

**PROPOSED PV2-4PHOTOVOLTAIC ENERGY PLANTS
ON THE FARM DU PLESSIS DAM NEAR DE AAR,
NORTHERN CAPE**

Avian impact assessment

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1. EXECUTIVE SUMMARY

This study contains a review of the relevant literature on the impacts on avifauna of solar energy facilities and their associated electrical infrastructure, and identifies potential impacts of the proposed PV2-4 Photovoltaic (PV) Energy Plants on the avifauna of the De Aar area, Northern Cape. The proposed plants are located on the same farm as an approved 19.9MW facility (PV1) which was proposed by the same applicant and has already been authorized. The expected impacts are: habitat destruction by the construction of the facilities themselves and their associated power lines or substation/s, disturbance by construction and maintenance activities and possibly by the operation of the facilities, and possible displacement or disturbance of sensitive species, and mortality caused by collision with the associated power line network, and electrocution of avifauna on the required power line and substation infrastructure. In addition, some birds may interfere with the efficient running of the proposed PV installations.

The broader impact zone of the proposed PV facilities is contained within an extensive tract of flat Nama Karoo, traversed by some minor drainage lines, while the immediate vicinity features degraded natural veld with some anthropogenic influences. The area potentially supports up to 220 bird species, including 69 endemic or near-endemic species, 15 red-listed species, and four species red-listed endemics. The birds of greatest potential relevance and importance in terms of the possible impacts of the proposed PV development are likely to be resident or seasonal influxes of threatened, large terrestrial birds – Blue Crane *Anthropoides paradiseus*, Ludwig's Bustard *Neotis ludwigii*, Kori Bustard *Ardeotis kori* and possibly Blue Korhaan *Eupodotis caerulescens*, locally resident or passing raptors, especially red-listed species - Martial Eagle *Polemaetus bellicosus*, Tawny Eagle *Aquila rapax* and Lesser Kestrel *Falco naumanni*, local populations of endemic, and possibly red-listed passerines, and possibly over-flights of commuting wetland birds, especially flamingos. Pigeons, crows, weavers, sparrows and some raptor species may perch, roost, forage or even nest on or around the facilities and cause fouling problems.

When assessed in isolation, and given the relative homogeneity of the habitat within and surrounding the site, and its close proximity to the town of De Aar and the associated, existing levels of disturbance prevalent in the area, this proposed complex of solar energy plants is considered unlikely to have any significant, long-term impacts on the local avifauna. However, the considerable spatial extent of this development suggests that it may be an important contributor to the potentially significant, cumulative impacts imposed by this and a number of other planned renewable energy projects on the natural environment of the De Aar area.

A comprehensive programme is put forward to fully monitor and research the actual impacts of this PV proposal on the broader avifauna of the area, from pre-construction and into the operational phase of the development, and the first set of data collected as part of this programme is presented.

2. INTRODUCTION

Mulilo Renewable Energy (Pty) Ltd is planning to construct three photovoltaic (PV) power generation facilities (project name 'Du Plessis DamPV2-4') on portions of the farm Du Plessis Dam 179, just north-east of De Aar, Northern Cape Province, South Africa. Aurecon South Africa (Pty) Ltd were appointed to do the Environmental Impact Assessment (EIA) study, and subsequently appointed *AVISENSE* Consulting cc to conduct the specialist avifaunal assessment. The present report was compiled by Dr Andrew Jenkins and Johan du Plessis. Dr Jenkins is an established ornithologist, with over 20 years of experience in ornithology and impact assessment work. He has been involved in many power line, and wind and solar farm EIA and EMP studies in South Africa, and also does academic research on raptors, bustards and cranes in various parts of the country. Johan du Plessis holds an MSc degree in Zoology from the University of Stellenbosch. He has over six years of experience as a field biologist, and has assisted with field data collection in support of various zoological surveys and EIA studies, including avifaunal monitoring at various wind energy facilities throughout South Africa.

3. DECLARATION OF INDEPENDENCE

Andrew Jenkins and Johan du Plessis (*AVISENSE* Consulting) are independent consultants to Aurecon South Africa (Pty) Ltd and Mulilo Renewable Energy (Pty) Ltd. They have no business, financial, personal or other interest in the activity, application or appeal in respect of which they were appointed other than fair remuneration for work performed in connection with the activity, application or appeal. There are no circumstances that compromise the objectivity of these specialists in performing such work.

4. TERMS OF REFERENCE

The terms of reference for the full EIA, as supplied by Aurecon, were to:

- Review the latest literature on bird-solar power interactions as a desk-top exercise.
- Undertake the requisite field work to directly assess the habitats present within the inclusive impact zone, and to determine the *in situ* avifauna.
- Integrate the on-site information with bird atlas (Southern African Bird Atlas Project - SABAP - 1 & 2) and any other relevant data available for the general area, to develop and inclusive, annotated list of the birds likely to occur on the site, highlighting red-listed species, endemic, restricted-range or other species of particular concern that may occur in the study area.
- Identify, describe and assess potential direct and indirect and cumulative impacts resulting from the proposed development both on the footprint and the immediate surrounding area during construction and operation.
- Recommend mitigation measures to reduce or eliminate potential negative impacts on avifauna, and improve positive impacts.

5. LIMITATIONS AND ASSUMPTIONS

Any inaccuracies or deficiencies in the primary sources of information used in the compilation of this report could limit its value. The SABAP1 data (see below) for the De Aar area are now >15 years old (Harrison *et al.* 1997), and comprise only 27 bird atlas cards for the relevant quarter-degree square, while there is presently only five SABAP 2 atlas card for the relevant pentad. No more reliable and/or more recent formal data on bird species presence and abundance in the study area currently exist.

The site visit (conducted on 7 May and 11 May 2013), in combination with previous visits to the immediate area for EIA work on neighbouring or associated renewable energy projects (Jenkins 2010, 2011, 2012), goes some way towards remedying this knowledge deficiency. However, with limited time in the field, and no seasonal spread, it is possible that important components of the local avifauna – nest sites, localized areas of key habitat for rare or threatened species – were missed.

Given that there are currently no solar energy facilities operative in South Africa, there are no existing data on the environmental effects of these installations in this country.

6. STUDY METHODOLOGY

6.1 Approach

The study included the following steps:

- A review was done of available published and unpublished literature pertaining to bird interactions with solar energy facilities and associated power infrastructure, summarizing the issues involved and the current level of knowledge in this field. Various information sources (listed below), including data on the birdlife of the area and previous studies of bird interactions with solar energy facilities and electricity infrastructure, were examined.
- A short visit to the development area to determine first-hand the avian habitats present, and to start the process of data collection to quantify aspects of the avifauna as part of a monitoring project spanning the pre-construction to operational phases of the proposed development (see below).
- Compilation of an inclusive, annotated list of the avifauna likely to occur within the impact zone of the proposed PV facilities was compiled using a combination of the existing distributional data, species seen during the site visit, and previous experience of the avifauna of the general area.
- Compilation of a short-list of priority bird species (defined in terms of conservation status and endemism) which could be impacted by the proposed PV facilities was extracted from the total bird list. These species were subsequently considered as adequate surrogates for the local avifauna in general, and mitigation of impacts on these species was considered likely to accommodate any less important bird populations that may also potentially be affected.

- Construction of a matrix of possible impacts on the local avifauna was drawn up for the proposed PV facilities, and the significance of these impacts was assessed in terms of the available suite of mitigation options.

6.2 Data sources used

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

- Bird distribution data of the SABAP (Harrison *et al.* 1997) were obtained from the Animal Demography Unit website (<http://sabap2.adu.org.za/index.php>) for the SABAP 1 quarter-degree square covering the proposed PV facilities and its associated infrastructure (3024CDe Aar), and for the relevant SABAP 2 pentad (3035_2400). A composite list of species likely to occur in the impact zone of the PV facilities was drawn up as a combination of these data, refined by a more specific assessment of the actual habitats affected, based on general knowledge of the birds of the region (Appendix 1).
- The conservation status and endemism of all species considered likely to occur in the area was determined from the national Red-list for birds (Barnes 2000), and the most recent and comprehensive summary of southern African bird biology (Hockey *et al.* 2005).
- Information on nesting raptors and large bird collision rates on the nearby Eskom Hydra-Droërivier 1-3 and Hydra-Proteus 400 kV transmission lines from the Eskom Electric Eagle Project (Jenkins *et al.* 2007, Jenkins *et al.* 2013), and recent bustard and crane collision surveys (Jenkins *et al.* 2009, Jenkins *et al.* 2011).
- Lesser Kestrel roost counts for De Aar from the Endangered Wildlife Trust's Migrating Kestrel Project (A.J. Van Zyl pers. comm., <https://www.ewt.org.za/programmes/BoPP/kestrel.html>).

7. OVERVIEW OF THE PROPOSAL

The Du Plessis Dam Energy Facilities are proposed for the farm Du Plessis Dam 179, near the town De Aar, Northern Cape, and in addition to an already authorized 19.9 MW PV plant on a different portion of the same property. The new proposal is for three additional, but encompassing, 75MW PV energy plants (Fig. 1) with a combined extent of approximately 854 ha. Additional electrical infrastructure will include three dedicated substations i.e. one for each of the proposed PV facilities, all of which will feed into a forth three-bay substation via a 132 kV overhead transmission line. The entire facility will then be connected to the De Aar Substation via a 132 kV overhead transmission line, running in one of two proposed transmission corridors. The proposed alternative to the preferred project (Fig. 1) extends and combines the three proposed 75MW plants and the already authorized 19.9 MW plant into a single 400 MW facility with a total extent of approximately 1068 ha. Additional proposed infrastructure includes a road network and a construction camp.

