Bird Impact Assessment Study
Bravo Integration Project: Phase 4

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Executive summary

Eskom obtained environmental authorisation to construct the new 400kV Bravo power station between Bronkhorstspruit and Witbank in 2007. Construction of this power station has already commenced. Since the Bravo power station will aid in the delivery of additional electricity supply, the proposed Bravo Integration Project is necessary to integrate and connect Bravo power station into the existing Eskom electricity network. Part of this process is the proposed construction of two new 400 kV power lines, from the Kendal Power Station (near Ogies) to the Zeus substation (near Secunda), Mpumalanga. These lines will run parallel to each other and will be approximately 90 km in length. Three alternative route corridors have been identified. This report deals with the potential impacts that the proposed lines could have on birdlife.

A number of power line sensitive, Red Data species could potentially occur along any of the corridors in small densities, mostly in the remaining natural grassland. The biggest potential risk that the proposed power line will pose, **unless mitigated**, is bird collisions with the earth wire of the proposed line. Other potential risks are the destruction of sensitive habitat through the construction of access roads, and disturbance of breeding birds during construction operations. The proposed corridors run through very similar habitat, which means that the potential bird impacts are likely to be similar in nature (but not in extent) along all the proposed corridors. The preferred corridor would be one that strives to avoid natural grassland and wetlands, or alternatively, is situated within the zone of influence of factors that lessen the risk of interactions for example close to existing transmission lines or within urban areas. There is reason to believe that the impact of existing power lines may have been a major contributory factor to the low density and/or absence of power line sensitive grassland species such as cranes.

The demarcation of sections that need to be mitigated can only be done once the alignment has been finalized, and **only through a combination of physical inspection of the entire length of the final alignment, and detailed analysis of high resolution satellite imagery.** It is standard procedure by the Eskom Transmission Group to perform this procedure with the help of a suitably experienced ornithologist once the line has been pegged. At that stage, specific spans are demarcated for anti-collision devices, based on a variety of factors (mentioned earlier), and at that stage minor deviations can still be effected. Sensitive sections will include dams, wetlands, drainage crossings and areas of natural grassland.

1 Background

1.1 Project background

The growing demand for electricity is placing increasing pressure on Eskom's existing power generation and transmission capacity. Eskom are committed to implementing a sustainable energy strategy that complements the policies and strategies of national government. Eskom aims to improve the reliability of electricity supply to the country, and in particular to provide for the growth in electricity demand in the Gauteng and Mpumalanga provinces. For this reason, Eskom obtained environmental authorisation to construct the new 400kV Bravo power station between Bronkhorstspruit and Witbank in 2007. Construction of this power station has already commenced.

Since the Bravo power station will aid in the delivery of additional electricity supply, the proposed Bravo Integration Project is necessary to integrate and connect Bravo power station into the existing Eskom electricity network. Part of this process is the proposed construction of two new 400 kV power lines, from the Kendal Power Station (near Ogies) to the Zeus substation (near Secunda), Mpumalanga. These lines will run parallel to each other and will be approximately 90 km in length. Three alternative route corridors have been identified.

Cymbian Enviro-Social Consulting Services was appointed by Eskom Transmission to conduct the necessary environmental impact assessments for the new power line. They appointed Chris van Rooyen Consulting to conduct the investigation into the potential impacts that the line might have on birds.

1.2 Scope of work

The brief for this avian impact report is as follows:

- provide a description of the study area pertaining to the specialist study;
- identify concerns and potential impacts;
- highlight sensitive and possible 'no-go' areas;
- identify a preferred alignment;
- provide an evaluation of the envisaged impacts on sensitive avifauna and
- suggest mitigation measures to reduce the impacts where necessary.

1.3 Description of typical impacts of power lines on birds

Because of their size and prominence, electrical infrastructures constitute an important interface between wildlife and man. Negative interactions between wildlife and electricity structures take many forms, but two common problems in southern Africa are electrocution of birds and other animals and birds colliding with power lines. (Ledger & Annegarn 1981; Ledger 1983; Ledger 1984; Hobbs & Ledger 1986a; Hobbs & Ledger 1986b; Ledger et al. 1992; Verdoorn 1996; Kruger & Van Rooyen 1998; Van Rooyen 1998; Kruger 1999; Van Rooyen 1999; Van Rooyen 2000, Anderson 2001). Other problems are electrical faults caused by bird excreta when roosting or breeding on electricity infrastructure (Van Rooyen *et.al*. 2002), and disturbance and habitat destruction during construction and maintenance activities.

1.3.1 Electrocutions

Large birds of prey are the most commonly electrocuted on power lines. The large transmission lines from 220 kV to the massive 765 kV structures are usually not a threat to large raptors, because the pylons are designed in such a manner that the birds do not perch in close proximity the potentially lethal conductors. In fact, these power lines have proved to be beneficial to birds such as Martial Eagles *Polemaetus bellicosus*, Tawny Eagles *Aquila rapax*, White-backed Vultures *Gyps africanus*, and even occasionally Verreaux's Eagles *Aquila verreauxii* by providing safe nesting and roosting sites in areas where suitable natural alternatives are scarce (pers.obs). Cape Vultures *Gyps coprotheres* have also taken to roosting on power lines in certain areas in large numbers, while Lappet-faced Vultures *Torgos tracheliotis* are increasingly using power lines as roosts, especially in the Northern Cape (pers.obs.).

