DEVELOPMENT OF THE HARMONY JOEL SOLAR PV FACILITY NEAR THEUNISSEN, FREE STATE PROVINCE

Avifauna Baseline Report

January 2023

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EXECUTIVE SUMMARY

Pachnoda Consulting cc was requested by Savannah Environmental (Pty) Ltd on behalf of Freegold Harmony (Pty) Ltd to compile an avifauna baseline report for the proposed Harmony Joel Solar PV facility and associated infrastructure with a contracted capacity of up to 18MW located on a site 20km north east of the town of Theunissen in the Free State Province.

The objectives of the avifaunal study were to: (a) describe the avifauna associations in the study area according to species composition and richness prior to construction activities; (b) provide an inventory of bird species occurring in the project area including species prone towards collisions with the proposed infrastructure; (c) provide an impact assessment; and (d) provide an indication of the occurrence of species of concern (e.g. threatened and near threatened species). Baseline avian data was obtained from point count sampling techniques during two independent sampling sessions).

Three avifaunal habitat types were identified on the study site and surroundings, consisting of open grassland with bush clump mosaics, the doring river system with riverine woodland and transformed units (ranging from build-up land and mining infrastructure). The study site was also surrounded by slimes dams and the doring River system, which provided additional habitat for waterbird and shorebird taxa. Approximately 162 bird species are expected to occur in the wider study area, of which 91 species were observed in the study area (during two independent surveys). The expected richness included four threatened or near threatened species, 15 southern African endemics and 19 near-endemic species. However, the occurrence of threatened and near threatened bird species was predicted to be low, although the natural broad-scale habitat units provided foraging habitat for the occasional occurrence of the vulnerable Lanner Falcon (*Falco biarmicus*) and endangered Secretarybird (*Sagittarius serpentarius*). Eleven southern African endemics and 13 near-endemic species were confirmed on the study site. In addition, a total of 50 collision-prone bird species have been recorded from the study area (*sensu* atlas data), of which 29 species were waterbird and shorebird taxa, and another 11 species were birds of prey.

The main potential impacts associated with the proposed PV solar facility are expected to be the following:

- The loss of habitat and subsequent displacement of bird species due to the ecological footprint required during construction.
- Direct interaction (collision trauma) by birds with the surface infrastructure (photovoltaic panels) caused by polarised light pollution and/or waterbirds colliding with the panels (as they are mistaken for waterbodies).
- Collision with associated infrastructure (mainly overhead powerlines and reticulation).

An evaluation of potential and likely impacts on the avifauna revealed that the impact significance was moderate to low after mitigation (depending on the type of impact). However, the risk for certain waterbirds (mainly large-bodied waterfowl such as the South African Shelduck *Tadorna cana* and Egyptian Goose *Alopochen aegyptiacus*) colliding with the PV infrastructure remained eminent due to the presence of wetland-associated features and the nearby Doring river system (including the Theronspruit river to the west). Post-construction monitoring was recommended along with the installation of appropriate bird diverters to minimise the potential risk of collision trauma in birds.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

DECLARATION OF INDEPENDENCE

I, Lukas Niemand (Pachnoda Consulting CC) declare that:

- I act as the independent specialist in this application to Savannah Environmental (Pty) Ltd and Freegold Harmony (Pty) Ltd.;
- I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have no vested financial, personal or any other interest in the application;
- I have no, and will not engage in, conflicting interests in the undertaking of the activity;
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority; and
- All the particulars furnished by me in this form are true and correct.

Lukas Niemand (Pr.Sci.Nat)
24 January 2023

Lukas Niemand is registered with The South African Council for Natural Scientific Professionals (400095/06) with more than 20 years of experience in ecological-related assessments and more than 15 years in the field of bird interactions with electrical and renewable energy infrastructure. He has conducted numerous ecological and avifaunal impact assessments including Eskom Transmission projects, hydro-electric schemes, solar farms and other activities in South Africa and other African countries.

1. INTRODUCTION

1.1 Project Description

Pachnoda Consulting cc was requested by Savannah Environmental (Pty) Ltd on behalf of Freegold Harmony (Pty) Ltd to compile an avifauna baseline report for the proposed Harmony Joel Solar PV facility and associated infrastructure with a contracted capacity of up to 18MW. The Harmony Joel Solar PV facility is based approximately 900m north east of the Harmony Joel mining operations, and located 20km north east of the town of Theunissen within the Masilonyana Local Municipality, and within the Lejweleputswa District Municipality, Free State Province.

A project site[1] considered to be technically suitable for the development of the solar PV facility, with an extent of approximately 1000ha, was identified, of which a development area[2] of ~220ha was demarcated within the project site which allows for an adequate footprint (~47ha)[3] for the installation of a solar PV facility, while allowing for the avoidance of environmental site sensitivities (Figure 2).

The infrastructure associated PV facility includes:

- PV modules and mounting structures;
- Inverters and transformers a SCADA room, and maintenance room;
- Cabling between the project components, to be laid underground where practical;
- Access roads, internal roads and fencing around the development area;
- Temporary and permanent laydown areas and O&M buildings; and
- Grid connection solution including an on-site facility substation, switching station, to be connected to the Shafts 1 & 2 HJ Joel Mining Substation via an overhead power line (located ~830m south west of the development footprint).

The PV development area is located on the following farm portions:

Farm Name	Portion Number
Leeuwbult 580	0

[1] The project site comprises the affected properties for that identified area within which the development area and development footprint are located. It is the broader geographic area assessed as part of the EIA process, within which direct effects of the proposed project may occur. The project site is ~920ha in extent.

[2] The development area is that identified area where the 18MW PV facility is planned to be located. This area has been selected as a practicable option for the facility, considering technical preference and constraints. The development area is ~220ha in extent.

[3] The development footprint is the defined area (47ha) located within the development area) where the PV panel array and other associated infrastructure for the Harmony Joel Solar PV facility is planned to be constructed. This includes the actual footprint of the facility, and the area which would be disturbed.

The facility will tie-in to the Joel Plant substation. The grid line of approximately 1.1km in length will have a connection capacity of up to 132kV. The line connecting the PV facility to the respective substation will be up to 44kV.

1.2 Objectives and Terms of Reference

The main objectives of the avifaunal study were to: (a) describe the avifauna associations in the study area according to species composition and richness prior to construction activities; (b) provide an inventory of bird species occurring in the study area including species prone towards collisions with the proposed infrastructure; (c) provide an impact assessment; and (d) provide an indication of the occurrence of species of concern (e.g. threatened and near threatened species; sensu IUCN, 2022; Taylor et al., 2015; Marnewick et al., 2015).

A bird assessment is required as part of the Environmental Impact Assessment process to investigate the impacts of the proposed solar facility on the avian attributes at the study site and its immediate surroundings. The avifaunal attributes at the proposed PV facility will be determined by means of a desktop analysis of GIS based information, third-party datasets and a number of site surveys. It also provides the results from two independent pre-construction surveys as per the best practice guidelines of Jenkins *et al.* (2017).

The terms of reference are to:

- conduct a baseline bird assessment based on available information pertinent to the ecological and avifaunal attributes on the project area and habitat units;
- conduct an assessment of all information on an EIA level in order to present the following results:
    - typify the regional and site-specific avifaunal macro-habitat parameters that will be affected by the proposed project;
    - provide a shortlist of bird species present as well as highlighting dominant species and compositions;
    - provide an indication on the occurrence of threatened, near threatened, endemic and conservation important bird species likely to be affected by the proposed project;
    - provide an indication of sensitive areas or bird habitat types corresponding to the study area;
    - highlight areas of concern or "hotspot" areas;
    - identify and describe impacts that are considered pertinent to the proposed development;
    - highlight gaps of information in terms of the avifaunal environment; and
    - recommend additional surveys and monitoring protocols (*sensu* Jenkins et al., 2017).

1.3 Scope of Work

The following aspects form part of the Scope of Work:

- A desktop study of bird species expected to occur (e.g. species that could potentially be present), as well as species recorded in the past (e.g. SABAP1);
- A baseline survey of observed bird species according to ad hoc observations and two sampling surveys;
- A list of bird species historically recorded within the relevant quarter degree grid in which the study site occurs (SABAP1);
- Any protected or threatened bird species recorded in the past within the relevant quarter degree grid, their scientific names and colloquial names, and protected status according to IUCN red data lists; and
- The potential of these protected or threatened species to persist within the study area.

The following aspects will be discussed during this avifaunal assessment:

- Collision-prone bird species expected to be present and or observed;
- A list of the dominant bird species;
- A list of observed and expected threatened and near threatened species (according to IUCN red data list);
- Possible migratory or nomadic species;
- Potential important flyways/ congregatory sites and/or foraging sites; and
- Avian impacts associated with the PV solar facility.

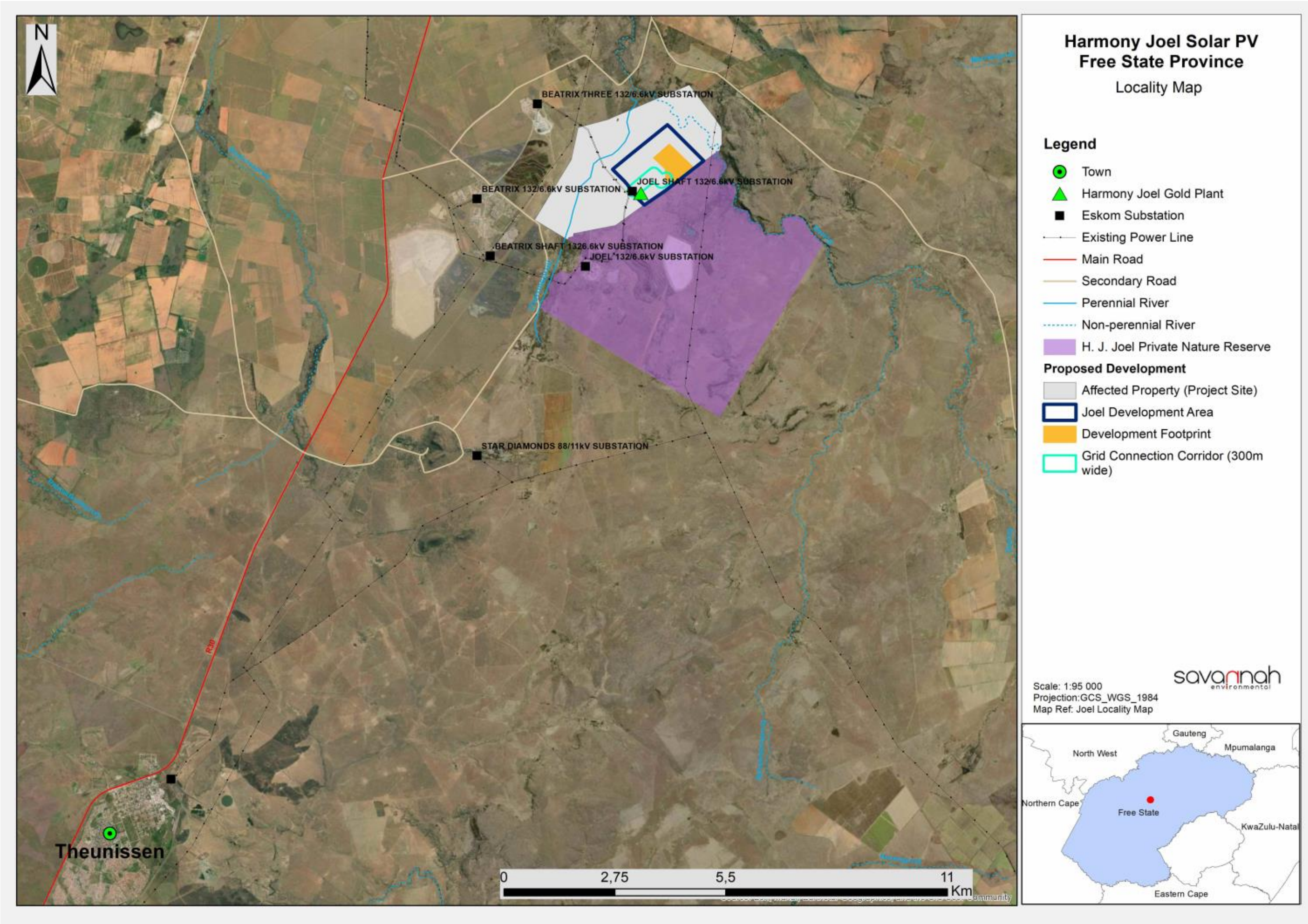


Figure 1: A map illustrating the geographic position of the proposed Harmony Joel Solar PV facility.

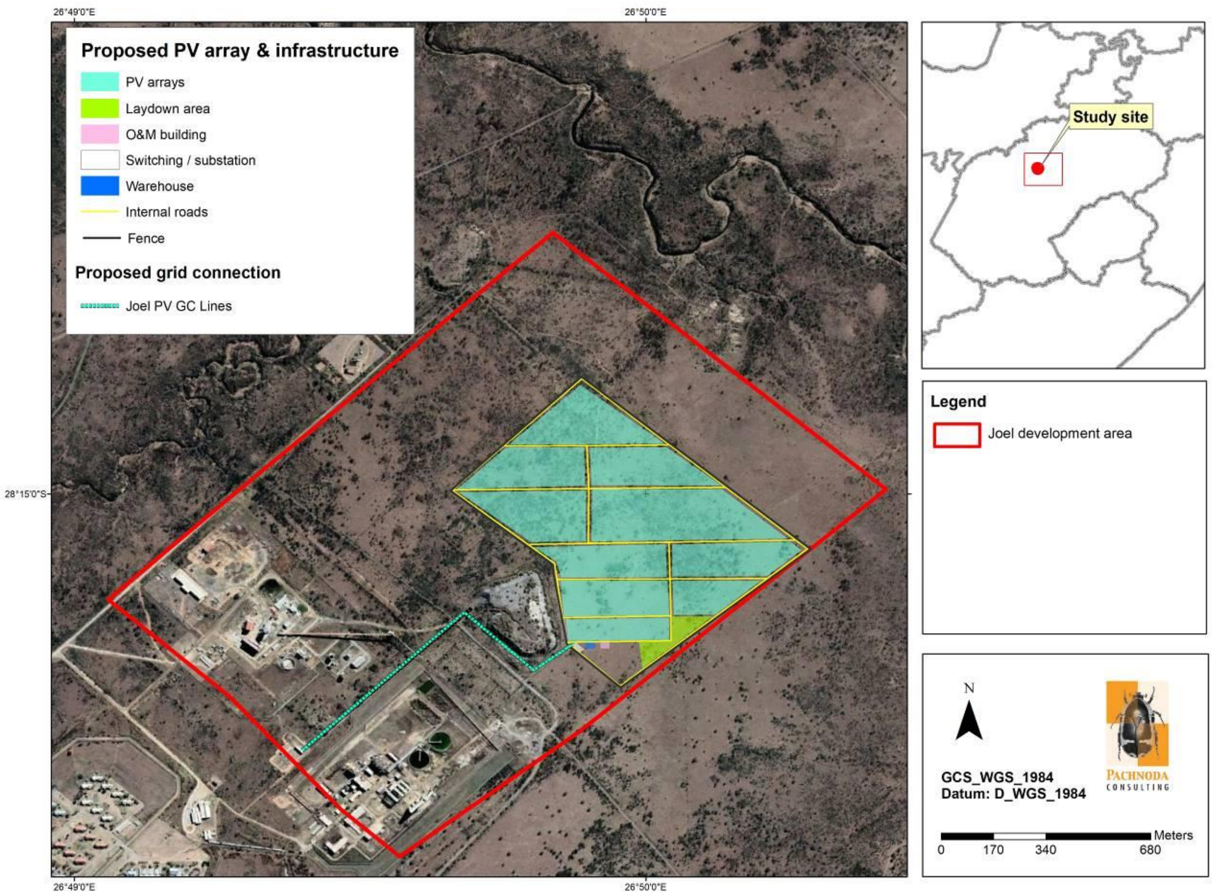

Proposed PV array & infrastructure
PV arrays
Laydown area
O&M building
Switching / substation
Warehouse
Internal roads
Fence
Proposed grid connection
Joel PV GC Lines
Study site
Legend
Joel development area
N
GCS_WGS_1984
Datum: D_WGS_1984
Meters
0
170
340
680

Figure 2: A satellite image illustrating the geographic position of the proposed Harmony Joel Solar PV facility.