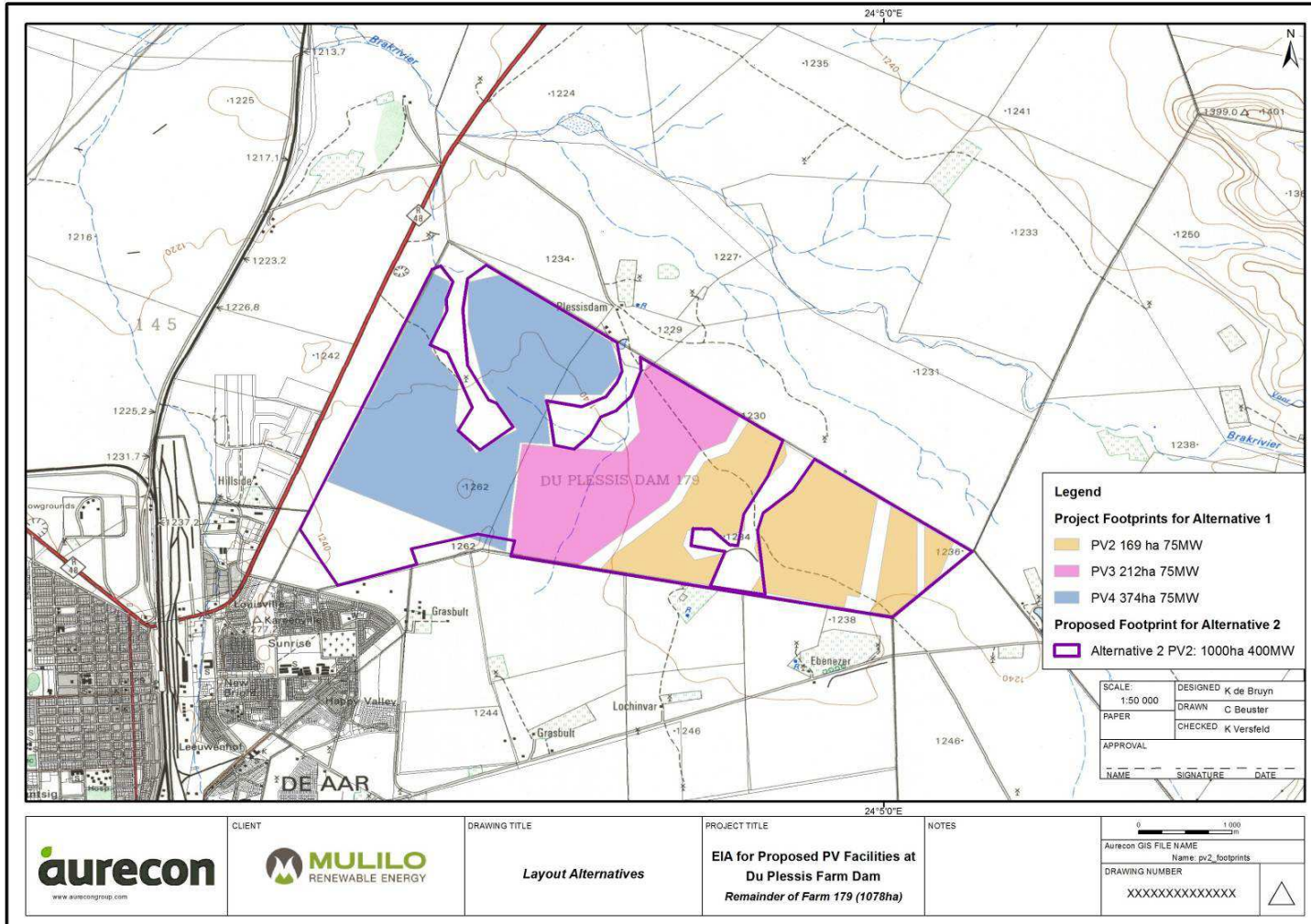


Figure1. The preferred location and layout of the Du Plessis DamPV2-4 Energy Facilities, in relation to the entire contracted property, and the town of De Aar.

8. DESCRIPTION OF THE AFFECTED ENVIRONMENT

8.1 Vegetation of the study area

The study area is located in the Upper Karoo Bioregion of the Nama Karoo Biome (Mucina & Rutherford 2006). The natural vegetation of both location options is dominated by Northern Upper Karoo – dry Karoo shrubland with drought resistant grasses and scattered low trees (Mucina & Rutherford 2006). Altitude on the site varies very little (1230-1370 metres above sea level). The area receives about 200 mm of rain per annum, most of which falls in autumn (February-March). Temperatures range from a mean winter minimum of about 0.3°C, to a mean summer maximum of about 30°C.

8.2 Avian microhabitats

These comprise mainly degraded areas of grassy Karoo veld, with limited amounts of taller vegetation and low trees (including alien spp.) along drainage lines, at least one small artificial waterbody and possibly some ephemeral wetlands present in wet years. High stocking rates and grazing pressure has resulted in lower vegetation and a generally more open habitat than would naturally occur in the area. The site is closely adjacent to the town of De Aar and is already subject to significant levels of human disturbance. It is also proximal to the Eskom Hydra substation and a number of major power transmission lines run close to or through the site, including the new Gamma-Perseus 765 kV line. Land-use is primarily small stock and game farming, and the area includes a network of minor farm roads or tracks.

8.3 Avifauna of the impact area

Up to 220 bird species could occur within the anticipated, broader impact zone of the solar energy facilities (Appendix 1), including 69 endemic or near-endemic species, 15 red-listed species, and four species – Ludwig's Bustard *Neotis ludwigii*, Blue Korhaan *Eupodotis caerulescens*, Blue Crane *Anthropoides paradiseus* and Black Harrier *Circus maurus* – which are both endemic and red-listed (Barnes 1998, 2000, Table 1). The site falls within the Platberg-Karoo Conservancy Important Bird Area (Barnes 1998), which supports critical or regionally significant populations of a number of potentially collision prone or otherwise sensitive species.

The birds of greatest potential relevance and importance in terms of the possible impacts of the PV facilities are likely to be local populations of endemic passerines (including Karoo Long-billed Lark *Certhilauda subcoronata*, Rufous-eared Warbler *Malcorus pectoralis*, and Black-headed Canary *Serinus alario*), visiting or resident Blue Korhaan, Karoo Korhaan *Eupodotis vigorsii*, Northern Black Korhaan *Afrotis afroides* and Blue Crane, and locally resident or passing raptors, especially red-listed species - Martial Eagle *Polemaetus bellicosus*, Tawny Eagle *Aquila rapax*, Lesser Kestrel *Falco naumanni*, and possibly Peregrine Falcon *Falco peregrines*, Lanner Falcon *Falco biarmicus*, and regional endemics such as Jackal Buzzard *Buteo rufofuscus* and Southern Pale Chanting Goshawk *Melierax canorus*. Surveys of large raptors nesting in Eskom transmission pylons in this area (Jenkins *et al.* 2007, 2013) suggest that the closest site to the development area is a recently active Tawny Eagle nest on tower 33 (30° 43.466 S, 23°

58.457 E) of the Hydra-Kronos 400 kV line – 11.4 km to the south-west of the development area. Note that there may be other large eagle nests on un-surveyed pylon lines located closer to the site than this. There is also a large (up to 12 000 birds – A.J. Van Zyl pers. Comm.), Lesser Kestrel roost located around the De Aar Hospital about 4 km to the south-west of the development area, used by these Palaearctic migrants during the austral summer (October to March). Numbers of this species were seen on the site during a specialist site visit in 2012 (Harebottle 2012).

The birds most likely to proliferate and become active around the facility, possibly causing fouling problems, could include Speckled Pigeon *Columba guinea*, Greater Kestrel *Falco rupicolus*, Southern Pale Chanting Goshawk, Cape Crow *Corvus capensis*, Pied Crow *Corvus albus*, Common Starling *Sturnus vulgaris*, Cape Sparrow *Passer melanurus*, and House Sparrow *Passer domesticus*, and possibly variety of other perch-hunting and insectivorous passerines.

Only 34 species were seen on the study site during the May field visit (Appendix 1), including an adult Martial Eagle seen perched on the 765 kV pylon just to north-east of the site, with an immature flying overhead, and two sightings of single Ludwig's Bustards, and two flocks of Blue Cranes, comprising nine and 16 birds. Northern Black Korhaan was present in numbers, and densities of regionally endemic passerines – e.g. Sabota Lark *Calendulauda sabota*, Large-billed Lark *Galerida magnirostris*, Eastern Clapper Lark *Mirafra fasciolata*, Spike-heeled Lark *Chersomanes albofasciata* and Rufous-eared Warbler were relatively high across much of the development area (see monitoring data in Table 3 and Appendix 2, below).

On the basis of these observations, in combination with already documented information on the avifauna of the general area, 11 priority species are recognized as key in the assessment of avian impacts of the proposed Du Plessis Dam PV Energy Facilities (Table 1). These are mostly nationally and/or globally threatened species which are known to occur, or could occur, in relatively high numbers in the development area and which are likely to be, or could be, negatively affected by the PV solar power plant project. Four species were included despite the fact that they were not recorded in either SABAP 1 or SABAP 2 data for the area, either because (a) they were seen on site, (b) the site is located within their respective distributions and the available habitat is possibly suitable, or (c) they may occasionally fly over the site *en route* between distant resource areas, and in so doing be exposed possible impacts.

Overall, the avifauna of the development site itself is entirely replaceable, at best replicating that which occurs across huge areas of the Eastern Karoo. However, the considerable spatial extent of this development suggests that it may be an important contributor to the potentially significant, cumulative impacts imposed by this and a number of other planned renewable energy projects on the natural environment of the De Aar area.

Table 1. Priority bird species considered central to the avian impact assessment process for the proposed Du Plessis DamPV Energy Facilities, selected mainly on the basis of South African (Barnes 2000) or global conservation status (www.iucnredlist.org or <http://www.birdlife.org/datazone/species/>), level of endemism, relative abundance on site (SABAP reporting rates, direct observation), and estimated conservation or ecological significance of the local population. Red-listed endemic species are shaded in grey.