Unfortunately, the same can not be said of the smaller sub-transmission and reticulation lines of 11kV to 132kV (Van Rooyen 1998; 2000). Raptors and vultures instinctively seek out the highest vantage point as suitable perches from where they scan the surrounding area for prey or carrion. In flat, treeless habitat power pylons often provide ideal vantage points for this purpose. The vast majority of electrical structures were designed and constructed at a time when the awareness of the danger that they pose for raptors was very limited or totally absent. Depending on the design of the pole, a large raptor can potentially touch two live components or a live and earthed component simultaneously, almost inevitably resulting in instant electrocution and a concomitant disruption in the electrical supply (Van Rooyen 1998).

1.3.2 Collisions

Anderson (2001) summarizes collisions as a source of avian mortality as follows:

"The collision of large terrestrial birds with the wires of utility structures, and especially power lines, has been determined to be one of the most important mortality factors for this group of birds in South Africa (Herholdt 1988; Johnsgard 1991; Allan 1997). It is possible that the populations of two southern African endemic bird species, the Ludwig's Bustard *Neotis ludwigii* and Blue Crane *Anthropoides paradiseus*, may be in decline because of this single mortality factor (Anderson 2000; McCann 2000). The Ludwig's Bustard (Anderson 2000) and Blue Crane (McCann 2000) are both listed as "vulnerable" in The Eskom Red Data Book of Birds of South Africa, Lesotho & Swaziland (Barnes 2000) and it has been suggested that power line collisions is one of the factors which is responsible for these birds' present precarious conservation status

Collisions with power lines and especially overhead earth-wires have been documented as a source of mortality for a large number of avian species (e.g. Beaulaurier et al. 1982; Bevanger 1994, 1998). In southern Africa, this problem has until recently received only limited attention. Several studies however have identified bird collisions with power lines as a potentially important mortality factor (for example, Brown & Lawson 1989; Longridge 1989). Ledger *et al.*(1993), Ledger (1994) and Van Rooyen & Ledger (1999) have provided overviews of bird interactions with power lines in South Africa. Bird collisions in this country have been mainly limited to Greater and Lesser Flamingos, various species of waterbirds (ducks, geese, and waders), Stanley's *Neotis denhami* and Ludwig's Bustards, White Storks *Ciconia ciconia*, and Wattled *Grus carunculatus*, Grey Crowned *Balearica regulorum* and Blue Cranes (for example, Jarvis 1974; Johnson 1984; Hobbs 1987; Longridge 1989; Van Rooyen & Ledger (1999)). Certain groups of birds are more susceptible to collisions, namely the species which are slow fliers and which have limited maneuverability (as a result of high wing loading) (Bevanger 1994). Birds which regularly fly between roosting and feeding grounds, undertake regular migratory or nomadic movements, fly in flocks, or fly during low-light conditions are also vulnerable. Other factors which can influence collision frequency include the age of the bird (younger birds are less experienced fliers), weather factors (decreased visibility, strong winds, etc.), terrain characteristics and power line placement (lines that cross the flight paths of birds), power line configuration (the larger structures are more hazardous [for collisions, with electrocutions the opposite is the case]), human activity (which may cause birds to panic and fly into the overhead lines), and familiarity of the birds with the area (therefore nomadic Ludwig's Bustards would be more susceptible) (Anderson 1978; APLIC 1994).

Although collision mortality rarely affects healthy populations with good reproductive success, collisions can be biologically significant to local populations (Beer & Ogilvie 1972) and endangered species (Thompson 1978; Faanes 1987). The loss of hundreds of Northern Black Korhaans *Eupodotis afraoides* due to power line collisions would probably not affect the success of the total population of this species and would probably not be biologically significant, but if one Wattled Crane was killed due to a collision, that event could have an effect on the population that would be considered biologically significant. Biological significance is an important factor that should be considered when prioritising mitigation measures. Biological significance is the effect of collision mortality upon a bird population's ability to sustain or increase its numbers locally and throughout the range of the species."

Unfortunately, many of the species that are collision sensitive are considered as threatened in southern Africa. Of the five species most affected by transmission line collisions (Van Rooyen 2006) namely the Blue Crane, White Stork, Greater Flamingo *Phoenicopterus ruber*, Ludwig's Bustard and Cape Vulture, three are potentially present in this study area. It should be noted that these statistics are based on reported mortalities only; it is suspected that a big number of mortalities go unreported. In one instance, where bi-monthly monitoring did take place, a single 10km section of 132kV distribution line killed 59 Blue Cranes, 29 Ludwig's Bustard, and 13 White Storks during a three year period. In 2004, fifty-four Blue Crane carcasses were discovered near Graaf-Reinet in the Northern Cape province under 3.7km of distribution line (Van Rooyen unpubl. data).

