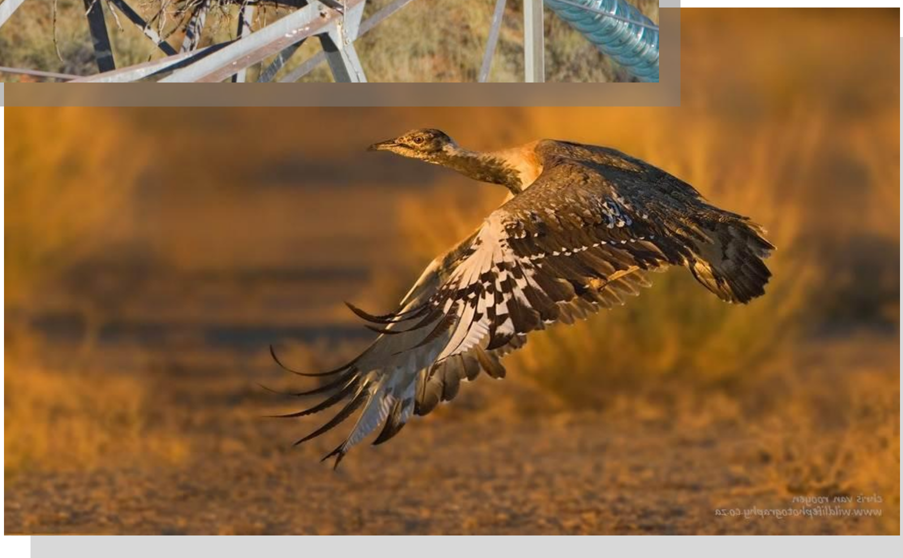
Solar Park Integration Project

Bird Impact Assessment Study

Preliminary Desk Top Report



OCTOBER 2012

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EXECUTIVE SUMMARY

Eskom is planning to construct a 100 MW Concentrating Solar Power (CSP) plant near Upington in the Northern Cape. The electricity generated at the Upington Solar Park (by IPP's and Eskom) will need to be integrated into the National Grid. The purpose of the Solar Park Integration Project is to address the major infrastructural investments that Eskom will need to make in order to tie the Upington Solar Park into the National Grid. The proposed Solar Park Integration Project entails the construction of a substation at the Upington Solar Park, 400kV transmission lines to the east and south of Upington to feed the electricity into Eskom's National Grid as well as the construction of a number of 132kV power lines inter-linking the IPP solar plants with the Eskom Grid and distributing the power generated to Upington. This desk top report deals with the potential impact on birds of the following proposed infrastructure:

- Solar Park Substation (132kV and 400kV);
- 2 x (±) 125km 400kV lines from Solar Park to Aries substation (southwest of Kenhardt);
- 1 x (±) 70km 400kV line from Solar Park to Nieuwehoop substation (northeast of Kenhardt);
- 1 x (±) 200km 400kV line from Solar Park to Ferrum substation (Kathu);
- 3 x 132kV lines for the Eskom CSP Site;
- 3 x 132kV lines for the IPP in Solar Park;
- 5 x 132kV lines for the DoE Solar Park; and
- 2x (±) 25km 132kV lines to Gordonia Substation (Upington).

The following potential impacts on avifauna were identified:

- Collisions with the earthwire of the proposed transmission lines
- Displacement due to habitat destruction
- Displacement due to disturbance

COLLISIONS

The most obvious candidates for collision mortality on the proposed power lines are Ludwig's Bustards followed by Kori Bustards. For Ludwig's Bustard, this risk is particularly relevant in Nama-Karoo, as that is the preferred habitat for the species. Kori Bustards are also likely candidates for collisions, particularly in the Kalahari Duneveld and Eastern Kalahari Bushveld, where the species are likely to be most numerous. Secretarybirds might also be at risk, with the highest risk in the Kalahari Duneveld and Eastern Kalahari Bushveld. The highest risk for Black Stork will be where the alignments cross rivers, particularly the Orange River. Flamingos might be at risk near water bodies, particularly salt pans. Overall, the impact of collisions was rated as high.

DISPLACEMENT DUE TO HABITAT DESTRUCTION

In the present instance, the biggest risk of displacement of Red Data species due to habitat destruction is likely to be in the Eastern Kalahari Bushveld, as the construction of the line in that habitat may require the removal of large trees, which are important breeding and roosting substrate for large raptors and vultures. This could result in temporary or permanent local displacement of these species. All three proposed Solar Park Substation sites are situated in low karroid shrubland which forms part of the Bushmanland bioregion, and does not contain unique features that will make it critically important for power line sensitive Red Data species. It is not envisaged that any Red Data species will be permanently displaced by the habitat transformation that will take place. The proposed construction of the new substation should therefore have a low displacement impact on Red Data species, irrespective of which of the alternative sites is used. Overall, the impact of displacement due to habitat destruction was rated low.

DISPLACEMENT DUE TO DISTURBANCE

As far as the natural habitat is concerned, the biggest potential disturbance impact is likely to be on large raptors and vultures in the Eastern Kalahari Bushveld, as breeding populations of these species are most numerous in that habitat due to the presence of large trees which is utilised for roosting and breeding. Transmission lines are much favoured by large raptors as breeding substrate. Should any new lines be constructed next to existing lines, the construction activities could lead to temporary displacement of breeding eagles, resulting in breeding failure in a particular season, or even permanent abandonment of a breeding territory. Overall, the impact of displacement due to disturbance was rated low.

PREFERRED ALTERNATIVE

Each of the transmission line alternatives were assessed for potential bird impacts. The following alternatives emerged as the preferred alternatives:

- Aries Solar 3
- Nieuwehoop Solar 2
- Ferrum Solar 3 Alternative

MITIGATION

It is not the objective of this desk top report to attempt to demarcate all sections of potential power line for all the alternative corridors that would need to be mitigated for potential collisions. This can only be done once the final alignment has been finalized through the EIA process, through a combination of physical inspection and analysis of satellite imagery. At that stage, specific spans are demarcated for the fitting of anti-collision devices, based on a variety of factors (mentioned earlier), and at that stage minor deviations can still be effected. This is also the stage when site specific measures are suggested to prevent displacement due to habitat destruction or disturbance for example what areas access roads should avoid e.g. to avoid sensitive raptor breeding areas. At this stage of the process, the most important recommendation flowing from this study is a rating of the different alternatives from a bird impact perspective, to inform the final selection of an alignment.

CONCLUSIONS

The conclusions reached in this desk top report is subject to further investigations on the ground, and may change should new information come to light during field investigations.

1 Introduction

ESKOM has appointed Zitholele Consulting to undertake an Environmental Impact Assessment (EIA) for the proposed in Solar Park Integration Project. Zitholele Consulting has appointed Chris van Rooyen Consulting as specialist to investigate the potential bird related impacts associated with the proposed new transmission lines. The infrastructure which forms the subject of this report is tabled below:

Table 1: Scope of work

EA APPLICATION PROCESS	DESCRIPTION OF THE PROPOSED ACTIVITIES
S&EIR No 1	• Solar Park substation (400kV and 132kV); • 2 x (±) 125km 400kV lines from Solar Park to Aries substation (southwest of Kenhardt) and associated feeder bays; • 1 x (±) 70km 400kV line from Solar Park to Nieuwehoop substation (northeast of Kenhardt) and associated feeder bays
S&EIR No 2	• 1 x (±) 200km 400kV line from Solar Park to Ferrum substation (Kathu) and associated feeder bays.
BA No 1	• 3 x 132kV lines for the Eskom CSP Site and 2 x 20MVA Transformers at Solar Park site.
BA No 2	• 3 x 132kV lines for the IPP in Solar Park.
BA No 3	• 5 x 132kV lines for the DoE Solar Park; and • 2x (±) 25km 132kV lines to Gordonia Substation (Upington).

A full project description of the proposed infrastructure is provided in Chapter 3 of the Final Scoping Reports (Zitholele 2012a and 2012b).

2 Background and brief

The terms of reference for this preliminary desk top specialist study are as follows:

- Describe the affected environment.
- Indicate how birdlife will be affected.
- Discuss gaps in baseline data.
- List and describe the expected impacts.
- Assess the expected impacts.
- Evaluate the proposed alignments and indicate a preferred alignment from a bird impact perspective.
- Provide proposals for mitigation of identified impacts.

3 Study Approach

3.1 Sources of information

The study made use of the following data sources:

- Bird distribution data of the Southern African Bird Atlas Project1 (SABAP1) and 2 (SABAP 2) was obtained (http://sabap2.adu.org.za/), in order to ascertain which species occur in the study area. A separate data set was obtained for each quarter degree grid cell (QDGC) which overlapped with the proposed corridors. QDGCs are grid cells that cover 15 minutes of latitude by 15 minutes of longitude (15. × 15.), which correspond to the area shown on a 1:50 000 map. SABAP1 covers the late 1980s to early 1990s.The SABAP2 data covers the period 2007 to present.