Common name	Scientific name	SA conservation status/ (Global conservation status)	Regional endemism	Average reporting rate ¹ (n = 32cards)	Estimated importance of local population	Preferred habitat	Risk posed by		
							Collision	Electro-cution	Disturbance / habitat loss
Ludwig's Bustard	<i>Neotis ludwigii</i>	Vulnerable (Endangered)	Near-endemic	6.3	Moderate-High	Open Karoo	High	-	Moderate
Kori Bustard	<i>Ardeotis kori</i>	Vulnerable	-	18.8	Moderate	Open Karoo	High	-	Moderate
Blue Korhaan		Near-threatened	-	0.0	Moderate	Grassy Karoo	High	-	Moderate
Blue Crane	<i>Anthropoides paradiseus</i>	Vulnerable	Endemic	31.3	High		High	-	Moderate
Tawny Eagle	<i>Aquila rapax</i>	Vulnerable	-	0.0	Low				
Martial Eagle	<i>Polemaetus bellicosus</i>	Vulnerable (Near-threatened)	-	3.1	Moderate-High	Open Karoo, power pylons	High	High	Moderate
Secretarybird	<i>Sagittarius serpentarius</i>	Near-threatened (Vulnerable)	-	18.8	Moderate	Open Karoo	High	-	Moderate
Lesser Kestrel	<i>Falco naumanni</i>	Vulnerable	-	15.6	Moderate	Open Karoo, power pylons	Moderate	-	Moderate
Lanner Falcon	<i>Falco biarmicus</i>	Near-threatened	-	0.0	Moderate	Open Karoo, power pylons	High	Moderate	-
Peregrine Falcon	<i>Falco peregrinus</i>	Near-threatened	-	0.0			High	Moderate	-
Greater Flamingo	<i>Phoenicopterus ruber</i>	Near-threatened	-	9.4	Low	Wetlands, flying over	High	-	-

¹ Reporting rate calculated as the % of bird lists submitted for a given area which include each species.

9. ASSESSMENT OF IMPACTS

9.1 General assessment of impacts & mitigation

9.1.1 Impacts of solar energy facilities

Habitat loss – destruction, disturbance and displacement

Perhaps the most significant potential impact on birds of any solar energy generation facility is the displacement or exclusion of threatened, rare, endemic or range-restricted species from critical areas of habitat. Given the considerable space requirements of commercially viable facilities (>50-100 ha), this effect could be significant in some instances, particularly given the possibility that the initial footprint of successful facilities may be expanded over time, and allowing for the possible cumulative effects of multiple facilities in one area.

To a lesser extent, construction and ongoing maintenance activities are likely to cause some disturbance of birds in the general surrounds of a solar facility, and especially of shy and/or ground-nesting species resident in the area. Mitigation of such effects requires that generic best-practice principles be rigorously applied - sites are selected to avoid the destruction of key habitats, and construction and final footprints, as well as sources of disturbance of key species, must be kept to an absolute minimum.

Other effects

Any vertical, reflective surfaces may confuse approaching birds with the result that numbers are killed in collisions with such surfaces. If this source of unnatural mortality is a realistic expectation of a proposed solar installation, efforts should be made to restrict access by birds into the relevant, hazardous areas of the facility. Solar installations generally feature large areas of reflective paneling. It is possible that nearby or overflying birds may be disorientated by the reflected light, and consequently be displaced from an area more extensive than just the developed footprint of the facility. Conversely, certain bird species may be attracted to the solar arrays. The possibility also exists that waterbirds will mistake the reflective surface for an expanse of water, and attempt to land on the panels, incurring injury and/or being disorientated in the process. Other species may seek to benefit from the installations, using the erected structures as prominent perches, sheltered roost sites or even nesting sites, and possibly foraging around the infrastructure in response to changes in the distribution of preferred foods (plants growing under the paneling, other animals attracted to the facility). Such scenarios might be associated with fouling of critical components in the solar array, bringing local bird populations into conflict with the facility operators. Under these circumstances, specialist advice should be sought in devising effective avian deterrents to minimize associated damage.

9.1.2 Impacts of associated infrastructure

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

Construction and maintenance of power lines and substations

Some habitat destruction and alteration inevitably takes place during the construction of power lines, substations and associated roadways. Also, power line service roads or servitudes have to be cleared of excess vegetation at regular intervals in order to allow access to the line for maintenance, and to prevent vegetation from intruding into the legally prescribed clearance gaps between the ground and the conductors. These activities have an impact on birds breeding, foraging and roosting in or in close proximity to the servitude, and retention of cleared servitudes can have the effect of altering bird community structure along the length of any given power line (e.g. King & Byers 2002).

Collision with power lines

Power lines pose a significant collision risk to birds, affecting a particular suite of collision prone species (Bevanger 1994, 1995, 1998, Janss 2000b, Anderson 2001, van Rooyen 2004a, Drewitt & Langston 2008, Jenkins *et al.* 2010). Mitigation of this risk involves the informed selection of low impact alignments for new power lines relative to movements and concentrations of high risk species, and the use of either static or dynamic marking devices to make the lines, and in particular the earthwires, more conspicuous. While various marking devices have been used globally, many remain largely untested in terms of their efficacy in reducing collision incidence, and those that have been fully assessed have all been found to be only partially effective (Drewitt & Langston 2008, Jenkins *et al.* 2010).

Electrocution on power infrastructure

Avian electrocutions occur when a bird perches or attempts to perch on an 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 2004b, Lehman *et al.* 2007). Electrocution risk is strongly influenced by the voltage and design of the power lines erected (generally occurring on lower voltage infrastructure where air gaps are relatively small), and mainly affects larger, perching species, such as vultures, eagles and storks, easily capable of spanning the spaces between energised components. Mitigation of electrocution risk involves the use of bird-safe structures (ideally with critical air gaps >2 m), the physical exclusion of birds from high risk areas of live infrastructure, and comprehensive insulation of such areas (van Rooyen 2004b, Lehman *et al.* 2007).

9.2 Project specific impacts

Specific impacts of the proposed Du Plessis Dam PV Energy Facilities are most likely to be manifested in the following ways (summarised in Table 2):

- (i) Disturbance and displacement of seasonal influxes of large terrestrial birds (especially Blue Crane, Ludwig's Bustard and Kori Bustard) from nesting and/or foraging areas by construction and/or operation and/or decommissioning of the facilities, and /or mortality of these species in collisions with new power lines while commuting between resource areas.
- (ii) Disturbance and displacement of resident or visiting raptors (especially Martial Eagle, Tawny Eagle and Lesser Kestrel) from foraging areas by construction and/or operation and/or decommissioning of the facilities, and /or mortality of these species in collisions with new power lines or by electrocution when perched on power infrastructure.
- (iii) Disturbance and displacement of resident/breeding Karoo endemics.

- (iv) Injury or mortality of wetland birds (especially flamingos) using possible flight lines in and out of resource areas in the broader vicinity, in collisions with the PV infrastructure or associated new power lines.

Generally, however, the anticipated impacts on birds of the proposed development are not considered to be of any great significance (Boxes 1.1 – 1.3, Table 3). There will be some habitat loss for Karoo endemic species (although the general area at the site is already somewhat degraded and disturbed), some species (Karoo endemics, large terrestrial species, raptors) may be displaced from a broader area either temporarily by construction and maintenance activities, or more permanently by the disruptive, reflective properties of the solar panels, and some species (large terrestrial species, raptors, commuting wetland birds) may be killed in interactions (collisions, electrocutions) with the new power infrastructure, but again, numbers affected are likely to be low.

Table 2. Impact characteristics: Du Plessis DamPV Energy Facilities – Birds.

Summary	Construction	Operation	Decommissioning
Project Aspect/ activity	<ul style="list-style-type: none"> (i) Disturbance/displacement associated with noise and movement of construction equipment and personnel. (ii) Loss of vegetation and avian habitat through site clearance, road upgrade and establishment of the camp, lay-down and assembly areas. 	<ul style="list-style-type: none"> (i) Loss of habitat to space occupied by solar panels and associated infrastructure, and disturbance / displacement associated with routine maintenance work. (ii) Mortality in collisions with solar panels and/or power lines, or by electrocution on new power infrastructure. 	<ul style="list-style-type: none"> (i) Disturbance/displacement associated with noise and movement of decommissioning equipment and personnel.
Impact Type	Direct	Direct	Direct
Receptors Affected	<ul style="list-style-type: none"> (i) All birds on site; key species: Ludwig’s Bustard, Kori Bustard, Blue Korhaan, Blue Crane, Martial Eagle, Tawny Eagle, Lesser Kestrel, Blue Crane, Karoo endemics. (ii) All birds on site; key species: Ludwig’s Bustard, Kori Bustard, Blue Korhaan, Blue Crane, Martial Eagle, Tawny Eagle, Lesser Kestrel, Karoo endemics. 	<ul style="list-style-type: none"> (iii) All birds on site; key species: Ludwig’s Bustard, Kori Bustard, Blue Korhaan, Blue Crane, Martial Eagle, Tawny Eagle, Lesser Kestrel, Blue Crane, Karoo endemics. (i) All birds on site; Ludwig’s Bustard, Kori Bustard, Blue Korhaan, Blue Crane, Martial Eagle, Tawny Eagle, Lesser Kestrel, Blue Crane, overflying wetland birds. 	<ul style="list-style-type: none"> (i) All birds on site; key species: Ludwig’s Bustard, Kori Bustard, Blue Korhaan, Blue Crane, Martial Eagle, Tawny Eagle, Lesser Kestrel, Blue Crane, Karoo endemics.

Box 1.1.

Pre-mitigation Construction Impact: Du Plessis Dam PV2-4 Energy Facilities – Birds, with ratings for the alternative proposal (where these differ) in square brackets. Significance ratings ascribed as per the criteria provided by Aurecon South Africa.

(A) Habitat loss

Nature: All construction activities would result in a **negative direct** impact on the avifauna of the Du Plessis Dam site; loss of vegetation and habitat affecting Karoo endemics, raptors and large terrestrial species, through site clearance, road upgrade and establishment of the camp and assembly areas.

Impact Magnitude – Low-Medium [Medium]

- **Extent:** The extent of the impact is **local**.
- **Duration:** The duration would be **short-term** as the ecology of the area may be altered beyond the completion of the project.
- **Probability:** Habitat will **definitely** be lost.

IMPACT SIGNIFICANCE – LOW-MEDIUM [MEDIUM]

Confidence: Certain

Reversibility: Reversible

Cumulative impacts: Could be substantially amplified by multiple renewable energy projects in the area, which seems highly likely.

(B) Disturbance

Nature: All construction activities would result in a **negative direct** impact on the avifauna of the Du Plessis Dam PV site; disturbance associated with noise and movement of construction equipment and personnel, affecting Karoo endemics, raptors and large terrestrial species.