The Red Data species that are vulnerable to power line collisions are often long-lived, slow reproducing species under natural conditions. Some require very specific conditions for breeding, resulting in very few successful breeding attempts, or breeding might be restricted to very small areas. A good example of this is the two flamingo species that occur in southern Africa, which have hardly had any successful breeding attempts at Etosha Pan in Namibia for several decades. Another example is the Great White Pelican *Pelecanus onocrotalus* that only breeds successfully at Dassen Island in the Western Cape. These types of species (which include the Blue Crane, which is potentially present in the study area) have not evolved to cope with high adult mortality, with the results that consistent high adult mortality over an extensive period could have a serious effect on a population's ability to sustain itself in the long or even medium term. Many of the anthropogenic threats to these species are non-discriminatory as far as age is concerned (e.g. habitat destruction, poisonings, disturbance and power lines) and therefore contribute to adult mortality, and it is not known what the cumulative effect of these impacts could be over the long term.

From the figures quoted above, it is clear that power lines can be a major cause of avian mortality among power line sensitive species, especially Red Data species. Furthermore, the cumulative effects of power lines and other sources of unnatural mortality might only manifest itself decades later, when it might be too late to reverse the trend. It is therefore imperative to reduce any form of unnatural mortality in these species, regardless of how insignificant it might seem at present, especially in the case of regionally threatened species such as the Blue Crane in the present study area.

1.3.3 Habitat destruction

During the construction phase and maintenance of power lines, some habitat destruction and alteration inevitably takes place. This happens with the construction of access roads, and the clearing of servitudes. Servitudes have to be cleared of excess vegetation at regular intervals in order to allow access to the line for maintenance, to prevent vegetation from intruding into the legally prescribed clearance gap between the ground and the conductors and to minimize the risk of fire under the line which can result in electrical flashovers. These activities could have an impact on birds breeding, foraging and roosting in or in close proximity of the servitude, through destruction of habitat

1.3.4 Disturbance

The construction of a power line can be highly disturbing to birds breeding in the vicinity of the construction activities. Many birds are highly susceptible to disturbance, and should this disturbance take place during a critical time in the breeding cycle, for example when the eggs have not hatched or just prior to the chick fledging, it could lead to temporary or permanent abandonment of the nest or premature fledging. In both instances, the consequences are almost invariably fatal for the eggs or the fledgling. Such a sequence of events can have far reaching implications for certain large, rare species that only breed once a year or once every two years.

1.4 Bird habitats in the study area

The study area falls in the following quarter degree squares (1:50 000 map units):

- 2628BB
- 2628BD
- 2628DB
- 2629AC
- 2629CA

Table 1 below indicates how the quarter degree squares are divided in vegetation types, according to the classification of Harrison *et al* (1997) in the Atlas of Southern African Birds (the Bird Atlas). It is widely accepted that vegetation structure, rather than the actual plant species, influences bird species' distribution and abundance. Therefore, the vegetation description used in the Bird Atlas does not focus on lists of plant species, but rather on factors which are relevant to bird distribution. It is important to note that no new boundaries were created and use was made only of previously published data.

Table 1: Vegetation types in the study area (Harrison *et al* 1997)

Name	Sour Grasslands %	Mixed Grasslands%
2628BB	58	42
2628BD	1	99
2628DB		100
2629AC	3	97
2629CA		100

The dominant plants in the grassland biome are grass species, with geophytes and herbs also well represented. Grasslands are maintained mainly by a combination of the following factors: relatively high summer rainfall; frequent fires; frost and grazing. These factors generally preclude the growth of trees and shrubs. This biome has been largely transformed through various land uses such as forestry and crop cultivation. **Sour grassland** generally occurs in the higher rainfall areas on leached soils and forms the dominant vegetation type in the study area. Many grassland bird species show a preference for sour grassland over sweet or mixed grasslands. **Sweet grassland** is generally found in the lower rainfall areas. Vegetation is taller and sparser, and nutrients are retained in the leaves during winter. **Mixed grassland** represents a transition between sour and sweet grassland and contains characteristics of both.

The grassland biome is very important from a Red Data perspective, as it is the preferred habitat of several grassland "specialists" birds (see discussion below). It has also been transformed to a large degree by intensive cultivation, which has placed it (and the species dependant on it) under severe pressure.

Although much of the distribution and location of bird species within the study area can be explained by vegetation as discussed briefly above, it is necessary to look more closely at the habitats available to birds, namely the microhabitats, in order to determine where the relevant species will most likely occur within the study area. These microhabitats do not always correspond to vegetation types and are determined by a combination of vegetation type, topography, land use, food sources and other factors.

The following distinct bird microhabitats were identified in the study area during field visits in December 2008 (see APPENDIX A for examples of the microhabitats):