- The Important Bird Areas project data was consulted to get an overview of important bird areas and species diversity in the study area (Barnes 1998).
- The power line bird mortality incident database of the Endangered Wildlife Trust (1996 to 2007) was consulted to determine which of the species occurring in the study area are typically impacted upon by power lines (Jenkins *et al* 2010).
- Land cover data for the study area was obtained from the National land Cover Project (NLCP) (updated version 2009), obtained from the South African National Biodiversity Institute.
- Data on biomes, bioregions, vegetation types and rivers in the study area was obtained from the Vegetation Map of South Africa (Mucina & Rutherford 2006).
- Data on the alignment of existing high voltage lines were obtained from Eskom.
- The conservation status of all species considered likely to occur in the area was determined as per the most recent iteration of the southern African Red Data list for birds (Barnes 2000), and the most recent and comprehensive summary of southern African bird biology (Hockey *et al.* 2005).
- The author has travelled and worked extensively in the Northern Cape Province since 1996. Personal observations have therefore also been used to supplement the data that is available from SABAP, and has been used extensively in forming a professional opinion of likely bird/habitat associations.

3.2 Limitations & assumptions

This study made the assumption that the above sources of information are reliable. However, the following factors may potentially detract from the accuracy of the predicted results:

- Although the NLCP data was updated in 2009, the land cover situation on the ground may have changed in places since then.
- Different levels of survey effort for QDGCs in both the SABAP1 and SABAP2 coverage means that the reporting rates of species may not be an accurate reflection of relative densities in QDGCs that were sparsely covered to date. The reporting rates were therefore not treated as a realistic reflection of the actual densities, but merely as a guideline for the potential presence of a specific species. Strong reliance was placed on professional judgment (see 3.1 above).
- Predictions in this study are based on experience of these and similar species in different parts of South Africa. Bird behaviour can never be entirely reduced to formulas that will hold true under all circumstances; therefore professional judgment played an important role in this assessment. It should also be noted that the impact of power lines on birds has been well researched with a robust body of published research stretching over thirty years.
- It is important to note that, although the predicted impacts are mostly concerned with Red Data species, the power line sensitive non-Red Data species will also benefit from the proposed mitigation measures as they share the same habitat and face the same potential impacts as the Red Data species.
- This is a desk top report. The findings of this report are preliminary and will be adapted where needed by incorporating additional data that will become available through field investigations on the ground.

4 Study area

The study area extends from from Kathu to Upington, and from Upington to north-east and south-west of Kenhardt in the Northern Cape Province (see Figure 1 below). The study area does not overlap with any Important Bird Areas, the closest IBA is the Augrabies Falls National Park (SA029), which is situated approximately 30km north-west at its closest point to any of the alignments. The next closest IBA, Mattheus Gat Conservation Area (SA034), is situated approximately 86km west at its closest point (Barnes 1998).

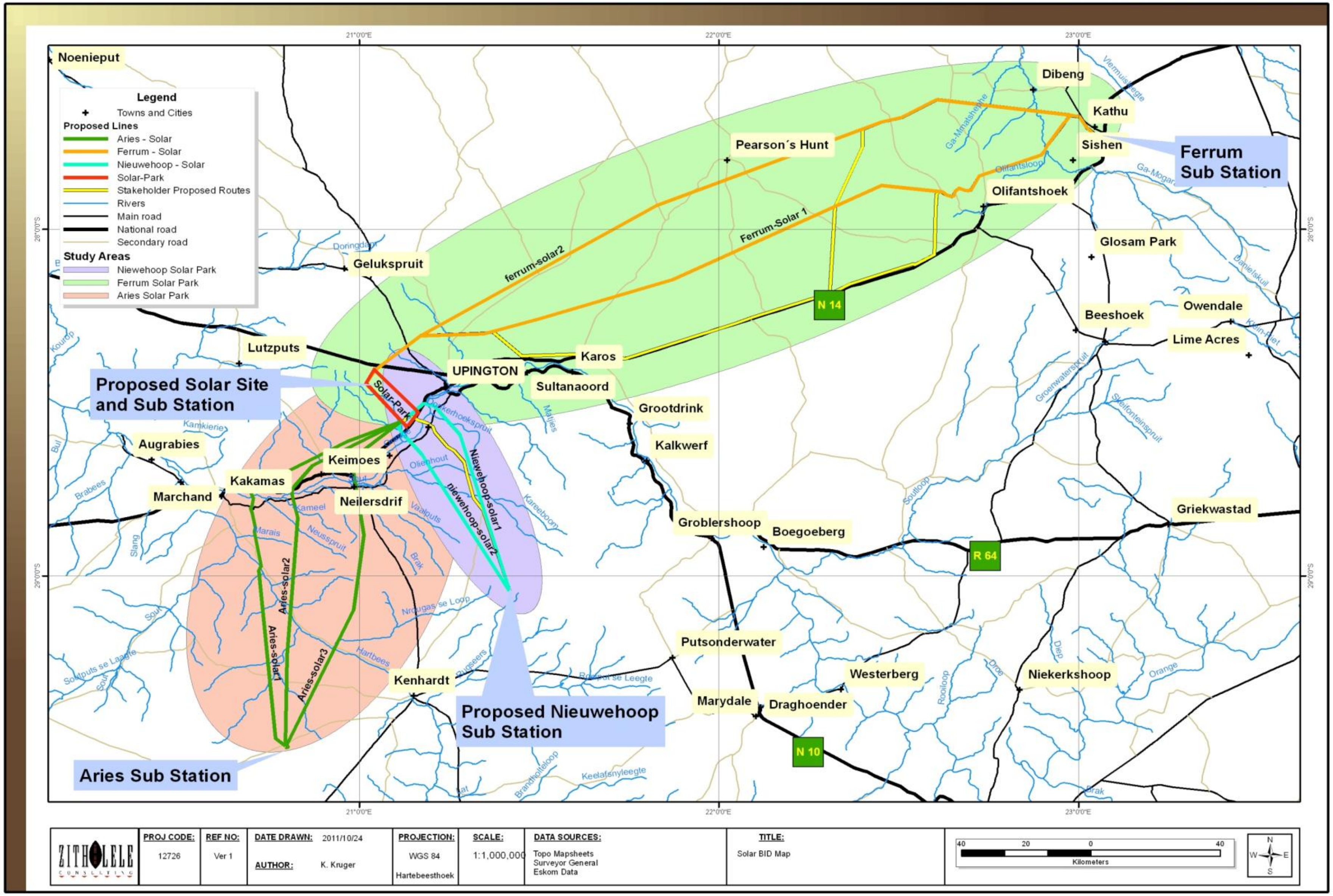

Figure 1: EIA corridor alternatives (Zitholele 2012a and 2012b)

4.1 Description of vegetation types

The study area extends over two biomes, namely Savanna and Nama Karoo, with small sections falling within Azonal Vegetation (Mucina & Rutherford 2006), mostly along the Orange River and at salt pans. The study area further falls within three bioregions, namely Eastern Kalahari Bushveld, Kalahari Duneveld and Bushmanland (see Figures 2 and 3 below). Table 1 below provides a break-down of the biomes, bioregions and vegetation types that are present within the combined surface area that is taken up by a 1km corridor along all the different transmission line alignments (Mucina & Rutherford 2006).

Table 2: Biomes, bioregions and vegetation types present in the various corridors

Biomes, bioregions and vegetation types Mucina & Rutherford 2006	Surface area (ha)
Azonal Vegetation	**6311**
Alluvial Vegetation	**5933**
Lower Gariep Alluvial Vegetation	5933
Inland Saline Vegetation	**378**
Bushmanland Vloere	1
Southern Kalahari Salt Pans	377
Nama-Karoo Biome	**212357**
Bushmanland Bioregion	**212357**
Bushmanland Arid Grassland	138440
Bushmanland Basin Shrubland	6861
Kalahari Karroid Shrubland	58290
Lower Gariep Broken Veld	8766
Savanna Biome	**199744**
Eastern Kalahari Bushveld Bioregion	**127270**
Gordonia Plains Shrubland	63408
Kathu Bushveld	24062
Koranna-Langeberg Mountain Bushveld	8023
Olifantshoek Plains Thornveld	31777
Kalahari Duneveld Bioregion	**72474**
Gordonia Duneveld	72474
Grand Total	**418411**