Impact Magnitude – Medium

- **Extent:** The extent of the impact is **local [regional]**.
- **Duration:** The duration will not extend beyond the **construction period**.
- **Probability:** There will **definitely** be disturbance.

IMPACT SIGNIFICANCE – [MEDIUM]

Confidence: Certain

Reversibility: Possibly reversible

Cumulative impacts: Could be substantially amplified by multiple renewable energy projects in the area, which seems highly likely.

Box 1.2.

Pre-mitigation Operation Impact: Du Plessis Dam PV2-4 Energy Facilities – Birds, with ratings for the alternative proposal (where these differ) in square brackets. Significance ratings ascribed as per the criteria provided by Aurecon South Africa.

(A) Habitat loss and disturbance

Nature: Operational activities would result in a **negative direct** impact on the avifauna of the Du Plessis Dam PV site; loss of habitat for Karoo endemics, raptors and large terrestrial species, to space occupied by solar panels and associated infrastructure, and disturbance or displacement of these birds by routine maintenance activities.

Impact Magnitude – Low-Medium [Medium]

- **Extent:** The extent of the impact is potentially **local**.
- **Duration:** The duration would be **long-term** as the ecology of the area would be affected until the project stops operating and is fully decommissioned.
- **Probability:** Habitat will **definitely** be lost and some priority species will be disturbed/displaced.

IMPACT SIGNIFICANCE – LOW- MEDIUM [MEDIUM]

Confidence: Certain

Reversibility: Possibly reversible

Cumulative impacts: Could be substantially amplified by multiple renewable energy projects in the area, which seems highly likely.

(B) Mortality

Nature: Operational activities would result in a **negative direct** impact on the avifauna of the Du Plessis Dam PV site; mortality of raptors, large terrestrials in collisions with solar panels and/or power lines, or by electrocution on new power infrastructure.

Impact Magnitude – Medium-High

- **Extent:** The extent of the impact is potentially **regional**.
- **Duration:** The duration would be **long-term** as the ecology of the area would be affected at least until the project stops operating and is fully decommissioned.
- **Probability:** It is **probable** that some individuals of priority species will be killed.

IMPACT SIGNIFICANCE – MEDIUM-HIGH

Confidence: Unsure

Reversibility: Irreversible

Cumulative impacts: Could be substantially amplified by multiple renewable energy projects in the area, which seems highly likely.

Box 1.3. Pre-mitigation Decommissioning Impact: Du Plessis Dam PV2-5 Energy Facilities – Birds, with ratings for the alternative proposal (where these differ) in square brackets. Significance ratings ascribed as per the criteria provided by Aurecon South Africa.

(A) Disturbance

Nature: All decommissioning activities would result in a **negative direct** impact on the avifauna of the Du Plessis Dam PV site; disturbance associated with noise and movement of decommissioning equipment and personnel, affecting Karoo endemics, raptors and large terrestrial species.

Impact Magnitude – Low-Medium [Medium]

- **Extent:** The extent of the impact is **local [regional]**.
- **Duration:** The duration will not extend beyond the **decommissioning period**.
- **Probability:** There will **definitely** be disturbance.

IMPACT SIGNIFICANCE – LOW-MEDIUM [MEDIUM]

Confidence: Certain

Reversibility: Reversible

Cumulative impacts: Could be substantially amplified by multiple renewable energy projects in the area, which seems highly likely.

Table 3. Pre- and Post- Mitigation Significance: Du Plessis Dam PV2-4 Energy Facilities - Birds; preferred vs alternative layout options. Significance ratings ascribed as per the criteria provided by Aurecon South Africa.

Impact	Alternative layout Pre-mitigation	Alternative layout Residual (post-mitigation)	Preferred layout Pre-mitigation	Preferred layout Residual (post-mitigation)
Construction Phase				
Habitat loss	MEDIUM	LOW-MEDIUM	LOW-MEDIUM	LOW
Disturbance	MEDIUM	LOW-MEDIUM	MEDIUM	LOW-MEDIUM
Operation Phase				
Habitat loss & disturbance	MEDIUM	MEDIUM	LOW-MEDIUM	LOW-MEDIUM
Mortality	MEDIUM-HIGH	LOW-MEDIUM	MEDIUM-HIGH	LOW-MEDIUM
Decommissioning Phase				
Disturbance	MEDIUM	LOW-MEDIUM	LOW-MEDIUM	LOW

Cumulative avifauna impacts

Key impacts	Magnitude	Duration	SIGNIFICANCE	Probability	Confidence	Reversibility
Without Mitigation	High	Permanent	Very High (-)	Definite	Certain	Irreversible
With Mitigation	High	Permanent	High (-)	Definite	Certain	Irreversible

Note that the anticipated net impacts of this proposed development should ideally be considered in the context of accumulated impacts imposed by multiple other renewable energy projects proposed (and some already authorized and under construction) within a 20 km radius of De Aar (Fig. 2).

Furthermore, the project itself comprises a number of potentially independent PV installations, each of which has its own inherent impact profile, contributing to the net aggregate impact of the whole proposed development. While the impact potential of each separate PV array must, by definition, be less than the sum of all the components together, we have assumed here that each component has the same impact as the sum, partly in the interests of conservatism and pragmatism, and partly because the assessment criteria imposed on the study do not allow for a finer scale evaluation of relative impacts.

The negative impacts resulting from all phases of this proposed development (i.e. development to the extent of individual farms) would certainly be substantially amplified by the construction and operation of multiple renewable energy projects in the area (development to the extent of broader localities or even regions). Relatively minor levels of disturbance at the individual project level (i.e. farm) would escalate to combined levels likely to cause complete and possibly long-term evacuation of the locality or region by more sensitive species. These disturbance effects would be exacerbated by the loss or degradation of markedly more habitat to a much larger aggregate construction and operational footprint, possibly resulting in the permanent loss from the affected area of key elements of the avifauna. Bearing this in mind, it is essential that the suitability of this single proposal be considered in the context of broader renewable energy development plans for De Aar and surrounding areas.

10. MITIGATION

Should the proposed PV Facilities be approved, mitigation of impacts on birds should focus on:

- (i) Selecting the preferred layout option, given that this occupies a markedly smaller development footprint.
- (ii) Minimizing the inclusive construction footprint of the development and abbreviating construction time.
- (iii) Minimizing noise and disturbance associated with maintenance activities at the plant once it becomes operational.
- (iv) Selecting the PV technology that is least likely to be mistaken for a waterbody by overflying wetland birds.
- (v) Selecting the alternative 2 proposed transmission line corridor, this decision is based on the fact that this option is shorter in length and therefore decreases the risk to collision prone species.
- (vi) Minimising the length of any new power lines installed and burying lines wherever possible. If lines cannot be buried, ensure that all new lines are marked with bird flight diverters (Jenkins *et al.* 2010) along their entire length, and that all new power line infrastructure is adequately insulated and bird friendly in configuration (Lehman *et al.* 2007). Note that current understanding of power line collision risk in birds precludes any guarantee of successfully distinguishing high risk from medium or low risk sections of a new line (Jenkins *et al.* 2010). The relatively low cost of marking the entire length of a new line during construction, especially quite a short length of line in an area frequented by collision prone birds, more than offsets the risk of not marking the correct sections, causing unnecessary mortality of birds, and then incurring the much greater cost of retro-fitting the line post-construction. In situations where new lines run in parallel with existing, unmarked power lines, this approach has the added benefit of reducing the collision risk posed by the older line.
- (vii) Minimising the amount of fencing used to enclose the development areas, given that these may present a collision risk for collision-prone birds.
- (viii) Instituting a comprehensive impact monitoring scheme, and using the results of this scheme to inform and refine a dynamic approach to mitigation.

11. CONCLUSION

The proposed Du Plessis Dam PV Facilities are likely to have little, if any significant, long-term impact on the avifauna of the area, after mitigation. Careful and responsible implementation of the required mitigation measures should reduce construction and operational phase impacts to tolerable and sustainable levels, especially if every effort is made to monitor impacts throughout, to learn as much as possible about the effects of solar energy developments on South African avifauna, and to implement mitigation measures suggested as a result of ongoing monitoring.