- Wetlands: The study area contains many wetlands, often associated with drainage lines. Amongst large terrestrial birds it is especially the three cranes species that depend on shallow, vegetated wetlands that are unpolluted and not excessively disturbed by live-stock and fire. When wetlands are made deeper by dredging or the construction of weirs (as is often the case in the study area), or made shallower by the digging of drainage ditches or infilling, their ecological functions are disrupted (Young *et.al.* 2003). Many of the wetlands and watercourses in the study area have been modified to such an extent that they will not be suitable for cranes anymore. The data from the Co-ordinated Road Count project (CAR) of the Avian Demography Unit shows that the wetlands in the Mpumalanga highveld are extensively used by Spurwing Goose *Plectropterus gambensis*, Black-headed Heron A*rdea melanocephala* and Grey Crowned Crane *Balearica regulorum*. All three species of cranes have been recorded in the study area, but the Grey Crowned Crane and Wattled Crane *Bugeranus carunculatus* now only occur as vagrants, and the Blue Crane *Anthropoides paradiseus* is fast approaching the same status. The reasons for their vagrant status are not only the extensive habitat modification, but also because of disturbance and the proliferation of power lines which no doubt have taken their toll on birds over the years. However, some of the wetlands, including modified ones, are still suitable for other species such as various species of ducks, cormorants, as well as Red Data species such as African Marsh-harriers *Circus ranivorus* and African Grass-owl *Tyto capensis*.
- Water bodies: This habitat is represented in the study area mostly by man-made impoundments. The largest among the dams is Leeuwpan, which is an important refuge for waterbirds. Leeuwpan is a large dam with fringing reeds and sedges, and open shoreline. The dam provides refuge to a large variety of waterbirds, which include Black-necked Grebe Podiceps *nigricollis*, Hadeda Ibis Bostrychia *hagedash*, Whitefaced Duck *Dendrocygna viduata*, Egyptian Goose *Alopochen aegyptiacus*, Spur-winged Goose *Plectropterus gambensis*, Yellowbilled Duck *Anas undulate*, Red-billed Teal *Anas erythrorhyncha*, Redknobbed Coot *Fulica cristata*, Southern Pochard *Netta erythrophthalma*, Great Crested Grebe *Podiceps cristatus*, Cape Teal *Anas capensis*, African Darter *Anhinga rufa*, Glossy Ibis *Plegadis falcinellus* and many waders and cormorants. The dam is also important for Red Data species with both species of flamingo, Yellow-billed Stork *Mycteria ibis*, Greater Painted-snipe *Rostratula benghalensis*, Caspian Tern *Sterna caspia* and African Marsh-harrier *Circus ranivorus* recorded on occasion (CWAC 2008). All the dams in the study area could potentially offer refuge to the most of the species listed above depending on water levels and shoreline vegetation. Existing power lines are a major threat at many of the dams; the Cymbian project team discovered the carcasses of 12 Lesser Flamingos *Phoenicopterus minor* under the Kendal-Tutuka 400kV transmission line, directly opposite Leeuwpan.
- Agriculture: The study area has been extensively transformed through dryland cultivation, especially in the northern part of the study area. The farm land in the study area is used for a variety of mixed farming practices. Grazing is developed in parallel with crop farming. The highveld has summer rainfall; therefore intensive crop farming is practiced on a wide scale. Some of the maize lands are bordered by tracts of grassland ideal for grazing. Extensive areas

stand under stubble during the winter and provide alternative grazing (Young *et.al.* 2003). Data from the CAR project indicates that agricultural land is used to a limited extent by large terrestrial birds in the Mpumalanga highveld, as they prefer natural grassland. Fallow fields are used to a limited extent by Blue Cranes in summer, and pastures are used by Southern Bald Ibis *Geronticus calvus.* Blue Cranes also use recently ploughed fields in winter (Young *et.al.* 2003). Indications are that Blue Korhaan *Eupodotis caerulescens* may also utilise agricultural fields to a limited extent (Young *et.al* 2003). All of these species have been recorded in the study area.

- Grassland: Some areas of untransformed natural grassland have remained in the study area, as well as abandoned lands that have reverted back to grassland. The CAR data indicate that natural grassland remains the preferred habitat of large terrestrial birds in the Mpumalanga highveld (Young *et.al*. 2003). Generally reporting rates for large terrestrial grassland species such as Blue Crane and Denham's Bustard *Neotos denhami* are low, which could be the result of the extensive fragmentation of natural grassland by agriculture, opencast mining and associated infrastructure, particularly power lines and roads. On the other hand, several typical Red Data grassland species were recorded including White-bellied Korhaan *Eupodotis senegalensis*, Secretarybird *Sagittarius serpentarius*, Pallid Harrier *Circus macrourus,* Lesser Kestrel *Falco naumanni*, Black Harrier *Circus maurus,* Botha's Lark *Spizocorys fringillaris* and Melodious Lark *Mirafra cheniana*. In those quarter degree squares where large pockets of unfragmented grassland survive e.g. 2628DB, reporting rates for grassland species are generally higher. The impact of existing power lines in natural grassland areas was again noted when the Cymbian project team discovered a dead Secretarybird *Sagittarius serpentarius* under the Kendal-Tutuka 400kV line, killed after it presumably collided with the earth wire.

2 Power line sensitive bird species

Generally speaking, it is unavoidable that birds get killed through interaction with electricity infrastructure, including power lines, despite the best possible mitigation measures. It is therefore important to direct risk assessments and mitigation efforts towards species that have a high biological significance, in order to achieve maximum results with the available resources at hand.

In accordance with this principle, the risk assessment is primarily aimed at assessing the potential threat to Red Data species (see the concept of biological significance under 1.3.2). It is important to note that non Red Data species will also benefit from the proposed mitigation measures, as they share the habitat and run the same risks as the Red Data species.