2. METHODS & APPROACH

The objectives of this phase of the project were to obtain a basic overview of the variation and general status of the avifaunal habitat types and expected bird species likely to be affected by the proposed project.

Also take note that the current report put emphasis on the avifaunal community as a key indicator group on the proposed study site and immediate surroundings, thereby aiming to describe the preliminary conservation significance of the ecosystems in the area. Therefore, the occurrence of certain bird species and their relative abundances could determine the outcome of the ecological sensitivity of the area and the subsequent layout of the proposed solar facility infrastructure.

The information provided in this report was principally sourced from the following sources/observations:

- relevant literature – see section below;
- observations made during two site visits (06 - 09 June 2022 and 28 – 29 July 2022); and
- personal observations from similar habitat types in close proximity to the study area, with emphasis on assessments conducted by Pachnoda Consulting (2020).

2.1 Literature survey and Database acquisition

A desktop and literature review of the area under investigation was commissioned to collate as much information as possible prior to the detailed baseline survey. Literature consulted primarily makes use of small-scale datasets that were collected by citizen scientists and are located at various governmental and academic institutions (e.g. Animal Demography Unit & SANBI). These include (although are not limited to) the following:

- Hockey *et al*. (2005) for general information on bird identification and life history attributes.
- Marnewick *et al.* (2015) was consulted for information regarding the biogeographic affinities of selected bird species that could be present on the study area.
- The conservation status of bird species was categorised according to the global IUCN Red List of threatened species (IUCN, 2022) and the regional conservation assessment of Taylor *et al.* (2015).
- Distributional data was sourced from the South African Bird Atlas Project (SABAP1) and verified against Harrison et al. (1997) for species corresponding to quarter-degree grid cells (QDGCs) 2826BB (Virginia) and 2826BD (Theronskop) (Figure 3). The information was then modified according to the prevalent habitat types present on the study area. The SABAP1 data provides a "snapshot" of the abundance and composition of

species recorded within a quarter degree grid cell (QDGC) which was the sampling unit chosen (corresponding to an area of approximately 15 min latitude x 15 min longitude). It should be noted that the atlas data makes use of reporting rates that were calculated from observer cards submitted by the public as well as citizen scientists. It therefore provides an indication of the thoroughness of which the QDGCs were surveyed between 1987 and 1991.

- Additional distributional data was also sourced from the SABAP2 database (http://www.sabap2.birdmap.africa). The information was then modified according to the prevalent habitat types present on the study area. Since bird distributions are dynamic (based on landscape changes such as fragmentation and climate change), SABAP2 was born (and launched in 2007) from SABAP1 with the main difference being that all sampling is done at a finer scale known as pentad grids (5 min latitude x 5 min longitude, equating to 9 pentads within a QDGC). Therefore, the data is more site-specific, recent and more comparable with observations made during the site visit (due to increased standardisation of data collection). The pentad grids relevant to the current project are 2810_2645, 2810_2650, 2815_2645 and 2815_2650 (although the surrounding grids were also scrutinised to obtain information relevant to the potential occurrence of threatened and near threatened species; Figure 4).
- The choice of scientific nomenclature, taxonomy and common names were recommended by the International Ornithological Committee (the IOC World Bird List v. 12.2), unless otherwise specified (see www.worldbirdnames.org as specified by Gill et al, 2022). Colloquial (common) names were used according to Hockey *et. al.* (2005) to avoid confusion.
- The best practice guidelines for assessing and monitoring the impact of solar power generating facilities on birds in southern Africa were also consulted (Jenkins *et al.,* 2017).
- Additional information regarding bird-power line interactions was provided by the author's own personal observations.

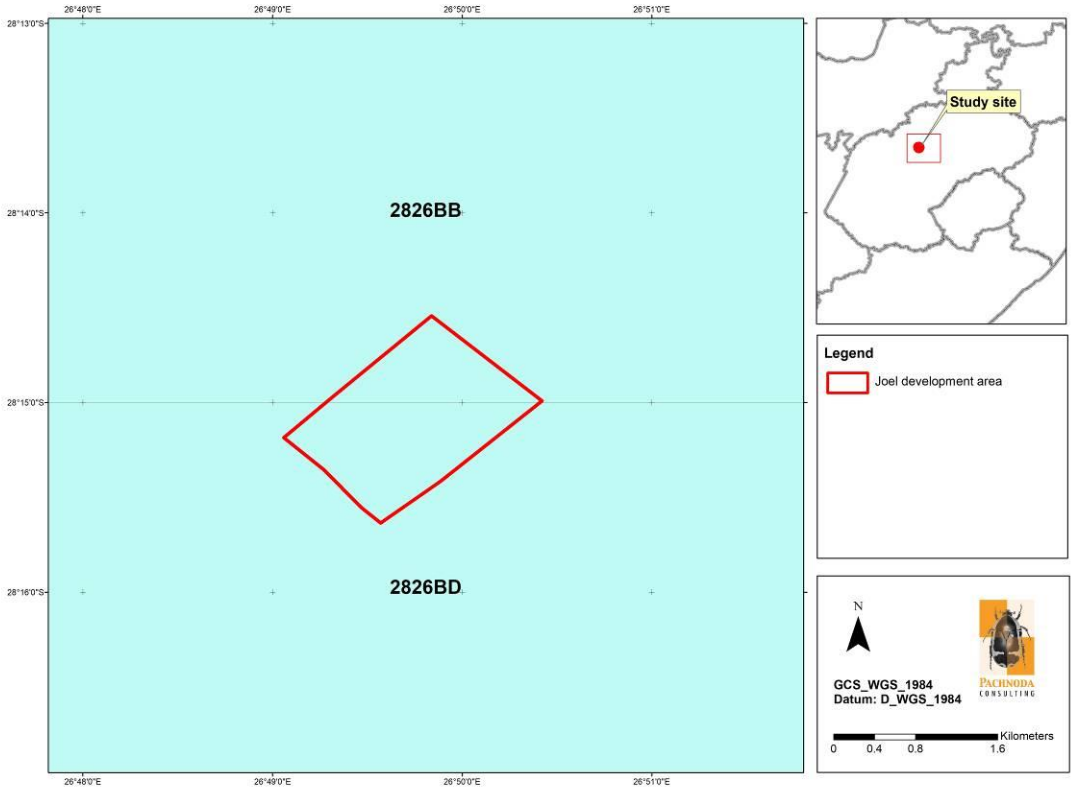


Figure 3: A map illustrating the quarter-degree grid cells that were investigated for this project.

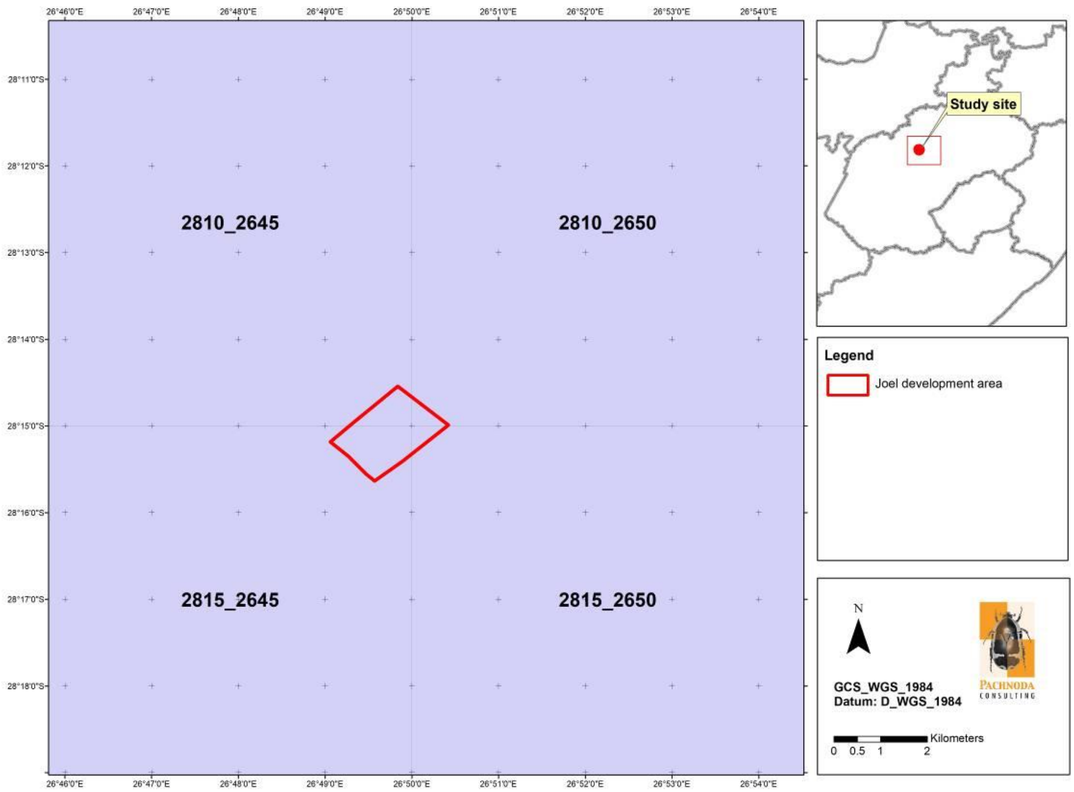


Figure 4: A map illustrating the pentad grids that were investigated for this project.

2.2 Field Methods

The avifauna of the study area was surveyed during two independent site visits (June and July 2022).

The baseline avifaunal survey was conducted by means of the following survey techniques:

2.2.1 Point Counts

Bird data was collected by means of 12 point counts (as per Buckland et al. 1993) from the study area, which were replicated during two independent surveys. Data from the point counts has been analysed to determine dominant and indicator bird species (so-called discriminant species), relative densities and to delineate the different bird associations present.

The use of point counts is advantageous since it is the preferred method to use for skulking or elusive species. In addition, it is the preferred method to line transect counts where access is problematic, or when the terrain appears to be complex (e.g. mountainous). It is considered to be a good method to use, and very efficient for gathering a large amount of data in a short period of time (Sutherland, 2006). The spatial position of each point count is illustrated in Figure 5. The spatial placement of the point counts was determined through a stratified random design which ensures coverage of each habitat type and/or macro-habitat (Sutherland et al., 2004).

Therefore, the sampling approach was adapted so that all the bird species seen within approximately 50m from the centre of the point were recorded (resulting in an area of 0.78 ha) along with their respective abundance values (a laser rangefinder was used to delineate the area to be surveyed at each point). Each point count lasted approximately 20 -30 minutes, while the area within the 50m radius of homogenous habitat was slowly traversed to ensure that all bird species were detected and or flushed (as proposed by Watson, 2003). To ensure the independence of observations, points were positioned at least 200 m apart. Observations were not truncated, and in order to standardise data collection, the following assumptions were conformed to (according to Buckland *et al.*, 1994):

- All birds on the point must be seen and correctly identified. This assumption is in practice very difficult to meet in the field as some birds in the nearby vicinity may be overlooked due to low visibility or were obscured by vegetation (e.g. graminoid cover). Therefore, it is assumed that the portion of birds seen on the point count represents the total assemblage on the point.
- All birds must be recorded at their initial location. All movements of the birds are random and therefore natural in relation to the movements of the observer. None of the birds moved in response to the presence of the observer, and birds flying past without landing were omitted from the analysis.
- In other words, no bird is recorded more than once.

2.2.2 Random (ad hoc) surveys

To obtain an inventory of bird species present (apart from those observed during the point counts), all bird species observed/detected while moving between point counts were identified and noted. Particular attention was devoted to suitable roosting, foraging and nesting habitat for species of conservation concern (e.g. threatened or near threatened species). In addition, the fly patterns of large non-passerine and birds of prey were recorded, as well as the locality of collision-prone birds.

2.2.3 Analyses

Data generated from the point counts was analysed according to Clarke & Warwick (1994) based on the computed percentage contribution (%) of each species, including the consistency (calculated as the similarity coefficient/standard deviation) of its contribution. Hierarchical Agglomerative Clustering (a cluster analysis-based group-average linkages; Clarke & Warwick 1994) was performed on calculated Bray-Curtis coefficients derived from the data. A cluster analysis is used to assign "species associations" between samples with the aim to objectively delineate groups or assemblages. Therefore, sampling entities that group together (being more similar) are believed to have similar compositions.

The species richness and diversity of each bird association was analysed by means of richness measures (such as the total number of species recorded (S) and Shannon Wiener Index) were calculated to compare the associations with each other.

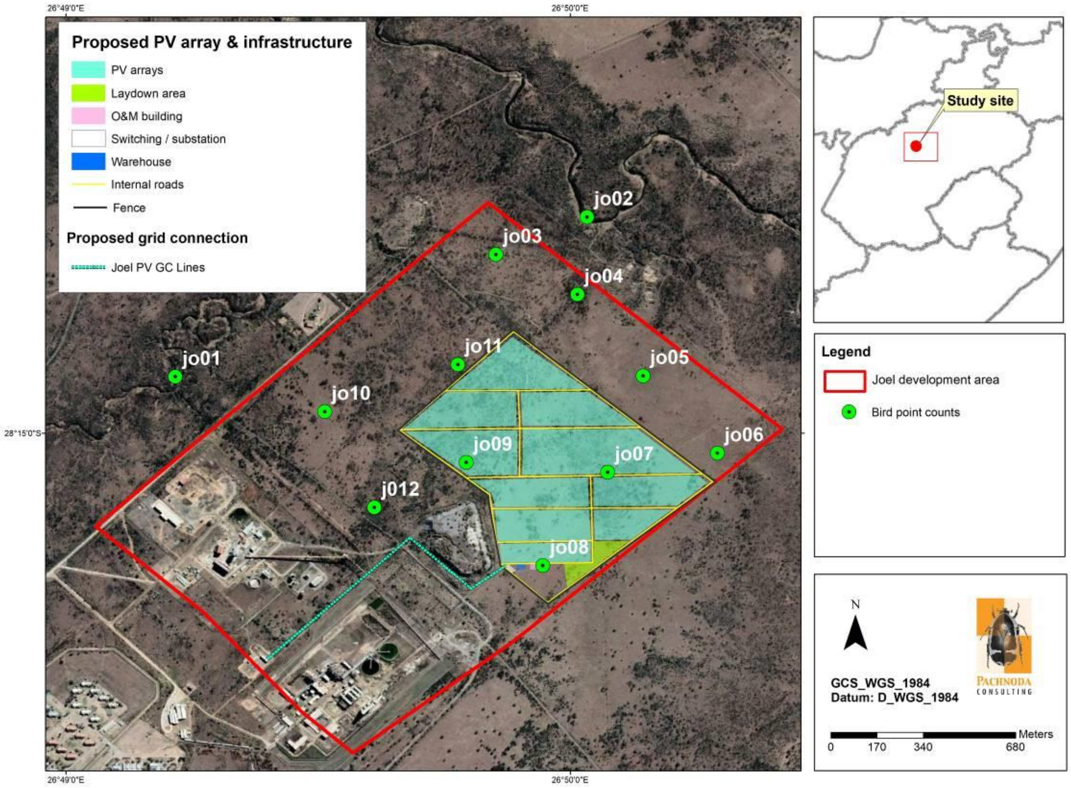


Figure 5: A map illustrating the spatial position of eight bird point counts located within the study area.

2.3 Sensitivity Analysis

A preliminary sensitivity map was compiled based on the outcome of a desktop analysis.

The ecological sensitivity of any piece of land is based on its inherent ecosystem service (e.g. wetlands) and overall preservation of biodiversity.

2.3.1 Ecological Function

Ecological function relates to the degree of ecological connectivity between systems within a landscape matrix. Therefore, systems with a high degree of landscape connectivity amongst one another are perceived to be more sensitive and will be those contributing to ecosystem service (e.g. wetlands) or the overall preservation of biodiversity.

2.3.2 Avifaunal Importance

Avifaunal importance relates to species diversity, endemism (unique species or unique processes) and the high occurrence of threatened and protected species or ecosystems protected by legislation.

2.3.3 Sensitivity Scale

- *High* – Sensitive ecosystems with either low inherent resistance or low resilience towards disturbance factors or highly dynamic systems considered important for the maintenance of ecosystem integrity. Most of these systems represent ecosystems with high connectivity with other important ecological systems OR with high species diversity and usually provide suitable habitat for a number of threatened or rare species. These areas should preferably be protected;
- *Medium* – These are slightly modified systems which occur along gradients of disturbances of low-medium intensity with some degree of connectivity with other ecological systems OR ecosystems with intermediate levels of species diversity but may include potential ephemeral habitat for threatened species; and
- *Low* – Degraded and highly disturbed/transformed systems with little ecological function and are generally very poor in species diversity (most species are usually exotic or weeds).