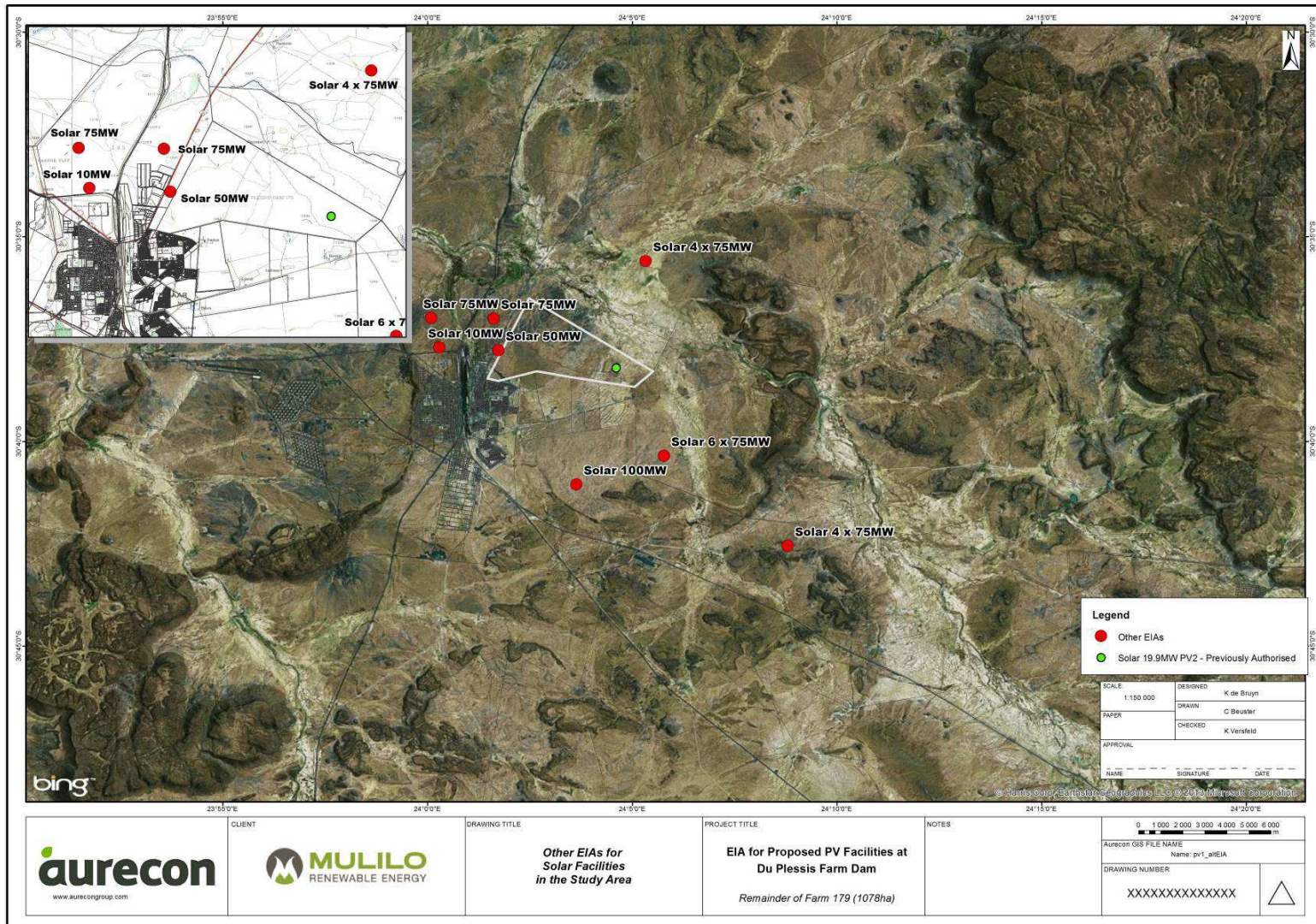


Figure 2. The location of the Du Plessis Dam PV Energy Facilities in relation to other renewable energy projects proposed for the De Aar area.

12. LONG-TERM MONITORING

12.1 Rationale for monitoring

Given that solar energy development is relatively new to South Africa, and its potential impacts on birds are generally not well understood, it is strongly recommended that attention be given to improving this understanding by initiating quantitative studies of the avifauna at proposed sites both pre- and post-construction (Smit 2012). The primary aims of such monitoring work would be to:

- (i) Determine the densities of birds resident within the impact area of the solar power plant before construction of the plant, and afterwards, once the plant, or phases of the plant, become operational.
- (ii) Register and as far as possible document the circumstances surrounding all avian mortalities associated with the ancillary infrastructure of the solar plant for at least six months after the plant becomes operational.
- (iii) Register and as far as possible document the circumstances surrounding all other avian interactions with the solar arrays of the solar power plant for at least six months after the plant becomes operational.

Bird density and activity monitoring should focus on rare and/or endemic, potentially disturbance or collision prone species, which occur with some regularity in the area. Ultimately, the study should provide much needed quantitative information on the effects of the solar power plant on the distribution and abundance of birds, and the actual risk it poses to the local avifauna, and serve to inform and improve mitigation measures to reduce this risk.

Monitoring protocols: Avian densities before and after

A set of at least 10 walk-transect routes, each of at least 20 minutes in duration or 750 m in length, should be established in areas representative of all the avian habitats present within and around the periphery of the Du Plessis PV site. Each of these should be walked at least once every two months over the six months preceding construction, and at least once every two months over the same calendar period, at least six months after the PV plant is commissioned. The transects should be walked after 06h00 and before 09h00 in summer, and after 07h00 and before 12h00 in winter, and the species, number and perpendicular distance from the transect line of all birds seen should be recorded for subsequent analysis and comparison.

Monitoring protocols: collisions and fouling

The area within 5 m on either side of any new lengths of power line, should be checked regularly for bird casualties (Anderson *et al.* 1999, Morrison 2002). The frequency of these surveys should be informed by assessments of scavenger and decomposition rates. All suspected mortality incidents should be comprehensively documented, detailing the apparent cause of death, precise location (preferably a GPS reading), date and time at which the evidence was found, and the site of the find should be photographed with all the evidence *in situ*. All physical evidence should then be collected, bagged and carefully labeled, and refrigerated or frozen to await further examination. If any injured birds are recovered, each should be contained in a suitably-sized cardboard box, and the local conservation authority should be notified and

requested to transport casualties to the nearest reputable veterinary clinic or wild animal/bird rehabilitation centre.

These post-construction surveys should also include detailing (location, extent, size, number) of all bird products (e.g. faeces, pellets, nest structures etc) found on and around the solar panels.

12.2 Results of first monitoring iteration

Seventeen walk transects were established within ($n = 9$) and outside ($n = 5$) of the proposed development area (Fig. 4), and surveys of small terrestrial bird densities were measured along each of these transect lines as per the stipulated protocols (Table 4, Appendix 2). In combination with the data obtained in two further site visits, these initial density estimates will establish a baseline against which to estimate the numbers of Karoo endemic passerines displaced by the development, and to monitor the effect of the built and operational PV plants on the density and community structure of surrounding passerine populations.

Other results of the first monitoring iteration are integrated into this EIA report.

Table 4. Parameters describing the 20 min walked transects plotted (see Fig. 4) and sampled in and around the Du Plessis Dams Pan PV development area. Cloud cover: 0-8 eighths; Temp(erature): 1 = cool, 2 = mild, 3 = warm, Wind: 1= calm, 2 = breeze, 3 = wind, 4 = strong wind.

Transect number	Start time (hh:mm)	Cloud cover	Temp	Wind	Inside PV footprint?	Habitat	Gradient	Length (km)	Mean transect width (m)	<i>n</i> sightings	<i>n</i> birds	Density (birds.ha ⁻¹)
D01	08:05	0	1	2	Yes	Karoo	Flat	0.73	48	9	44	2.59
D02	08:30	0	1	2	No	Karoo	Flat	0.86	15	9	17	6.90
D03	09:00	0	2	2	No	Karoo	Flat	0.75	51	11	18	2.86
D04	09:26	0	2	2	No	Karoo	Flat	0.95	39	8	12	2.15
D05	09:52	0	2	2	Yes	Karoo	Flat	1.09	27	9	11	3.11
D06	10:20	0	2	2	Yes	Karoo	Flat	1.32	38	4	4	0.81
D07	10:47	0	2	2	Yes	Karoo	Flat	0.73	38	10	32	3.62
D08	08:10	0	1	2	Yes	Karoo	Flat	0.66	24	8	12	5.12
D09	08:40	0	1	2	Yes	Grassy/Karoo	Flat	0.58	40	8	10	3.43
D10	09:05	0	2	2	Yes	Grassy/Karoo	Undulating	0.77	37	9	21	3.17
D11	09:30	0	2	2	Yes	Grassy/Karoo	Undulating	0.71	58	8	15	1.97
D12	10:00	0	2	2	No	Karoo	Undulating	0.45	29	10	34	7.61
D13	10:30	0	2	2	Yes	Karoo	Flat	0.88	32	9	28	3.16
D14	11:10	0	2	2	Yes	Karoo	Flat	0.84	65	6	10	1.09
Overall								0.81	39	8.4	19.1	3.40

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Appendix 1. Inclusive, annotated list of the bird species considered likely to occur within the broader impact zone of the proposed locations for the Du Plessis Dam Energy Facilities.

Common name	Scientific name	Conservation status	Regional endemism	Habitat					Susceptibility to		
				Karoo veld	Drainage lines	Rocky koppies	Dams & ephemeral waterbodies	Fly over	Collision	Electrocution	Disturbance / habitat loss
Common Ostrich	<i>Struthio camelus</i>	-	-	X					-	-	High
Common Quail	<i>Coturnix coturnix</i>	-	-	X					-	-	High
Helmeted Guinea fowl	<i>Numida meleagris</i>	-	-		X				Moderate	-	High
White-faced Duck	<i>Dendrocygna viduata</i>	-	-				X		Moderate	-	-
Maccoa Duck	<i>Oxyura maccoa</i>	-	-				X		Moderate	-	-
Egyptian Goose	<i>Alopochen aegyptiaca</i>	-	-				X		High	High	-
South African Shelduck	<i>Tadorna cana</i>	-	Endemic				X		High	-	-
Spur-winged Goose	<i>Plectropterus gambensis</i>	-	-				X		High	Moderate	-
Cape Teal	<i>Anas capensis</i>	-	-				X		Moderate	-	-
African Black Duck	<i>Anas sparsa</i>	-	-				X		Moderate	-	-
Yellow-billed Duck	<i>Anas undulata</i>	-	-				X		Moderate	-	-
Cape Shoveler	<i>Anas smithii</i>	-	Endemic				X		Moderate	-	-
Red-billed Teal	<i>Anas erythrorhyncha</i>	-	-				X		Moderate	-	-

Common name	Scientific name	Conservation status	Regional endemism	Habitat					Susceptibility to		
				Karoo veld	Drainage lines	Rocky koppies	Dams & ephemeral waterbodies	Fly over	Collision	Electrocution	Disturbance / habitat loss
Southern Pochard	<i>Netta erythroptalma</i>	-	-				X		Moderate	-	-
Kurrichane Buttonquail	<i>Turnix sylvaticus</i>	-	-	X					-	-	High
Greater Honeyguide	<i>Indicator indicator</i>	-	-		X				-	-	-
Lesser Honeyguide	<i>Indicator minor</i>	-	-		X				-	-	Moderate
Cardinal Woodpecker	<i>Dendropicos fuscescens</i>	-	-		X				-	-	Moderate
Acacia Pied Barbet	<i>Tricholaema leucomelas</i>	-	Near-endemic		X				-	-	Moderate
African Hoopoe	<i>Upupa africana</i>	-	-		X				-	-	Moderate
European Roller	<i>Coracias garrulus</i>	-	-	X	X				-	-	-
Malachite Kingfisher	<i>Alcedo cristata</i>	-	-				X		-	-	-
Pied Kingfisher	<i>Ceryle rudis</i>	-	-				X		-	-	-
Giant Kingfisher	<i>Megaceryle maximus</i>	-	-				X		-	-	-
Swallow-tailed Bee-eater	<i>Merops hirundineus</i>	-	-	X	X	X	X		-	-	Moderate