The methodology that was used to evaluate impacts in the current study was as follows:

- The Bird Atlas (Harrison *et.al.* 1997) species lists for the relevant quarter degree squares within which the study area is located were obtained from the SANBI website (http://www.birds.sanbi.org). This information was supplemented with information from the CAR Project, as well as the Co-ordinated Waterbird Counts Project (CWAC).
- The study area was inspected with a vehicle and on foot to obtain first-hand perspectives of the proposed alternatives, birdlife and bird habitats.
- A combination of high resolution Google Earth satellite imagery and CSIR Land Cover data was used to delineate the different sensitivity zones in the study area for purposes of rating the different corridor options.
- The impacts were evaluated on the basis of experience by the author in gathering and analysing data on wildlife impacts with power lines throughout southern Africa since 1996 (see van Rooyen & Ledger 1999 for an overview of methodology), supplemented with first hand data obtained during the field visits.

The Red Data bird species that were recorded by the Bird Atlas project in the relevant quarter degree squares are listed in Table 2 below. The five squares were quite well surveyed during the Bird Atlas period with a combined total of 608 cards completed. The reporting rates are an indication of densities on the ground – the number in the reporting rate column in Table 2 below represents the percentage of cards on which a species was recorded. With a few exceptions the reporting rates for Red Data species were generally low, indicating that the impacts on the habitat have been extensive, reducing many of the species to the status of vagrants. Those species that could interact with the proposed power line is shaded in grey.

Table 2: Red Data species (Harrison *et.al* 1997)

Species	**Reporting rate %**	**Conservation status (Barnes 2000)**	**Habitat requirements (Barnes 2000; Hockey *et al* 2005; Harrison *et al* 1997; Young *et al* 2003; personal observations)**
YELLOW-BILLED STORK *Mycteria ibis*	2628BB:7.4 2628BD:2.7 2628DB:8.7 2629AC:4.1 2629CA:4.0	near threatened	Always associated with water – dams, wetlands, rivers, marshes, even small pools. Could be present at larger water bodies e.g. Leeuwpan. **Vulnerable to collisions.**
PINK-BACKED PELICAN	2628BB:- 2628BD:- 2628DB:- 2629AC:- 2629CA:1.3	vulnerable	Always associated with large water bodies. Could be present at larger water bodies e.g. Leeuwpan. **Vulnerable to collisions.**
LANNER FALCON *Falco biarmicus*	2628BB:- 2628BD:1.8 2628DB:1.1 2629AC:1.4 2629CA:0.7	near threatened	Generally prefers open habitat, but exploits a wide range of habitats. Will nest in wooded areas if suitable cliffs are present. **No negative interaction expected,** except possible breeding on crow nests on the proposed lines.
WATTLED CRANE *Bugeranus carunculatus*	2628BB:- 2628BD:- 2628DB:1.1 2629AC:- 2629CA:-	critically endangered	Shallow wetlands with extensive short emergent vegetation. To a lesser degree in natural grassland and croplands. No suitable habitat along the alignment. Vagrant to the area.
BLUE KORHAAN *Eupodotis caerulescens*	2628BB:1.9 2628BD:10.8 2628DB:14.1 2629AC:- 2629CA:12.7	near threatened	Grasslands, pastures and cultivated fields. **Vulnerable to collisions**.
GREATER PAINTED SNIPE *Rostratula benghalensis*	Not recorded by Bird Atlas but recorded by CWAC	near threatened	Various aquatic habitats, preferring exposed mud adjacent to cover. Recorded at Leeuwpan. No interactions expected.
BLACK-WINGED PRATINCOLE *Glareola nordmanni*	2628BB:3.7 2628BD:3.6 2628DB:1.1 2629AC:2.0 2629CA:3.3	near threatened	Agricultural landscapes, ploughed lands. No interactions expected.

MELODIOUS LARK *Mirafra cheniana*	2628BB:- 2628BD:- 2628DB:1.1 2629AC:- 2629CA:-	near threatened	Open climax *Themeda* grassland, pastures and fallow lands. **Vulnerable to habitat destruction and disturbance.**
BLACK STORK *Ciconia nigra*	2628BB:- 2628BD:- 2628DB:- 2629AC:- 2629CA:1.3	near threatened	Associated with rivers, dams and cliffs. Could be present at larger water bodies e.g. Leeuwpan. **Vulnerable to collisions.**
SECRETARYBIRD *Sagittarius serpentarius*	2628BB:5.6 2628BD:6.3 2628DB:10.9 2629AC:6.1 2629CA:7.3	near threatened	Prefer open grassland, densities low in maize growing areas. Was recorded during field visits in the study area. **Vulnerable to collisions**.
WHITE-BELLIED KORHAAN *Eupodotis senegalensis*	2628BB:3.7 2628BD:1.8 2628DB:5.4 2629AC:- 2629CA:0.7	vulnerable	Often in the interface between grassland and savanna. Avoids severely grazed and recently burnt sites. **Vulnerable to collisions**.
LESSER FLAMINGO *Phoenicopterus minor*	2628BB:0.9 2628BD:0.9 2628DB:5.4 2629AC:0.7 2629CA:7.3	near threatened	Moves extensively between water bodies. May be found in small numbers on any suitable dam. **Vulnerable to collisions.**
GREATER FLAMINGO *Phoenicopterus ruber*	2628BB:2.8 2628BD:2.7 2628DB:21.7 2629AC:5.4 2629CA:17.3	near threatened	Moves extensively between water bodies. May be found in small numbers on any suitable dam. **Vulnerable to collisions.**
LESSER KESTREL *Falco naumanni*	2628BB:11.1 2628BD:9.9 2628DB:8.7 2629AC:10.2 2629CA:10.0	vulnerable	**No negative impacts expected from power line.** Small and nimble species, likely to use the power line as hunting perch.
AFRICAN GRASS-OWL *Tyto capensis*	2628BB:- 2628BD:1.8 2628DB:1.1 2629AC:- 2629CA:2.0	vulnerable	Likely to be found in rank grass adjacent to wetlands. **Could be vulnerable to collisions with power line** as potentially suitable habitat could exist in wetlands**. Also vulnerable to habitat destruction.**
BLUE CRANE *Anthropoides paradiseus*	2628BB:0.9 2628BD:14.4 2628DB:39.1 2629AC:- 2629CA:3.3	vulnerable	Low reporting rate but can be present in the pockets of remaining grassland and wetlands. **Vulnerable to collisions**.

