and a control site 2 km south-west, every 2-months for a total of five visits over 12 months, will allow a comprehensive assessment

The full EIA incorporates relevant sections of the review above and additionally

- Summarizes the more likely and significant impacts of the wind energy facility on the local avifauna. I also discuss the likely impacts following two field site surveys and I suggest suitable mitigation strategies where problems are envisaged.

Background

8.1 Interactions between wind energy facilities and birds

Recent literature reviews (www.nrel.gov, Kingsley & Whittam 2005, Drewitt & Langston 2006, Kuvlevsky *et al.* 2007, Stewart *et al.* 2007, Drewitt & Langston 2008) are essential summaries and sources of information in this field. The number of longer-term analyses of the effects of wind energy facilities on birds is increasing, but scientific research in this field is still in its infancy (Madders & Whitfield 2006, Stewart *et al.* 2007). Available information mainly originates from short-term, unpublished, studies, from the United States, and western Europe, where wind power generation is well established.

There are three major ways wind farms can influence birds and they are:

- Through displacement and disturbance (birds avoid the area reducing the habitat available to them)
- Through habitat loss and fragmentation (the infrastructure and building phase directly destroys habitat)
- Through direct mortality (birds are struck by the turbines and die)

Concern about the impacts of wind facilities on birds first arose in the 1980s when numerous raptor mortalities were detected in California (Altamont Pass - USA) and at Tarifa (Spain). Mortalities at these sites focused attention on the impact of wind energy on birds, and subsequently much monitoring has been done at many terrestrial and offshore wind energy facility sites. More recently, there has been additional concern about the degree to which birds avoid or are excluded from the areas occupied by wind energy facilities – either because of the action of the turbine blades or because of the noise they generate - and hence suffer a loss of habitat (Larsen & Guillemette 2007, Stewart *et al.* 2007, Devereaux *et al.* 2008, Pearce-Higgins *et al.* 2009). With a few important exceptions, most studies suggest very low numbers of bird fatalities at wind energy facilities numbering tens to hundreds of birds per year (Kingsley & Whittam 2005). The observed mortality caused by wind energy facilities is also very low compared to other existing sources of anthropogenic avian mortality on a per structure basis (Crockford 1992, Colson & associates 1995, Gill *et al.* 1996, and Erickson *et al*. 2001). Problems arise when the few hundred birds are rare or highly threatened species.

8.1.1. Collisions with turbines

Collision rates

As more monitoring has been conducted, bird mortality rates at wind energy facilities have ultimately been compared in terms of a common unit: mortalities/turbine/year, or mortalities MW^{-1} $year^{-1}$ (Smallwood & Thelander 2008). Wherever possible, measured

collision rates should allow for (i) the proportion of actual casualties which are detected by observers (searcher efficiency), and (ii) the rate at which carcasses are removed by scavengers (scavenger removal rate – important in an African landscape). Although collision rates may appear relatively low in many instances, cumulative effects over time, especially when applied to large, long lived, slow reproducing and/or threatened species (many of which are collision-prone), may be of considerable conservation significance.
The National Wind Co-ordinating Committee (2004) estimates that 2.3 birds are killed/turbine/year in the US outside California – correcting for searcher efficiency and scavenger rates. However, this index ranges from as low as 0.63 in Oregon to as high as 10 in Tennessee (NWCC 2004) illustrating the wide variance in mortality rates between sites. Curry & Kerlinger (2000) found that only 13% of the >5000 turbines at Altamont Pass, California were responsible for all Golden Eagle *Aquila chrysaetos* and Red-tailed Hawk *Buteo jamaicensis* collisions. However, the most recent total casualty estimates for Altamont run to >1000 raptors, and nearly 3000 birds, killed in turbine collisions at the facility annually (Smallwood & Thelander 2008). This large figure includes >60 Golden Eagles, and at a mean rate of about 2-4 mortalities MW^{-1} $year^{-1}$.

At the Tarifa and Navarre wind energy facility sites on the Straits of Gibraltar, southern Spain, about 0.04-0.08 birds are killed/turbine/year (Janss 2000a, de Lucas *et al.* 2008), with relatively high collision rates for threatened raptors such as Griffon Vulture *Gyps fulvus*, of particular concern. At the same sites, collisions have also been found to be non-randomly distributed between turbines, with >50% of the vulture casualties recorded at Tarifa being killed by only 15% of the turbines at the facility (Acha 1997). Collision rates from other European sites are equally variable, with certain locations sporadically problematic (Everaert 2003). Migration highways and other areas where birds funnel through a bottleneck are sites to be avoided.

To date, only seven wind turbines have been constructed in South Africa at two pilot wind energy facilities at Klipheuwel and Darling in the Western Cape (van Rooyen 2001, Jenkins 2001, 2003). An avian mortality monitoring program was established at the Klipheuwel facility once the turbines were operational, involving regular site visits to monitor bird traffic through the area, and to detect bird mortalities (Küyler 2004). This study found that (i) 9-57% of birds observed within 500m of the turbines per survey period were flying at blade height, and (ii) 0 - 32% of birds sighted were flying either between the turbines or within the arc of the rotors of the outermost turbines. Five bird carcasses were found on the three-turbine site during the 8-month monitoring period, of which two, a Horus Swift *Apus horus* and a Large-billed Lark *Galerida magnirostris*, were thought to have been killed by collision with turbine blades, indicating a net collision rate for birds of about 1.00 mortality/turbine/year. A pilot study of birds associated with the 4 turbines at the Darling site has been undertaken by Jenkins (2004) who found 1 bird h^{-1} of 12 priority species were passing over the site in 86 h observation, and by Simmons, Retief and van Beuningen (in press) who observed 10 birds h^{-1} passing through the area including eagles, harriers and pelicans.

Causes of collision

Multiple factors influence the number of birds killed at wind energy facilities. These can be classified into three broad groupings: (i) avian variables, (ii) location variables, and (iii) facility-related variables. Although only one study has so far shown a direct relationship between the abundance of birds in an area and the number of collisions (Everaert 2003), it seems logical to assume that the more birds there are flying through an array of turbines, the higher the chances of a collision occurring. The identity of the species present in the area is also very important as some birds are more vulnerable to collision with turbines than others, and feature disproportionately frequently in collision surveys (Drewitt & Langston 2006, 2008, de Lucas *et al.* 2008). Species-specific variation in behaviour, such as foraging, commuting or courting, also affect susceptibility to collision (Barrios & Rodríguez 2004, Smallwood *et al.* 2009). There may also be seasonal and temporal differences in behaviour, for example breeding males displaying may be particularly at risk.

Landscape features often channel birds towards a certain area, and in the case of raptors, influence their flight and foraging behaviour. Ridges and steep slopes are important factors in determining the extent to which an area is used by gliding and soaring birds (Barrios & Rodríguez 2004). High densities of prey will attract raptors, increasing the time spent hunting, and as a result reducing the time spent being vigilant. Poor weather affects visibility. Birds fly lower during strong headwinds (Hanowski & Hawrot 2000, Richardson 2000), so when the turbines are functioning at their maximum speed, birds are likely to be flying at their lowest, exponentially increasing collision risk (Drewitt & Langston 2006, 2008).

Larger wind energy facilities, with more turbines, are almost by definition more likely to incur significant numbers of bird casualties (Kingsley & Whittam 2005), and turbine size may be proportional to collision risk, with taller turbines associated with higher mortality rates in some instances (e.g. de Lucas *et al.* 2009, although see Howell 1995, Erickson *et al.* 1999, Barclay *et al.* 2007). However, with newer technology, fewer, larger turbines are needed to generate the same amount of power, which may result in fewer collisions per Megawatt of power produced (Erickson *et al.* 1999). Certain turbine tower structures, and particularly the old-fashioned lattice designs, present many potential perches for birds, increasing the likelihood of collisions occurring as birds land at or leave these perch or roost sites. This problem has largely been solved with more modern, tubular tower designs (Drewitt & Langston 2006, 2008).

Illumination of turbines and other infrastructure often increases collision risk (Winkelman 1995, Erickson *et al.* 2001), either because birds moving long distances at night navigate using stars, and mistake lights for stars (Kemper 1964), or because lights attract insects, which in turn attract birds. Changing constant lighting to intermittent lighting has been shown to reduce nocturnal collision rates (Richardson 2000, APLIC 1994, Jaroslow 1979, Weir 1976) and changing flood-lighting from white to red (or green) can affect an 80% reduction in mortality rates (Weir 1976).