Common name	Scientific name	Conservation status	Regional endemism	Habitat					Susceptibility to		
				Karoo veld	Drainage lines	Rocky koppies	Dams & ephemeral waterbodies	Fly over	Collision	Electrocution	Disturbance / habitat loss
European Bee-eater	<i>Merops apiaster</i>	-	-						-	-	-
White-backed Mousebird	<i>Colius colius</i>	-	Endemic		X				-	-	Moderate
Red-faced Mousebird	<i>Urocolius indicus</i>	-	-		X				-	-	Moderate
Jacobin Cuckoo	<i>Clamator jacobinus</i>	-	-		X				-	-	Moderate
Diderick Cuckoo	<i>Chrysococcyx caprius</i>	-	-		X				-	-	Moderate
Alpine Swift	<i>Tachymarptis melba</i>	-	-					X	-	-	-
Common Swift	<i>Apus apus</i>	-	-					X	-	-	-
African Black Swift	<i>Apus barbatus</i>	-	-			X		X	-	-	-
Little Swift	<i>Apus affinis</i>	-	-			X			-	-	-
White-rumped Swift	<i>Apus caffer</i>	-	-					X	-	-	-
Barn Owl	<i>Tyto alba</i>	-	-	X	X	X			-	Moderate	Moderate
Southern White-faced Scops-Owl	<i>Ptilopsis granti</i>	-	-		X				-	-	Moderate
Cape Eagle-Owl	<i>Bubo capensis</i>	-	-			X			-	High	Moderate

Common name	Scientific name	Conservation status	Regional endemism	Habitat					Susceptibility to		
				Karoo veld	Drainage lines	Rocky koppies	Dams & ephemeral waterbodies	Fly over	Collision	Electrocution	Disturbance / habitat loss
Spotted Eagle-Owl	<i>Bubo africanus</i>	-	-	X	X	X			-	High	Moderate
Fiery-necked Nightjar	<i>Caprimulgus pectoralis</i>	-	-	X	X				-	-	Moderate
Rufous-cheeked Nightjar	<i>Caprimulgus rufigena</i>	-	-	X					-	-	Moderate
Rock Dove	<i>Columba livia</i>	-	-			X		X	-	-	Moderate
Speckled Pigeon	<i>Columba guinea</i>	-	-			X		X	-	-	Moderate
Laughing Dove	<i>Streptopelia senegalensis</i>	-	-		X				-	-	Moderate
Cape Turtle-Dove	<i>Streptopelia capicola</i>	-	-		X				-	-	Moderate
Red-eyed Dove	<i>Streptopelia semitorquata</i>	-	-		X				-	-	Moderate
Namaqua Dove	<i>Oena capensis</i>	-	-	X	X				-	-	Moderate
Ludwig's Bustard	<i>Neotis ludwigii</i>	Vulnerable	Near-endemic	X					High	-	Moderate
Kori Bustard	<i>Ardeotis kori</i>	Vulnerable	-	X					High	-	Moderate
Northern Black Korhaan	<i>Afrotis afraoides</i>	-	Endemic	X					Moderate	-	Moderate
Karoo Korhaan	<i>Eupodotis vigorsii</i>	-	Endemic	X					Moderate	-	Moderate

Common name	Scientific name	Conservation status	Regional endemism	Habitat					Susceptibility to		
				Karoo veld	Drainage lines	Rocky koppies	Dams & ephemeral waterbodies	Fly over	Collision	Electrocution	Disturbance / habitat loss
Blue Korhaan	<i>Eupodotis caerulescens</i>	Near-threatened	Endemic	X					Moderate	-	Moderate
Blue Crane	<i>Anthropoides paradiseus</i>	Vulnerable	Endemic	X			X		High	-	Moderate
Common Moorhen	<i>Gallinula chloropus</i>	-	-				X		-	-	-
Red-knobbed Coot	<i>Fulica cristata</i>	-	-				X		-	-	-
Namaqua Sandgrouse	<i>Pterocles namaqua</i>	-	Near-endemic	X			X		-	-	-
African Snipe	<i>Gallinago nigripennis</i>	-	-				X		-	-	-
Marsh Sandpiper	<i>Tringa stagnatilis</i>	-	-				X		-	-	-
Common Greenshank	<i>Tringa nebularia</i>	-	-				X		-	-	-
Wood Sandpiper	<i>Tringa glareola</i>	-	-				X		-	-	-
Common Sandpiper	<i>Actitis hypoleucos</i>	-	-				X		-	-	-
Little Stint	<i>Calidris minuta</i>	-	-				X		-	-	-
Curlew Sandpiper	<i>Calidris ferruginea</i>	-	-				X		-	-	-
Ruff	<i>Philomachus pugnax</i>	-	-				X		-	-	-

Common name	Scientific name	Conservation status	Regional endemism	Habitat					Susceptibility to		
				Karoo veld	Drainage lines	Rocky koppies	Dams & ephemeral waterbodies	Fly over	Collision	Electrocution	Disturbance / habitat loss
Spotted Thick-knee	<i>Burhinus capensis</i>	-	-	X	X				-	-	-
Black-winged Stilt	<i>Himantopus himantopus</i>	-	-				X		-	-	-
Pied Avocet	<i>Recurvirostra avosetta</i>	-	-				X		-	-	-
Kittlitz's Plover	<i>Charadrius pecuarius</i>	-	-				X		-	-	-
Three-banded Plover	<i>Charadrius tricollaris</i>	-	-				X		-	-	-
Blacksmith Lapwing	<i>Vanellus armatus</i>	-	-				X		-	-	-
Crowned Lapwing	<i>Vanellus coronatus</i>	-	-	X					-	-	-
Double-banded Courser	<i>Rhinoptilus africanus</i>	-	-	X					-	-	-
Burchell's Courser	<i>Cursorius rufus</i>	-	Near-endemic	X					-	-	-
Whiskered Tern	<i>Chlidonias hybrida</i>	-	-				X		-	-	-
White-winged Tern	<i>Chlidonias leucopterus</i>	-	-				X		-	-	-
Black-shouldered Kite	<i>Elanus caeruleus</i>	-	-	X	X				-	-	Moderate

Common name	Scientific name	Conservation status	Regional endemism	Habitat					Susceptibility to		
				Karoo veld	Drainage lines	Rocky koppies	Dams & ephemeral waterbodies	Fly over	Collision	Electrocution	Disturbance / habitat loss
Black Kite	<i>Milvus migrans</i>	-	-	X				X	-	-	-
African Fish-Eagle	<i>Haliaeetus vocifer</i>	-	-					X	-	High	-
Black-chested Snake-Eagle	<i>Circaetus pectoralis</i>	-	-					X	-	Moderate	Moderate
Black Harrier	<i>Circus maurus</i>	Near-threatened	Endemic	X			X		-	-	Moderate
African Harrier-Hawk	<i>Polyboroides typus</i>	-	-		X			X	-	-	Moderate
Southern Pale Chanting Goshawk	<i>Melierax canorus</i>	-	Near-endemic	X	X				-	Moderate	Moderate
Gabar Goshawk	<i>Melierax gabar</i>	-	-		X				-	-	Moderate
Rufous-chested Sparrowhawk	<i>Accipiter rufiventris</i>	-	-		X				-	-	Moderate
Steppe Buzzard	<i>Buteo vulpinus</i>	-	-	X				X	-	Moderate	Moderate
Jackal Buzzard	<i>Buteo rufofuscus</i>	-	Endemic	X				X	-	Moderate	Moderate
Tawny Eagle	<i>Aquila rapax</i>	Vulnerable	-		X			X	-	High	Moderate
Verreauxs' Eagle	<i>Aquila verreauxii</i>	-	-					X	Moderate	High	Moderate
Booted Eagle	<i>Aquila pennatus</i>	-	-					X	-	-	Moderate

Common name	Scientific name	Conservation status	Regional endemism	Habitat					Susceptibility to		
				Karoo veld	Drainage lines	Rocky koppies	Dams & ephemeral waterbodies	Fly over	Collision	Electrocution	Disturbance / habitat loss
Martial Eagle	<i>Polemaetus bellicosus</i>	Vulnerable	-					X	Moderate	High	Moderate
Secretarybird	<i>Sagittarius serpentarius</i>	Near-threatened	-	X				X	High	-	Moderate
Lesser Kestrel	<i>Falco naumanni</i>	Vulnerable	-	X	X			X	Moderate	-	Moderate
Rock Kestrel	<i>Falco rupicolus</i>	-	-	X		X			-	-	Moderate
Greater Kestrel	<i>Falco rupicoloides</i>	-	-	X					-	-	Moderate
Lanner Falcon	<i>Falco biarmicus</i>	Near-threatened	-	X				X	High	Moderate	-
Peregrine Falcon	<i>Falco peregrinus</i>	Near-threatened	-	X				X	High	Moderate	-
Little Grebe	<i>Tachybaptus ruficollis</i>	-	-				X		-	-	-
Black-necked Grebe	<i>Podiceps nigricollis</i>	-	-				X		-	-	-
African Darter	<i>Anhinga rufa</i>	-	-				X		-	-	-
Reed Cormorant	<i>Phalacrocorax africanus</i>	-	-				X		-	-	-
White-breasted Cormorant	<i>Phalacrocorax lucidus</i>	-	-				X	X	Moderate	-	-
Little Egret	<i>Egretta garzetta</i>	-	-				X		-	-	-
Grey Heron	<i>Ardea cinerea</i>	-	-				X		Moderate	Moderate	-
Black-headed Heron	<i>Ardea melanocephala</i>	-	-	X			X		Moderate	Moderate	-