CASPIAN TERN *Sterna caspia*	2628BB:- 2628BD:- 2628DB:3.3 2629AC:1.4 2629CA:1.3	near threatened	Estuaries and large inland water bodies. No negative interactions expected.
AFRICAN MARSH-HARRIER *Circus ranivorus*	2628BB:0.9 2628BD:9.9 2628DB:- 2629AC:2.7 2629CA:1.3	vulnerable	Large permanent wetlands with dense reed beds. Sometimes forages in smaller wetlands and adjacent grassland. **Could be vulnerable to collisions with power line** as potentially suitable habitat could exist in wetlands**. Also vulnerable to habitat destruction.**
BLACK HARRIER *Circus maurus*	2628BB:- 2628BD:- 2628DB:- 2629AC:4.1 2629CA:4.0	near threatened	Dry grassland and rarely in agricultural fields. **Vulnerable to collisions with power lines.**
PALLID HARRIER *Circus macrourus*	2628BB:- 2628BD:- 2628DB:1.1 2629AC:0.7 2629CA:-	near threatened	Grasslands associated with open pans and floodplains. **Vulnerable to collisions with power lines.**
BOTHA'S LARK *Spizocorys fringillaris*	2628BB:- 2628BD:- 2628DB:- 2629AC:2.0 2629CA:0.7	endangered	Prefers short grass, such as heavily grazed grassland in upland areas. No negative interactions expected. **Vulnerable to habitat destruction and disturbance.**
CHESTNUT-BANDED PLOVER *Charadrius pallidus*	2628BB:2.8 2628BD:- 2628DB:- 2629AC:- 2629CA:-	near threatened	Found primarily in salt pans. No negative interactions expected.
DENHAM'S BUSTARD *Neotis denhami*	2628BB:- 2628BD:0.9 2628DB:- 2629AC:- 2629CA:-	vulnerable	In the grassland biome it favours sour grassland in high rainfall areas. Vagrant to the area, no negative interactions expected.
SOUTHERN BALD IBIS *Geronticus calvus*	2628BB:- 2628BD:1.8 2628DB:- 2629AC:2.0 2629CA:-	vulnerable	Likely to be found on recently burnt ground and unburnt, short-grazed grassland, cultivated pastures, reaped maize fields and ploughed lands. **Vulnerable to collision with power lines.**
GREY CROWNED CRANE *Balearica regulorum*	2628BB:- 2628BD:- 2628DB:1.1 2629AC:- 2629CA:-	vulnerable	Breeds in marshes, pans, and dam margins with tall emergent vegetation. Feeds in adjacent short grasslands and croplands. **Vulnerable to collision with power lines.**

3 Discussion

3.1 Electrocutions

Fortunately, the electrocution risk on the future 400kV power lines is non-existent, due to the large clearances between the phases and the earthed components on the structures. No bird is able to bridge those clearances with its body parts; therefore no electrocution risk is present.

3.2 Collisions

The most severe potential impact that the proposed line will have is bird collisions with the overhead earth wire. This impact will most likely occur close to wetlands, where the line skirts a dam, where it crosses a drainage line and in areas of natural grassland.

Species at risk are water birds of several species, including Red Data species such as flamingos where it skirts larger dams, particularly Leeuwpan, where flamingo collisions have been recorded (see 1.4 above). Collision hazards also exist where the line will cross pockets of natural grassland, as this is the preferred habitat of most of the remaining large terrestrial Red Data species, including the Blue Crane, Blue Korhaan, White-bellied Korhaan and Secretarybird in the Mpumalanga highveld. As mentioned earlier, the impacts on grassland and wetlands that are evident in the study area have been severe, reducing most Red Data, large terrestrial species to vagrants. The dense grid of existing power lines that covers the whole study area is a death trap for cranes, and the impact of these lines on the remaining Blue Cranes in the area can only be guessed at. Large areas of what seems to be suitable grassland remain the study area, yet they are devoid of any cranes. Given the extreme vulnerability of cranes to power lines, there is no question that the power lines must have effectively sterilized large areas for these birds. There are, however, substantial numbers of non Red Data power line sensitive species in the study area that have managed to survive and even thrive in some instances despite the habitat degradation that have occurred. In some instances, man-made developments such as the proliferation of artificial water bodies have benefited certain species. Examples are Red-knobbed Coot, Reed Cormorant *Phalacrocorax africanus*, Egyptian Goose, White-breasted Cormorant *Phalacrocorax lucidus*, Black-headed Heron *Ardea melanocephala*, Grey Heron *Ardea cinerea* and Yellow-billed Duck (Harrison *et.al* 1997). These species (and many other non Red Data ducks, herons and waders) run the risk of collision with the proposed power lines.