Spacing between turbines at a wind facility can also effect the number of collisions. Some authors have suggested that paths need to be left between turbines so that birds can move through these areas. Alternatively, where certain turbines are known to kill more birds they can be temporarily be taken out of service (e.g. during migration or breeding). For optimal wind generation, relatively large spaces are required between turbines in order to avoid wake and turbulence effects.

Collision prone birds

Collision prone birds are generally either (i) large species and/or species with high ratios of body weight to wing surface area, and low maneuverability (cranes, bustards, vultures, gamebirds, waterfowl, falcons), (ii) species which fly at high speeds (gamebirds, pigeons and sandgrouse, waterfowl, swifts, falcons), (iii) species which are distracted in flight - predators or species with aerial displays (many raptors, aerial insectivores, some open country passerines), (iv) species which habitually fly in low light conditions, and (v) species with narrow fields of forward binocular vision (Drewitt & Langston 2006, 2008, Jenkins *et al.* 2010, Simmons 2011). 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 turbines area (Jenkins *et al.* 2010). Exposure is greatest in (i) highly aerial species, (ii) species that make regular and/or long distance movements (migrants, any species with widely separated resources food, water, roost and nest sites), (iii) species that fly in flocks (increasing the chances of incurring multiple fatalities in single collision incidents). Soaring species may be particularly prone to colliding with wind turbines or power lines where these are placed along ridges, the turbines to exploit the same updrafts favoured by such birds - vultures, storks, cranes, and most raptors (Erickson et al. 2001, Kerlinger & Dowdell 2003, Drewitt & Langston 2006, 2008, Jenkins *et al.* 2010).

For southern Africa new data is emerging on exactly how high collision mortality rates are. In her PhD research Jess Shaw recently found no less than 34 bustards (mainly Ludwig's) under just 7 km of 400 kV line near Van Rhynsdorp over a 3 month period. This is a hotspot but represents 1.6 bustards/km/month at peak mortality times.

Mitigating collision risk

One direct way to reduce the risk of birds colliding with turbine blades is to render the blades more conspicuous and hence easier to avoid. Blade conspicuity is compromised by a phenomenon known as 'motion smear' or retinal blur, in which rapidly moving objects become less visible the closer they are to the eye (McIsaac 2001, Hodos 2002). The retinal image can only be processed up to a certain speed, after which the image cannot be perceived. This effect is magnified in low light conditions, so that even slow blade rotation can be difficult for birds to see.

Laboratory-based studies of visual acuity in raptors have determined that (i) visual acuity in kestrels appears superior when objects are viewed at a distance, suggesting that the birds may view nearby objects with one visual field and objects further away with another, (ii) moderate motion of the visual stimulus significantly influences acuity, and kestrels may be unable to resolve all portions of an object such as a rotating turbine blade because of motion smear, especially under low contrast or dim lighting conditions, (iii) this deficiency can be addressed by patterning the blade surface in a way which maximizes the time between successive stimulations of the same retinal region, and (v) the easiest, cheapest and most visible blade pattern for this purpose, effective across the widest variety of backgrounds, is a single black blade in an array of white blades (McIsaac 2001, Hodos 2002). Hence blade marking may be an important means to reduce collision rates by making the rotating turbine blades as conspicuous as possible under the least favourable visual conditions, particularly at facilities where raptors are known or considered to be the most likely collision casualties. The possibility of painting turbines with Ultra-violet paint, readily seen by birds may increase the possibilities of detection, but as far as I know this has yet to be tested.

Marking turbine rotors in this way, does not guarantee reduced collision frequency, especially during strong winds (when rotor speeds increase and birds tend to fly low and with less control) and when visibility is poor (at night or in thick mist). All other collision mitigation options operate indirectly, by reducing the frequency with which collision prone species are exposed to collision risk. This is achieved mainly by: (i) siting farms and individual turbines away from areas of high density or groupings and regular commuting or slope-soaring regions; (ii) using low risk turbine designs (i.e vertical-axis "barrel" turbines) and configurations, which discourage birds from perching on turbine towers or blades, and allow corridors for commuting birds to fly safely through the turbine strings; and (iii) monitoring collision incidence, and being prepared to shut-down problem turbines at particular times or under particular conditions (e.g. increased migration activity).

8.1.2 Habitat loss – destruction, disturbance and displacement

Although the final footprint of most wind energy facilities is likely to be relatively small, the construction phase of development inevitably incurs temporary damage or permanent destruction of habitat, which may be of lasting significance in cases where wind energy facility sites coincide with critical areas for restricted range, endemic and/or threatened species. Similarly, construction, and to a lesser extent ongoing maintenance activities, are likely to cause some disturbance of birds in the general surrounds, and especially of shy and/or ground-nesting species resident in the area. Mitigation of such effects requires that generic best-practice principles be rigorously applied - sites are selected to avoid the destruction of key habitats, and construction and final footprints, as well as sources of disturbance of key species, must be kept to an absolute minimum.

Some studies have shown significant decreases in the numbers of certain birds in areas where wind energy facilities are operational as a result of avoidance of the noise or movement of the turbines (e.g. Larsen & Guillemette 2007); others have shown decreases which may be attributed to a combination of collision casualties and avoidance or exclusion from the impact zone of the facility in question (Stewart *et al.* 2007). Such displacement effects are probably more relevant in situations where wind energy facilities are built in natural habitat (Pearce-Higgins *et al.* 2009, Madders & Whitfield 2006) than in modified environments such as farmland (Devereaux *et al.* 2008).

8.1.3 Impacts of associated infrastructure

Infrastructure commonly associated with wind energy facilities can be detrimental to birds. The construction and maintenance of substations, power lines, servitudes and roadways causes both temporary and permanent habitat fragmentation and disturbance. New overhead power lines also pose a collision and possibly an electrocution threat to certain species (Van Rooyen 2004a, Lehman *et al.* 2007, Jenkins *et al.* 2010).

Habitat destruction during construction and maintenance of power lines and substations
Some habitat destruction and alteration inevitably takes place during the construction of power lines, substations and associated roadways. Also, power line servitudes have to be cleared of excess vegetation at regular intervals to allow access to the line for maintenance, and to prevent vegetation from intruding into the legally prescribed clearance gaps between the ground and the conductors. These activities have an impact on birds breeding, foraging and roosting in close proximity 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).

Collision 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). Mitigation of this risk involves the careful selection of low impact alignments for new power lines relative to bird movements and avoidance of concentrations of high risk species. Where this cannot be avoided the use of marking devices to make the lines, (particular the earth wires), more conspicuous are needed. While static and dynamic marking devices have been used

globally, many remain untested in terms of reducing collisions, and those that have been are only partially effective (Drewitt & Langston 2008, Jenkins *et al.* 2010).

Electrocution on power lines

Avian electrocutions occur when a bird perches on an electrical structure and causes a short circuit by physically bridging the air gap between live components and earthed components (van Rooyen 2004b, 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 by the use of bird-safe structures (with critical air gaps >2 m), the physical exclusion of birds from high risk areas of live infrastructure, and comprehensive insulation of such areas (van Rooyen 2004b, Lehman *et al.* 2007).

To summarize the risks and solutions:

- On average 2.3 birds are killed/turbine/yr in the USA (range 0.63 to10.0 birds killed).
- A few turbines are responsible for most deaths.
- Over 1000 raptors and 3000 birds are killed annually at Altamont Pass, California by turbines, so misplacing turbines can be extremely risky. These are old turbines and these are being replaced and problematic ones moved (pers. obs.).
- Landscape features such a ridges for soaring, or valleys for commuting, are high risk areas for raptors or migrants. Poor weather and high winds induce birds to fly lower and increase the chances of collision.
- Illuminating turbines increases avian mortality but gaps left in corridors of turbines may reduce overall mortality risk.
- High risk birds include those with low maneuverability (cranes, bustards), or high air speed (raptors, wetland birds), or distracted fliers (raptors chasing prey, courting birds), and soaring species that seek lift off slopes (pelicans, vultures, storks).
- There are no published studies in South Africa allowing us to compare mortality or displacement rates.

Mitigating the risks is compromised by fast-moving objects being difficult even for raptors to detect (due to retinal blur); however, painting one blade black (or with UV paint) can help detection.

- Site wind farms away from: (i) large concentrations of birds (e.g. roosts or wetlands or breeding colonies); (ii) migration corridors (iii) slopes used by soaring birds (iv) breeding birds.
- Re-design or experiment with vertical axis turbines that do not kill birds and monitor deaths per turbine and be prepared to shut down high mortality blades or turbines at times of high risk (i.e. migration seasons).