2.3 Limitations

- It is assumed that third party information (obtained from government, academic/research institution, non-governmental organisations) is accurate and true.
- Some of the datasets are out of date and therefore extant distribution ranges may have shifted although these datasets provide insight into historical distribution ranges of relevant species.
- The datasets are mainly small-scale and could not always consider azonal habitat types that may be present on the study area (e.g. wetland features). In addition, these datasets encompass surface areas larger than the study area, which could include habitat types and species that are not present on the study site. Therefore, the potential to overestimate species richness is highly

likely while it is also possible that certain cryptic or specialist species could have been be overlooked in the past.

- Some of the datasets (e.g. SABAP2) managed by the Animal Demography Unit of the University of Cape Town were recently initiated and therefore incomplete.
- A replicative sampling protocol (two sampling surveys) was followed representing the end of the austral wet season and during the peak austral dry season. The austral dry season is not the optimal time of the year to conduct bird surveys since many of the migratory species (Palearctic and Intra-African migratory species) will be absent. However, these species represent a small percentage of the expected species that could occur on the study site. In addition, many resident species also become less vocal (e.g. cisticolas) during the dry season with the risk that these species may be overlooked. However, replicative surveys detected the majority of these species and the observed species list for the study site is considered to be a true representation of the expected richness.
- This company, the consultants and/or specialist investigators do not accept any responsibility for conclusions, suggestions, limitations and recommendations made in good faith, based on the information presented to them, obtained from the surveys or requests made to them at the time of this report.

3. DESCRIPTION OF THE AFFECTED ENVIRONMENT

3.1 Locality

The proposed PV facility will be located near Harmony Joel mining operations located ~20km north east of the town of Theunissen, Free State Province (Figure 1).

3.2 Regional Vegetation Description

The proposed PV facility corresponds to the Grassland Biome and more particularly to the Dry Highveld Grassland Bioregion as defined by Mucina & Rutherford (2006). It comprehends an ecological type known as Central Free State Grassland (Mucina & Rutherford, 2006) (Figure 6).

From an avifaunal perspective it is evident that bird diversity is positively correlated with vegetation structure, and floristic richness is not often regarded to be a significant contributor of patterns in bird abundance and their spatial distributions. Although grasslands are generally poor in woody plant species, and subsequently support lower bird richness values, it is often considered as an important habitat for many terrestrial bird species such as larks, pipits, korhaans, cisticolas, widowbirds including large terrestrial birds such as Secretarybirds, cranes and storks. Many of these species are also endemic to South Africa and display particularly narrow distribution ranges. Due to the restricted spatial occurrence of the Grassland Biome and severe habitat transformation, many of the bird species that are restricted to the grasslands are also threatened or experiencing declining population sizes.

This vegetation type is confined the Free State Province and marginally also into Gauteng, where it is typical of the undulating plains from Sasolburg in the north to Dewetsdorp in the south. It is typified by short grassland dominated by *T. triandra*, while *Eragrostis curvula* and *E. chloromelas* tend to dominate areas where degradation is evident. Areas with high clay content are often earmarked by the occurrence of *Vachellia (Acacia) karroo*.

The Central Free State Grassland is **Vulnerable** with small sections conserved in the Willem Pretorius and Koppies Dam Nature Reserves. It is transformed by cultivation and large sections are lost due to inundation during the construction of large reservoirs.

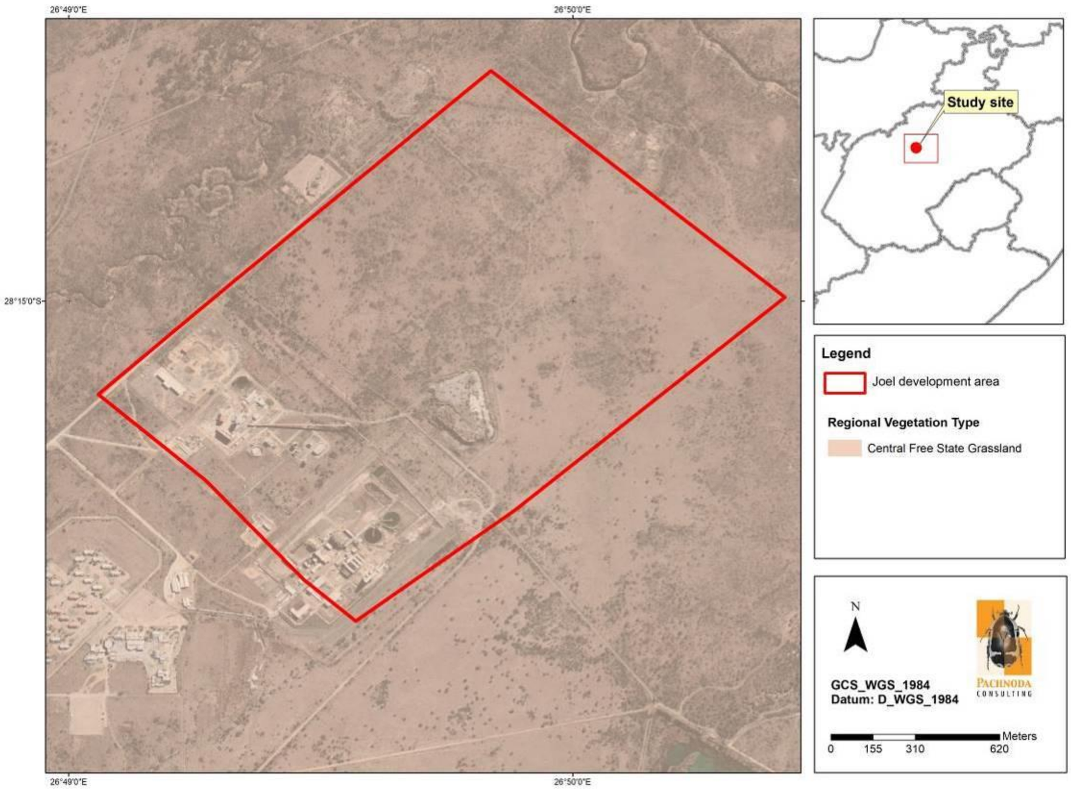


Figure 6: A satellite image illustrating the regional vegetation type corresponding to the study site and immediate surroundings. Vegetation type categories were defined by Mucina & Rutherford (2006; updated 2012).

3.3 Land cover, land use and existing infrastructure.

According to the South African National dataset of 2013-2014 (Geoterrainimage, 2015) the study site comprehends the following land cover categories (Figure 7):

Natural areas:

- Grassland;
- Low shrubland; and
- Open bush;

Transformed areas:

- Mines and quarries.

From the land cover dataset it is evident that most of the study site is predominantly covered in natural grassland which is part of the Central Free State Grassland vegetation type. However, mining activities and mine-related infrastructure occurs on the western and southern section of the study site. The majority of the study site (consisting of natural grassland) is primarily vacant and used for livestock grazing.

Note that the Doring rive and one of its tributaries are located north of the study site (within 200m from the study site boundary).

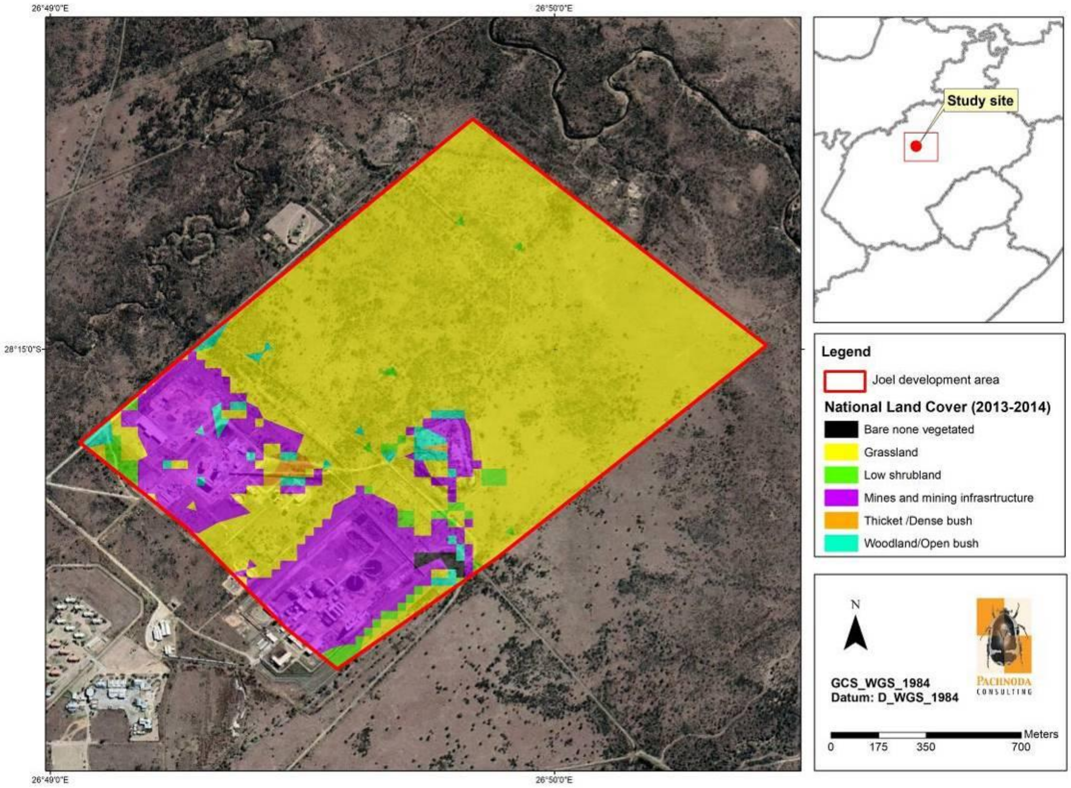


Figure 7: A map illustrating the land cover classes (Geoterrainimage, 2015) corresponding to the proposed study site.

3.4 Conservation Areas, Protected Areas and Important Bird Areas

The study site does not coincide with any statutory/formal conservation area or Important Bird and Biodiversity Area (IBA). The nearest formal conservation area to the proposed study site is the Willem Pretorius Game Reserve, which is located 28 km east of the study site. The Willem Pretorius Game Reserve is also a recognised IBA (SA044). However, the H.J. Joel Private Nature Reserve is located adjacent to the eastern boundary of the study site (see Figure 1).

3.5 Annotations on the National Web-Based Environmental Screening Tool

Regulation 16(1)(v) of the Environmental Impact Assessment Regulations, 20145 (EIA Regulations) provides that an applicant for Environmental Authorisation is required to submit a report generated by the Screening Tool as part of its application. On 5 July 2019, the Minister of Environmental Affairs, Forestry and Fisheries published a notice in the Government Gazette giving notice that the use of the Screening Tool is compulsory for all applicants to submit a report generated by the Screening Tool from 90 days of the date of publication of that notice.

The Screening Tool is intended to allow for pre-screening of sensitivities in the landscape to be assessed within the EA process. This assists with implementing the mitigation hierarchy by allowing developers to adjust their proposed development footprint to avoid sensitive areas. The Screening Tool report will indicate the (preliminary) environmental sensitivities that intersect with the proposed development footprint as defined by the applicant as well as the relevant Protocols.

As the Screening Tool contains datasets that are mapped at a national scale, there may be areas where the Screening Tool erroneously assigns, or misses, environmental sensitivities because of mapping resolution and a high paucity of available and accurate data. Broad-scale site investigations will provide for an augmented and site-specific evaluation of the accuracy and 'infilling' of obvious and large-scale inaccuracies. Information extracted from the National Web-based Environmental Screening Tool (Department of Environmental Affairs, 2020), indicated that the study site and immediate surroundings hold a **medium to high** sensitivity with respect to the relative animal species protocol (Figure 8) (report generated 25/04/2022):

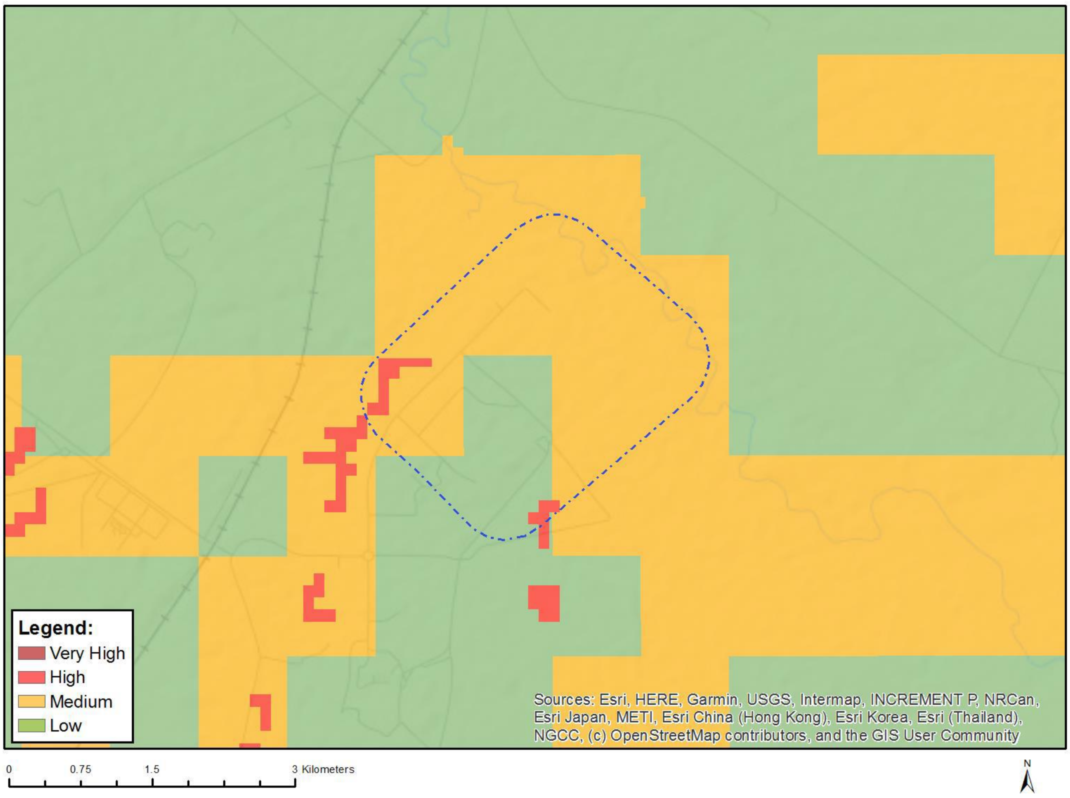


Figure 8: The animal species sensitivity of the study site and immediate surroundings according (500m buffer added to the site boundary) to the Screening Tool.

Sensitive features include the following:

Sensitivity	Feature(s)
High	Aves-*Circus ranivorus*
Low	Low sensitivity
Medium	Aves-*Circus ranivorus*
Medium	Mammalia-*Hydrictis maculicollis*

According to the results of the screening tool, a high probability of occurrence is evident for the endangered African Marsh Harrier (*Circus ranivorus*), which could potentially occur along a tributary of the Doring river.

It is evident that the study site and immediate surroundings correspond to a **low** avian theme sensitivity (see Figure 9).