3.3 Habitat destruction

A limited degree of habitat destruction always takes place when a power line is constructed. In this instance large sections of the study area have already been intensively transformed through agriculture and industrial development, which has destroyed a significant portion of the original habitat. However, there are wetlands and pockets of grassland in the study area that could be damaged (or further damaged) in the course of construction activities, which could in turn impact on birds using these habitats. An example of Red Data species that could be impacted through the destruction of habitat is the African Grass-Owl, African Marsh-harrier and Grey Crowned Crane, which is dependent on rank grassland on the fringes of wetlands and/or the wetlands themselves, which might be damaged if roads are constructed in wetlands during the construction of the power line.

3.4 Disturbance

Disturbance of breeding birds in the natural grassland during construction operations is a distinct possibility. This could have an impact on Red Data species such as Blue Crane, Blue Korhaan, White-bellied Korhaan, Botha's Lark and Melodious Lark. Such disturbance would be most harmful in summer which is the breeding season for the majority of birds. Fortunately, such disturbance as would take place is likely to be temporary and should cease after the construction of the line.

4 Identifying a preferred corridor

One of the objectives of this study is to arrive at a preferred corridor for the proposed power line in terms of impacts on avifauna. In order to achieve this, a formula was designed to assist in the identification of a preferred corridor. The following factors were incorporated in the formula to arrive at a preferred corridor, using high resolution Google Earth satellite imagery as the main source of data:

- Wetlands and dams: Wetlands and dams are always of particular importance for birds. The presence of wetlands and dams are an indicator of a higher collision risk.
- Drainage lines: The study area contains several small drainage lines. These drainage lines are obviously important for birds and many water bird species occur along these drainage lines. Drainage lines are therefore an indication of a higher collision risk.
- Transmission lines: It is a proven fact that the placement of a new line next to an existing line reduces the risk of collisions to birds. The reason for this is two-fold namely it creates a more visible obstacle to birds and the resident birds, particularly breeding adults, are used to an obstacle in that geographic location and have learnt to avoid it (APLIC 1994; Sundar & Choudhury 2005). Other transmission lines running parallel to the proposed corridors were therefore treated as a risk reducing factor.
- Roads: These were taken as an indication of human activity and particularly vehicle and pedestrian traffic. It was assumed that the birds will avoid the immediate vicinity of roads due to the presence of traffic and pedestrians, and therefore it will reduce the risk of collision with lines running next to roads.
- Urbanisation and industry: Urban areas and industry are centres of human activity and are generally avoided by large power line sensitive species. Towns and industry are therefore risk reducing factors.
- Natural grassland: According to Young *et.al*. (2003) the large terrestrial species on the Mpumalanga highveld favour natural grassland habitat in contrast to agricultural landscapes. Natural grassland was therefore taken as a higher collision risk. Old lands that have reverted back to grassland were included in this category.

The factors mentioned above were incorporated into the formula to arrive at a risk rating for each potential corridor. The formula was implemented as follows:

- Wetlands and dams: The length of corridor running within 500m of a dam or wetland was measured.
- The number of drainage lines crossed by each corridor was counted.
- The distance that the proposed corridors are running parallel to existing roads within a 500m zone was measured.
- The length of corridor running through or within 1km of industrial/urban activity was measured.
- The distance that the proposed corridor is running directly next to existing transmission lines was measured.

- The length of corridor skirting or running across natural grassland was measured.

Table 3: The results of the measurements for each corridor

Factor	Option 1	Option 2	Option 3
Drainage lines	15	21	10
Dams and wetlands	26.24	32.16	17.33
TX lines	66.53	35.09	0
Roads	0	3.63	12.54
Suburban/industry	3	1.57	12.9
Grassland	38.37	38.78	25.66

Obviously all these factors do not have an equal impact on the size of the risk, therefore a weighting was assigned to each factor, based on the author's judgment on how important the factor is within the total equation. The weights that were assigned are tabled below. Risk reducing factors were assigned a negative weight.

Table 4: Weighting of risk reducing factors

Factor	Weighting
Drainage lines	5
Dams and wetlands	3
TX lines	-1
Roads	-2
Sub-urban/industrial	-5
Grassland	4

The final risk score for a **factor** was calculated as follows: measurements/counts x weighting. The final risk rating for a **corridor** was calculated as the sum the risk scores of the individual factors:

Table 5: The final scores for the respective corridor options

Factor	Option 1	Option 2	Option 3
Drainage lines	75	105	50
Dams and wetlands	78.72	96.48	51.99
TX lines	-66.53	-35.09	0
Roads	0	-7.26	-25.08
Suburban/industrial	-15	-7.85	-64.5
Grassland	153.48	155.12	102.64
Total	**225.67**	**306.4**	**115.05**

From the analysis above it is clear that **Option 3** is the **preferred corridor** from a bird interaction perspective. **Option 2** is the **least preferred** option.