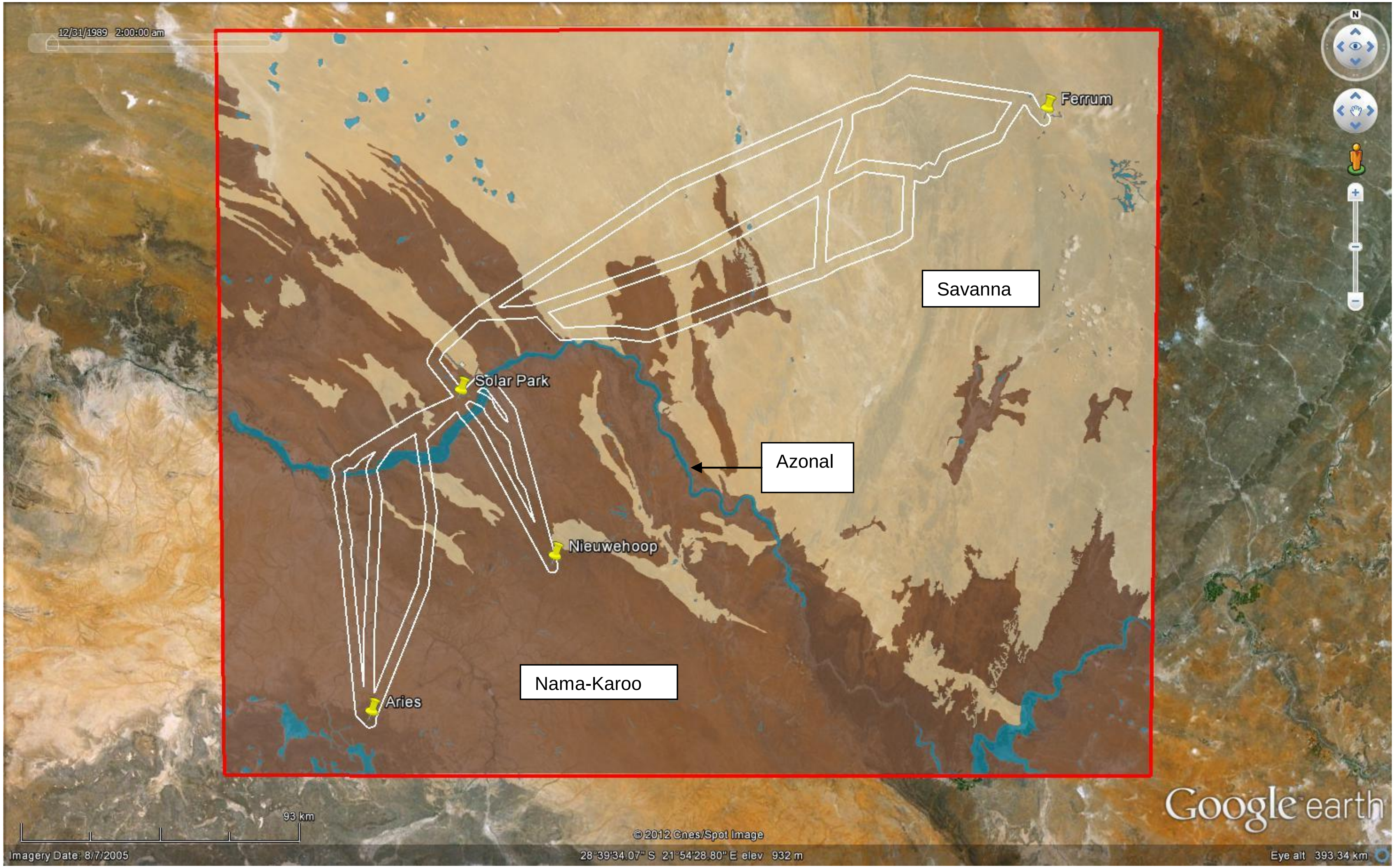

Figure 2: Biomes in the study area (Mucina & Rutherford 2006)

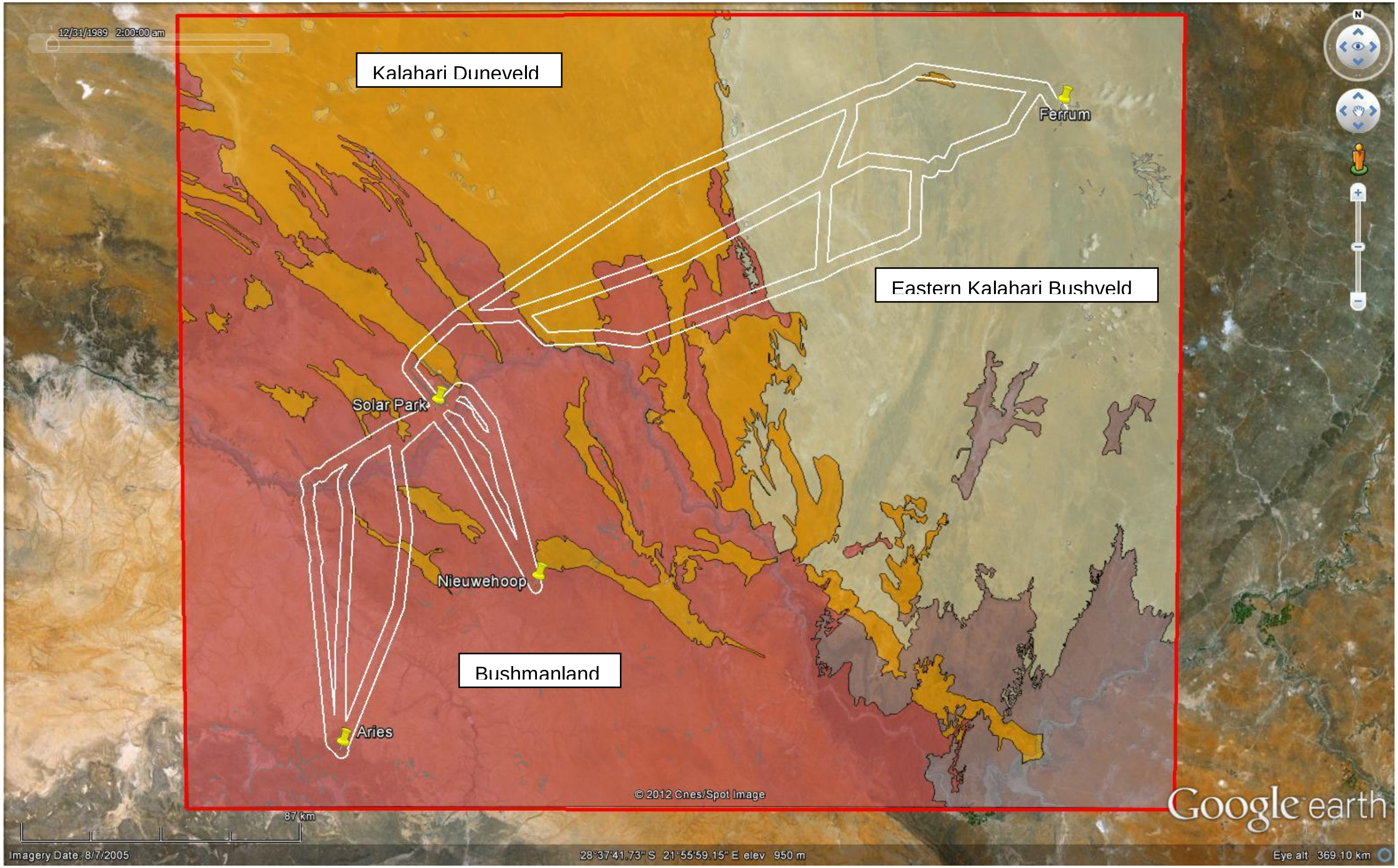

Figure 3: Bioregions in the study area (Mucina & Rutherford 2006)