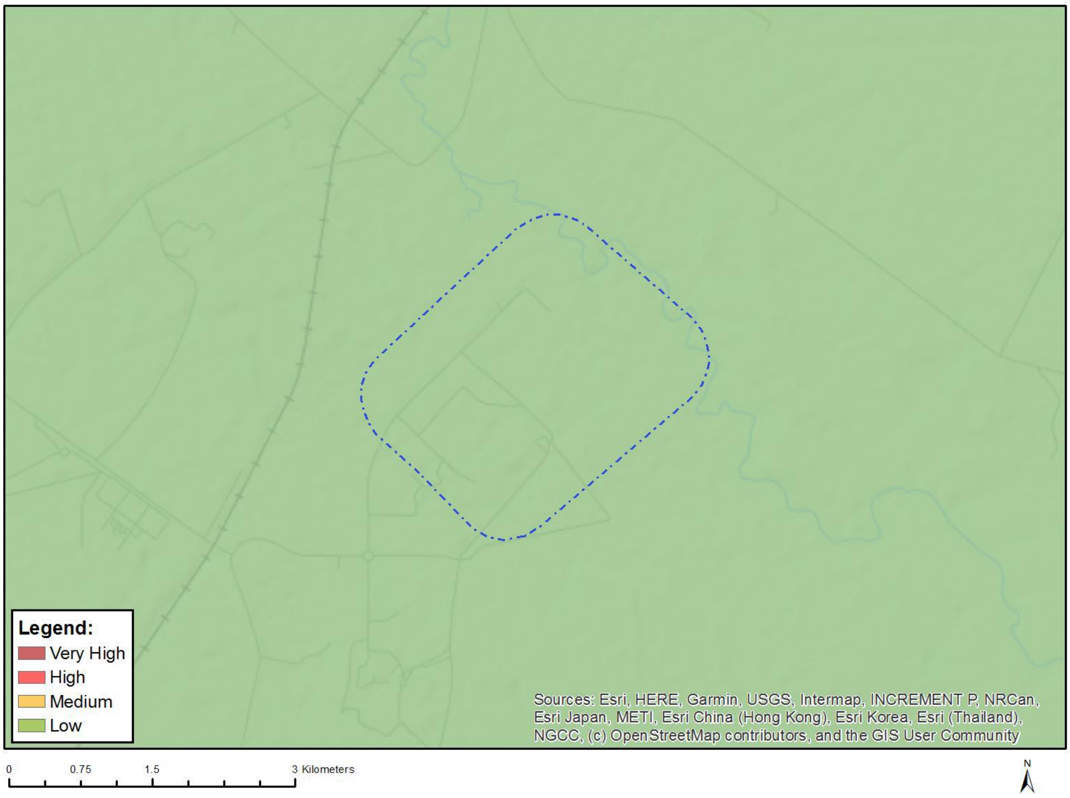


Figure 9: The relative avian sensitivity of the study site and immediate surroundings (500m buffer added to the site boundary) according to the Screening Tool.

Sensitive features include the following:

Sensitivity	Feature(s)
Low	Low sensitivity

However, the study site and immediate surroundings hold a **very high** sensitivity with respect to the relative terrestrial biodiversity theme (Figure 10):

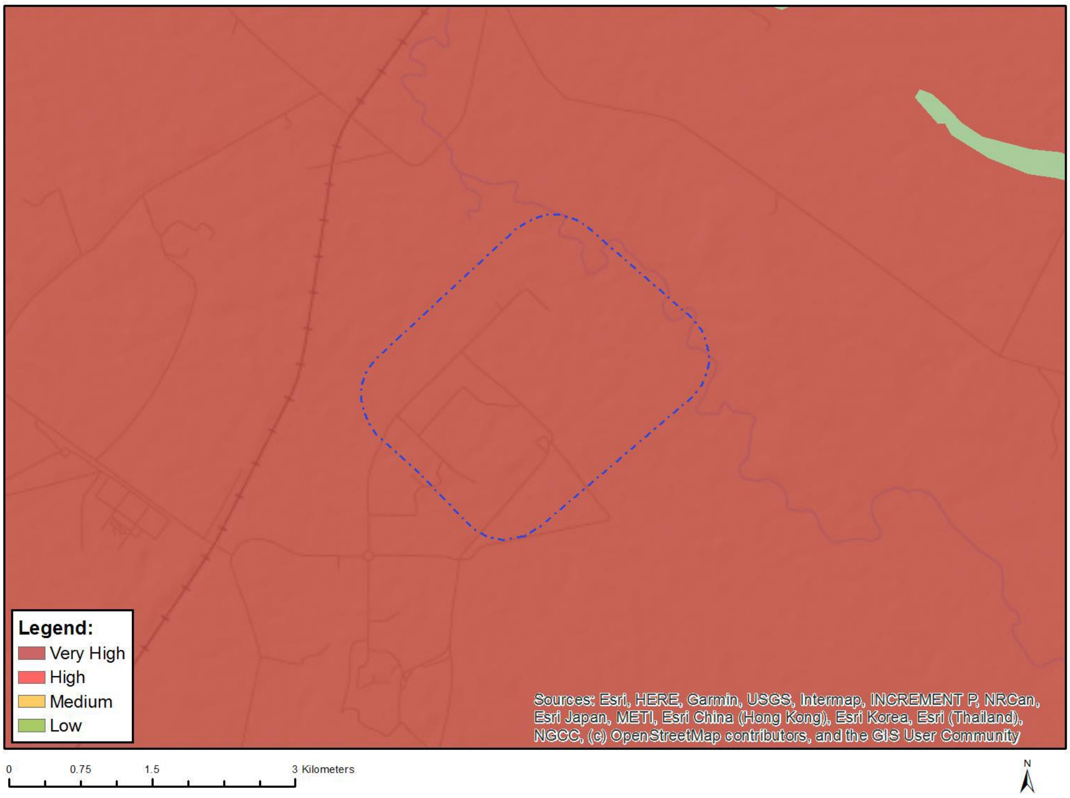


Figure 10: The relative terrestrial biodiversity sensitivity of the study site and immediate surroundings (500m buffer added to the site boundary) according to the Screening Tool.

Sensitive features include the following:

Sensitivity	Feature(s)
Very High	Critical Biodiversity Area 1
Very High	Critical Biodiversity Area 12
Very High	Ecological Support Area 1
Very High	Ecological Support Area 2
Very High	Protected Areas Expansion Strategy
Very High	H.J. Joel Private Nature Reserve

It is evident from the results of the Screening Tool report that part of the entire study area coincides with a Critical Biodiversity Area 1 and 2 (CBA 1 & 2) and an Ecological Support Are 1 and 2 (ESA 1 & 2) as per the Free State Biodiversity Plan (DESTEA, 2015). In addition, the study site is also located adjacent to the H. J. Joel Private Nature Reserve which is proposed to be included as part of the protected areas expansion strategy.

4. RESULTS AND DISCUSSION

4.1 Broad-scale avifaunal habitat types

Apart from the regional vegetation type, the local composition and distribution of the vegetation associations on the study area are a consequence of a combination of factors simulated by soil type, anthropogenic activities and grazing intensity (presence of livestock) which have culminated in three major broad-scale habitat units that deserve further discussion (Figure 11 and Figure 12):

1. *Open savannoid grassland with bush clumps:* This unit is dominant on the study site and covers a significant extent in surface area of the proposed PV facility footprint. It is represented by two discrete floristic variations which also provide habitat for two discrete avifaunal associations. The first floristic variation consists of open grazed Central Free State Grassland dominated by *Themeda triandra*. It is occupied by a grassland bird composition dominated by insectivorous and granivore passerine bird species such as Desert Cisticola, (*Cisticola aridulus*), Ant-eating Chat and Cape Longclaw (*Macronyx capensis*). The overall bird richness was low.

   The bush clumps form a prominent mosaic characterised by the dominance of a woody layer of *Vachellia karoo* on clay soils. The eminent increase in vertical heterogeneity provided by the woody layer is colonised by a "Bushveld" bird association consisting of insectivorous passerines such as Black-chested Prinia (*Prinia flavicans*), Chestnut-vented Warbler (*Curruca subcoerulea*), Kalahari Scrub Robin (*Cercotrichas paena*), Neddicky (*Cisticola fulvicapilla*), African Red-eyed Bulbul (*Pycnonotus nigricans*), Orange-river White-eye (*Zosterops pallidus*) as well as granivores such as Yellow Canary (*Crithagra flaviventris*), Blue Waxbill (*Uraeginthus angolensis*) and Black-faced Waxbill (*Brunhilda erythronotos*). Non-passerine bird taxa are represented by Ring-necked Dove (*Streptopelia capicola*), Acacia Pied Barbet (*Tricholaema leucomelas*) and White-backed Mousebird (*Colius colius*).

2. *Transformed areas*: These areas are represented by build-up land and mining infrastructure. These features are invariably artificial and present an urban and industrial landscape which is colonised by generalist bird taxa such as Speckled Pigeon (*Columba guinea*), House Sparrow (*Passer domesticus*) and Cape Sparrow (*Passer melanurus*).

3. *Doring river and associated tributaries (riverine woodland)*: The perennial Doring River and one of its tributaries occur north of the study site (approximately 200m from the development area). The system is characterised by a very narrow marginal and floodplain zone, and relatively deeply incised banks. Therefore, the marginal zone is often colonised by a variety of facultative wetland vegetation which include amongst others taxa

such as *Imperata cylindrica, Pennisetum* spp., *Miscanthus cf. junceus*, while the riverbanks are covered on vegetation that is similar to the savannoid grassland habitat although the prevalence of woody vegetation is higher with a high abundance cover (e.g. *Asparagus laricinus*). The marginal zone provides potential habitat for bird species such as the Levaillant's Cisticola (*Cisticola tinniens*) and African Stonechat (*Saxicola torquatus*), while the river canal itself (open surface water) provides foraging habitat for waterfowl such as the Yellow-billed Duck (*Anas undulata*), South African Shelduck (*Tadorna cana*) and Egyptian Goose (*Alopochen aegyptiacus*).

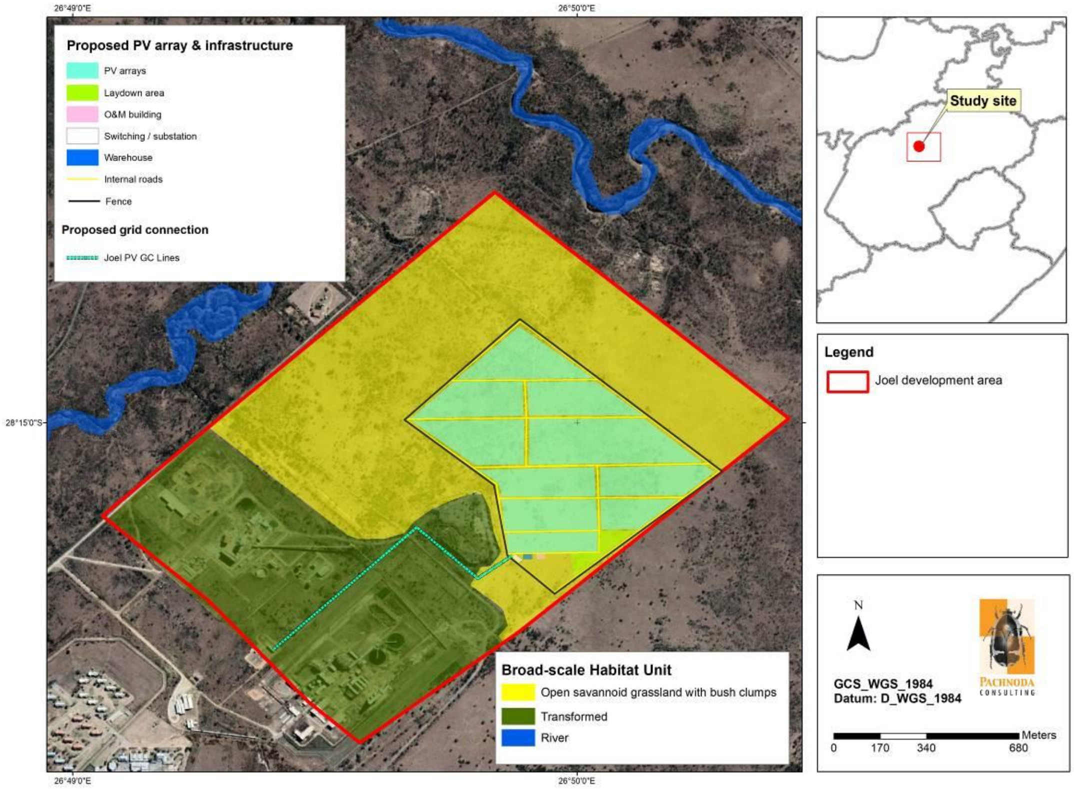
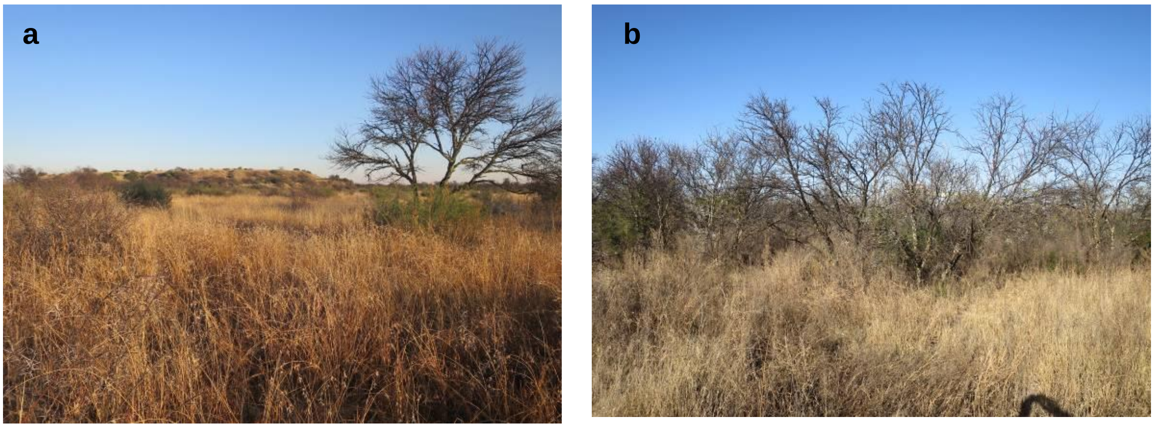


Figure 11: A habitat map illustrating the avifaunal habitat types on the study site and immediate surroundings.



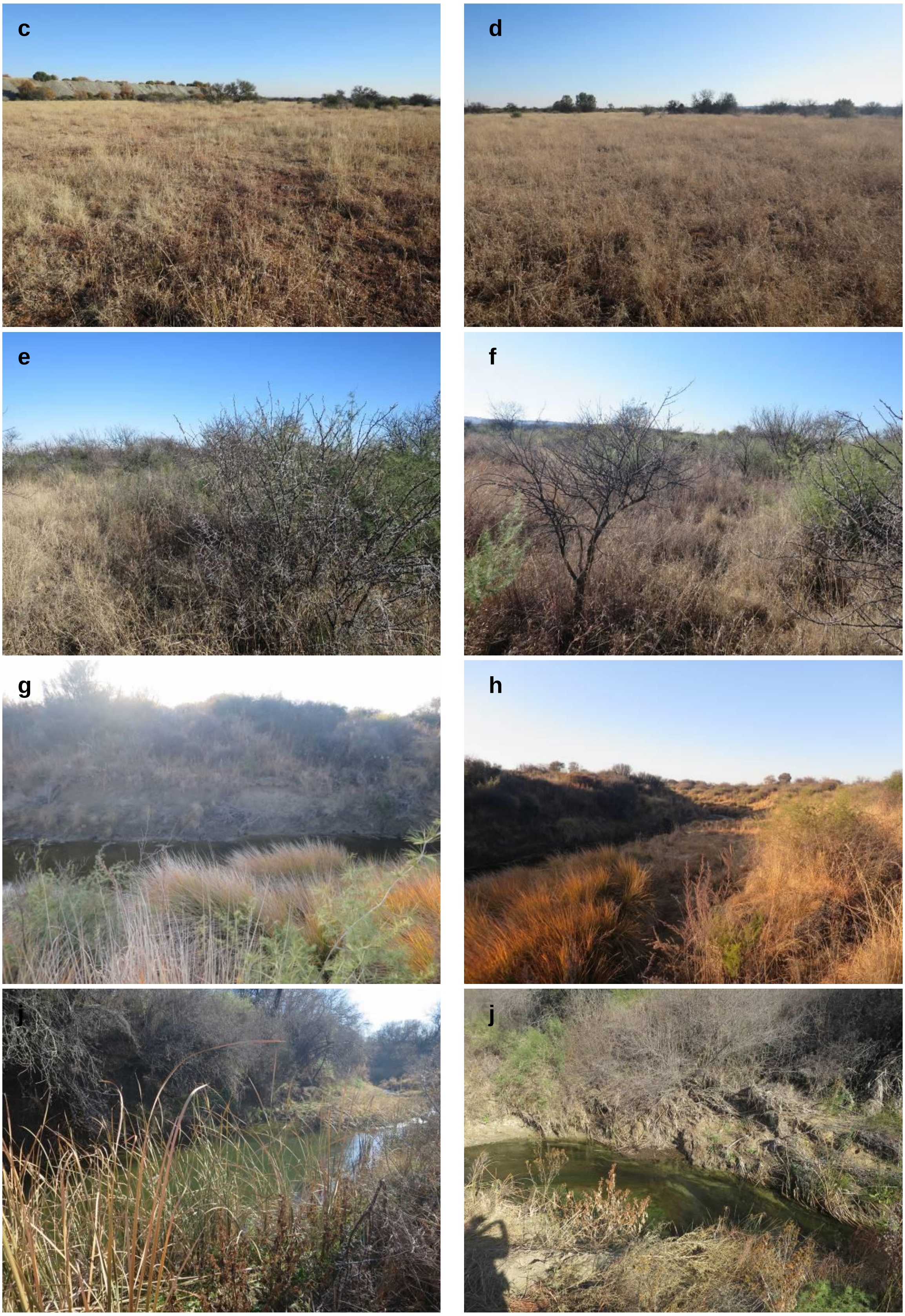


Figure 12: A collage of images illustrating examples of natural avifaunal habitat types observed on the study area: (a - f) Open savannoid grassland with bush clumps and (g - j) the nearby Doring river and associated tributaries.