5 Conclusions

- A number of power line sensitive, Red Data species could potentially occur along any of the corridors in small densities, mostly in the remaining natural grassland.

- The biggest potential risk that the proposed power line will pose, **unless mitigated**, is bird collisions with the earth wire of the proposed line.
- Other potential risks are the destruction of sensitive habitat through the construction of access roads, and disturbance of breeding birds during construction operations.
- The proposed corridors run through very similar habitat, which means that the potential bird impacts are likely to be similar in nature (but not in extent) along all the proposed corridors.
- The preferred corridor would be one that strives to avoid natural grassland and wetlands, or alternatively, is situated within the zone of influence of factors that lessen the risk of interactions for example close to existing transmission lines or within urban areas.
- There is reason to believe that the impact of existing power lines may have been a major contributory factor to the low density and/or absence of power line sensitive grassland species such as cranes.

6 Recommendations

6.1 Collisions with the earth wire

The most significant impact that is foreseen is collisions with the earth wire of the proposed line. It has been proven convincingly that the earth wire is the most hazardous obstacle for birds when crossing a power line (Meyer 1978; James & Haak 1979; Beaulaurier 1981; Faanes 1981). Quantifying this impact in terms of the likely number of birds that will be impacted, is very difficult because such a huge number of variables play a role in determining the risk, for example weather, rainfall, wind, age, flocking behaviour, power line height, light conditions, topography, population density and so forth (Bevanger 1999). However, it is possible to give a measure of what species are likely to be impacted upon, based on personal experience and existing literature. This only gives a measure of the general susceptibility of the species to power line collisions, and not an absolute measurement for this specific line.

The mitigation of bird impacts caused by power lines is to a large extent determined by the microhabitat within a zone of a hundred metres to about 1km on both sides of the line. This is particularly relevant as far as mitigation for bird collisions are concerned. The demarcation of sections that need to be mitigated can only be done once the alignment has been finalized, and **only through a combination of physical inspection of the entire length of the final alignment, and detailed analysis of high resolution satellite imagery.** It is standard procedure by the Eskom Transmission Group to perform this procedure with the help of a suitably experienced ornithologist once the line has been pegged. At that stage, specific spans are demarcated for anti-collision devices, based on a variety of factors (mentioned earlier), and at that stage minor deviations can still be effected. Sensitive sections will include dams, wetlands, drainage crossings and areas of natural grassland.

Bird flappers have been used extensively in South Africa since 1996 to mitigate for bird collisions. The idea behind the bird flapper is that a dynamic device will be more effective than a static device to prevent bird collisions, because the movement will draw the bird's attention to the wire and therefore give it time to take evasive action. Although some evidence exists to support this theory (Anderson 2001), it has not been conclusively proven. However, it intuitively makes sense: There are both ecological and physiological reasons why this should be so - moving stimuli tend to be biologically important, so it is no surprise that eyes and neural processing have evolved to deal with them preferentially. This is especially so among birds, probably the fastest moving class of animals on average (Dittrich & Lea 2001). This is borne out by anecdotal evidence from landowners and Eskom field staff over the past 11 years that indicate that bird flappers are effective in preventing bird collisions. The problem comes in with the requirement of "proven design and performance". The simple truth is that no bird flappers currently being used in South Africa have convincingly proven to be durable, long term solutions from a **mechanical point** of view. Some flappers have failed as quickly as six weeks after application, and it seems that three years to five years is a realistic life expectancy for most flappers (pers. obs). The point is that dynamic devices have an inherent limited life expectancy, due to the constant wear and tear which inevitably happens if the device functions correctly. It must therefore be seen as a solution that requires maintenance i.e. the line will have to be monitored all the time and faulty devices will have to be replaced on a continuous basis. This raises issues of practicality and cost effectiveness.

Figure 1: An example of a commercially available bird flapper

However, static devices can also be used with success. Many studies have proven that marking a line with PVC spiral type **Bird Flight Diverters (BFD's**) can reduce the mortality rates by at least 60% (Alonso & Alonso 1999; Koops & De Jong 1982). Beaulaurier (1981) summarised the results of 17 studies that involved the marking of earth wires and found an average reduction in mortality of 45%. Koops and De Jong (1982) found that the spacing of the spirals were critical in reducing the mortality rates - mortality rates are reduced up to 86% with a spacing of 5 metres, whereas using the same devices at 10 metre intervals only reduces the mortality by 57%.

Figure 2: Spiral type Bird Flight Diverter

6.2 Disturbance during the construction and maintenance activities associated with the power line

All construction and maintenance activities should be undertaken in accordance with Eskom Transmission's environmental best practice standards. Care should be taken not to unnecessarily disturb any birds along the servitude. The Environmental Control Officer should identify any breeding birds along the servitude, particularly large terrestrial species such as cranes, korhaans or Secretarybirds and notify the author of these so that advice can be given on how to best deal with the situation.

6.3 Habitat destruction during the construction and maintenance activities associated with the power line

All construction and maintenance activities should be undertaken in accordance with Eskom Transmission's environmental best practice standards. The construction of new access roads in particular should be limited to a minimum. All vehicle and pedestrian movement should be restricted to the actual construction site and, in the case of maintenance patrols, to the actual servitude.

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