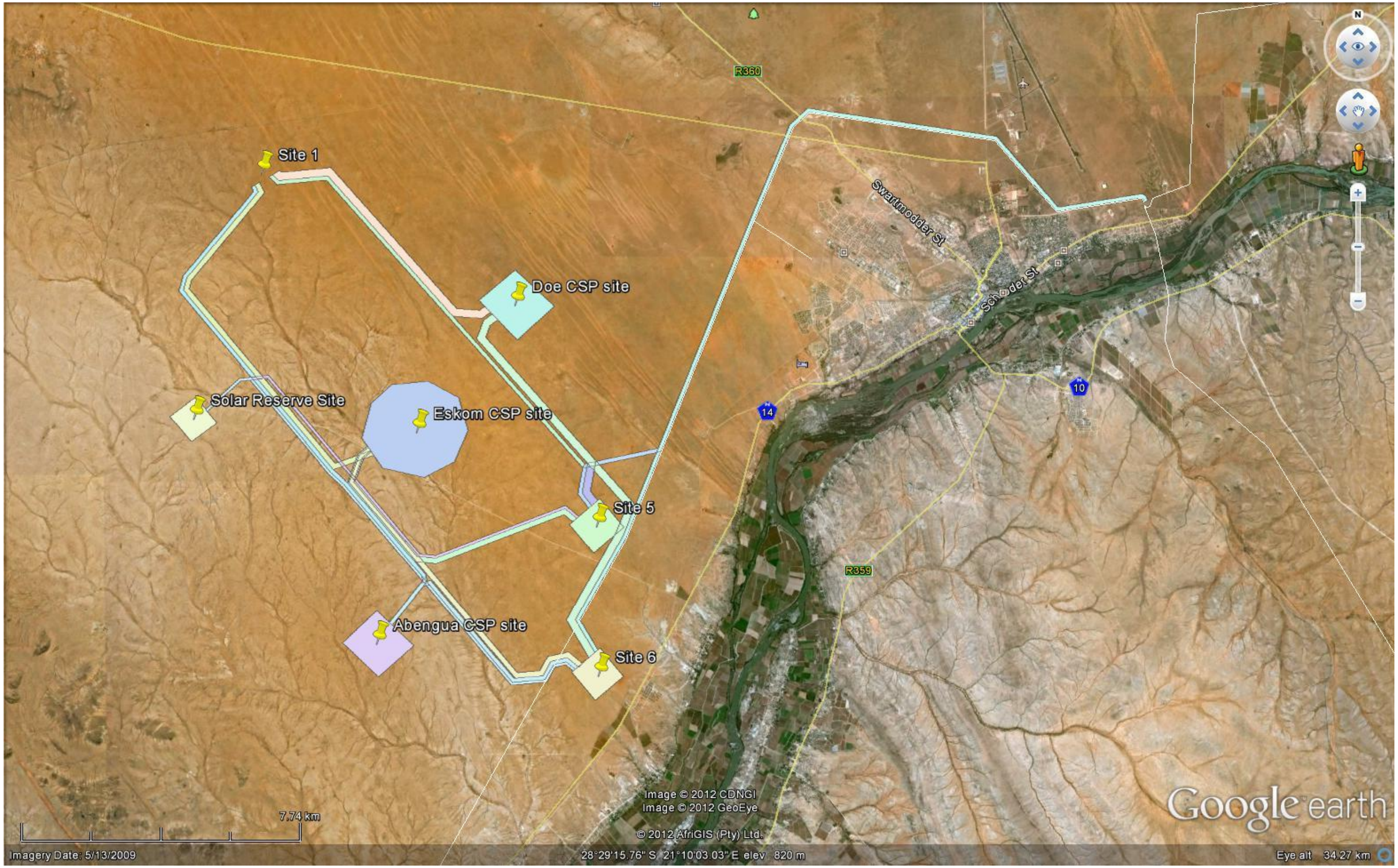

Figure 4: Satellite image of the proposed Solar Park CSP sites and associated substation alternatives (sites 1, 5 and 6) and 132kV power line alternatives.

Vegetation structure, rather than the actual plant species, is more significant for bird species distribution and abundance (in Harrison *et al* 1997). Therefore, the vegetation description below does not focus on lists of plant species, but rather on factors which are relevant to bird distribution. The description of the vegetation types occurring in the study area largely follows the classification system presented in the Atlas of southern African birds (Harrison *et al* 1997). The criteria used to amalgamate botanically defined vegetation units, or to keep them separate were (1) the existence of clear differences in vegetation structure, likely to be relevant to birds, and (2) the results of published community studies on bird/vegetation associations. It is important to note that no new vegetation unit boundaries were created, with use being made only of previously published data. The description of vegetation presented in this study therefore concentrates on factors relevant to the bird species present, and is not an exhaustive list of plant species present.

Savanna (or woodland) is defined as having a grassy under-storey and a distinct woody upper-storey of trees and tall shrubs. Soil types are varied but are generally nutrient poor. The savanna biome contains a large variety of bird species (it is the most species-rich community in southern Africa) but very few bird species are restricted to this biome. In the study area, the savanna biome contains two bioregions, namely Eastern Kalahari Bushveld and Kalahari Duneveld. **Eastern Kalahari Bushveld** (which forms part of the Central Kalahari vegetation type in Harrison *et al* 1997) is characterised by sparse to dense shrubland or parkland woodland dominated by semi-deciduous *Acacia, Boscia albitrunca, Terminalia sericea* and *Lonchocarpus nelsii* trees and *Acacia* and *Grewia* shrubs on deep Kalahari sands. Tall trees are fairly numerous, mostly *Acacia erioloba* (Camelthorn). Grass cover is variable dependent on rain, grazing and fires. There are no watercourses, but there are fossil river valleys and many pans on calcrete, which irregularly hold water. The climate is characterised by hot summer and cold winter seasons; rainfall takes place in summer (average 450-550mm), but variable between years. **Kalahari Duneveld** (which forms part of the Southern Kalahari vegetation type in Harrison *et al* 1997), is on deep Kalahari sands with rolling dunes, and consists of open shrubland with ridges of grassland and semi-deciduous *Acacia* and *Boscia albitrunca* trees along intermittent fossil watercourses and interdunal valleys. Tall trees are generally absent, except along some fossil rivers. Grass cover is very variable dependent on rain and grazing. Summers are hot, winters cold, rainfall very variable averaging <250mm and mostly in summer.

The **Nama-Karoo** vegetation largely comprises low shrubs and grasses; peak rainfall occurs in summer – in the extremely arid region of the study area this is usually less than 130mm per annum. Trees e.g. *Acacia karroo* and alien species such as Mesquite *Prosopis glandulosa* are mainly restricted to watercourses where fairly luxurious stands can develop, especially along the Orange River. In the study area, the Nama-Karoo contains one bioregion, namely **Bushmanland**. The vegetation structure consists mainly of extensive to irregular plains sparely vegetated by grassland dominated by white grasses (*Stipagrostis* species) giving the landscape the character of semi-desert "steppe", with a few low shrubs in places. In some sections, mostly near the Orange River, koppies and low mountains are present with sparse vegetation dominated by shrubs and dwarf shrubs, with groups of widely scattered low trees e.g. *Aloe dichotoma* and *Acacia mellifera*. Large trees are generally absent.

4.2 Description of bird habitat classes

Whilst much of the distribution and abundance of the bird species in the study area can be explained by the description of the biomes, bioregions and vegetation types above, it is as important to examine the modifications which have changed the natural landscape, and which may have an effect on the distribution of power line sensitive species. These are sometimes evident at a much smaller spatial scale than the biome types, and are determined by a host of factors such as vegetation type, topography, land use and man-made infrastructure. For purposes of the analysis in this report, bird habitat classes were defined from an avifaunal Red Data power line sensitive perspective:

4.2.1 Eastern Kalahari Bushveld

This habitat class is described above under 4.1 and is of importance for a variety of Red Data power line sensitive species. The Eastern Kalahari Bushveld is particularly rich in large raptors, and in the study area it forms the stronghold of Red Data species such as White-backed Vulture *Gyps africanus*, Martial Eagle *Polemaetus bellicosus*, Tawny Eagle *Aquila rapax*, Bateleur *Terathopius ecaudatus* and Lappet-faced Vulture *Torgos tracheliotis*. All these species require large trees for breeding and roosting, and the multitude of large *Acacia erioloba* trees is ideal for that purpose. Cape Vulture *Gyps coprotheres* may also occur sparsely, although they do not breed in the area. Apart from Red Data species, it also supports several non-Red Data large raptor species, such as the Brown Snake Eagle *Circaetus cinereus*, Black-chested Snake Eagle *Circaetus pectoralis*, and in mountainous habitat (such as the Langeberg near Olifantshoek), Verreaux's Eagle *Aquila verreauxii*. A multitude of smaller raptor species also occur in Eastern Kalahari Bushveld, as well as the large terrestrial Red Data Secretarybird *Sagittarius serpentarius* and Kori Bustard *Ardeotis kori*. Potential impacts that could result due to the power line in this habitat are collisions with the earthwire (Secretarybird and Kori Bustard) and displacement of breeding raptors and vultures due to habitat destruction.

4.2.2 Kalahari Duneveld

This habitat class is described above under 4.1 and is also of importance for the same suite of power line sensitive species described under 4.2.1. However, the scarcity of large trees means that large breeding raptors and vultures are more sparsely distributed. The habitat is very suitable for Secretarybird, as the species generally breeds in small trees and forages in open duneveld. Kori Bustard is also common in this habitat, while Ludwig's Bustard *Neotis ludwigii* occurs sporadically. Black Harrier *Circus maurus* occurs sparsely as a non-breeding migrant. The major expected impact in this habitat is collisions with the earthwire (Secretarybird, Kori Bustard and Ludwig's Bustard), and to a lesser extent displacement due to disturbance and habitat destruction.

4.2.3 Bushmanland

This habitat class is described above under 4.1. The Karoo vegetation types support a particularly high diversity of bird species endemic to Southern Africa, particularly in the family Alaudidae (Larks)(Harrison *et al* 1997). Its avifauna typically comprises ground-dwelling species of open habitats. Many typical karroid species are nomads, able to use resources that are patchy in time and space, especially enhanced conditions associated with rainfall (Barnes 1998). Power line sensitive Red Data species associated with Bushmanland are mainly large terrestrial species, in particular the nomadic Ludwig's Bustard, which may occur in flocks following rainfall events, and to a lesser extent Kori Bustard. Martial Eagle and Black-chested Snake-Eagle occurs sparsely. Koppies and inselbergs provide breeding habitat for Lanner Falcon *Falco biarmicus*, Peregrine Falcon *Falco peregrinus,* Verreauxs Eagle *Aquila verrauxii* and Black Stork *Ciconia nigra*. Black Harrier *Circus maurus* occurs sparsely as a non-breeding migrant. The major envisaged impact is collisions with the earthwire (mainly large terrestrial species).