4.2 Species Richness and Predicted summary statistics

Approximately ~162 bird species have been recorded within the study area (refer to Appendix 1 & Table 1), although it is more likely that between 90-100 bird species could occur within the physical boundaries of the study area (according to the habitat types and the ecological condition thereof). The richness was inferred from the South African Bird Atlas Project (SABAP2)[4] (Harrison et al., 1997; www.sabap2.birdmap.africa) and the presence of suitable habitat in the study area. This equates to 16 % of the approximate 990[5] species listed for the southern African subregion[6] (and approximately 18.5% of the 871 species recorded within South Africa[7]). However, an average number of 47 species for each full protocol card submitted were recorded for the pentad grids corresponding to the study area (for observations of two hours or more; range= 19 - 79 species). It provides a more realistic species tally of the bird composition on the physical study area. In addition, three of the observed species represented new records for the study area and included the Cape White-eye (*Zosterops virens*), Cape Penduline Tit (*Anthoscopus minutus*) and the Long-billed Crombec (*Sylvietta rufescens*).

According to Table 1, the study area is poorly represented by biome-restricted[8] (see Table 2) and local endemic and near-endemic bird species (Table 3). However, it supports *ca*. 30 % of the near -endemic species present in the subregion. According to Table 3, it was evident that a higher proportion of the endemic and threatened bird species will become displaced from the study area due to the loss of habitat, when compared to the number of species that are at risk of colliding with the PV/electrical infrastructure.

Table 1: A summary table of the total number of species, Red listed species (according to Taylor et al., 2015 and the IUCN, 2022), endemics and biome-restricted species (Marnewick et al., 2015) expected (*sensu* SABAP2) to occur in the study site and immediate surroundings.

Description	Expected Richness Value (study area and surroundings)***	Observed Richness Value (study area)****
Total number of species*	162 (16 %)	91 (56 %)
Number of Red Listed species**	4 (3%)#	0 (0 %)
Number of biome-restricted species – Zambezian, Namib-Karoo and Kalahari-Highveld Biomes *	3 (9%)	2 (67 %)

[4] The expected richness statistic was derived from pentad grid 2810_2645, 2810_2650, 2815_2645 and 2815_2650 totalling 161 bird species (based on 22 full protocol cards). The Common Ostrich (*Struthio camelus*) was removed from the expected list since these represent introduced individuals that are not natural (free-range) birds.

5 *sensu* www.zestforbirds.co.za (Hardaker, 2022), including recently confirmed bird species (vagrants.

6 A geographical area south of the Cunene and Zambezi Rivers (includes Namibia, Botswana, Zimbabwe, southern Mozambique, South Africa, eSwatini and Lesotho).

7 With reference to South Africa (including Lesotho and eSwatini (BirdLife South Africa, 2022).

[8] A species with a breeding distribution confined to one biome. Many biome-restricted species are also endemic to southern Africa.

Description	Expected Richness Value (study area and surroundings)***	Observed Richness Value (study area)****
Number of local endemics (BirdLife SA, 2022)*	2 (5 %)	0 (0 %)
Number of local near-endemics (BirdLife SA, 2022)*	6 (20 %)	4 (67 %)
Number of regional endemics (Hockey *et al.*, 2005)**	15 (14 %)	11 (73 %)
Number of regional near-endemics (Hockey *et al.*, 2005)**	19 (31 %)	13 (68 %)

* only species in the geographic boundaries of South Africa (including Lesotho and eSwatini) were considered.

** only species in the geographic boundaries of southern Africa (including Namibia, Botswana, Zimbabwe and Mozambique south of the Zambezi River) were considered

*** Percentage values in brackets refer to totals compared against the South African avifauna (*sensu* BirdLife SA, 2022).

Table 2: Expected biome-restricted species (Marnewick *et al*, 2015) likely to occur on the study site and immediate surroundings.

Species	Zambezian	Kalahari-Highveld	Namib-Karoo	Expected Frequency of occurrence
Kalahari Scrub-robin (*Cercotrichas paena)*		X		Common
Sickle-winged Chat (*Emarginata sinuata*)			X	Vagrant and highly nomadic (known from a single record during 22 April 2022; sensu SABAP2)
White-bellied Sunbird (*Cinnyris talatala*)	X			Common

Table 3: Important bird species occurring in the broader study area which could collide and/ or become displaced by the proposed PV and grid connection infrastructure.

Common Name	Scientific name	Regional Status	Global Status	Observed (Jun & Jul 2022)	Collision with power lines	Collision with PV panels	Displacement (disturbance & loss of habitat)
Maccoa Duck	*Oxyura maccoa*	VU	EN		1	1	
South African Shelduck	*Tadorna cana*	End		1	1	1	
Cape Shoveller	*Anas smithii*	End		1	1	1	
Northern Black Korhaan	*Afrotis afraoides*	End		1	1		1
Karoo Thrush	*Turdus smithi*	End		1			1

Common Name	Scientific name	Regional Status	Global Status	Observed (Jun & Jul 2022)	Collision with power lines	Collision with PV panels	Displacement (disturbance & loss of habitat)
White-backed Mousebird	*Colius colius*	End		1			1
Sickle-winged Chat	*Cercomela sinuata*	End					1
Ant-eating Chat	*Myrmecocichla formicivora*	End		1			1
Karoo Scrub Robin	*Cercotrichas coryphoeus*	End					11
Fiscal Flycatcher	*Melaenornis silens*	End		1			1
Fairy Flycatcher	*Stenostira scita*	End		1			1
Cape Longclaw	*Macronyx capensis*	End		1			1
Cape White-eye	*Zosterops virens*	End		1			1
Orange River White-eye	*Zosterops pallidus*	End		1			1
Pied Starling	*Lamprotornis bicolor*	End					1
South African Cliff Swallow	*Petrochelidon spilodera*	N-end					1
Pale chanting Goshawk	*Melierax canorus*	N-end			1		
Orange-River Francolin	*Scleroptila gutturalis*	N-end		1	1		1
Natal Spurfowl	*Pternistis natalensis*	N-end		1	1		1
Ashy Tit	*Melaniparus cinerascens*	N-end		1			1
Cape Penduline Tit	*Anthoscopus minutus*	N-end		1			1
Acacia Pied Barbet	*Tricholaema leucomelas*	N-end		1			1
African Red-eyed Bulbul	*Pycnonotus nigricans*	N-end		1			1
Mountain Wheatear	*Oenanthe monticola*	N-end					1
Kalahari Scrub Robin	*Cercotrichas paena*	N-end		1			1
Chestnut-vented Warbler	*Curruca subcoerulea*	N-end		1			1
Pririt Batis	*Batis pririt*	N-end		1			1
Crimson-breasted Shrike	*Laniarius atrococcineus*	N-end		1			1
Bokmakierie	*Telophorus zeylonus*	N-end		1			1
Scaly-feathered Weaver	*Sporopipes squamifrons*	N-end					1
Red-headed Finch	*Amadina erythrocephala*	N-end					1
Shaft-tailed Whydah	*Vidua regia*	N-end					1
Yellow Canary	*Crithagra flaviventris*	N-end		1			1
Cloud Cisticola	*Cisticola textrix*	N-end					1
African Marsh Harrier	*Circus ranivorus*	EN			1		
Secretarybird	*Sagittarius serpentarius*	EN	EN		1		1
	Totals:	**36**	**2**	**23**	**9**	**3**	**31**

Threatened and near threatened species are indicated in red
CR - Critically endangered, EN - endangered, VU - vulnerable, NT - near threatened
End - southern African endemic
N-end - southern African near-endemic

4.3 Bird species of conservation concern

Table 4 provides an overview of bird species of conservation concern that could occur on the study site and immediate surroundings based on their historical distribution ranges and the presence of suitable habitat. According to Table 4, a total of four species could occur on the study area which include two globally threatened species and two regionally threatened species.

It is evident from Table 4 that the occurrence of threatened species on the study site was low (sensu SABAP2). Suitable habitat for the occurrence of the globally endangered Maccoa Duck (*Oxyura maccoa*) and the regionally endangered African Marsh Harrier (*Circus ranivorus*) was sub-optimal, thereby suggesting that the probability that these species could occur within the physical boundaries of the study site is low. According to Figure 13, optimal habitat for the African Marsh Harrier (*Circus ranivorus*) occurs within the “pan corridor” west of the town of Welkom where the pan edges and extensive *Phragmites* and *Typha* stands associated with pan floodplains provide suitable habitat for this species to breed. In addition, suitable foraging habitat corresponding to open grassy floodplain habitat (as opposed to the well-wooded and deeply incised stream channel adjacent to the study area) was observed along the upper catchment of the Doring River system south of the study site (e.g. Farm Malgaskraal 374 and Farm Wiids Draai 53).

In addition, the open grassland-bush clump mosaics provides ephemeral foraging habitat for the occurrence of the globally endangered Secretarybird (*Sagittarius serpentarius*) and the regionally vulnerable Lanner Falcon (*Falco biarmicus*). The former species was probably displaced from the study site due to livestock farming regimes and mining activities although suitable habitat was observed approximately 5 km south-east of the study site at the border between Farm Leeuwfontein 256 and Farm Schoemanskop 654. The latter species is regarded as an occasional foraging visitor to the study site.

Table 4: Bird species of conservation concern that could utilise the study site based on their historical distribution range and the presence of suitable habitat. Red list categories according to the IUCN (2022)* and Taylor et al. (2015)**.

Species	Global Conservation Status*	National Conservation Status**	SABAP2 reporting rate	Preferred Habitat	Potential Likelihood of Occurrence
Circus ranivorus (African Marsh Harrier)	-	Endangered	5.26 (ad hoc record)	Restricted to permanent wetlands with extensive reedbeds.	Probably absent from the study site and adjacent Doring river due to the absence of extensive floodplains and reedbeds (suitable habitat absent) Only known from a single old observation during 2008 (sensu SABAP2). in the study region.
Falco biarmicus (Lanner Falcon)	-	Vulnerable	Not observed/recorded	Varied, but prefers to breed in mountainous areas although also using old disused mine voids.	Could be an occasional foraging visitor to the study site.
Oxyura maccoa (Maccoa Duck)	Endangered	Vulnerable	5.26 (ad hoc record)	Large saline pans and shallow impoundments.	Probably absent on the physical study site due to the absence of suitable habitat. It was last recorded during 07 April 2008 on the wider study region (sensu SABAP2).

Species	Global Conservation Status*	National Conservation Status**	SABAP2 reporting rate	Preferred Habitat	Potential Likelihood of Occurrence
Sagittarius serpentarius (Secretarybird)	Endangered	Endangered	8.70	Prefers open grassland or lightly wooded habitat.	An irregular foraging visitor to the study site. Potentially displaced from study area due to agricultural and mining activities. It is known from two records obtained from grid 2815_2650, where optimal habitat was observed approx. 5km south-east of the study site at the border between Farm Leeuwfontein 256 and Farm Schoemanskop 654.

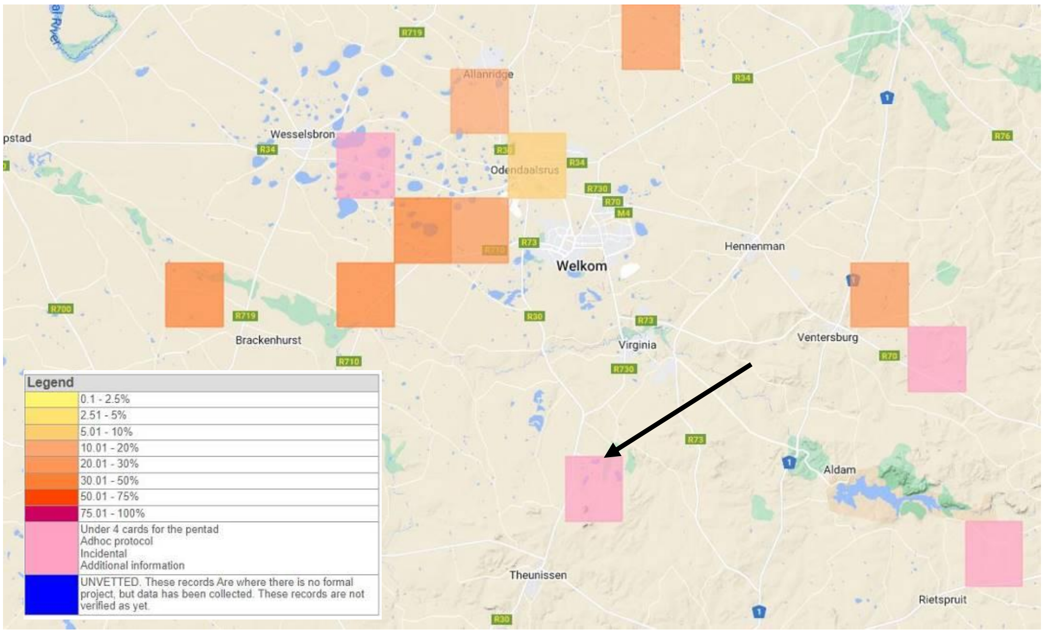


Figure 13: The extant (current) occurrence of African Marsh Harrier (*Circus ranivorus*) on the wider study area according to SABAP2 reporting rates (the arrow indicates the position of the study site). Note the occurrence to the west of the town of Welkom (map courtesy and copyright of SABAP2 and Animal Demography Unit).

4.4 Bird Assemblage Structure and Composition

4.4.1 Species Accumulation Curve

Prior to further analyses where species richness values are considered, it is imperative to determine if all bird species present were sufficiently sampled. Species accumulation curves (SAC) provide a means to examine data and sampling efficacy. For this project the species accumulation curves (SAC) for the point count data were generated using the software program Estimates S (version 9) with 100 randomizations (as recommended in Colwell, 2013). Curves were generated for the full data set (all point counts). Sampling sufficiency was determined by establishing whether a point had been reached where a line representing one new sample adding one new species was tangent to the curve (Brewer & McCann, 1982). The Michaelis-Menten equation (Soberôn & Llorente 1993) was fitted to the predicted number of species using Estimates S (Raaijmakers, 1987). A satisfactory level of sampling was achieved if between 80-90 % of the bird species were detected, and hence predicted by the model (Moreno & Halffter, 2000).

The species accumulation curve (SAC) reached an asymptote at approximately 16 point counts (Figure 14). The sampling captured approximately 83/71% of the number of species predicted by the Michaelis-Menten model at 16 point counts. Approximately 88.5% of the species was captured by 24 counts. Sampling effort was considered sufficient and recorded most of the species present on the study area during the respective survey sessions.