9. OVERVIEW OF THE PROPOSED FACILITY

Description of the proposed wind energy facility

The wind energy facility known as Walker Bay proposed for the farm Grootvlei, comprises up to 11 wind turbines of up to 3 MW each, to generate about 18 MW. The turbines are distributed on the highest ground above the Grootvlei farm at about 300 m asl. The area covers approximately 1.7 km x 1.3 km on the south west side of the highest slope, and south of the highest point, Grootkop at 390 m asl. The wind farm will link directly to existing power infrastructure at the Stanford substation. In addition, one weather masts was already operational during our site visit on 9-10 July and 9-10 August 2011.

10. DESCRIPTION OF THE AFFECTED ENVIRONMENT

10.1 Vegetation of the study area

The study area of the proposed site is dominated by natural montane Fynbos with ericas, proteas, leucadendrons and some restios present. It is described as Agulhas Limestone Fynbos FFl 1 (Mucina & Rutherford 2006, p170). The vegetation comprises a relatively uniform carpet of low vegetation of 5-6 yrs old except where the previous fire had less impact. In these wetter areas the vegetation is more mature and about 1 m in height and held more Fynbos endemic birds. This region just north of Gansbaai lies in the winter rainfall region with mean annual rainfall of 560 mm/yr, peaking in June-August. It is part of the Agulhas Plain, and is one of the wettest areas of limestone Fynbos units (Mucina and Rutherford 2006).

In more lowland areas the region is dominated by farmland where cattle and a few pigs are grazed in the wetland valleys and floodplains. These are ephemeral, with the Uilskraal River rising and falling with the rains. On the slopes around the proposed farm, flower-picking is the main land-use and many areas contain bee-hives presumably to enhance pollination.

10.2 Avian microhabitats

The uniform vegetation on the upper slopes of the farm were dominated by the limestone Fynbos and held mainly Fynbos endemics such as the sugarbirds, sunbirds and prinias. However, other parts of the lower slopes where some turbines are planned were dominated by aliens such as rooikrans and held a slightly different bird community of weavers and robins, not found on the more open slopes. In the valley 3.4 km south-east of the wind mast, farmland and wetland provides habitat for a large suite of wetland species such egrets, ducks and geese.

10.3 Avifauna of the impact area

At least 177 bird species are considered likely to occur with some regularity within the vicinity of the wind energy facility (i.e. within 3 km). This total may rise as further bird surveys are conducted. For example in 4 days we added four important species to the list (a bustard, a harrier and duck and a sugarbird) not previously recorded or rarely recorded.

However, almost one third (40) of this total are endemic or near-endemic species. More importantly, 8 species are red-listed species, and three species (Denham's Bustard, Cape Vulture and Black Harrier)––are both endemic and red-listed (Table 1). Two of these species (Denham's Bustard and Black Harrier) and a third non-endemic (African Marsh Harrier) all have a moderate to high probability of occurring in the impact zone. One endemic non-threatened raptor – a Jackal Buzzard was also present in the area and has a high probability of occurrence of about 55% (Appendix 1).

Table 1. Eight red-listed bird species known **(in bold)** or likely to occur within the impact zone of the proposed wind energy facility. Estimates of their relative susceptibility to the environmental impacts of the construction and operation phase of the development are given together with their likelihood of occurrence. *Endemic* red-listed species are highlighted in grey.

Common name	Conservation status	Regional endemicity	Relative importance of local population[1]	Susceptibility to collision	Susceptibility to electrocution	Susceptibility to disturbance	Likelihood of occurrence
Denham's Bustard	**Vulnerable**	**Endemic**	**Moderate to High**	**High**	**-**	**High**	**2%**
Cape Vulture	Vulnerable	Endemic	Low	High	High	Moderate	1%
Black Harrier	**Vulnerable***	**Endemic**	**Moderate to High**	**Moderate**	**-**	**High**	**15%**
African Marsh Harrier	**Vulnerable**	**-**	**Moderate**	**Moderate**	**-**	**High**	**14%**
Martial Eagle	Vulnerable	-	Low	Moderate	High	Moderate	7%
Secretarybird	Near-threatened	-	Low	High	-	Low	7%
Lesser Kestrel	Near-threatened	-	Low	Moderate	Moderate	Low	2%
Lanner Falcon	Near-threatened	-	Low	High	Moderate	-	4%

[1]Relative to the national/global population

*Global IUCN classification

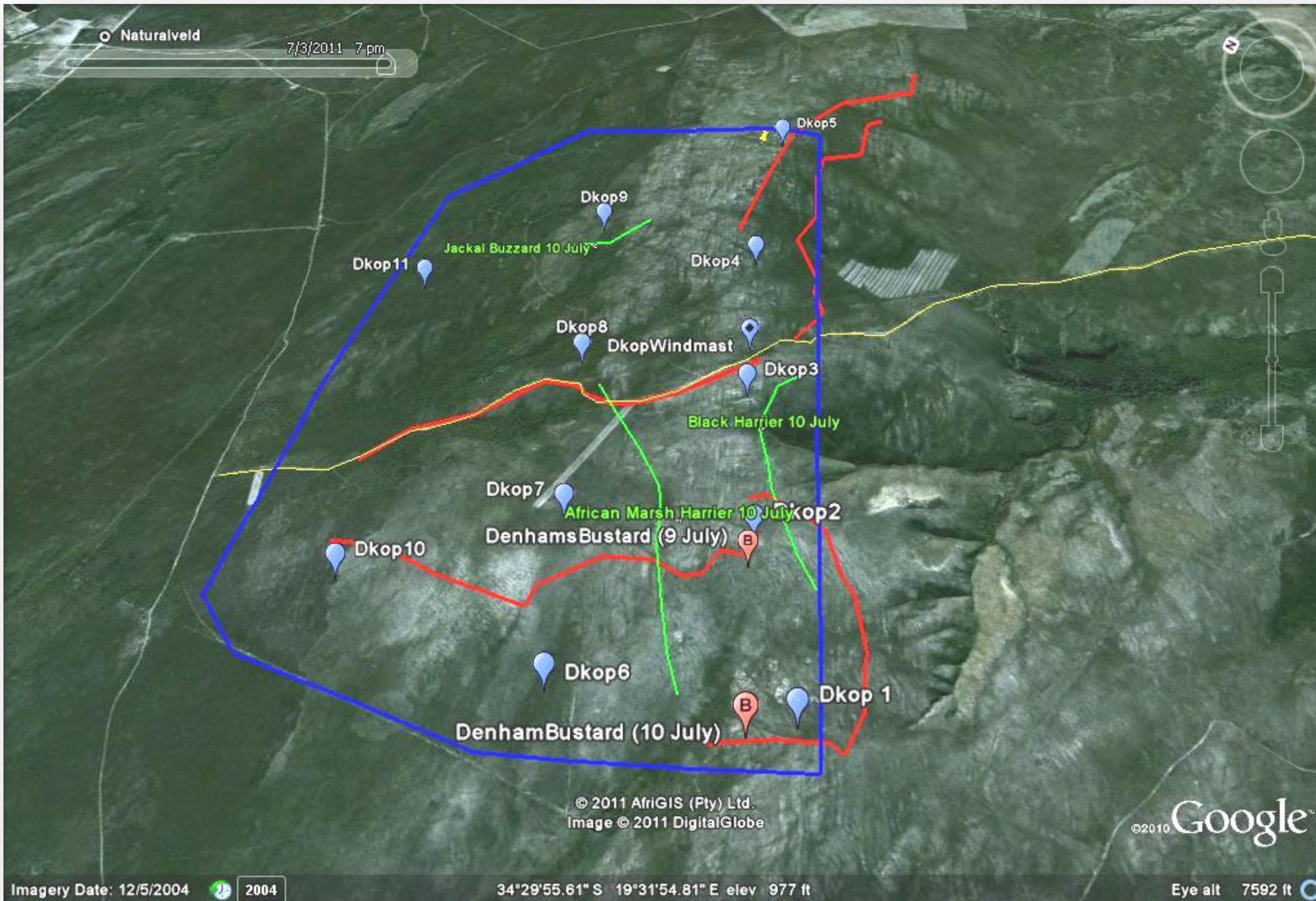


Figure 1: The proposed Driekop wind Energy Farm on the farm Grootvlei, near Stanford. The approximate boundary of the wind farm is shown in blue and the proposed sitings of the 11 wind turbines (as supplied by RES) are indicated in blue and numbered Dkop 1-11. Our four, 1 km-long, bird transects are given in red.