4.2.4 Waterbodies and rivers

Waterbodies and rivers are of specific importance to a variety of Red Data power line sensitive species in this arid study area. The perennial Orange River flows through the study area, and the river channel, pools of water and riverine islands with riparian thickets, reed beds, flooded grasslands and sandbanks provide habitat for a multitude of waterbirds, including the Red Data Black Stork *Ciconia nigra.* The non-Red Data African Fish-Eagle *Haliaeetus vocifer* occurs commonly along the river. An important feature of the arid landscape where the proposed power lines are located is the presence of pans. Pans are endorheic wetlands having closed drainage systems; water usually flows in from small catchments but with no outflow from the pan basins themselves. They are characteristic of poorly drained, relatively flat and dry regions. Water loss is mainly through evaporation, sometimes resulting in saline conditions, especially in the most arid regions. Water depth is shallow (<3m), and flooding characteristically ephemeral (Harrison *et al*. 1997). Pans are important for a variety of non-Red Data waterbirds, and in the study area specifically for the Red Data Greater Flamingo *Phoenicopterus roseus* and Lesser Flamingo *Phoenicopterus minor*. Pans, dams and pools of water with exposed sandbanks are also used by large raptors for drinking and bathing. Ephemeral drainage lines are also corridors for woodland, which Kori Bustard often associate with, and occasionally, after good rains when pools form in the channels, it act as a draw card for waterbirds. During such times, small birds are attracted to the water, which in turn may attract Lanner Falcons and other raptors. The major envisaged impact is collisions with the earthwire (waterbirds and to a lesser extent raptors).

4.2.5 Transmission lines

Transmission lines are an important roosting and breeding substrate for large raptors in the study area. Existing transmission lines are used extensively by large raptors e.g. in 2005 the author did an aerial survey of the Ferrum – Garona 275kV line together with Eskom, and found a total of 19 Martial Eagle and 7 Tawny Eagle nests on transmission line towers (Van Rooyen 2007). Transmission lines therefore hold a special importance for large raptors. Should any new lines be constructed next to existing lines, the construction activities could lead to temporary displacement of breeding eagles, resulting in breeding failure in a particular season, or even permanent abandonment of a breeding territory.

4.2.6 Low impact areas

The proposed corridors run through several types of habitat which would generally not attract power line sensitive Red Data species. For purposes of the analysis, these have all been grouped together under low impact areas. These are degraded areas, mines, urban/industrial areas, agricultural areas along the Orange River (mostly irrigated vineyards) and major roads. No significant impacts on power line sensitive Red Data species are expected in these areas.

4.2 Power line sensitive species occurring in the study area

A total of 18 Red Data have to date been recorded by SABAP1 and SABAP2 in the QDGCs that are bisected by the various alignments (see Table 3). Vagrants are indicated with an asterisk. For each species, the potential for occurring in a specific habitat class was indicated, as well as the potential impact most likely associated with this specific species.

Table 3: Red Data species recorded by SABAP1 and SABAP2 in the study area

NT=Near threatened V=Vulnerable

Name	Scientific name	Status	Eastern Kalahari Bushveld	Kalahari Duneveld	Bushmanland	Waterbodies and rivers	Transmission lines	Low impact areas	Collisions	Displacement through disturbance	Displacement through habitat destruction
Bateleur	*Terathopius ecaudatus*	V	x	x					x	x	x
Black Harrier	*Circus maurus*	V		x	x				x		
Black Stork	*Ciconia nigra*	NT				x			x		
Blue Crane*	*Anthropoides paradiseus*	V	x			x			x		
Cape Vulture	*Gyps coprotheres*	V	x				x		x	x	
Corn Crake*	*Crex crex*	V	x						x		
Greater Painted-snipe*	*Rostratula benghalensis*	NT				x			x	x	
Kori Bustard	*Ardeatis kori*	V	x	x	x				x		
Lanner Falcon	*Falco biarmicus*	NT	x	x	x		x		x	x	
Lappet-faced Vulture	*Torgos tracheliotis*	V	x	x			x		x	x	x
Lesser Kestrel	*Falco naumanni*	V	x	x	x						
Ludwig's Bustard	*Neotos ludwigii*	V		x	x				x		
Martial Eagle	*Polemaetus bellicosus*	V	x	x	x				x	x	x
Peregrine Falcon	*Falco peregrinus*	NT			x				x	x	

Name	Scientific name	Status	Eastern Kalahari Bushveld	Kalahari Duneveld	Bushmanland	Waterbodies and rivers	Transmission lines	Low impact areas	Collisions	Displacement through disturbance	Displacement through habitat destruction
Sclater's Lark	*Spizocorys sclateri*	NT			x						
Secretarybird	*Sagittarius serpentarius*	NT	x	x	x				x	x	x
Tawny Eagle	*Aquila rapax*	V	x	x					x	x	x
White-backed Vulture	*Gyps africanus*	V	x	x					x	x	x

*   Vagrant

5 Selecting a preferred corridor for the transmission lines

One of the main objectives of this study is to arrive at a preferred corridor for the proposed transmission power lines, from an avifaunal interaction perspective. Chapter 4 of the Final Scoping Reports (Zitholele 2012a and 2012b) provides a description of the various transmission line corridor alternatives that were considered for this study (see also Figure 1 above). The methodology that was followed to select a preferred corridor alternative is outlined below.

5.1 Methodology

The potential for interaction with the proposed power line was assessed for each of the Red Data species listed in Table 3. This was done by assessing the probability of each potential impact (collisions, displacement through disturbance and displacement through habitat destruction) occurring, for each species, within each of the described habitat classes. The following probability scale was used: 1 = low, 2 = medium, 3 = high. Each habitat class therefore received a risk score for each species. The total risk score for a habitat class was calculated as the sum of the various individual species scores for that habitat class. Table 4 below gives the risk scores for each of the habitat classes:

Table 4: Risk scores for each habitat class

Habitat class	Risk score
Eastern Kalahari Bushveld	62
Kalahari Duneveld	51
Bushmanland	25
Waterbodies & rivers	5
Transmission lines	30
Low impact	0

The risk scores in Table 4 were incorporated into a formula to arrive at a risk rating for each 1km wide corridor alternative. The surface area of a corridor that intersected with a habitat class was calculated. Buffers were designed as follows for the following habitat classes:

- Waterbodies and rivers: A buffer of 250m was drawn around waterbodies, which were identified from the National Land Cover Project (2009). Rivers (including alluvial vegetation) were identified from the Vegetation Map of South Africa (Mucina & Rutherford 2006), and also buffered by 250m. The perennial Orange River was buffered, as well as two large ephemeral rivers, namely the Ga-Mogara River near Kathu and the Hartbees River in the extreme south-west of the study area, on the assumption that the latter two rivers may at times hold water after rains.
- Existing transmission lines: A buffer of 200m was drawn around existing transmission lines.
- Low impact areas: Degraded areas, mines, urban/industrial areas, agricultural areas along the Orange River (mostly irrigated vineyards) and major roads were identified from the National Land Cover Project (2009). A buffer of 100m was drawn around major roads.

The **risk rating** for a power line **corridor alternative** was calculated by multiplying the surface area of each habitat class that overlaps with the 1km wide corridor with the risk score for that habitat class. The risk ratings of the respective corridors are listed in Table 5 below. The corridors that have emerged with the lowest risk scores are highlighted in green.

Table 5: Risk ratings of the alternative corridors

Corridor	Risk Rating
Aries Solar 1	122
Aries Solar 2	109
Aries Solar 3	105
Ferum Solar 1	462
Ferum Solar 2	482
Ferum Solar 3	491
Ferum Solar 3 alt	455
Nieuwehoop Solar 1	66
Nieuwehoop Solar 2	56
Nieuwehoop Solar 3	59