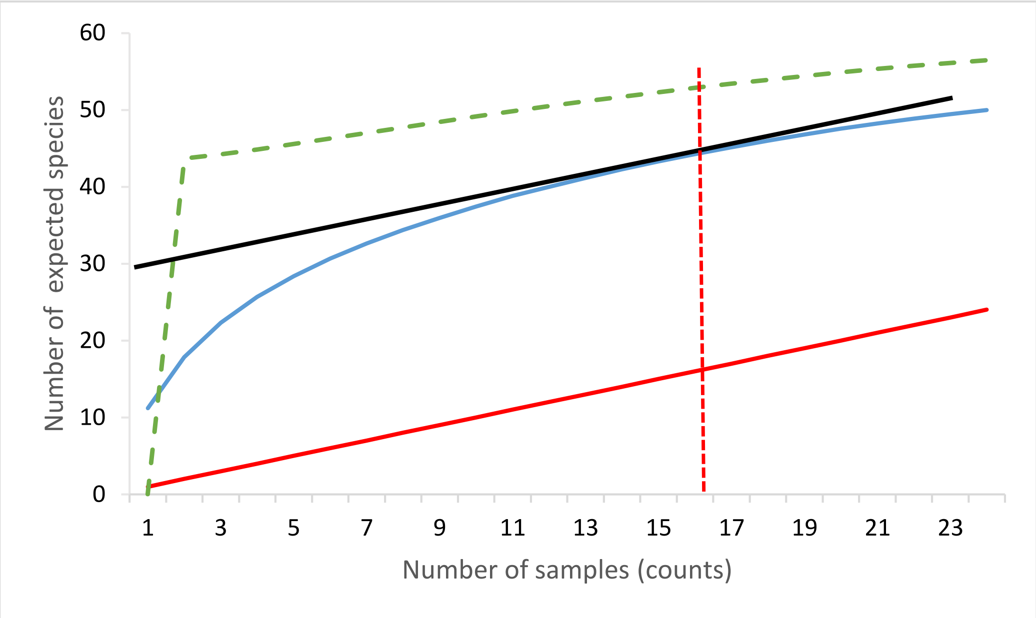


Figure 14: The species accumulation curve (SAC) (red line) for bird points sampled during the June 2022 and July 2022 survey sessions. The blue line represents an accumulation of one species for every additional point count. The black line is parallel to the blue one and is tangent to the SAC approximately after 16 counts (as

represented by the vertical red stippled line). The green stippled line represents the Michaelis-Menten curve.

4.4.2 Summary of point counts

A total of 50 bird species with an average abundance of 267.5 individuals were recorded from 12 bird points (representing two replicative counts) located on the study area. The data provides an estimate of the bird richness and their numbers on the study site and immediate surroundings obtained during two independent survey sessions. A mean of 15.08 species and 22.29 individuals were recorded per point count. The highest number of species and individuals recorded from a point count was respectively 24 species (from riverine woodland to the north of the development area) and 42.5 individuals (manly from stunted *Vachellia karoo* bushveld). The lowest number of species and individuals was respectively three species and three individuals (moribund open grassland).

The mean frequency of occurrence of a bird species in the study area was 30.17 % and the median was 16.67%, while the most common value (mode) was 8.33%. The latter represents those species that were encountered in only one point count. Six species occurred 70% or more of the point counts (Table 5) and were represented by a combination of passerine insectivores (of the families Cisticolidae, Sylviidae and Muscicapidae), facultative frugivores (family Pycnonotidae) and non-passerine granivores (family Columbidae).

Table 5: Bird species with a frequency of occurrence greater than 70% observed on the study area (according to 12 counts).

Species	Frequency (%)	Species	Frequency (%)
African Red-eyed Bulbul (*Pycnonotus nigricans*)	75.00	Kalahari Scrub Robin (*Cercotrichas paena*)	75.00
Black-chested Prinia (*Prinia flavicans*)	75.00	Neddicky (*Cisticola fulvicapilla*)	75.00
Chestnut-vented Warbler (*Curruca subcoerulea)*)	75.00	Red-eyed dove (*Streptopelia semitorquata*)	75.00

4.4.3 Summary of richness and average abundance (per point count)

Displacement of birds by the proposed infrastructure is one of the impacts that is anticipated to occur. By mapping the spatial distribution of the number of species and average abundance values obtained from each point count, it is possible to predict where displacement of birds will be more intensive. According to Figure 17 and Figure 18 it is evident that the highest bird numbers were observed from dense *Vachellia karroo – Asparagus laricinus* bush clumps and from riverine woodland along the Doring river system. The presence of tall canopy tree cover and riverine habitat were responsible for moderate to high numbers of bird species (Figure 17). Nevertheless, it appeared that bird richness and abundance values on open grassland were relatively low. Therefore, the potential displacement of birds due to the loss of habitat during construction is likely to occur at natural habitat which features the presence of riverine systems and dense large natural bush clumps.

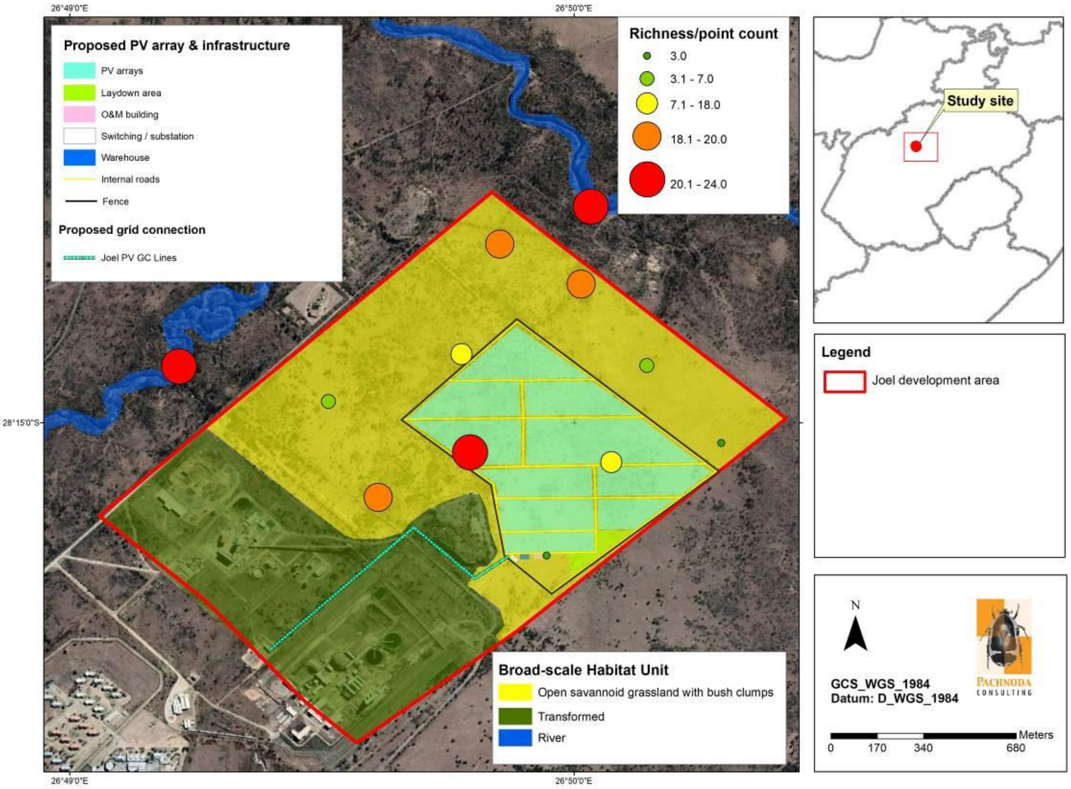


Figure 15: A map of the study area illustrating the spatial distribution of bird richness values (number of species) obtained for each point count.

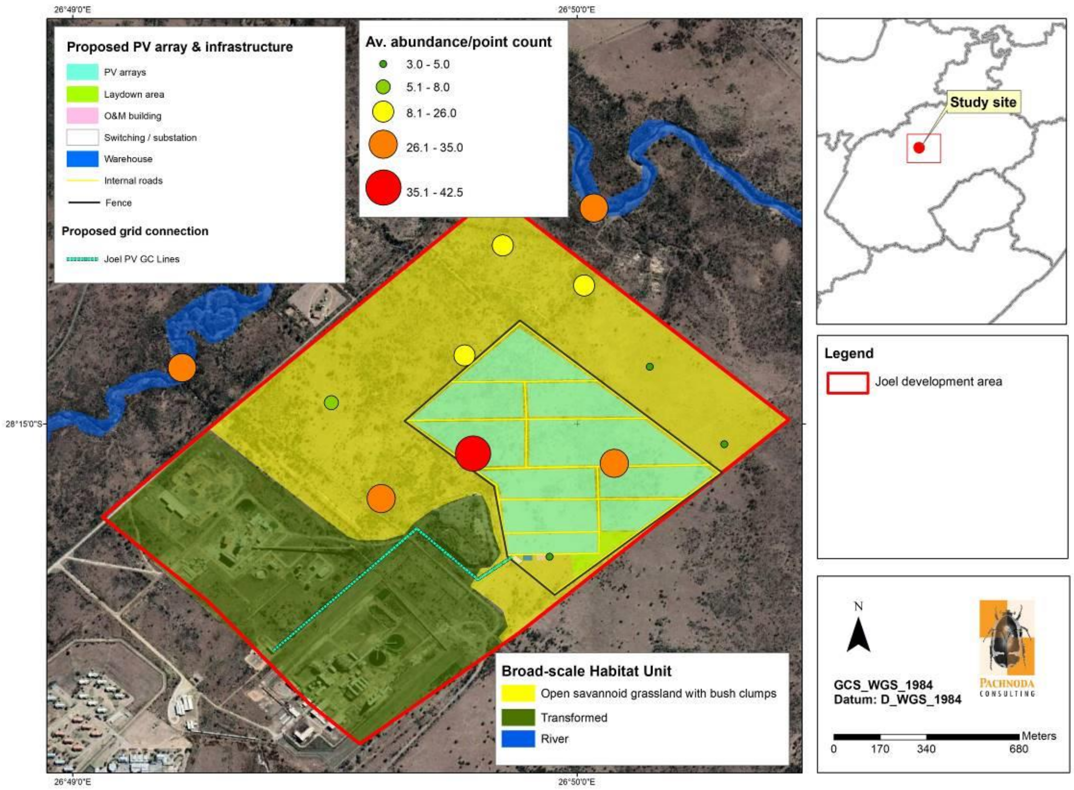


Figure 16: A map of the study area illustrating the distribution of bird abundance values (average number of individuals) obtained for each point count.

4.4.4 Dominance and typical bird species

The dominant (typical) species on the study area are presented in Table 6. Only those species that cumulatively contributed to more than 90% to the overall similarity between the point counts are presented.

The three most typical bird species on the study area include the Chestnut-vented Warbler (*Curruca subcoerulea*), Black-chested Prinia (*Prinia flavicans*) and Neddicky (*Cisticola fulvicapilla*). These species are considered widespread species in the broader study area and occur in most of the habitat types that area present. It is also evident from Table 6 that approximately 60% of the typical bird assemblage is represented by small cryptic passerine insectivores (insect-eating), 25% by granivores (seed-eating taxa; mainly doves and estrildid waxbills) and approximately 12% by facultative frugivores (fruit-eating birds, mainly bulbuls and barbets). The Chestnut-vented Warbler (*Curruca subcoerulea*), Black-chested Prinia (*Prinia flavicans*) and Red-faced Mousebirds (*Urocolius indicus*) were also the three most dominant species (numerically abundant) on the study site. The latter is also a facultative frugivore.

Table 6: Typical (high frequency of occurrence) bird species on the study area.

Species	Av.Abundance	Consistency (Sim/SD)	Contribution (%)	Primary Trophic Guild
Chestnut-vented Warbler (*Curruca subcoerulea*)	1.75	1.04	9.29	Insectivore: upper canopy foliage gleaner
Black-chested Prinia (*Prinia flavicans*)	1.50	1.05	9.03	Insectivore: upper canopy foliage gleaner
Neddicky (*Cisticola fulvicapilla*)	1.13	1.04	8.18	Insectivore: upper canopy foliage gleaner
African Red-eyed Bulbul (*Pycnonotus nigricans*)	1.00	1.03	7.83	Frugivore/Insectivore: upper canopy gleaner
Ring-necked Dove (*Streptopelia capicola*)	0.88	1.04	7.70	Granivore: ground gleaner
Blue Waxbill (*Uraeginthus angolensis*)	1.08	0.75	7.28	Granivore: lower to ground gleaner
Kalahari Scrub Robin (*Cercotrichas paena*)	0.75	1.03	7.18	Insectivore: upper canopy foliage gleaner
Southern Fiscal (*Lanius collaris*)	0.33	0.41	6.05	Insectivore: ground hawker

4.4.5 Composition and diversity

Multidimensional scaling and hierarchical agglomerative clustering ordination of bird abundance values obtained from 12 point counts on the study area differentiate between three discrete bird associations (Global R= 0.58, p=0.002; Figure 17), with statistically significant differences between open grassland and dense bush clump mosaics (R=0.74, p<0.05). Although three discrete units were evident, the bird composition on the bush clump units and the riverine woodland was more similar to each other (R=0.34, p<0.1).

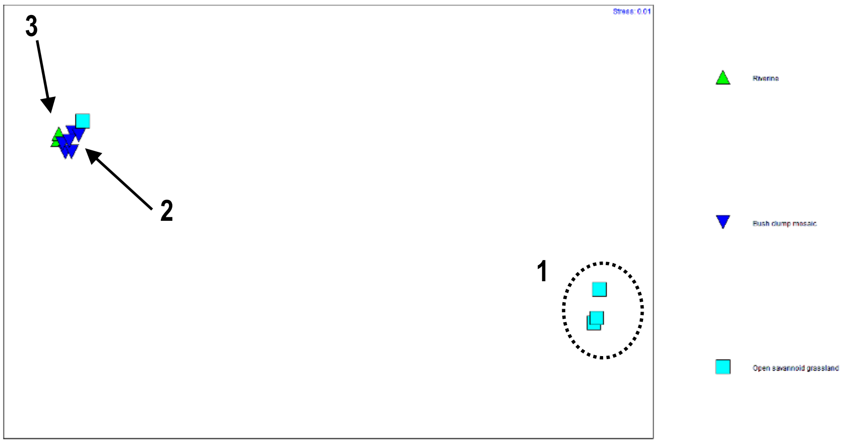


Figure 17: A two-dimensional non-metric multidimensional scaling ordination (stress=0.01) of the relative abundances of bird species based on Bray-Curtis similarities obtained from 12 point counts on the project area. It differentiates between three major bird associations: (1) an association on open grassland habitat, (2) an association on bush clump mosaics and (3) an association confined to riverine woodland and open water.

The following bird associations are relevant to the study site and immediate surroundings:

1. Association on open grassland (in the absence of woody cover)

Dominant species: Desert Cisticola (*Cisticola aridulus*) and Southern Fiscal (*Lanius collaris*).

Indicator species[9]: Cape Longclaw (*Macronyx capensis*), African Stonechat (*Saxicola torquatus*) and African Pipit (*Anthus cinnamomeus*).

2. Association on bush clump mosaics

Dominant species: Black-chested Prinia (*Prinia flavicans*), Chestnut-vented Warbler (*Curruca subcoerulea*), Neddicky (*Cisticola fulvicapilla*), Ring-necked Dove (*Streptopelia capicola*), African Red-eyed Bulbul (*Pycnonotus nigricans*), Kalahari Scrub Robin (*Cercotrichas paena*), Blue Waxbill (*Uraeginthus angolensis*) and Laughing Dove (*Spilopelia senegalensis*).

[9] Indicator species refers to a species with high numbers that is restricted to a particular habitat.

Indicator species: Sabota Lark (*Calendulauda sabota*), Cape White-eye (*Zosterops virens*), White-browed Sparrow-weaver (*Plocepasser mahali)*, Rattling Cisticola (*Cisticola cheniana*) and Pririt Batis (*Batis pririt*).

3. Association on riverine woodland and open water habitat (Doring River system)

Dominant species: Orange River White-eye (*Zosterops pallidus*), Chestnut-vented Warbler (*Curruca subcoerulea*), Cape Robin-chat (*Cossypha caffra*), Southern Masked Weaver (*Ploceus velatus*) and African Red-eyed Bulbul (*Pycnonotus nigricans*).

Indicator species: Cape Robin-chat (*Cossypha caffra*), Ashy Tit (*Melaniparus cinerascens*), Jameson's Firefinch (*Lagonosticta rhodopareia*), Yellow-billed duck (*Anas undulata*) and Egyptian Goose (*Alopochen aegyptiacus*).

The highest number of bird species on the study area was observed from the bushch clump habitat, followed by the riverine woodland (Table 7). The lowest number of bird species was recorded from the open grassland, with only seven species recorded (compared to >30 species from wooded and bushveld habitat). The highest mean number of individuals were observed from the riverine woodland (c. >30 individuals), with the lower mean number of individuals recorded from open grassland (c. <5 individuals).

Table 7: A summary of the observed species richness and number of bird individuals confined to the bird associations on the study area.