Common name	Scientific name	Conservation status	Regional endemism	Habitat					Susceptibility to		
				Karoo veld	Drainage lines	Rocky koppies	Dams & ephemeral waterbodies	Fly over	Collision	Electrocution	Disturbance / habitat loss
Goliath Heron	<i>Ardea goliath</i>	-	-				X	X	High		
Cattle Egret	<i>Bubulcus ibis</i>	-	-				X		-	-	-
Hamerkop	<i>Scopus umbretta</i>	-	-				X	X	Moderate	-	-
Greater Flamingo	<i>Phoenicopterus ruber</i>	Near-threatened	-					X	High	-	-
Lesser Flamingo	<i>Phoenicopterus minor</i>	Near-threatened	-					X	High	-	-
Glossy Ibis	<i>Plegadis falcinella</i>	-	-				X	X	Moderate	-	-
Hadedda Ibis	<i>Bostrychia hagedash</i>	-	-		X			X	Moderate	-	-
African Sacred Ibis	<i>Threskiornis aethiopicus</i>	-	-				X	X	Moderate	-	-
African Spoonbill	<i>Platalea alba</i>	-	-				X	X	Moderate	-	-
Black Stork	<i>Ciconia nigra</i>	Near-threatened	-				X	X	High	Moderate	-
Abdim's Stork	<i>Ciconia abdimii</i>	-	-				X	X	Moderate	Moderate	-
White Stork	<i>Ciconia ciconia</i>	-	-				X	X	High	High	-
Fork-tailed Drongo	<i>Dicrurus adsimilis</i>	-	-		X				-	-	Moderate
Bokmakierie	<i>Telophorus zeylonus</i>	-	Near-endemic		X				-	-	Moderate
Pirit Batis	<i>Batis pririt</i>	-	Near-endemic		X				-	-	Moderate
Cape Crow	<i>Corvus capensis</i>	-	-	X	X				-	-	Moderate

Common name	Scientific name	Conservation status	Regional endemism	Habitat					Susceptibility to		
				Karoo veld	Drainage lines	Rocky koppies	Dams & ephemeral waterbodies	Fly over	Collision	Electrocution	Disturbance / habitat loss
Pied Crow	<i>Corvus albus</i>	-	-	X	X	X			-	-	Moderate
White-necked Raven	<i>Corvus albicollis</i>	-	-	X		X			-	-	Moderate
Red-backed Shrike	<i>Lanius collurio</i>	-	-	X					-	-	Moderate
Lesser Grey Shrike	<i>Lanius minor</i>	-	-	X					-	-	Moderate
Common Fiscal	<i>Lanius collaris</i>	-	-	X	X				-	-	Moderate
Cape Penduline-Tit	<i>Anthoscopus minutus</i>	-	Near-endemic	X					-	-	Moderate
Ashy Tit	<i>Parus cinerascens</i>	-	Near-endemic	X					-	-	Moderate
Grey Tit	<i>Parus afer</i>	-	Endemic	X					-	-	Moderate
Brown-throated Martin	<i>Riparia paludicola</i>	-	-				X	X	-	-	Moderate
Barn Swallow	<i>Hirundo rustica</i>	-	-				X	X	-	-	Moderate
White-throated Swallow	<i>Hirundo albigularis</i>	-	-				X		-	-	Moderate
Pearl-breasted Swallow	<i>Hirundo dimidiata</i>	-	-	X				X	-	-	Moderate
Greater Striped Swallow	<i>Hirundo cucullata</i>	-	-				X	X	-	-	Moderate

Common name	Scientific name	Conservation status	Regional endemism	Habitat					Susceptibility to		
				Karoo veld	Drainage lines	Rocky koppies	Dams & ephemeral waterbodies	Fly over	Collision	Electrocution	Disturbance / habitat loss
South African Cliff Swallow	<i>Hirundo spilodera</i>	-	Breeding endemic	X		X		X	-	-	Moderate
Rock Martin	<i>Hirundo fuligula</i>	-	-			X	X	X	-	-	Moderate
African Red-eyed Bulbul	<i>Pycnonotus nigricans</i>	-	Near-endemic		X				-	-	Moderate
Fairy Flycatcher	<i>Stenostira scita</i>	-	Endemic		X				-	-	Moderate
Long-billed Crombec	<i>Sylvietta rufescens</i>	-	-	X	X				-	-	Moderate
Yellow-bellied Eremomela	<i>Eremomela icteropygialis</i>	-	-	X	X				-	-	Moderate
Karoo Eremomela	<i>Eremomela gregalis</i>	-	Endemic	X					-	-	Moderate
African Reed-Warbler	<i>Acrocephalus baeticatus</i>	-	-				X		-	-	Moderate
Lesser Swamp-Warbler	<i>Acrocephalus gracilirostris</i>	-	-				X		-	-	Moderate
Willow Warbler	<i>Phylloscopus trochilus</i>	-	-		X				-	-	Moderate
Layard's Tit-Babbler	<i>Parisoma layardi</i>	-	Endemic	X	X				-	-	Moderate

Common name	Scientific name	Conservation status	Regional endemism	Habitat					Susceptibility to		
				Karoo veld	Drainage lines	Rocky koppies	Dams & ephemeral waterbodies	Fly over	Collision	Electrocution	Disturbance / habitat loss
Chestnut-vented Tit-Babbler	<i>Parisoma subcaeruleum</i>	-	Near-endemic		X				-	-	Moderate
Orange River White-eye	<i>Zosterops pallidus</i>	-	Endemic		X				-	-	Moderate
Grey-backed Cisticola	<i>Cisticola subruficapilla</i>	-	Near-endemic	X	X				-	-	Moderate
Levaillant's Cisticola	<i>Cisticola tinniens</i>	-	-				X		-	-	Moderate
Neddicky	<i>Cisticola fulvicapilla</i>	-	-	X					-	-	Moderate
Zitting Cisticola	<i>Cisticola juncidis</i>	-	-				X		-	-	Moderate
Desert Cisticola	<i>Cisticola aridulus</i>	-	-				X		-	-	Moderate
Black-chested Prinia	<i>Prinia flavicans</i>	-	-		X				-	-	Moderate
Karoo Prinia	<i>Prinia maculosa</i>	-	Endemic	X	X				-	-	Moderate
Namaqua Warbler	<i>Phragmacia substriata</i>	-	Endemic		X				-	-	Moderate
Rufous-eared Warbler	<i>Malcorus pectoralis</i>	-	Endemic	X					-	-	Moderate
Cinnamon-breasted Warbler	<i>Euryptila subcinnamomea</i>	-	Endemic	X					-	-	Moderate

Common name	Scientific name	Conservation status	Regional endemism	Habitat					Susceptibility to		
				Karoo veld	Drainage lines	Rocky koppies	Dams & ephemeral waterbodies	Fly over	Collision	Electrocution	Disturbance / habitat loss
Eastern Clapper Lark	<i>Mirafra fasciolata</i>	-	Near-endemic	X					-	-	Moderate
Sabota Lark	<i>Calendulauda sabota</i>	-	-	X					-	-	Moderate
Karoo Lark	<i>Calendulauda albescens</i>	-	Endemic	X					-	-	Moderate
Spike-heeled Lark	<i>Chersomanes albofasciata</i>	-	-	X					-	-	Moderate
Karoo Long-billed Lark	<i>Certhilauda subcoronata</i>	-	Endemic	X					-	-	Moderate
Black-eared Sparrowlark	<i>Eremopterix australis</i>	-	Endemic	X					-	-	Moderate
Grey-backed Sparrowlark	<i>Eremopterix verticalis</i>	-	Near-endemic	X					-	-	Moderate
Red-capped Lark	<i>Calandrella cinerea</i>	-	-	X					-	-	Moderate
Pink-billed Lark	<i>Spizocorys conirostris</i>	-	Near-endemic	X					-	-	Moderate
Large-billed Lark	<i>Galerida magnirostris</i>	-	Endemic	X					-	-	Moderate
Cape Rock Thrush	<i>Monticola rupestris</i>	-	Endemic	X					-	-	Moderate
Sentinel Rock Thrush	<i>Monticola explorator</i>	-	Endemic	X					-	-	Moderate
Short-toed Rock-Thrush	<i>Monticola brevipes</i>	-	Near-endemic			X			-	-	Moderate

Common name	Scientific name	Conservation status	Regional endemism	Habitat					Susceptibility to		
				Karoo veld	Drainage lines	Rocky koppies	Dams & ephemeral waterbodies	Fly over	Collision	Electrocution	Disturbance / habitat loss
Karoo Thrush	<i>Turdus smithi</i>	-	Endemic		X				-	-	Moderate
Chat Flycatcher	<i>Bradornis infuscatus</i>	-	Near-endemic	X					-	-	Moderate
Marico Flycatcher	<i>Bradornis mariquensis</i>	-	Near-endemic	X	X				-	-	Moderate
Fiscal Flycatcher	<i>Sigelus silens</i>	-	Endemic		X				-	-	Moderate
Spotted Flycatcher	<i>Muscicapa striata</i>	-	-		X				-	-	Moderate
Cape Robin-Chat	<i>Cossypha caffra</i>	-	-		X				-	-	Moderate
Kalahari Scrub-Robin	<i>Cercotrichas paena</i>	-	Near-endemic	X	X				-	-	Moderate
Karoo Scrub-Robin	<i>Cercotrichas coryphoeus</i>	-	Endemic	X	X				-	-	Moderate
African Stonechat	<i>Saxicola torquatus</i>	-	-	X					-	-	Moderate
Mountain Wheatear	<i>Oenanthe monticola</i>	-	Near-endemic	X		X			-	-	Moderate
Capped Wheatear	<i>Oenanthe pileata</i>	-	-	X					-	-	Moderate
Sickle-winged Chat	<i>Cercomela sinuata</i>	-	Endemic	X					-	-	Moderate
Karoo Chat	<i>Cercomela schlegelii</i>	-	Near-endemic	X					-	-	Moderate

Common name	Scientific name	Conservation status	Regional endemism	Habitat					Susceptibility to		
				Karoo veld	Drainage lines	Rocky koppies	Dams & ephemeral waterbodies	Fly over	Collision	Electrocution	Disturbance / habitat loss
Tractrac Chat	<i>Cercomela tractrac</i>	-	Near-endemic	X					-	-	Moderate
Familiar Chat	<i>Cercomela familiaris</i>	-	-	X					-	-	Moderate
Ant-eating Chat	<i>Myrmecocichla formicivora</i>	-	Endemic	X					-	-	Moderate
Pale-winged Starling	<i>Onychognathus nabouroup</i>	-	Near-endemic			X		X	-	-	Moderate
Cape Glossy Starling	<i>Lamprotornis nitens</i>	-	-		X				-	-	Moderate
Pied Starling	<i>Spreo bicolor</i>	-	Endemic			X		X	-	-	Moderate
Wattled Starling	<i>Creatophora cinerea</i>	-	-	X	X			X	-	-	Moderate
Common Starling	<i>Sturnus vulgaris</i>	-	-		X	X			-	-	Moderate
Malachite Sunbird	<i>Nectarinia famosa</i>	-	-		X				-	-	Moderate
Southern Double-collared Sunbird	<i>Cinnyris chalybeus</i>	-	Endemic		X				-	-	Moderate
Dusky Sunbird	<i>Cinnyris fuscus</i>	-	Near-endemic	X	X				-	-	Moderate
Scaly-feathered Finch	<i>Sporopipes squamifrons</i>	-	Near-endemic	X					-	-	Moderate