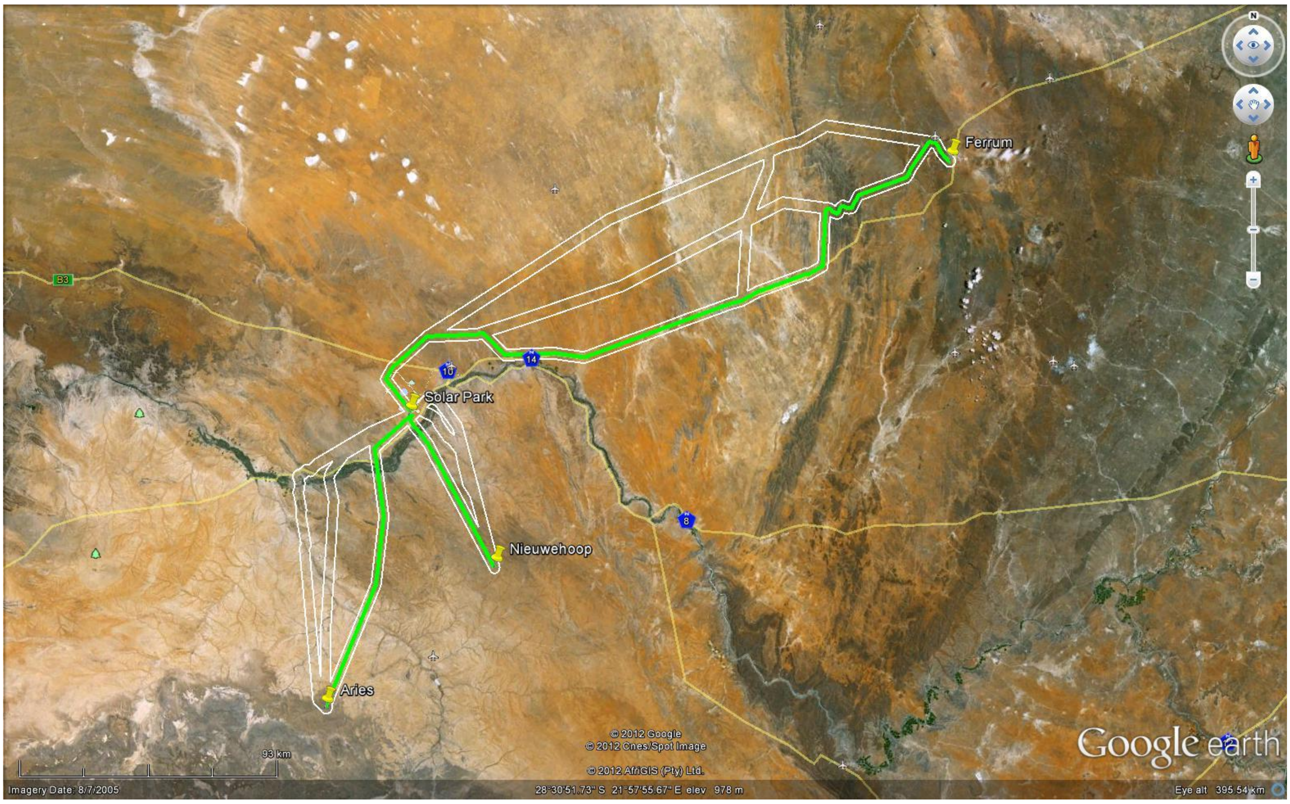

Figure 5: A map indicating the corridors that have emerged with the lowest ratings from a bird impact assessment perspective.

6 Description of expected impacts

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 and Annegarn 1981; Ledger 1983; Ledger 1984; Hobbs and Ledger 1986a; Hobbs and Ledger 1986b; Ledger, Hobbs and Smith, 1992; Verdoorn 1996; Kruger and Van Rooyen 1998; Van Rooyen 1998; Kruger 1999; Van Rooyen 1999; Van Rooyen 2000).

6.1 Electrocutions

Electrocution refers to the scenario where a bird is perched or attempts to perch on the electrical structure and causes an electrical short circuit by physically bridging the air gap between live components and/or live and earthed components (van Rooyen 2004). The electrocution risk is largely determined by the pole/tower design. Several tower design alternatives have been proposed for this project, which are illustrated and discussed in the Final Scoping Reports (Zitholele 2012a and 2012b). Potential tower types that could be utilised are self-supporting towers, cross-rope suspension towers and guyed-V towers. The topography will largely dictate the type of tower that will be used. **Due to the large size of the clearances on overhead lines of 400kV, electrocutions are ruled out as even the largest birds cannot physically bridge the gap between energised and/or energised and earthed components.**

A mono-pole steel pole will be used for the new 132kV lines that will link the new 400kV transmission lines into the grid from the new Solar Park Substation. Clearance between phases on the same side of the pole structure is approximately 2.2m for this type of design, and the clearance on strain structures is 1.8m. This clearance should be sufficient to prevent phase – phase electrocutions of birds on the towers. The length of the stand-off insulators is approximately 1.5m. If very large species attempts to perch on the stand-off insulators, they are potentially able to touch both the conductor and the earthed pole simultaneously potentially resulting in a phase – earth electrocution. This is particularly likely when more than one bird attempts to sit on the same pole, which is an unlikely occurrence, except with vultures. **However, the likelihood of vultures occurring at the CSP site is remote and the risk is therefore regarded as negligible.**

In summary it can be stated that the risk of electrocution posed to Red Data species by the new power line infrastructure is likely to be negligible. This issue will again be investigated when the field work is conducted, but no impacts of any significance are envisaged at this stage.

6.2 Collisions

Collisions are probably the biggest single threat posed by transmission lines to birds in southern Africa (van Rooyen 2004). Most heavily impacted upon are bustards, storks, cranes and various species of waterbirds. These species are mostly heavy-bodied birds with limited manoeuvrability, which makes it difficult for them to take the necessary evasive action to avoid colliding with power lines (van Rooyen 2004, Anderson 2001).

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 (Denham'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."

A significant impact that is foreseen is collisions with the earth wire of the proposed line. 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. However, from incidental record keeping by the Endangered Wildlife Trust, it is possible to give a measure of what species are likely to be impacted upon (see Figure 6 below - Jenkins *et al* 2010). This only gives a measure of the general susceptibility of the species to power line collisions, and not an absolute measurement for any specific line.

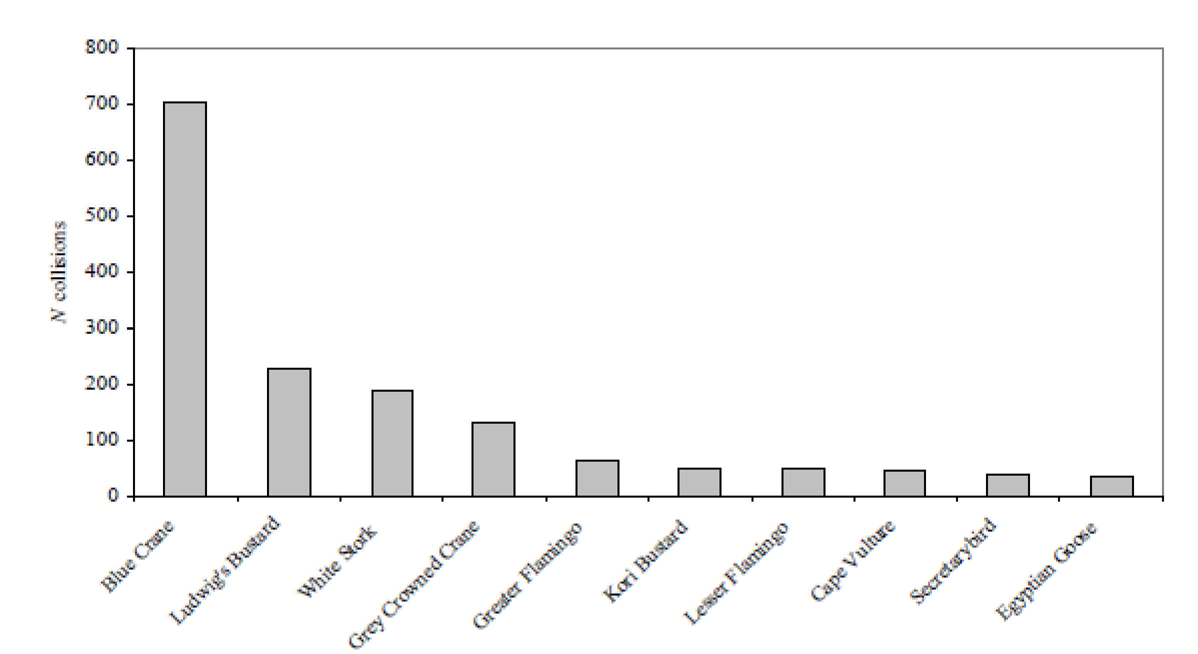

Figure 6: The top 10 collision prone bird species in South Africa, in terms of reported incidents contained in the Eskom/EWT Strategic Partnership central incident register 1996 - 2008 (Jenkins *et al* 2010)

The most obvious candidates for collision mortality on the proposed power lines are Ludwig's Bustards followed by Kori Bustards. For Ludwig's Bustard, this risk is particularly relevant in Nama-Karoo, as that is the preferred habitat for the species. Ludwig's Bustard is highly vulnerable to power line collisions (Jenkins & Smallie 2009; Jenkins et *al* 2010). Ludwig's Bustard will be at risk, based on the species flight characteristics and tendency to fly long distances between foraging and roosting areas and when migrating. Movements by this species are triggered by rainfall (Allan 1994), and so are inherently erratic and unpredictable in this arid environment, where the quantity and timing of rains are highly variable between years. Hence, it is difficult to anticipate the extent to which Ludwig's Bustard may be exposed to collision risk, but the alignments cross suitable habitat and the species is likely to be present in varying numbers, depending on foraging conditions. Kori Bustards are also likely candidates for collisions, particularly in the Kalahari Duneveld and Eastern Kalahari Bushveld, where the species are likely to be most numerous. Secretarybirds might also be at risk, with the highest risk in the Kalahari Duneveld and Eastern Kalahari Bushveld. The highest risk for Black Stork will be where the alignments cross rivers, particularly the Orange River. Flamingos might be at risk near water bodies, particularly salt pans.

6.3 Displacement due to habitat destruction and disturbance

During the construction phase and maintenance of power lines and substations, some habitat destruction and transformation inevitably takes place. This happens with the construction of access roads, the clearing of servitudes and the levelling of substation yards. 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 have an impact on birds breeding, foraging and roosting in or in close proximity of the servitude through transformation of habitat, which could result in temporary or permanent displacement. In the present instance, the biggest risk of displacement of Red Data species due to **habitat destruction** is likely to be in the Eastern Kalahari Bushveld, as the construction of the line in that habitat may require the removal of large trees, which are important breeding and roosting substrate for large raptors and vultures. This could result in temporary or permanent local displacement of these species.