Bird Association	Number of species	Mean Number of Individuals	Shannon Wiener Index H'(log_e)
Bush Clump Mosaics	38	26.7	3.21
Riverine woodland (Doring river system)	31	34.5	3.20
Open grassland	7	3.8	1.58

4.5 Passerine bird densities

Thirty-five passerine bird species were recorded from 12 point counts on the study area. The study area accommodates approximately 14.43 species.ha^{-1} (Appendix 2). The average density per hectare is 21.05 birds.ha^{-1} and ranges between 3.85 birds.ha^{-1} to 42.31 birds.ha^{-1}.

4.6 Movements/dispersal of Collision-prone birds

The only **regular** movements observed for waterbird species were the South African Shelduck (*Tadorna cana*), Yellow-billed Duck (*Anas undulata*), African Black Duck (*A. sparsa*) and Egyptian Goose (*Alopochen aegyptiacus*) which could potentially collide with the PV infrastructure when visiting nearby water features in the area (Figure 18). Both species were regularly observed (especially in the early mornings) flying along the Doring River and its associated tributaries located to the north and east of the development area. In addition, some of these species were also observed crossing the eastern section of the study area when commuting in the mornings and the afternoon (Figure 19). The doring River system is regarded as an important dispersal corridor for commuting waterbirds in the wider study area and it was proposed that a buffer area of at least 500m be set aside on both sites of these tributaries to alleviate potential collision risk of flying birds with the PV infrastructure.

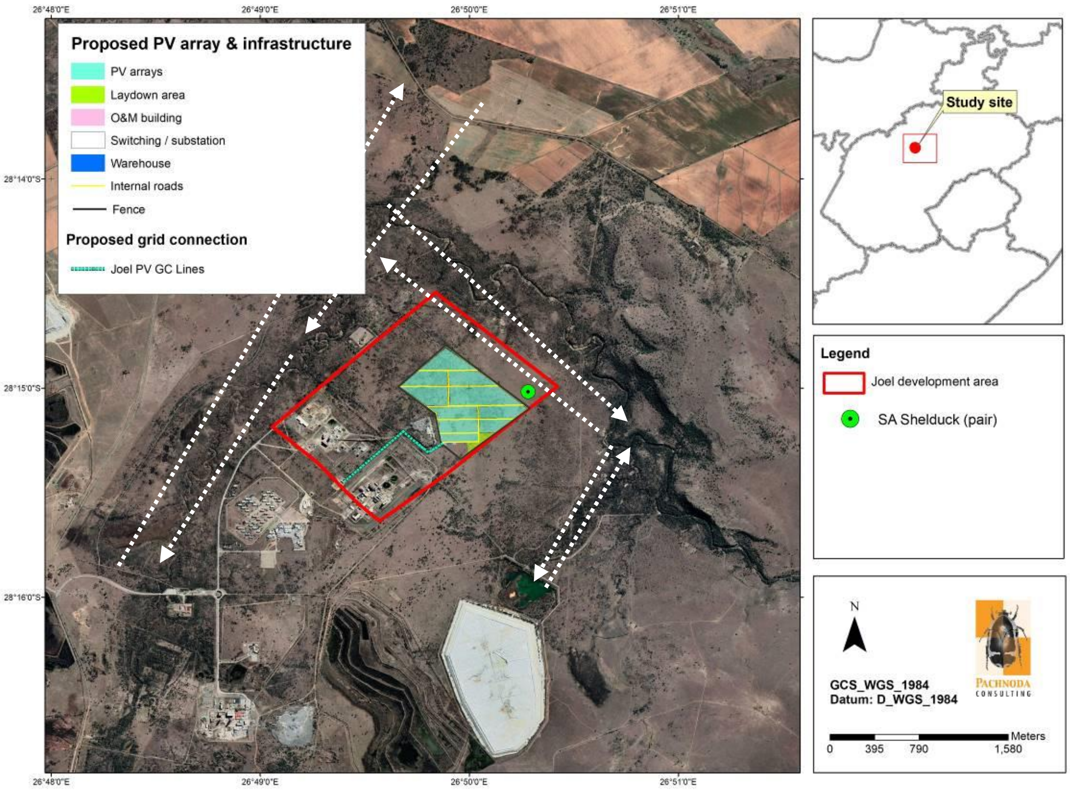


Figure 18: A map of the study site illustrating the major dispersal routes of collision-prone birds.

4.7 Avifaunal sensitivity

A sensitivity map was compiled, illustrating habitat units comprising of potential sensitive elements based on the following arguments (Figure 19):

Areas of high sensitivity

Areas of high sensitivity include the nearby Doring River and its tributaries and the proposed buffer zones (500m).

The Doring River system provides foraging habitat for a number of waterbird taxa (mainly waterfowl of the genera *Anas, Alopochen, Tadorna* and *Plectropterus*), of which these taxa may collide with the proposed PV panels and infrastructure when dispersing (especially when dispersing towards nearby impoundments, dams and inundated wetland features). More importantly, the linear configuration of the Doring River and its associated tributaries are important flyways for waterbird taxa in the region, and should preferably be buffered by at least 500m to avoid or minimise the risk of these bird interacting with the proposed PV infrastructure.

Areas of medium sensitivity

Areas of medium sensitivity represent habitat units of open savannoid grassland and bush clump mosaics. These habitat types provide ephemeral foraging habitat for certain threatened bird species (e.g. Secretarybird), as well as terrestrial bird species (e.g. Northern Black Korhaan) with the potential to interact (e.g. collide) with the proposed electrical infrastructure. However, reporting rates for threatened bird species was relatively low, thereby suggesting a medium sensitivity rating instead of a high sensitivity even though the majority of the habitat units were natural.

Areas of low sensitivity

Areas of low sensitivity include habitat units represented by transformed types and mining infrastructure, thereby contributing little towards local biodiversity.

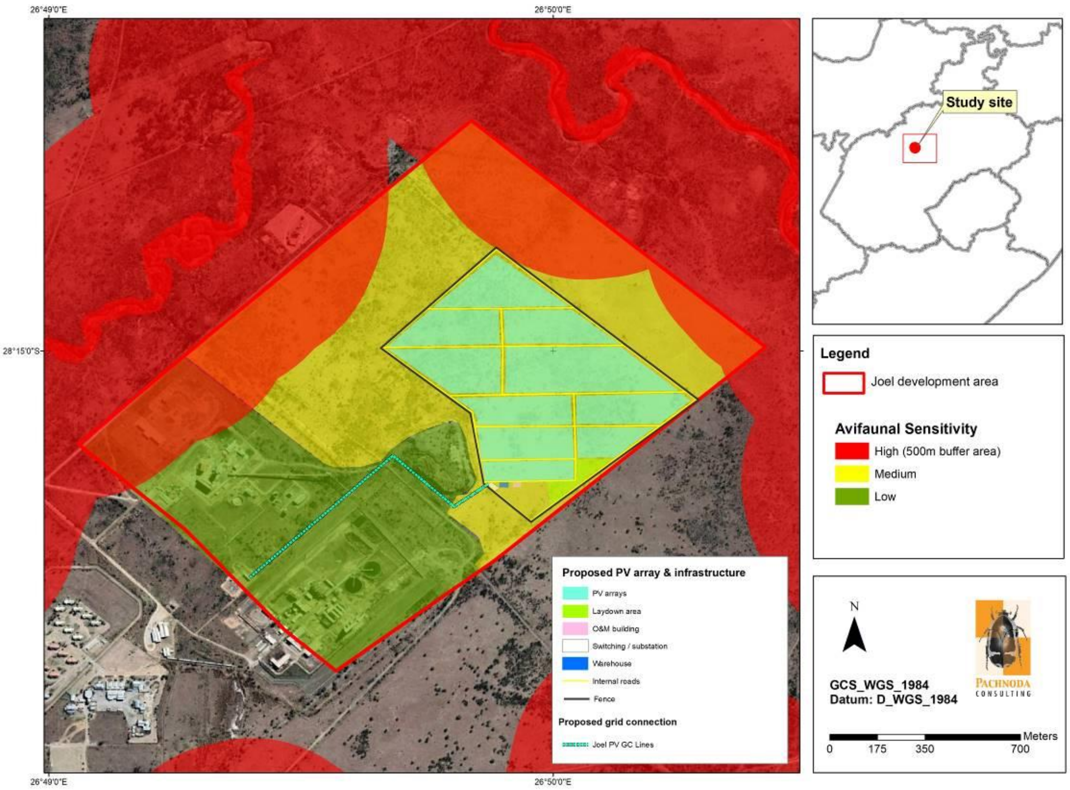


Figure 19: A map illustrating the preliminary avifaunal sensitivity of the area based on habitat types supporting bird taxa of conservation concern and important ecological function.

4.8 Overview of Avian Impacts at Solar Facilities

Table 8 provides a preliminary summary of the impacts anticipated and a preliminary quantification thereof.

4.8.1 Background to solar facilities and their impact on birds

Birds are mobile, and are therefore also more readily affected by solar facilities than other taxonomic groups (e.g. mobile mammals that could move away from the facilities due to displacement). In fact, birds are also vulnerable to impacts caused by other types of energy facilities such as overhead power lines and wind farms. Little information is available on the impacts of solar energy facilities on birds although Gunerhan *et al.* (2009), McCrary *et al.* (1986), Tsoutsos *et al.* (2005) and the recent investigation reports on bird fatalities in the USA by Kagen *et al*. (2014) and Walston *et al*. (2016) provide discussions thereof. These studies have shown that avian fatalities vary greatly between the geographic positions of the solar facilities and also depend on the type of solar facility. In addition, very few of the large solar facilities in operation undertake systematic monitoring of avian fatalities, which explains the lack of detailed information of avian impacts. According to these studies conducted at both Concentrated Solar Power (CSP) and PV facilities, avian incidental fatalities range from 14 to over 180 birds which were summarised over a survey period conducted during one to three years. According to the Walston *et al.* (2016) assessment, the average annual mortality rate for known utility-scale solar facilities (the annual number of estimated bird deaths per megawatt of electrical capacity) is 2.7, and 9.9 for known and unknown fatalities (which include carcasses found on the project site of which the death is not known). McCrary *et al.* (1986) found an average rate of mortality of 1.9-2.2 birds per week affecting 0.6-0.7 % of the local bird population. However, most of the avian fatalities at these solar facilities are also probably underestimated since 10-30 % of dead birds are removed by scavengers before being noted.. From these analyses and assessments it was evident that:

- Medium levels of bird fatalities occur at PV sites when compared to CSP sites (when taking powerline collisions into account).
- Approximately 81 % of all avian mortalities were caused by collisions, including collisions with electrical distribution lines.
- Most of the mortalities were small passerines (especially swallows).
- Fatalities at these solar facilities also include waterbirds (e.g. grebes, herons and gulls) which were probably attracted by the apparent "lake effect" caused by the reflective surface of the PV panels.
- Approximately 10-11 % of the fatalities consists of waterbirds, but could be as high as 49 % at certain facilities.
- It is unclear if the "lake effect" caused by the panels (at PV facilities) or mirrors (at CSP facilities) are the main cause of birds colliding or interacting with the infrastructure (since both waterbirds and other passerines are colliding with the infrastructure).

- Most of the fatalities are of resident birds as opposed to migratory species.

In a review report by Harrison *et al.* (2016), an attempt was made to provide evidence of the impacts caused by solar PV facilities alone (not combined with CSP facilities) on birds in the UK. These authors reviewed approximately 420 scientific documents, including 37 so-called "grey" literature from non-government and government organisations for any evidence relating to the ecological impacts of solar PV facilities. Their main findings were as follows:

- The majority of the documents were not relevant and peer-reviewed documents of experimental scientific evidence on avian fatalities were non-existent.
- Results based on carcass searches suggest that the bird collision risk at PV developments are low, although these studies did not take collision by overhead power lines into account.
- Many of the documents recommended that PV developments in close proximity to protected areas should be avoided.
- The PV panels reflect polarised light, which can attract polarotactic insects with potential impact to their reproductive biology. In addition, the polarising effect of the PV panels may also induce drinking behaviour in some birds, which may mistake the panels for water.

They conclude that impact assessment reports should consider taxon-specific requirements of birds and their guilds.

4.8.2 Potential impacts of PV solar facilities on birds

The magnitude and significance of impacts to birds caused by solar facilities will depend on the following factors:

- The geographic locality of the planned solar facility;
- The size or surface extent of the solar facility;
- The type of solar facility (according to the technologies applied, e.g. PV or Concentrated Solar Power (CSP)); and
- The occurrence of collision-prone bird species (which are often closely related to the locality of the solar facility).

Any planned solar facility corresponding to an area with many threatened, range-restricted or collision-prone species will have a higher impact on these birds. In addition, any planned solar facility located in close proximity to important flyways, wetland systems or roosting/nesting sites used by the aforementioned species will have a higher impact.

The main impacts associated with PV solar facilities include (Jenkins *et al*., 2017):

- The loss of habitat and subsequent displacement of bird species due to the ecological footprint required during construction;

- Disturbances caused to birds during construction and operation;
- Direct interaction (collision trauma) by birds with the surface infrastructure (photovoltaic panels) caused by polarised light pollution and/or waterbirds colliding with the panels (as they are mistaken for waterbodies);
- Collision with associated infrastructure (mainly overhead powerlines and reticulation);
- Attracting novel species to the area (owing to the artificial provision of new habitat such as perches and shade) which could compete with the residing bird population.

4.9 Potential Impacts associated with the proposed Joel PV Solar Facility

4.9.1 Loss of habitat and displacement of birds

Approximately 47ha will be cleared of vegetation and habitat to accommodate the panel arrays and associated infrastructure. Clearing of vegetation will inevitably result in the loss of habitat and displacement of bird species. From the results, approximately 14.43 species.ha^{-1} and 21.05 birds.ha^{-1} will become displaced should the activity occur (as per Jenkins et al., 2017). Displacement will mainly affect regional endemic passerine and smaller non-passerine species inhabiting the open grassland and bush clump mosaics of medium avifaunal sensitivity.

The following bird species are most likely to be impacted by the loss of habitat due to their habitat requirements, endemism and conservation status (although not limited to) due to the proposed development:

- White-backed Mousebird (*Colius colius*);
- Fairy Flycatcher (*Stenostira scita*);
- Pririt Batis (Batis pririt);
- Orange River Francolin (*Scleroptila gutturalis*);
- Gabar Goshawk (*Micronisus gabar*)
- Kalahari Scrub Robin (*Cercotrichas paena*); and to a lesser extent also
- Northern Black Korhaan (*Afrotis afraoides*).

4.9.2 Creation of "new" avian habitat and bird pollution

It is possible that the PV infrastructure (during operation) could attract bird species which may occupy the site or interact with the local bird assemblages in the wider region. These include alien and cosmopolitan species, as well as aggressive omnivorous passerines which could displace other bird species from the area:

- House Sparrow (*Passer domesticus*);
- Common Myna (*Acridotheres tristis*);
- Pied Crow (*Corvus albus*);
- Speckled Pigeon (*Columba guinea*); and potentially also

- Egyptian Goose (*Alopochen aegyptiacus*).

The infrastructure may attract large numbers of roosting columbid taxa, especially Speckled Pigeons (*Columba guinea*), which may result in avian "pollution" through excreta, thereby fouling the panel surfaces. The same applies to the locally abundant Egyptian Goose (*Alopochen aegyptiacus*) which may roost on the infrastructure. The impact is manageable and will result in a low significance.

4.9.3 Collision trauma caused by photovoltaic panels (the "lake-effect")

The presence of the Doring river system, as well as a number of dams and impoundments in close proximity to the study site increase the risk of waterbirds and shorebird taxa interacting with the PV panels. A number of species were observed with a high frequency of occurrence which dispersed along the nearby Doring river system on a daily basis which could also potentially interact with the PV panels.

Placement of the proposed PV panels will be critical and should preferably avoid areas of high sensitivity as illustrated by Figure 19. Appropriate bird deterrent devices should be installed at strategic localities, and these should include a combination of rotating flashers/reflectors to increase the visibility of the infrastructure. In addition, post construction monitoring to quantify mortalities will be important during to early operational phase in order to determine "hotspot" areas (areas where high mortalities are prevalent) which may require additional mitigation measures. Waterbirds with a high frequency of occurrence which could interact with the PV panels are the Egyptian Goose (*Alopochen aegyptiaca*), South African Shelduck (*Tadorna cana*), Yellow-billed Duck (*Anas undulata*), African Black Duck (*Anas sparsa*), Spur-winged Goose (*Plectropterus gambiensis*) and potentially also Reed Cormorant (*Microcarbo africanus)*, Red-knobbed Coot (*Fulica cristata*), Common Moorhen (*Gallinula chloropus*), Little Grebe (*Tachybaptus ruficollis*) and Cape Shoveller (*Anas smithii*).