Important bird sightings are superimposed (in green) and occurred particularly in the south western corner of the farm. Two single Denham's Bustards, two harriers (one Black and one African Marsh) and a Jackal Buzzard were all observed within the wind farm boundary as shown. The Denham's Bustard may be resident given that a bird was located on two consecutive days (9 and 10 July) within 370 m of each other.

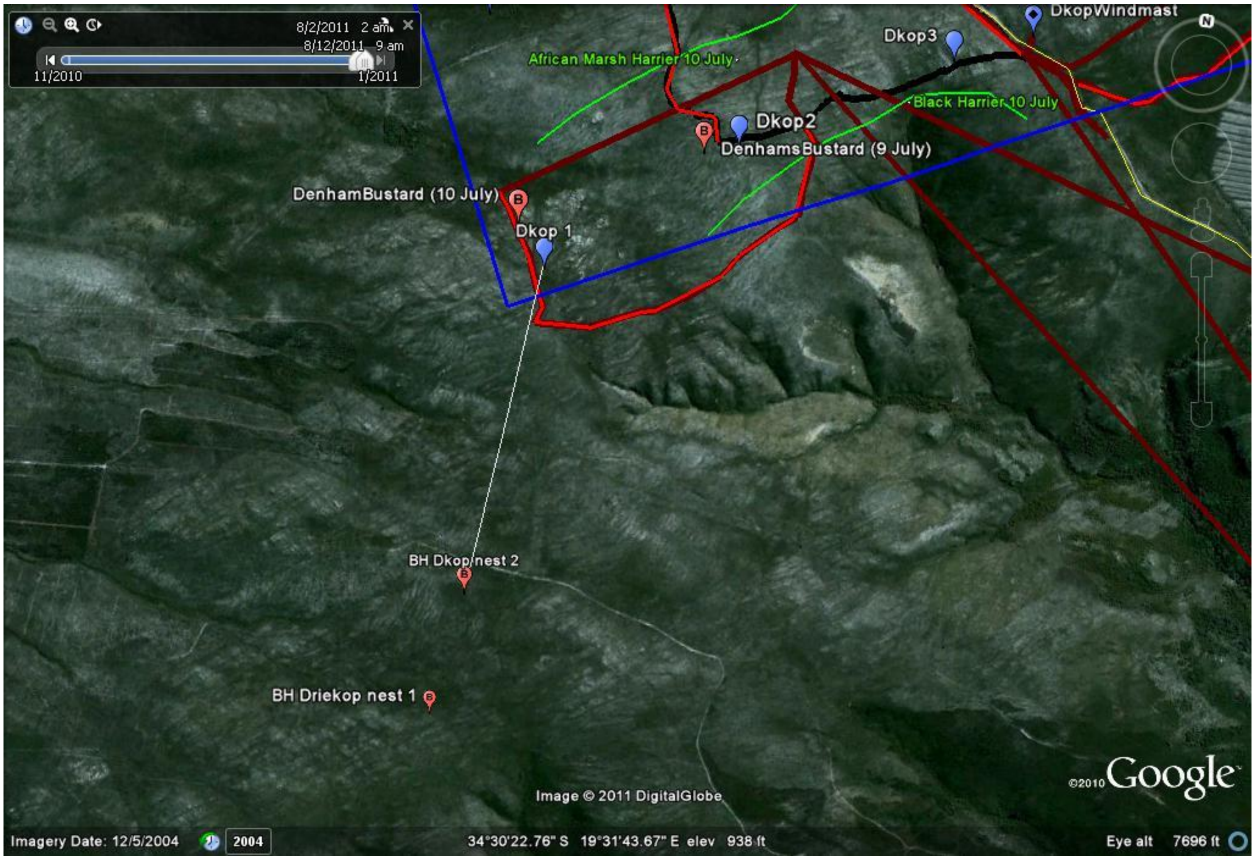


Figure 2: Two Black Harrier nests (endemic, globally Vulnerable) found less than 1 km from the south-west corner of the wind farm and proposed turbine Dkop1, 9-10 Aug 2011. The white line from BH nest2 to the closest wind turbine is 630 m.

Other than the red-listed species those species of greatest relevance in terms of the possible impacts of the proposed wind turbines are aggregations of waterbirds, bustards, and raptors. Waterbirds are fast-flying unmanouverable species that are collision-prone, and like bustards are frequently victims of collisions with power lines (Jenkins et al. 2010). The raptor community on the other hand is often highly agile with excellent vision, but which use uplands and slopes for soaring and some forage over Fynbos habitats. Despite their agility many still hit power lines when chasing prey or conspecifics (Simmons 2011).

10.3.1 Waterbirds

Waterbirds are surprisingly common in this area and the atlas data for Driekop and surrounds (Table 2) has recorded 28 species due to the proximity of the large marsh (Groot vlei on the Uilkraal Rivers) in the valley 3 km south of the wind farm. These birds comprise grebes (1 sp), herons and egrets (7 species), ibises and storks and spoonbills (4 species), geese and duck (11 species) and cormorants (3 species). Several of these were not recorded in the atlas period but were recorded during the site visit; but none are red-listed species. While 7 of the 28 species are relatively common with reporting rates over 30%, it is considered unlikely that they will occur on the ridge tops where the turbines are planned, as only one species was seen (Yellow-billed Duck) during the site surveys and this on the control area on the farm Fynbos Valley. Furthermore, no dams were observed to the west, and the landowner (Phillip de Villiers pers comm.) confirmed that none occur west of the ridge top. Thus wetland birds are unlikely to commute from the vlei (east of the proposed farm) to the west through the site. This will require confirmation at the pre-construction phase which is already underway.

Table 2. Waterbirds recorded in the study area (from SABAP 1 and SABAP 2 combined with **own records in bold**). Red-listed species are shown in red with their likelihood of occurrence.

	Species	**Reporting Rate**
1	White Stork	7%
2	White-breasted Cormorant	5%
3	**Reed Cormorant**	**33%**
4	African Darter	8%
5	Grey Heron	55%
6	**Black-headed Heron**	**64%**
7	Purple Heron	1%
8	**Little Egret**	**14%**
9	Yellow-billed Egret	5%
10	**Cattle Egret**	**71%**
11	Black-crowned Night Heron	1%
12	**Hamerkop**	**48%**
13	**African Sacred Ibis**	**12%**
14	**Hadeda Ibis**	**13%**
15	**African Spoonbill**	**10%**
16	**Egyptian Goose**	**80%**
17	South African Shelduck	1%
18	**Yellow-billed Duck**	**45%**
19	**African Black Duck**	**5%**
20	**Cape Teal**	**3%**
21	**Hottentot Teal**	**Observed**
22	**Cape Shoveler**	**5%**
23	Southern Pochard	1%
24	**Spur-winged Goose**	**28%**
25	**Red-billed Teal**	**5%**
26	**White-faced Duck**	**Observed**
27	**Red-knobbed Coot**	**Observed**
28	**Black Crake**	**Observed**

10.3.2. Raptors

Fourteen species of raptors are likely to occur in or around the study area (Table 3). Of these, seven are red-listed including large, scarce species such as the Cape Vulture. A breeding colony occurs at Potberg, in De Hoop, a straight line distance of 94 km from the wind farm. However their likelihood of occurrence in the wind farm area is very low (1%). More importantly, two of these species are red-listed and occur with regularity - the Black Harrier (Curtis *et al.* 2004, Simmons 2005), and the African Marsh Harrier. This was confirmed in the two site visits with the passage of two foraging birds recorded through the south western portion of the wind farm on the first visit and the presence of courting and nest-building Black Harriers recorded on the second August visit. The list also includes endemics such as the Jackal Buzzard which can be very common (over 50% likelihood of occurrence), and which were present in the study area. All of these three latter species may be at risk from the wind farm.