All three proposed Solar Park Substation sites are situated in low karroid shrubland which forms part of the Bushmanland bioregion, and does not contain unique features that will make it critically important for power line sensitive Red Data species (see Figure 4). It is not envisaged that any Red Data species will be permanently displaced by the habitat transformation that will take place. The proposed construction of the new substation should therefore have a low displacement impact on Red Data species, irrespective of which of the alternative sites is used.

Apart from direct habitat destruction, the above mentioned construction and maintenance activities also impact on birds through **disturbance**, particularly during breeding activities. This could lead to breeding failure if the disturbance happens during a critical part of the breeding cycle. As far as the natural habitat is concerned, the biggest potential disturbance impact is likely to be on large raptors and vultures in the Eastern Kalahari Bushveld, as breeding populations of these species are most numerous in that habitat due to the presence of large trees which is utilised for roosting and breeding.

As far as disturbance is concerned, a specific situation may arise if the line is constructed near an existing transmission line. As mentioned earlier in this report, transmission lines are highly sought after by large raptors, particularly Martial Eagles and Tawny Eagles, for roosting and breeding purposes, and vultures often form semi-permanent roosts on transmission towers (pers. obs). Construction activities in close proximity could be a source of disturbance and could lead to temporary breeding failure or even permanent abandonment of nests.

7 Assessment of impacts

The impact assessment methodology makes provision for the assessment of impacts against the following criteria:

- Significance;
- Spatial scale;
- Temporal scale;
- Probability; and
- Degree of certainty.

7.1 Significance Assessment

A detailed description of the impact significance rating scale is given in **Error! Not a valid bookmark self-reference.**6 below.

Table 6: Description of the significance rating scale

Rating		Description
5	VERY HIGH	Of the highest order possible within the bounds of impacts which could occur. In the case of adverse impacts: there is no possible mitigation and/or remedial activity which could offset the impact. In the case of beneficial impacts, there is no real alternative to achieving this benefit.
4	HIGH	Impact is of substantial order within the bounds of impacts, which could occur. In the case of adverse impacts: mitigation and/or remedial activity is feasible but difficult, expensive, time-consuming or some combination of these. In the case of beneficial impacts, other means of achieving this benefit are feasible but they are more difficult, expensive, time-consuming or some combination of these.
3	MODERATE	Impact is real but not substantial in relation to other impacts, which might take effect within the bounds of those which could occur. In the case of adverse impacts: mitigation and/or remedial activity are both feasible and fairly easily possible. In the case of beneficial impacts: other means of achieving this benefit are about equal in time, cost, effort, etc.
2	LOW	Impact is of a low order and therefore likely to have little real effect. In the case of adverse impacts: mitigation and/or remedial activity is either easily achieved or little will be required, or both. In the case of beneficial impacts, alternative means for achieving this benefit are likely to be easier, cheaper, more effective, less time consuming, or some combination of these.
1	VERY LOW	Impact is negligible within the bounds of impacts which could occur. In the case of adverse impacts, almost no mitigation and/or remedial activity is needed, and any minor steps which might be needed are easy, cheap, and simple. In the case of beneficial impacts, alternative means are almost all likely to be better, in one or a number of ways, than this means of achieving the benefit. Three additional categories must also be used where relevant. They are in addition to the category represented on the scale, and if used, will replace the scale.
0	NO IMPACT	There is no impact at all - not even a very low impact on a party or system.

7.2 Spatial scale

The spatial scale refers to the extent of the impact i.e. will the impact be felt at the local, regional, or global scale. The spatial assessment scale is described in more detail in Table 7.

Table 7: Description of the spatial rating scale.

Rating		Description
5	Global/National	The maximum extent of any impact.
4	Regional/Provincial	The spatial scale is moderate within the bounds of impacts possible, and will be felt at a regional scale (District Municipality to Provincial Level).
3	Local	The impact will affect an area up to 5 km from the proposed route corridor.
2	Study Area	The impact will affect a route corridor not exceeding the boundary of the corridor.
1	Isolated Sites / proposed site	The impact will affect an area no bigger than the route site.

7.3 Temporal scale

In order to accurately describe the impact it is necessary to understand the duration and persistence of an impact in the environment. The temporal scale is rated according to criteria set out in Table 8.

Table 8: Description of the temporal rating scale.

Rating		Description
1	Incidental	The impact will be limited to isolated incidences that are expected to occur very sporadically.
2	Short-term	The environmental impact identified will operate for the duration of the construction phase or a period of less than 5 years, whichever is the greater.
3	Medium term	The environmental impact identified will operate for the duration of life of the line.
4	Long term	The environmental impact identified will operate beyond the life of operation.
5	Permanent	The environmental impact will be permanent.

7.4 Degree of Probability

The probability or likelihood of an impact occurring will be described as shown in

Table 9 below.

Table 9: Description of the degree of probability of an impact accruing.

Rating	Description
1	Practically impossible
2	Unlikely
3	Could happen
4	Very Likely
5	It's going to happen / has occurred

7.5 Quantitative Description of Impacts

To allow for impacts to be described in a quantitative manner in addition to the qualitative description given above, a rating scale of between 1 and 5 was used for each of the assessment criteria. Thus the total value of the impact is described as the function of significance, spatial and temporal scale as described below:

Impact Risk = [(SIGNIFICANCE **+** *Spatial* **+** Temporal)÷3] X [Probability ÷ 5]

The impact risk is classified according to 5 classes as described in table 10 below.

Table 10: Impact risk classes.

Rating	Impact class	Description
0.1 – 1.0	1	Very Low
1.1 – 2.0	2	Low
2.1 – 3.0	3	Moderate
3.1 – 4.0	4	High
4.1 – 5.0	5	Very High

Table 11 below provides a summary of the impacts describing the impact, significance, spatial scale, temporal scale, probability and rating.

Table 11: Impact rating table

Impact	Significance	Spatial scale	Temporal scale	Probability	Rating
Collisions with the power line	4	*4*	3	*5*	**55**
Displacement due to habitat destruction	4	*3*	3	*3*	**30**
Displacement due to disturbance	4	*3*	2	*3*	**27**

The impact risk is classified according to 5 classes as described in the table below.

Table 12: Impact risk classes

Impact	Rating	Impact Class	Description
Collisions with the power line	3.66	4	High
Displacement due to habitat destruction	1.98	2	Low
Displacement due to disturbance	1.8	2	Low

8 Mitigation

Any attempt at quantifying the potential bird impacts for the proposed development would entail the collection of significant amounts of quantitative data, for example one would have to establish how many pairs of a given species are using a particular patch of woodland and document the potential breeding failure through disturbance that could occur if a transmission line is constructed through that patch of woodland. Then the influence of this impact on the ability of the local, regional or even national population to persist would have to be documented and quantified. Clearly such detailed studies fall outside the scope of this report. The fact that impacts such as habitat destruction and disturbance could be significant but difficult to quantify, requires that all possible mitigation measures should be implemented on the basis of the pre-cautionary principle. The World Charter for Nature, which was adopted by the UN General Assembly in 1982, was the first international endorsement of the precautionary principle. The principle was implemented in an international treaty as early as the 1987 Montreal Protocol and among other international treaties and declarations is reflected in the 1992 Rio Declaration on Environment and Development. Principle 15 of the Rio Declaration 1992 states that: "in order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, **lack of full scientific certainty shall be not used as a reason for postponing cost-effective measures to prevent environmental degradation."**.

There are many methods that can be used to mitigate avian power line interactions (for example, APLIC 1994) and several investigations dealing with the collision problem have focused on finding suitable mitigation measures (see APLIC 1994 for an overview). The most proactive measures are power line route planning (and the subsequent avoidance of areas with a high potential for bird strikes) and the modification of power line designs (this option includes line relocations, underground burial of lines, removal of over-head ground wires, and the marking of ground wires to make them more visible to birds in flight). In many instances, decisions on power line placement and possible mitigation measures are however eventually based on economic factors. The relocation of an existing line is the last option that is usually considered when trying to mitigate avian collisions. The huge expense of creating a new line and servitude usually cannot be justified unless there are biologically significant mortalities. Underground burial of power lines is another option available to utility companies in areas of high collision risk. This will obviously eliminate collisions, but the method has many drawbacks. The costs of burying lines can be from 20 – 30 times (or more) higher than constructing overhead lines, and such costs are related to the line voltage, type and length of cable, cable insulation, soil conditions, local regulations, reliability requirements, and requirement of termination areas. Limitations of cable burial include: no economically feasible methods of burying extra high voltage lines have been developed, there is a potential to contaminate underground water supplies if leakage of oil used in insulating the lines occurs, and extended outage risks due to the difficulty in locating cable failures (APLIC 1994). Since most strikes involve earth-wires (more than 80% of observed bird collisions), the removal of these wires would decrease the number of collisions. It is assumed that the large number of earth-wire collisions is because birds react to the more visible conductors by flaring and climbing and then collide with the thinner earth-wires (Anderson 2001). Earth-wire removal is, however, not a simple matter. Due to the need for lightning protection and other types of electricity overload, it is only possible on lower-voltage power lines (where polymer lightning arresters can be used). The marking of overhead earth-wires to increase their visibility is usually considered to be the most economical mitigation option for reducing collision mortality (APLIC 1994). This is particular so for the thousands of kilometres of established power lines through areas of high potential for avian interaction which cannot be rerouted.