Common name	Scientific name	Conservation status	Regional endemism	Habitat					Susceptibility to		
				Karoo veld	Drainage lines	Rocky koppies	Dams & ephemeral waterbodies	Fly over	Collision	Electrocution	Disturbance / habitat loss
White-browed Sparrow-Weaver	<i>Plocepasser mahali</i>	-	-	X	X				-	-	Moderate
Cape Weaver	<i>Ploceus capensis</i>	-	Endemic		X		X		-	-	Moderate
Southern Masked-Weaver	<i>Ploceus velatus</i>	-	-		X		X		-	-	Moderate
Red-billed Quelea	<i>Quelea quelea</i>	-	-	X	X		X	X	-	-	Moderate
Southern Red Bishop	<i>Euplectes orix</i>	-	-				X		-	-	Moderate
African Quailfinch	<i>Ortygospiza atricollis</i>	-	-	X					-	-	Moderate
Red-headed Finch	<i>Amadina erythrocephala</i>	-	Near-endemic	X	X				-	-	Moderate
Common Waxbill	<i>Estrilda astrild</i>	-	-				X		-	-	Moderate
Red-billed Firefinch	<i>Lagonosticta senegala</i>	-	-		X				-	-	Moderate
Pin-tailed Whydah	<i>Vidua macroura</i>	-	-		X				-	-	Moderate
House Sparrow	<i>Passer domesticus</i>	-	-		X				-	-	Moderate
Cape Sparrow	<i>Passer melanurus</i>	-	Near-endemic	X	X				-	-	Moderate

Common name	Scientific name	Conservation status	Regional endemism	Habitat					Susceptibility to		
				Karoo veld	Drainage lines	Rocky koppies	Dams & ephemeral waterbodies	Fly over	Collision	Electrocution	Disturbance / habitat loss
Southern Grey-headed Sparrow	<i>Passer diffusus</i>	-	-	X	X				-	-	Moderate
African Pied Wagtail	<i>Motacilla aguimp</i>	-	-				X		-	-	Moderate
Cape Wagtail	<i>Motacilla capensis</i>	-	-				X		-	-	Moderate
Cape Longclaw	<i>Macronyx capensis</i>	-	Endemic	X					-	-	Moderate
African Rock Pipit	<i>Anthus cinnamomeus</i>	-	Endemic	X					-	-	Moderate
Plain-backed Pipit	<i>Anthus leucophrys</i>	-	-	X					-	-	Moderate
Buffy Pipit	<i>Anthus vaalensis</i>	-	-	X					-	-	Moderate
African Pipit	<i>Anthus cinnamomeus</i>	-	-			X			-	-	Moderate
Long-billed Pipit	<i>Anthus similis</i>	-	-	X					-	-	Moderate
Cape Canary	<i>Serinus canicollis</i>	-	Endemic	X					-	-	Moderate
Black-headed Canary	<i>Serinus alario</i>	-	Endemic	X					-	-	Moderate
Black-throated Canary	<i>Crithagra atrogularis</i>	-	-	X					-	-	Moderate

Common name	Scientific name	Conservation status	Regional endemism	Habitat					Susceptibility to		
				Karoo veld	Drainage lines	Rocky koppies	Dams & ephemeral waterbodies	Fly over	Collision	Electrocution	Disturbance / habitat loss
Yellow Canary	<i>Crithagra flaviventris</i>	-	Near-endemic	X					-	-	Moderate
White-throated Canary	<i>Crithagra albogularis</i>	-	Near-endemic	X					-	-	Moderate
Lark-like Bunting	<i>Emberiza impetuani</i>	-	Near-endemic	X					-	-	Moderate
Cinnamon-breasted Bunting	<i>Emberiza tahapisi</i>	-	-	X					-	-	Moderate
Cape Bunting	<i>Emberiza capensis</i>	-	Near-endemic	X					-	-	Moderate

Appendix 2. Species, numbers and densities of birds observed during 20 min walked transects in and around the Du Plessis Dam PV development area in May 2013.

Transect number	Transect length	Species	<i>n</i> sightings	<i>n</i> birds	Mean transect width (m)	Density (Birds.ha ⁻¹)
D01	0.73	Eastern Clapper Lark	1	1	30.0	0.46
		Lark-like Bunting	1	1	10.0	1.37
		Red-headed Finch	1	5	12.0	5.72
		Rufous-eared Warbler	2	2	90.0	0.31
		Sickle-winged Chat	2	4	17.5	3.14
		Southern Red Bishop	2	31	2.6	164.96
D02	0.86	Ant-eating Chat	1	2	10.0	2.32
		Cape Wagtail	1	1	2.0	5.80
		Capped Wheatear	2	2	30.0	0.77
		Lark-like Bunting	1	1	2.0	5.80
		Sickle-winged Chat	1	1	10.0	1.16
		Spike-heeled Lark	3	10	4.2	27.60
D03	0.75	African Pipit	1	1	2.0	6.64
		Ant-eating Chat	1	2	50.0	0.53
		Capped Wheatear	1	1	100.0	0.13
		Large-billed Lark	1	1	80.0	0.17
		Rufous-eared Warbler	4	3	53.3	0.75
		Spike-heeled Lark	3	9	13.3	8.96
D04	0.95	African Pipit	1	1	80.0	0.13
		Capped Wheatear	1	1	60.0	0.17
		Common Fiscal	1	1	2.0	5.24
		Rufous-eared Warbler	2	4	15.0	2.80
		Sabota Lark	1	1	20.0	0.52
		Sickle-winged Chat	1	1	80.0	0.13
		Spike-heeled Lark	1	3	3.3	9.44
D05	1.09	Ant-eating Chat	1	1	120.0	0.08
		Common Fiscal	1	1	10.0	0.92
		Eastern Clapper Lark	1	1	6.0	1.53
		Rufous-eared Warbler	2	2	6.0	3.07
		Sickle-winged Chat	2	3	15.3	1.80
		Spike-heeled Lark	1	2	3.0	6.13
		Yellow-bellied Eremomela	1	1	40.0	0.23
D06	1.32	African Pipit	2	2	15.0	1.01
		Cape Weaver	1	1	100.0	0.08
		White-throated Canary	1	1	20.0	0.38
D07	0.73	Cape Sparrow	1	2	20.0	1.37

Transect number	Transect length	Species	<i>n</i> sightings	<i>n</i> birds	Mean transect width (m)	Density (Birds.ha ⁻¹)
		Capped Wheatear	1	1	40.0	0.34
		Common Fiscal	1	1	40.0	0.34
		Karoo Scrub-Robin	1	3	26.7	1.55
		Lark-like Bunting	1	1	40.0	0.34
		Red-billed Quelea	1	10	1.0	137.47
		Red-headed Finch	1	1	20.0	0.69
		Sickle-winged Chat	1	2	40.0	0.69
		Southern Red Bishop	2	11	2.7	55.45
D08	0.66	African Pipit	1	1	20.0	0.76
		Cape Sparrow	1	2	10.0	3.04
		Red-headed finch	1	2	10.0	3.04
		Rufous-eared Warbler	3	3	26.7	1.71
		Sabota Lark	1	1	10.0	1.52
		Spike-heeled lark	1	3	13.3	3.42
D09	0.58	Black-eared Sparrowlark	1	1	40.0	0.43
		Common Fiscal	1	1	20.0	0.86
		Eastern Clapper Lark	1	1	20.0	0.86
		Rufous-eared Warbler	2	2	50.0	0.69
		Sickle-Winged Chat	2	3	33.3	1.54
		Spike-heeled lark	1	2	20.0	1.72
D10	0.77	Ant-eating Chat	1	4	20.0	2.59
		Cape Sparrow	1	2	20.0	1.29
		Common Fiscal	1	2	20.0	1.29
		Eastern Clapper Lark	3	5	16.0	4.04
		Rock Martin	1	2	10.0	2.59
		Southern Red Bishop	1	4	2.5	20.69
		Spike-heeled lark	1	2	30.0	0.86
D11	0.71	Eastern Clapper Lark	3	5	36.0	1.97
		Lark-like Bunting	2	5	4.0	17.72
		Rufous-eared Warbler	1	2	10.0	2.83
		Sabota lark	1	1	60.0	0.24
		Spike-heeled lark	1	2	30.0	0.94
D12	0.45	Cape Sparrow	2	6	20.0	6.62
		Lark-like Bunting	4	21	4.3	108.10
		Rufous-eared Warbler	1	1	20.0	1.10
		southern Red Bishop	1	2	10.0	4.41
		Spike-heeled lark	1	2	10.0	4.41
		Yellow-Bellied Eremomela	1	2	10.0	4.41
D13	0.88	Cape Sparrow	1	2	20.0	1.13

Transect number	Transect length	Species	<i>n</i> sightings	<i>n</i> birds	Mean transect width (m)	Density (Birds.ha ⁻¹)
		Eastern Clapper Lark	1	1	40.0	0.28
		Lark-like Bunting	1	2	20.0	1.13
		Rufous-eared Warbler	2	2	35.0	0.65
		Sickle-Winged Chat	1	1	40.0	0.28
		Southern Red Bishop	1	8	2.5	36.18
		Spike-heeled lark	2	12	3.3	40.70
D14	0.84	Ant-eating Chat	1	3	33.3	1.07
		Rock Martin	2	3	46.7	0.76
		Rufous-eared Warbler	2	2	20.0	1.19
		Sickle-Winged Chat	1	2	50.0	0.47