Table 3. Raptors recorded in the study area (from SABAP 1 and SABAP 2 combined with own observations). Red-listed species are shown in red with their IUCN classification and

	Species	**IUCN status**	**Reporting Rate**
1	Cape Vulture	Vulnerable	1%
2	Black-shouldered Kite	-	69%
3	Verreaux's Eagle	-	23%
4	Booted Eagle	-	2%
5	**African Fish Eagle**	**-**	**1%**
6	Gymnogene	-	3%
7	**African Marsh-Harrier**	**Vulnerable**	**14%**
8	**Black Harrier**	**Vulnerable***	**15% BREEDING – 2 nests**
9	**Jackal Buzzard**	**-**	**55%**
10	Martial Eagle	Vulnerable	7%
11	Secretarybird	Near-threatened	7%
12	Lesser Kestrel	Near-Threatened	2%
13	**Rock Kestrel**	-	43%
14	Lanner Falcon	Near-threatened	4%

their likelihood of occurrence

10.3.3. Endemics

Another group of species that must be considered in any evaluation are the endemics and near-endemics, particularly those with a restricted range or susceptible to collisions. Two such species (Black Harrier and Jackal Buzzard) have already been mentioned but at least 38 additional species are known to occur (Appendix 1). Most important among these is the collision-prone Denham's Bustard, a large resident species that features high on mortality registers across the South African landscape. While passerines are not normally expected to be influenced by turbines, except when drawn by lights on migration on misty nights, the other endemic, the Southern Black Korhaan, is susceptible to collision. Of the 40 endemics listed, 17 (43%) are likely to be very common through the study area with reporting rates from surrounding areas above 40%.

11.1 Assessment of significance of direct, indirect and cumulative impacts

For the 28 species of waterbird, the 14 species of raptors and the 40 endemic species, a handful are likely to be negatively influenced by the wind farm, either through (i) direct impact with the turbine blades, (ii) avoidance of the area due to noise and turbine movement, or (iii) through the impact on the vegetation used by these species. The proposed 66 kV power line into the area will also influence this impact but the routing of these lines is presently unknown. Wherever the power line crosses wetlands – as they may in the Uilskraal River valley below the wind farm – they will require mitigation to avoid impacting wetland species commuting up and down the valley day and night.

As conjectured above, it is unlikely that any of the waterbirds will commute through the wind farm boundary as there are no dams or other waterbodies in the close vicinity. Thus no negative impacts are likely for the duration of the life of the wind farm. It must be noted that a pair of Yellow-billed Ducks were (unexpectedly) seen south of south-western portion of the wind farm boundary in August.

Of the 14 raptor species occurring regularly, three are expected to be negatively influenced by the presence of the wind farm: the Black and African Marsh Harrier and the Jackal Buzzard. All are either suspected to be collision prone or will avoid the area due to the noise and movement of the turbine blades. Any other soaring raptor (e.g. passing Cape Vultures, Martial, Verreaux's or African Fish Eagles) are also expected to avoid the area if the turbines are moving. This will happen over the lifetime of the wind farm and will be a local effect. This will occur with a distinct probability for all these species.

The main endemic species to be negatively influenced will be the Denham's Bustard and the breeding Black Harriers. The bustards are relatively likely to be killed by the turning blades as they collide with overhead power lines on a regular basis (0.31 ~ 3 cranes and bustards are killed per km of line per year in other areas of the Overberg : Shaw et al. 2010). This will happen over the lifetime of the wind farm, will be a local effect and will occur with a high probability.

As with any population where density is reduced but the habitat remains favourable, a “sink” can be produced and other birds (bustards in particular) are likely to move into the vacuum created by the removal of territorial birds. Thus while the immediate effect may be local, the influence may be greater if other birds are drawn in from surrounding areas.

11.2 Quantifying the impacts

Nature of the effect of the wind farm: Of the 28 waterbirds, 14 raptors and 40 endemics, four main species are expected to be negatively affected by displacement, loss of habitat or direct mortality: Black Harrier, African Marsh Harrier, Jackal Buzzard and Denham’s Bustard.

The Extent (E) of the impact will be local **(1)** reducing foraging habitat in the immediate wind farm area for the harriers and buzzard but higher for the Bustard **(3)** if the space created by the death of individuals brings in other birds to be killed.

The Duration (D) will be permanent **(5)** for the lifetime of the wind farm for all species

The Magnitude (M) will cause a slight impact **(4)** for the harriers and buzzard (unless the wind farm is expanded or others occur in the vicinity) but higher for the bustard **(8),** as mortality will decrease the local population and increase the likelihood of other birds being drawn in.

The Probability of occurrence (P) of the harriers avoiding the area is probable **(3)**, for the buzzard is improbable **(2)** and for the bustard collision is ranked a highly probable given its propensity to hit overhead power lines **(4).**

The Significance [calculated as S = (E+D+M)P], is as follows for the species identified as at risk:

Black Harrier:	S = (1 + 5 + 4)3 = **30 (Moderate)**
African Marsh Harrier	S = (1 + 5 + 4)3 = **30 (Moderate)**
Jackal Buzzard	S = (1 + 5 + 4)2 = **20** (Low) (other large raptors are likely to fall into this category too)
Denham’s Bustard	S = (3 + 5 + 8)4 = **64** (**High**) (other large slow species such as korhaans will likely fall in here)

From these ratings we can see that for 3 of the 4 species, the significance weightings (30, 30 and 20) suggests that the presence of these species will be sufficient to have a direct influence on the decision to develop the area, and mitigation is required. Moreover, for the Denham's Bustard the rating at 64 has a direct influence on the decision to develop and must be mitigated.

Table 4: A summary of the quantified impacts to the four main species likely to be impacted by the wind farm

<table>
<tr><td colspan="3">Nature:
Direct mortality or avoidance of area around the wind farm for the four bird species identified as at risk above, due to noise, or impacts with turbine blades (Black BH, and African Marsh Harrier AMH, Jackal Buzzard JB, and Denham's Bustard, DB)</td></tr>
<tr><td></td><td>Without mitigation</td><td>With mitigation</td></tr>
<tr><td>Extent</td><td>1(BH, AMH, JB) 3 (DB)</td><td>1 (BH, AMH, JB) 2 (DB)</td></tr>
<tr><td>Duration</td><td>5 (BH, AMH, JB, DB)</td><td>5 (BH, AMH, JB, DB)</td></tr>
<tr><td>Magnitude</td><td>4 (BH, AMH, JB) 8 (DB)</td><td>3 (BH, AMH JB) 6 (DB)</td></tr>
<tr><td>Probability</td><td>3 (BH, AMH) 2 (JB) 4 (DB)</td><td>3 (BH, AMH) 2 (JB) 4 (DB)</td></tr>
<tr><td>Significance (E+D+M)P</td><td>30 (BH) 30(AMH), 20 (JB), 64 (DB)</td><td>27 (BH, AMH) 18 (JB) 52 (DB)</td></tr>
<tr><td>Status (+ve or –ve)</td><td>Negative</td><td>Negative</td></tr>
<tr><td>Reversibility</td><td>Low</td><td>Low</td></tr>
<tr><td>Irreplaceable loss of species?</td><td>Yes</td><td>Reduced</td></tr>
<tr><td>Can impacts be mitigated?</td><td>Partially</td><td></td></tr>
<tr><td colspan="3">Mitigation: There are three classes of mitigation for birds around wind farms: (i) re-position the turbines to avoid intersecting the movements of the birds (ii) redesign the turbines to alter the present pattern/shape/size of the turbines so birds see them more readily and avoid contact or (iii) close down turbines when these birds approach. I suggest further research will show where the harriers and bustards forage and thus turbines can be re-positioned away from the bustard territories and at least 1 km from the breeding areas of the two harriers. On present (limited) evidence the southwest corner of the wind farm around turbines Dkop1, 2, 3, 6 and 7, would require re-positioning. I would also recommend painting one turbine blade either entirely black, or paint it with ultra-violet paint, readily seen by birds day and night.</td></tr>
<tr><td colspan="3">Cumulative impacts:
If resident territorial birds are killed by turbines then other individuals will be pulled in to take up the vacant territory. Thus for Bustards that may reside in the area, the impact may be greater than just around the immediate vicinity of the wind farm.
A local population reduction may occur as a result. Furthermore, if the wind farm is enlarged, or local farming practices (at present just flower picking occurs) change and dams</td></tr>
</table>

are introduced, then the bird community and its movements can change. The present study assumes that the land use here will remain stable and no further dams in particular will be placed near the wind farm.
Residual impacts: After mitigation mortality or area avoidance by the four species may still occur and it may be that further mitigation will be needed.