Several factors are thought to influence avian collisions, including the manoeuvrability of the bird, topography, weather conditions and power line configuration. An important additional factor that previously has received little attention is the visual capacity of birds; i.e. whether they are able to see obstacles such as power lines, and whether they are they looking ahead to see obstacles with enough time to avoid a collision. In addition to helping explain the susceptibility of some species to collision, this factor is key to planning effective mitigation measures (Martin *et al* 2010). Recent research conducted by Eskom and the Endangered Wildlife Trust provides the first evidence that birds can render themselves blind in the direction of travel during flight through voluntary head movements. Due to the variation in visual fields among species, there is unlikely to be a single solution for mitigating all collisions. Line marking alone is likely to be effective for storks, but for birds such as bustards, additional mitigation may be necessary, as these birds may not see obstacles at all when in flight. Distracting such birds away from obstacles or encouraging them to land nearby may help to prevent collisions, as they would be more aware of their surroundings and of marked power lines when taking off again (Martin *et al* 2010). In certain situations birds such as bustards, cranes and raptors are unlikely to see ahead of them, no matter what mitigation measures are placed upon the actual obstacle. This is because the visual field configuration, coupled with possible head movements associated with searching below, prevents it being detected. For these species it may be better to distract birds away from, or encourage them to land nearby to power lines. Placing markers on the ground might have this effect. Bird silhouettes, painted drums or flags could prove effective, and it is recommended that such methods be used in combination with line marking. Unfortunately, no research is available on the effectiveness of ground marking.

Despite the indications that line marking might not be effective in certain situations for certain species, there are many studies that provide evidence that marking a line with PVC spiral type Bird Flight Diverters (BFDs) 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 BFDs 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%. Jenkins *et al* (2010) reviewed 15 studies and found line marking to reduce mortality rates by 50-60%, although the efficacy for bustards may be lower than that. Barrios *et al* (2011) analysed 11 studies and found an average reduction of 78% in mortality on marked lines. Line markers should be as large as possible, and highly contrasting with the background. Colour is probably less important as during the day the background will be brighter than the obstacle with the reverse true at lower light levels (e.g. at twilight, or during overcast conditions). Black and white interspersed patterns are likely to maximise the probability of detection (Martin *et al* 2010).

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. It is not the objective of this desk top report to attempt to demarcate all sections of potential power line for all the alternative corridors that would need to be mitigated for potential collisions. This can only be done once the final alignment has been finalized through the EIA process, through a combination of physical inspection and analysis of satellite imagery**.** It is standard procedure for Eskom Transmission to perform this procedure with the assistance of a suitably experienced ornithological consultant once the line has been surveyed and pegged. At that stage, specific spans are demarcated for the fitting of anti-collision devices, based on a variety of factors (mentioned earlier), and at that stage minor deviations can still be effected. This is also the stage when site specific measures are suggested to prevent habitat destruction for example what areas access roads should avoid e.g. to avoid sensitive raptor breeding areas. At this stage of the process, the most important recommendation flowing from this study is a rating of the different alternatives from a bird impact perspective, to inform the final selection of an alignment.

9 References

Allan, D.G. 1994. The abundance and movements of Ludwig's Bustard *Neotis ludwigii*. *Ostrich* 65: 95-105.

Alonso, J.A. & Alonso, C.A. 1999. Mitigation of bird collisions with transmission lines through groundwire marking. In: Birds and Power Lines Eds: M. Ferrer & G. F. E. Janss, Quercus, Madrid.

Avian Power Line Interaction Committee (APLIC). 1994. Mitigating Bird Collisions with Power Lines: The State of the Art in 1994. Edison Electric Institute. Washington D.C.

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.

Barrientos, R., Alonso J.C., Ponce, C. & Palacin, C. 2011.Meta-Analysis Of The Effectiveness Of Marked Wire In Reducing Avian Collisions With Power Lines. Conservation Biology. Volume 24 Issue 5.

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.

Beaulaurier, D.L. 1981. Mitigation of bird collisions with transmission lines. Bonneville Power Administration. U.S. Dept. of Energy.

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

Hobbs, J.C.A. and Ledger J.A. 1986a. The Environmental Impact of Linear Developments; Power lines and Avifauna. (Third International Conference on Environmental Quality and Ecosystem Stability. Israel, June 1986).

Hobbs, J.C.A. and Ledger J.A. 1986b. "Power lines, Birdlife and the Golden Mean." Fauna and Flora, 44, pp 23-27.

Hockey P.A.R., Dean W.R.J., And Ryan P.G. (2005). *Robert's Birds of Southern Africa, seventh edition*. Trustees of the John Voelcker Bird Book Fund, Cape Town.

Jenkins, A. & Smallie, J. 2009. Terminal velocity: the end of the line for Ludwig's Bustard? Africa Birds and Birding. Vol 14, No 2.

Jenkins, A.R., Smallie, J.J. & Diamond, M. 2010. Avian collisions with power lines: a global review of causes and mitigation with a South African perspective. *Bird Conservation International* 20: 263-278.

Koops, F.B.J. & De Jong, J. 1982. Vermindering van draadslachtoffers door markering van hoogspanningsleidingen in de omgeving van Heerenveen. Electrotechniek 60 (12): 641 – 646.

Kruger, R. and Van Rooyen, C.S. 1998. Evaluating the risk that existing power lines pose to large raptors by using risk assessment methodology: the Molopo Case Study. (5th World Conference on Birds of Prey and Owls: 4 - 8 August 1998. Midrand, South Africa.)

Kruger, R. 1999. Towards solving raptor electrocutions on Eskom Distribution Structures in South Africa. M. Phil. Mini-thesis. University of the Orange Free State. Bloemfontein. South Africa.

Ledger, J. 1983. Guidelines for Dealing with Bird Problems of Transmission Lines and Towers. Escom Test and Research Division Technical Note TRR/N83/005.

Ledger, J.A. and Annegarn H.J. 1981. "Electrocution Hazards to the Cape Vulture (Gyps coprotheres) in South Africa". Biological Conservation, 20, pp15-24.

Ledger, J.A. 1984. "Engineering Solutions to the problem of Vulture Electrocutions on Electricity Towers." The Certificated Engineer, 57, pp 92-95.

Ledger, J.A., J.C.A. Hobbs and Smith T.V. 1992. Avian Interactions with Utility Structures: Southern African Experiences. (Proceedings of the International Workshop on Avian Interactions with Utility Structures, Miami, Florida, 13-15 September 1992. Electric Power Research Institute.)

Martin, G., Shaw, J., Smallie J. & Diamond, M. 2010. Bird's eye view – How birds see is key to avoiding power line collisions. Eskom Research Report. Report Nr: RES/RR/09/31613.

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

National Land Cover Project. 2009. www.bgis.sanbi.org.

Southern African Bird Atlas Project 2 (SABAP2). http://sabap2.adu.org.za. Accessed 12 October 2012.

Van Rooyen, C.S. and Ledger, J.A. 1999. "Birds and utility structures: Developments in southern Africa" in Ferrer, M. & G..F.M. Janns. (eds.) Birds and Power lines. Quercus: Madrid, Spain, pp 205-230

Van Rooyen, C.S. 1998. Raptor mortality on power lines in South Africa. (5th World Conference on Birds of Prey and Owls: 4 - 8 August 1998. Midrand, South Africa.)

Van Rooyen, C.S. 1999. An overview of the Eskom - EWT Strategic Partnership in South Africa. (EPRI Workshop on Avian Interactions with Utility Structures 2-3 December 1999, Charleston, South Carolina.)

Van Rooyen, C.S. 2000. "An overview of Vulture Electrocutions in South Africa." Vulture News, 43, pp 5-22. Vulture Study Group: Johannesburg, South Africa.

Van Rooyen, C.S. 2003. Mitigation programme for Avian Collisions with Eskom Transmission Lines. Unpublished Progress Report, September 2003. Endangered Wildlife Trust, Johannesburg, South Africa.

Van Rooyen, C.S. 2004. 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. 2007. Bird Impact Assessment Study. Ferrum-Garona 400kV. Endangered Wildlife Trust.

Verdoorn, G.H. 1996. Mortality of Cape Griffons Gyps coprotheres and African Whitebacked Vultures Pseudogyps africanus on 88kV and 132kV power lines in Western Transvaal, South Africa, and mitigation measures to prevent future problems. (2^{nd} International Conference on Raptors: 2-5 October 1996. Urbino, Italy.)

Zitholele Consulting. 2012a. EIA, WULA and EMP for the proposed solar CSP Integration Project: Project 1 – Solar substation, 2 x 400 kV power lines from Aries to the Solar Sub and 400 kV power lines from Nieuwehoop to the Solar Sub. Final Scoping Report. DEA Reference Number: 12/12/20/2606.

Zitholele Consulting. 2012b. EIA, WULA and EMP for the proposed solar CSP Integration Project: Project 2 – 400 kV power lines from Ferrum to the Solar Sub. Final Scoping Report. DEA Reference Number: 12/12/20/2607.