To summarize, four species of the suite of raptors and wetland birds that may be at risk were identified as particularly at risk given their high presence in the area. These were the Black and African Marsh Harrier, the Jackal Buzzard and especially the collision-prone Denham's Bustard. The probability that they will be affected by the wind farm is sufficient to warrant mitigation measures in all cases, particularly for the Denham's Bustard and the breeding Black Harriers. It is suggested first and foremost that the turbines in the south-west corner will need re-locating (northwards) and all turbines should either be painted such that one blade is black, or is painted with ultra-violet paint that is highly visible to birds. Further monitoring will give better data on the use of different parts of the wind farm by these and other birds. The effects of power lines into the wind farm and the potential impact on the birds of the area is difficult to gauge because the routing is unknown. However, most of the species mentioned above will be at risk, and particularly wetland species will be influenced where the proposed 66kV line crosses wetlands. Bird flappers will be required in such circumstances.

12. Environmental Management Plan

The most important management component of this wind farm is to monitor the use of the habitat by the collision-prone species and those likely to avoid it in future. This can occur during the pre-construction monitoring phase over 12 months. A post-construction monitoring of 12 months should follow this as laid out by the BAWESG guidelines (Jenkins et al. 2011).

Thus the objective would be regular pre-construction monitoring to determine: (i) the presence of all bird species within the footprint of the farm through transect or point counts; (ii) the presence and use of the available habitats by all larger species that are more collision prone; and (iii) the breeding of all species within the footprint of the wind farm.

Each of these variables should then be compared with similar counts from a matched-pair *control* area that is similar in (a) fire history (b) vegetation type (c) aspect (d) altitude and (e) rainfall. This necessitates that the controls are close enough that the fire and rainfall regimes do not change but are far enough that they do not include individual birds from the wind farm area. These principles follow those recommended by BAWESG (Jenkins et al. 2011).

Where larger species are concerned, the closest breeding or resident pairs to the ones under observation at the wind farm site may be sufficient to monitor as a control given that they are unlikely to occur in closely matched habitat in close proximity to the wind farm site.

These monitoring activities should take place at regular intervals over a 12 month pre-construction period. Typical periods of monitoring have occurred every second month for a total of 5 to 6 visits to the sites per year for a period of 4-6 days each. Exactly the same monitoring protocol should take place for 12 months post-construction. The results of bird densities and breeding activity of the larger species should be compared between wind farm sites pre- and post- construction and results from the control sites also compared before and after construction. Simultaneously, any direct mortality arising from the wind farms is being assessed by regular morning and evening checks of bird carcasses below the turbines after construction.

These activities should be undertaken by trained birders under the supervision of a qualified ornithologist using set methods as laid out by BAWESG (Jenkins et al. 2011).

13. SUMMARY OF KEY FINDINGS

This report has identified a minimum of 8 red-listed species 40 endemic species and 28 wetland species that occur in and around the proposed wind farm at Walker Bay. The reporting rates and a winter survey to the site revealed 4 species that appear to occur regularly within the boundary of the proposed farm that may thus be impacted negatively: Black Harrier, African Marsh Harrier, Jackal Buzzard and Denham's Bustard. Other species may occur and further pre-construction bird monitoring is required. The south-west corner of the proposed area was used by these species and mitigation measures for the re-position of several turbines is proposed. Quantifying the impacts revealed that all four species need some form of mitigation and especially so for the Denham's Bustard as a highly collision-prone species. It is suggested that these species and the presence of others will require further in-field assessments of their use of the proposed area. But on present evidence, re-positioning some turbines, and painting one turbine blade black or with UV-visible paint will help reduce the impact sufficiently to allow the wind farm to proceed. A 12 month period of pre-construction monitoring of avian populations with appropriate control areas, followed by a 12-month post-construction monitoring phase by trained birders and ornithologists is recommended in the management plan.

14. Acknowledgements

Thanks are due to P.E. Barnard for monitoring help on site and discussions regarding possible impacts, to Phillip and Marieka de Villiers for access to the Groot Vlei farm and information on land use and fire frequency, and Rogier Steensma (manager of Fynbos Valley) for access and additional information.

15. REFERENCES

Acha, A. 1997. Negative impact of wind generators on the Eurasian Griffon *Gyps fulvus* in Tarifa, Spain. *Vulture News* 38:10-18

Anderson, M.D. 2001. The effectiveness of two different marking devices to reduce large terrestrial bird collisions with overhead electricity cables in the eastern Karoo, South Africa. Draft report to Eskom Resources and Strategy Division. Johannesburg. South Africa.

Avian Powerline Interation Committee (APLIC). 1994. Mitigating bird collisions with power lines: the state of the art in 1994. Edison Electric Institute. Washington DC.

Barclay, R.M.R, Baerwald, E.F. & Gruver, J.C. 2007. Variation in bat and bird fatalities at wind energy facilities: assessing the effects of rotor size and tower height. *Canadian Journal of Zoology* 85: 381-387.

Barrios, L. & Rodríguez, A. 2004. Behavioural and environmental correlates of soaring-bird mortality at on-shore wind turbines. *Journal of Applied Ecology* 41: 72-81.

Barnes, K.N. (ed.) 1998. The Important Bird Areas of southern Africa. BirdLife South Africa, Johannesburg.

Barnes, K.N. (ed.) 2000. The Eskom Red Data Book of Birds of South Africa, Lesotho and Swaziland. BirdLife South Africa, Johannesburg.

Bevanger, K. 1994. Bird interactions with utility structures: collision and electrocution, causes and mitigating measures. *Ibis* 136: 412-425.

Bevanger, K. 1995. Estimates and population consequences of Tetraonid mortality caused by collisions with high tension power lines in Norway. *Journal of Applied Ecology* 32: 745-753.

Bevanger, K. 1998. Biological and conservation aspects of bird mortality caused by electric power lines. *Biological Conservation* 86: 67-76.

Colson & associates. 1995. Avian interaction with wind energy facilities: a summary. Prepared for the American Wind Energy Association. Washington DC.

Crockford, N.J. 1992. A review of the possible impacts of wind farms on birds and other wildlife. Joint Nature Conservation Committee. JNCC Report number 27. Peterborough, United Kingdom.

Curry, R.C., & Kerlinger, P. 2000. Avian mitigation plan: Kenetech model wind turbines, Altamont Pass WRA, California. In: Proceedings of the National Avian-Wind Power Planning Meeting III, San Diego California, May 1998.

De Lucas, M., Janss, G.F.E., Whitfield, D.P. & Ferrer, M. 2008. Collision fatality of raptors in wind farms does not depend on raptor abundance. *Journal of Applied Ecology* 45: 1695-1703.

Devereaux, C/L., Denny, M.J.H. & Whittingham, M.J. 2008. Minimal effects of wind turbines on the distribution of wintering farmland birds. *Journal of Applied Ecology* 45: 1689-1694.

Drewitt, A.L. & Langston, R.H.W. 2006. Assessing the impacts of wind farms on birds. *Ibis* 148: 29-42.

Drewitt, A.L. & Langston, R.H.W. 2008. Collision effects of wind-power generators and other obstacles on birds. *Annals of the New York Academy of Science* 1134: 233-266.

Erickson, W.P., Johnson, G.D., Strickland, M.D., Young, D.P., Sernka, K.J., Good, R.E. 2001. Avian collisions with wind turbines: a summary of existing studies and comparison to other sources of avian collision mortality in the United States. National Wind Co-ordinating Committee Resource Document.

Everaert, J. 2003. Wind turbines and birds in Flanders: Preliminary study results and recommendations. *Natuur. Oriolus* 69: 145-155.

Gill, J.P., Townsley, M. & Mudge, G.P. 1996. Review of the impact of wind farms and other aerial structures upon birds. *Scottish Natural Heritage Review* 21.

Hanowski, J.M., & Hawrot, R.Y. 2000. Avian issues in development of wind energy in western Minnesota. In Proceedings of the National Avian-Wind Power Planning Meeting III, San Diego California, May 1998.

Harrison, J.A., Allan, D.G., Underhill, L.G., Herremans, M., Tree, A.J., Parker, V & Brown, C.J. (eds). 1997. The atlas of southern African birds. Vol. 1&2. BirdLife South Africa, Johannesburg.

Hockey, P.A.R., Dean, W.R.J., Ryan, P.G. (Eds) 2005. Roberts – Birds of Southern Africa, VIIth ed. The Trustees of the John Voelcker Bird Book Fund, Cape Town.

Hodos, W. 2002. Minimization of motion smear: Reducing avian collisions with turbines. Unpublished subcontractor report to the National Renewable Energy Laboratory. NREL/SR 500-33249.

Howell, J.A. 1995. Avian mortality at rotor sweep areas equivalents Altamont Pass and Montezuma Hills, California. Prepared for Kenetech Wind Power, San Francisco, California.

Janss, G. 2000a. Bird behaviour in and near a wind farm at Tarifa, Spain: Management considerations. In: Proceedings of National Avian-Wind Power Planning Meeting III, San Diego California, May 1998.

Janss, G.F.E. 2000b. Avian mortality from power lines: a morphologic approach of a species-specific mortality. *Biological Conservation* 95: 353-359.

Jaroslow, B. 1979. A review of factors involved in bird-tower kills, and mitigation procedures. In: G.A. Swanson (Tech co-ord). The Mitigation symposium. A national workshop on mitigation losses of Fish and Wildlife Habitats. US Forest Service General Technical Report. RM-65.

Jenkins, A.R. 2001. The potential impact of a demonstration wind farm facility on the birds of the Darling / Yzerfontein area, Western Cape Province, South Africa. Unpublished report to the Environmental Evaluation Unit, University of Cape Town, Cape Town.

Jenkins, A.R. 2003. Populations and movements of priority bird species in the vicinity of the proposed Darling Demonstration Wind Farm facility. Unpublished report to the Environmental Evaluation Unit, University of Cape Town, Cape Town.

Jenkins, A.R. 2008. Eskom generation wind energy facility – Western Cape: Avifaunal impact assessment. Report to Savannah Environmental PTY (Ltd).

Jenkins, A.R. 2009. Hopefield wind energy facility: avifaunal impact assessment. Report to Savannah Environmental PTY (Ltd).

Jenkins, A.R. van Rooyen CS, Smallie JJ, Anderson, MD, Smit H. 2011. Best practice guidelines for avian monitoring and impact mitigationat proposed wind energy development sites in southern Africa. EWT and Birdlife South Africa, Johannesburg.

Jenkins, A.R., Smallie, J.J. & Diamond, M. In press. South African perspectives on a global search for ways to prevent avian collisions with overhead lines. *Bird Conservation International*.

Jordan M, Smallie J. 2010. A briefing document on best practices for pre-construction assessment of the impacts of on-shore wind farms on birds. EWT, Johanneburg,

Kemper, C.A. 1964. A tower for TV: 30 000 dead birds. *Audubon Magazine* 66: 86-90.

Kerlinger, P. & Dowdell, J. 2003. Breeding bird survey for the Flat Rock wind power project, Lewis County, New York. Prepared for Atlantic Renewable Energy Corporation.

King, D.I. & Byers, B.E. 2002. An evaluation of powerline rights-of-way as habitat for early-successional shrubland birds. *Wildlife Society Bulletin* 30: 868-874.

Kingsley, A. & Whittam, B. 2005. Wind turbines and birds – A background review for environmental assessment. Unpublished report for Environment Canada/Canadina Wildlife Service.

Küyler, E.J. 2004. The impact of the Eskom Wind Energy Demonstration Facility on local avifauna – Results from the monitoring programme for the time period June 2003 to Jan 2004. Unpublished report to Eskom Peaking Generation.

Kuvlevsky, W.P. Jnr, Brennan, L.A., Morrison, M.L., Boydston, K.K., Ballard, B.M. & Bryant, F.C. 2007. Wind energy development and wildlife conservation: challenges and opportunities. *Journal of Wildlife Management* 71: 2487-2498.

Larsen, J.K. & Guillemette, M. 2007. Effects of wind turbines on flight behaviour of wintering common eiders: implications for habitat use and collision risk. *Journal of Applied Ecology* 44: 516-522.

Lehman, R.N., Kennedy, P.L. & Savidge, J.A. 2007. The state of the art in raptor electrocution research: a global review. *Biological Conservation* 136: 159-174.

Madders, M. & Whitfield, D.P. 2006. Upland raptors and the assessment of wind farms impacts. *Ibis* 148: 43-56.

McIsaac, H.P. 2001. Raptor acuity and wind turbine blade conspicuity. Pp. 59-87. National Avian-Wind Power Planning Meeting IV, Proceedings. Prepared by Resolve, Inc., Washington DC.

Mucina. L. & Rutherford, M.C. (Eds) 2006. The vegetation of South Africa, Lesotho and Swaziland. *Strelitzia* 19. South African National Biodiversity Institute, Pretoria.

National Wind Co-ordinating Committee. 2004. Wind turbine interactions with birds and bats: A summary of research results and remaining questions. Fact Sheet Second Edition.

Nygard et al. 2010. A study of White-tailed Eagle *Haliaeetus albicilla* movements and mortality at a windfarm in Norway. BOU Proceeding – Climnate Change and birds, http://www.bou.org.uk/bouproc-net/ccb/nygard-etal.pdf

Pierce-Higgins, J.W., Stephen, L., Langston, R.H.W., Bainbridge, I.P. & Bullman, R. 2009. The distribution of breeding birds around upland wind farms. *Journal of Applied Ecology*, Published Online, September 24, 2009.

Richardson, W.J. 2000. Bird migration and wind turbines: Migration timing, flight behaviour and collision risk. In Proceedings of the National Avian-wind Power Planning Meeting III, San Diego, California, May 1998.

Shaw, J., Jenkins, A.R. Smallie JJ & Ryan, P.G. 2010. Modelling collision risk for the Blue Crane Anthropoides paradiseus in South Africa. Ibis 152:590-599.

Simmons RE, Barnard P, Dean WRJ, Midgley GF, Thuiller W, Hughes G. 2004. Climate change and birds: perspectives and prospects from southern africa. *Ostrich* 75: 295-308.

Simmons RE. 2005. Black Harrier. In: Hockey, P.A.R., Dean, W.R.J., Ryan, P.G. (Eds) 2005. Roberts – Birds of Southern Africa, VIIth ed. The Trustees of the John Voelcker Bird Book Fund, Cape Town.

Simmons RE 2011. Greater Kestrel survives impact with powerlines. Ostrich 8: ** -**.

Simmons, RE. Retief K, van Beuningen, D. in press. Jackal Buzzards and other birds at a wind farm environment in South Africa. Gabar

Stewart, G.B., Pullin, A.S. & Coles, C.F. 2007. Poor evidence-base for assessment of wind farm impacts on birds. *Environmental Conservation* 34: 1-11.

Smallwood, K.S. & Thelander, C. 2008. Bird mortality in the Altamont Pass Wind Resource Area, California. *Journal of Wildlife Management* 72: 215-223.

Smallwood, K.S., Rugge, L. & Morrison, M.L. 2009. Influence of behavior on bird mortality in wind energy developments. *Journal of Wildlife Management* 73: 1082-1098.

Van Rooyen, C. 2001. Bird Impact Assessment Study – Eskom Wind Energy Demonstration Facility, Western Cape South Africa. Prepared for Eskom Enterprises, TSI Division.

Van Rooyen, C.S. 2004a. The Management of Wildlife Interactions with overhead lines. In The fundamentals and practice of Overhead Line Maintenance (132kV and above), pp217-245. Eskom Technology, Services International, Johannesburg.

Van Rooyen, C.S. 2004b. Investigations into vulture electrocutions on the Edwardsdam-Mareetsane 88kV feeder, Unpublished report, Endangered Wildlife Trust, Johannesburg.

Walker D, McGrady M, McCluskie A, Madders M, McLeod, DRA. 2005. Resident Golden Eagle ranging behaviour before and after construction of a windfarm in Argyll [Scotland]. Scottish Birds 25: 24-40.

Weir, R. D. 1976. Annotated bibliography of bird kills at manmade obstacles: a review of the state of the art and solutions. Canadian Wildlife Services, Ontario Region, Ottawa.

Winkelman, J.E. 1995. Bird/wind turbine investigations in Europe. In Proceedings of the National Avian- wind Power Planning Meeting 1994.

Young, D.J., Harrison, J.A., Navarro, R.A., Anderson, M.D. & Colahan, B.D. (eds). 2003. Big birds on farms: Mazda CAR report 1993-2001. Avian Demography Unit, Cape Town.

Appendix 1: Endemic and **red-listed species** and other raptorial or wetland species expected or found in and around the Driekop Wind Energy Facility on the Farm Grootvlei, near Stanford. Drawn from bird atlas data from pentad 3425-1930 (3 cards), the quarter degree square 3419 BC (110 cards from 1987-1992) and our own observations **(in bold)** from July 2011**.** Reporting rate (4th column) refers to the probability that the species will be seen in the area, and is a guide to their relative abundance.

					Habitat			**Susceptibility to**	
Common name	**Scientific name**	**Conservation status**	**Reporting Rate (%)**	**Regional endemicity**	**Natural veld**	**Dams and wetlands**	**Rocky outcrops**	**Collision**	**Disturbance**
Cape Spurfowl	***Pternistes capensis***	**-**	**69%**	**Endemic**	**X**			**Moderate**	**High**
South African Shelduck	*Tadorna cana*	-	1%	Endemic		X		High	-
Cape Shoveler	*Anas smithii*	-	5%	Endemic		X		Moderate	-
Denham's Bustard	***Neotis denhami***	**Vulnerable**	**2%**	**Near-endemic**	**X**			**High**	**Moderate**
Southern Black Korhaan	*Afrotis afra*	-	2%	Endemic	X			High	Moderate
White-backed Mousebird	***Colius colius***	**-**	**1%**	**Endemic**	**X**			**-**	**Moderate**
Cape Vulture	*Gyps coprotheres*	Vulnerable	1%	Endemic	X		X	High	Moderate
Black-shouldered Kite	*Elanus caeruleus*	-	69%		X	X		Moderate	Moderate
Verreaux's Eagle	*Aquila verreauxii*	-	23%		X		X	High	Moderate
Booted Eagle	*Aquila pennatus*	-	2%	Endemic	X		X	High	Moderate
African Fish Eagle	***Hieraetus vocifer***	**-**	**1%**			**X**		**High**	**Moderate**
Gymnogene	*Polyboroides typus*	-	3%		X		X	High	Moderate
African Marsh-Harrier	***Circus ranivorus***	**Vulnerable**	**14%**	**-**		**X**		**High**	**Moderate**
Black Harrier	***Circus maurus***	**Vulnerable***	**15%**	**Endemic**	**X**	**X**		**High**	**Moderate**
Jackal Buzzard	***Buteo rufofuscus***	**-**	**55%**	**Endemic**	**X**		**X**	**Moderate**	**Moderate**
Martial Eagle	*Polemaetus bellicosus*	Vulnerable	7%	-	X			Moderate	Moderate
Secretarybird	*Sagittarius serpentarius*	Near-threatened	7%	-	X			High	Moderate
Lesser Kestrel	*Falco naumanni*	Near-Threatened	2%	-	X			Moderate	-
Rock Kestrel	*Falco rupicolis*	-	43%		X		X	Moderate	-

Lanner Falcon	*Falco biarmicus*	Near-threatened	4%	-	X		X	Moderate	-
White Stork	*Ciconia ciconi*		7%	-	X	X		High	-
White-breasted Cormorant	*Phalacrocorax lucidus*		5%			X		High	
Reed Cormorant	***Phalacrocoraxafricanus***		**33%**			**X**		**Moderate**	
African Darter	*Anhinga rufa*		8%			X		Moderate	
Grey Heron	*Ardea cinerea*		55%			X		Moderate	
Black-headed Heron	***Ardea melano cephala***		**64%**		**X**	**X**		**Moderate**	
Purple Heron	*Ardea purpurea*		1%			X		Moderate	
Little Egret	***Egretta garzatta***		**14%**			**X**		**Moderate**	
Yellow-billed Egret	*Egretta intermedia*		5%			X		Moderate	
Cattle Egret	***Bubulcus ibis***		**71%**		**X**	**X**		**Moderate**	
Black-crowned Night Heron	*Nycticorax nyciticorax*		1%			X		Moderate	
Hamerkop	***Scopus umbretta***		**48%**			**X**		**Moderate**	
African Sacred Ibis	***Threkiornis umbretta***		**12%**		**X**	**X**		**Moderate**	
Hadeda Ibis	***Bostrychia hagedash***		**13%**		**X**	**X**		**Moderate**	
African Spoonbill	***Platalea alba***		**10%**			**X**		**Moderate**	
Egyptian Goose	***Alopochen aegyptiaca***		**80%**		**X**	**X**		**High**	
South African Shelduck	*Tadorna cana*		1%	Endemic		X		High	
Yellow-billed Duck	***Anas undulate***		**45%**			**X**		**High**	
African Black Duck	***Anas sparsa***		**5%**			**X**		**High**	
Cape Teal	***Anas capensis***		**3%**			**X**		**High**	
Hottentot Teal	***Anas hottentota***		**Observed**			**X**		**High**	
Cape Shoveler	***Anas smithii***		**5%**	**Endemic**		**X**		**High**	
Southern Pochard	*Netta erythrophthalma*		1%			X		High	
Spur-winged Goose	***Plectropterusgambensis***		**28%**			**X**		**High**	
Red-billed Teal	***Anas***		**5%**			**X**		**High**	

	erythrorhynca								
Southern Boubou	***Laniarius ferrugineus***	**-**	**38%**	**Endemic**	**X**	**X**		**-**	**Moderate**
Bokmakierie	***Telophorus zeylonus***	**-**	**81%**	**Near-endemic**	**X**			**-**	**Moderate**
Cape Batis	*Batis capensis*	-	38%	Endemic	X			-	Moderate
Cape Bulbul	***Pycnonotus capensis***	**-**	**58%**	**Endemic**	**X**			**-**	**Moderate**
Cape Grassbird	***Sphenoeacus afer***	**-**	**44%**	**Endemic**	**X**			**-**	**Moderate**
Grey-backed Cisticola	***Cisticola subruficapilla***	**-**	**19%**	**Near-endemic**	**X**			**-**	**Moderate**
Karoo Prinia	***Prinia maculosa***	**-**	**65%**	**Endemic**	**X**			**-**	**Moderate**
Cape Long-billed Lark	*Certhilauda curvirostris*	-	6%	Endemic	X				Moderate
Large-billed Lark	***Galerida magnirostris***	**-**	**21%**	**Endemic**	**X**			**-**	**Moderate**
Cape Rock-Thrush	*Monticola rupestris*	-	23%	Endemic	X		X	-	Moderate
Sentinel Rock-Thrush	*Monticola explorator*	-	4%	Endemic	X		X	-	Moderate
Olive Thrush	*Turdus olivaceus*	-	30%	Endemic	X			-	-
Fiscal Flycatcher	***Sigelus silens***	**-**	**61%**	**Endemic**	**X**			**-**	**Moderate**
Karoo Scrub-Robin	*Cercotrichas coryphoeus*	-	18%	Endemic	X			-	Moderate
Cape Robin-Chat	***Cossypha caffra***	**-**	**70%**	**Endemic**	**X**			**-**	**-**
Pied Starling	***Spreo bicolor***	**-**	**93%**	**Endemic**	**X**		**X**	**-**	**Moderate**
Orange-breasted Sunbird	***Nectarinia violacea***	**-**	**55%**	**Endemic**	**X**			**-**	**Moderate**
Southern Double-collared Sunbird	***Cinnyris chalybeus***	**-**	**59%**	**Endemic**	**X**			**-**	**Moderate**
Cape Sugarbird	***Promerops cafer***	**-**	**Recorded**	**Endemic**	**X**			**-**	**Moderate**
Cape Weaver	***Ploceus capensis***	**-**	**79%**	**Endemic**	**X**	**X**		**-**	**Moderate**
Cape White-eye	***Zosterops capensis***	**-**	**65%**	**Endemic**	**X**	**X**		**-**	**-**
Cape Sparrow	*Passer melanurus*	-	69%	Near-endemic	X			-	Moderate

Cape Canary	***Serinus canicollis***	**-**	**77%**	**Endemic**	**X**	**X**		**-**	**Moderate**
Yellow Canary	***Crithagra flaviventris***	**-**	**25%**	**Near-endemic**	**X**			**-**	**Moderate**
White-throated Canary	*Crithagra albogularis*	-	5%	Near-endemic	X			-	Moderate
Cape Siskin	*Crithagra totta*	-	22%	Endemic	X		X	-	Moderate
Cape Bunting	*Emberiza capensis*	-	29%	Near-endemic	X			-	Moderate
Malachite Sunbird	***Nectarinia famosa***		**71%**	**Endemic**	**X**			**-**	**Moderate**
Red-listed species : 8 species, Endemics: 40 species									

Appendix 1: Endemic and **red-listed species** and other raptorial or wetland species expected or found in and around the Driekop Wind Energy Facility on the Farm Grootvlei, near Stanford. Drawn from bird atlas data from pentad 3425-1930 (3 cards), the quarter degree square 3419 BC (110 cards from 1987-1992) and our own observations **(in bold)** from July 2011**.** Reporting rate (4th column) refers to the probability that the species will be seen in the area, and is a guide to their relative abundance.