Desktop results and site observations show that the following species could interact with the panel infrastructure:

- South African Shelduck (*Tadorna cana*);
- Egyptian Goose (*Alopochen aegyptiaca*);
- Spur-winged Goose (*Plectropterus gambiensis*);
- Hamerkop (*Scopus umbretta*);
- Yellow-billed Duck (*Anas undulata*);
- White-faced Duck (*Dendrocygna viduata*);
- Red-billed Teal (*Anas erythrorhynchus*);
- African Black Duck (*Anas sparsa*);
- Cape Shoveller (*Anas smithii*);
- Glossy Ibis (*Plegadis falcinellus*);
- Black-winged Stilt (*Himantopus himantopus*);
- Three-banded Plover (*Charadrius tricollaris*); and potentially also
- White-breasted Cormorant (*Phalacrocorax lucidus*)

- Reed Cormorant (*Microcarbo africanus*);
- African Sacred Ibis (*Threskiornis aethiopicus*) and potentially also
- Little Grebe (*Tachybaptus ruficollis*);
- Blue-winged Teal (*Spatula hottentota*);
- Black-headed Heron (*Ardea melanocephala*);
- Red-knobbed Coot (*Fulica cristata*);
- Grey Heron (*Ardea cinerea*);
- African Darter (*Anhinga rufa*);
- Purple Heron (*Ardea purpurea*);
- Southern Pochard (*Netta erythrophthalma*);
- Whiskered Tern (*Chlidonias hybrida*);
- Grey-headed Gull (*Chroicocephalus cirrocephalus*);
- African Swamphen (*Porphyrio madagascariensis*);
- Common Moorhen (*Gallinula chloropus*)

4.9.4 Interaction with overhead powerlines and reticulation

A 132kV overhead powerline is proposed to tie-in to Shafts 1&2 HJ Joel Mining (6.6/132 kV) substation. The proposed overhead power line will traverse habitat of low avifaunal sensitivity (e.g. transformed habitat), whereby the anticipated impact will be reduced.

Birds are impacted in three ways by means of overhead powerlines (described below). It is however a common rule that large and heavy-bodied terrestrial bird species are more at risk of being affected in a negative way when interacting with powerlines in general. These include the following:

- *Electrocution*

Electrocution happens when a bird bridges the gap between the live components or a combination of a live and earth component of a power line, thereby creating a short circuit. This happens when a bird, mainly a species with a fairly large wingspan attempts to perch on a tower or attempts to fly-off a tower. Many of these species include vultures (of the genera *Gyps* and *Torgos*) as well as other large birds of prey such as the Martial Eagle (*Polemaetus bellicosus*) (Ledger & Annegarn, 1981; Kruger, 1999; Van Rooyen, 2000). These species will attempt to roost and even breed on the tower structures if available nesting platforms are a scarce commodity in the area. Other types of electrocutions happen by means of so-called "bird-streamers". This happens when a bird, especially when taking off, excretes and thereby causes a short-circuit through the fluidity excreta (Van Rooyen & Taylor, 1999).

Large transmission lines (from 220 kV to 765 kV) are seldom a risk of electrocution, although smaller distribution lines (88 – 132kV) pose a higher risk. However, for this project, the design of the pylon is an important consideration in preventing bird electrocutions.

- *Collision*

Collisions with earth wires have probably accounted for most bird-powerline interactions in South Africa. In general, the earth wires are much thinner in diameter when compared to the live components, and therefore less visible to approaching birds. Many of the species likely to be affected include heavy, large-bodied terrestrial species such as bustards, korhaans and a variety of waterbirds that are not very agile or manoeuvrable once airborne. These species, especially those with the habit of flying with outstretched necks (e.g. most species of storks) find it difficult to make a sudden change in direction while flying – resulting in the bird flying into the earth wires.

Areas where bird collisions are likely to be high could be ameliorated by marking the lines with appropriate bird deterrent devices such as “bird diverters” and “flappers” to increase the visibility of the lines.

- *Physical disturbances and habitat destruction caused during construction and maintenance*

It is anticipated that part of the powerline line servitude will be cleared of vegetation. In addition, construction activities go hand in hand with high ambient noise levels. Although construction is considered temporary, many species will vacate the area during the construction phase and will become temporarily displaced.

Table 8: The quantification of impacts associated with the proposed PV facility and its infrastructure.

1. Nature: Losses of natural habitat and displacement of birds through physical transformation, modifications, removals and land clearance. This impact is mainly restricted to the construction phase and is permanent.		
PV Layout (and associated infrastructure)	**Without mitigation**	**With mitigation**
Extent	Local (2)	Local (2)
Duration	Long-term (4)	Long-term (4)
Magnitude	High (8)	Moderate (6)
Probability	Definite (5)	Highly Probable (4)
Significance	**High (70)**	**Medium (48)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Low
Irreplaceable loss of resources?	Yes	Yes
Can impacts be mitigated?	Yes, to some extent	Yes, to some extent
Mitigation: It is difficult to mitigate against the loss of habitat since clearing of vegetation (or habitat) will be required for the		

infrastructure associated with the project. Both the PV facility and associated infrastructure occur predominantly on habitat types of medium and low sensitivity. The best practicable mitigation will be to consolidate infrastructure (e.g. proposed powerlines) to areas where existing impacts occur (e.g. placing the proposed powerline alongside existing powerlines) and to avoid areas of high sensitivity.
Residual: Decreased bird species richness, low evenness values and subsequent loss of avian diversity on a local scale. The impact will also result in sterilisation of local landscapes and increased fragmentation of habitat.

2. Nature:
The creation of novel or new avian habitat for commensal bird species or superior competitive species. This is expected to occur during the operation phase of the facility.

PV Layout (and associated infrastructure)	**Without mitigation**	**With mitigation**
Extent	Footprint (1)	Footprint (1)
Duration	Medium-term (3)	Medium-term (3)
Magnitude	Minor (2)	Minor (2)
Probability	Probable (3)	Improbable (2)
Significance	**Low (18)**	**Low (12)**
Status (positive or negative)	Negative	Negative
Reversibility	Moderate	Moderate
Irreplaceable loss of resources?	No	No
Can impacts be mitigated?	Yes, with experimentation	Yes

Mitigation:
Apply bird deterrent devices and remove nest structures constructed on infrastructure associated with the PV facility under the guidance of the ECO.

Residual:
Secondary displacement by completive bird species such as crows and increased fecundity rate for commensal bird species that are adapted to anthropogenic activities. The impact is regarded as low.

3. Nature:
Avian collision impacts related to the PV facility during the operation phase (collision with the PV panels).

PV Layout (and associated infrastructure)	**Without mitigation**	**With mitigation**
Extent	Site and immediate surroundings (4)	Site and immediate surroundings (3)
Duration	Long-term (4)	Long-term (4)
Magnitude	High (8)	Moderate (6)
Probability	Highly Probable (4)	Probable (3)
Significance	**High (64)**	**Medium (39)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Low
Irreplaceable loss of resources?	Yes, potential loss of waterfowl and certain shorebird taxa species.	Yes, potential loss of waterfowl and certain shorebird taxa species.
Can impacts be mitigated?	Yes, with experimentation	Yes, with experimentation

Mitigation:
Apply bird deterrent devices such as rotating flashers/reflectors to the panels for birds that may mistake the panels for open water and to prevent them from landing on the panels - these should especially be placed at panels nearest to wetland features and river systems. Security/CCTV cameras may be installed to quantify mortalities

(cameras are also installed along the perimeter fence for security measures and may also proved effective to quantify mortalities). Buffer rivers/streams by at least 500m. If post-construction monitoring predicts and/or confirms bird mortalities, an option is to employ video cameras at selected areas to document bird mortalities and to conduct direct observations and carcass searches on a regular and systematic basis.
Residual: Direct mortality is possible and may still occur irrespective of applied mitigation measures. Regular and systematic monitoring is proposed to assess the efficacy of applied mitigation and further research and testing is suggested to improve mitigation measures (e.g. bird deterrent devices). The residual impact is regarded as moderate.

4. Nature:
Avian collision impacts related to overhead power lines during operation.

Overhead powerline corridors	Without mitigation	With mitigation
Extent	Local (2)	Local (2)
Duration	Long-term (4)	Long-term (4)
Magnitude	Moderate (6)	Minor (2)
Probability	Probable (3)	Probable (3)
Significance	**Medium (36)**	**Low (24)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Low
Irreplaceable loss of resources?	Yes (to some extent), owing to the potential loss of terrestrial bird and waterbird species.	Yes
Can impacts be mitigated?	Yes	Yes

Mitigation:
Apply bird deterrent devices to the power lines and make use of "bird-friendly" pylon structures. To aid post-construction monitoring and/or monitoring of bird mortality rates, it is advised to conduct direct observations and carcass searches on a regular and systematic basis. Collisions will be reduced if the proposed corridors are placed alongside existing powerlines.

Residual:
Direct mortality is possible and may still happen irrespective of applied mitigation measures. The residual impact will be low.

5. Nature:
Avian electrocution related to the new distribution lines during operation.

Overhead powerline corridors	Without mitigation	With mitigation
Extent	Local (2)	Local (2)
Duration	Long-term (4)	Long-term (4)
Magnitude	Moderate (6)	Minor (2)
Probability	Probable (3)	Probable (3)
Significance	**Medium (36)**	**Low (24)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Low
Irreplaceable loss of resources?	Yes (to some extent), owing to the potential loss of terrestrial bird and waterbird species.	Yes (to some extent), owing to the potential loss of terrestrial bird and waterbird species.
Can impacts be mitigated?	Yes, to some extent	Yes, to some extent

Mitigation:
Avoid the placement of overhead electrical infrastructure in close proximity to wetland features and river/streams.

Make use of bird-friendly pylons and bird guards as recommended by EWT.
Residual: Direct mortality is possible and may still happen irrespective of applied mitigation measures. The residual impact will be low.

4.10 Collision-prone bird species

A total of 50 collision-prone bird species have been recorded from the wider study area, of which 29 species are waterbird species and 11 species are birds of prey (Table 8). According to Table 8, it is evident that the number of collision-prone species that could occur on the study area is moderately high (c. 30% of the total number of bird species recorded in the area).

Table 9: Collision-prone bird species and Red listed species (in red) expected to be present on the study site and immediate surroundings inferred from the South African Atlas Project (SABAP2).

Common Name	Scientific Name	SABAP2 Reporting Rate			
		Full Protocol (%)	Number of cards	Ad hoc Protocol (%)	Number of cards
Hadada Ibis	*Bostrychia hagedash*	82.61	19	15.79	3
Swainson's Spurfowl	*Pternistis swainsonii*	73.91	17	15.79	3
Helmeted Guineafowl	*Numida meleagris*	65.22	15	15.79	3
Speckled Pigeon	*Columba guinea*	65.22	15	10.53	2
Western Cattle Egret	*Bubulcus ibis*	60.87	14	21.05	4
Black-winged Kite	*Elanus caeruleus*	56.52	13	21.05	4
Egyptian Goose	*Alopochen aegyptiaca*	47.83	11	21.05	4
Northern Black Korhaan	*Afrotis afraoides*	43.48	10	15.79	3
Reed Cormorant	*Microcarbo africanus*	43.48	10	5.26	1
South African Shelduck	*Tadorna cana*	34.78	8	15.79	3
Black-headed Heron	*Ardea melanocephala*	30.43	7	5.26	1
Three-banded Plover	*Charadrius tricollaris*	30.43	7	10.53	2
Yellow-billed Duck	*Anas undulata*	30.43	7	15.79	3
Spur-winged Goose	*Plectropterus gambensis*	26.09	6	10.53	2
Little Grebe	*Tachybaptus ruficollis*	21.74	5	10.53	2
Red-billed Teal	*Anas erythrorhyncha*	17.39	4	5.26	1
Red-knobbed Coot	*Fulica cristata*	17.39	4	5.26	1
White-faced Whistling Duck	*Dendrocygna viduata*	17.39	4	0.00	0
Common Moorhen	*Gallinula chloropus*	13.04	3	5.26	1
Glossy Ibis	*Plegadis falcinellus*	13.04	3	5.26	1
Grey-headed Gull	*Chroicocephalus cirrocephalus*	13.04	3	5.26	1
Natal Spurfowl	*Pternistis natalensis*	13.04	3	10.53	2
Pale Chanting Goshawk	*Melierax canorus*	13.04	3	5.26	1
African Black Duck	*Anas sparsa*	8.70	2	5.26	1
African Darter	*Anhinga rufa*	8.70	2	0.00	0
African Sacred Ibis	*Threskiornis aethiopicus*	8.70	2	0.00	0
Black-crowned Night Heron	*Nycticorax nycticorax*	8.70	2	0.00	0
Common (Steppe) Buzzard	*Buteo buteo vulpinus*	8.70	2	5.26	1

Common Name	Scientific Name	SABAP2 Reporting Rate			
		Full Protocol (%)	Number of cards	Ad hoc Protocol (%)	Number of cards
Lesser Kestrel	*Falco naumanni*	8.70	2	0.00	0
Pied Crow	*Corvus albus*	8.70	2	0.00	0
Secretarybird	*Sagittarius serpentarius*	8.70	2	0.00	0
Southern Pochard	*Netta erythrophthalma*	8.70	2	5.26	1
Whiskered Tern	*Chlidonias hybrida*	8.70	2	0.00	0
African Fish Eagle	*Haliaeetus vocifer*	4.35	1	0.00	0
Amur Falcon	*Falco amurensis*	4.35	1	0.00	0
Black Sparrowhawk	*Accipiter melanoleucus*	4.35	1	0.00	0
Black-necked Grebe	*Podiceps nigricollis*	4.35	1	5.26	1
Cape Shoveler	*Spatula smithii*	4.35	1	5.26	1
Gabar Goshawk	*Micronisus gabar*	4.35	1	0.00	0
Hamerkop	*Scopus umbretta*	4.35	1	0.00	0
Marsh Owl	*Asio capensis*	4.35	1	10.53	2
Purple Heron	*Ardea purpurea*	4.35	1	0.00	0
White-breasted Cormorant	*Phalacrocorax lucidus*	4.35	1	0.00	0
African Marsh Harrier	*Circus ranivorus*	0.00	0	5.26	1
African Swamphen	*Porphyrio madagascariensis*	0.00	0	5.26	1
Black-winged Stilt	*Himantopus himantopus*	0.00	0	5.26	1
Blue-billed Teal	*Spatula hottentota*	0.00	0	5.26	1
Maccoa Duck	*Oxyura maccoa*	0.00	0	5.26	1
Orange River Francolin	*Scleroptila gutturalis*	0.00	0	10.53	2
Ruff	*Calidris pugnax*	0.00	0	5.26	1

4.11 Cumulative Impacts

Cumulative impacts are defined as impacts that result from additional or incremental activities caused by past or present actions together with the current project. Therefore, cumulative impacts are those that will affect the general avifaunal community on the study area due to other planned solar farm projects and electrical infrastructure in the region.

According to the National Screening Report (generated 25/04/2022), there is currently six solar PV facilities with an approved environmental authorisation under consideration within 30km of the proposed Harmony Joel Solar PV facility (Table 10). Two of these are within 2.2 km of the study area.

Table 10: Solar developments with an approved Environmental Authorisation or applications under consideration within 30 km of the proposed area (sensu the results of the National Screening Tool).

No	EIA Reference No	Classification	Status of application	Distance from proposed area (km)
1	12/12/20/2669/A	Solar PV	Approved	8.6
2	12/12/20/2666	Solar PV	Approved	8.6
3	12/12/20/2669	Solar PV	Approved	8.6

No	EIA Reference No	Classification	Status of application	Distance from proposed area (km)
4	12/12/20/2667	Solar PV	Approved	2.2
5	12/12/20/2668	Solar PV	Approved	2.2
6	12/12/20/2666/A	Solar PV	Approved	8.6

The cumulative impacts are likely to increase the displacement and loss of habitat. In addition while the grid connection (via overhead powerlines) of these facilities could potentially contribute towards bird strikes with powerlines and avian mortalities due to collision in the region.

A summary of the cumulative impacts is provided in Table 11.

Table 11: A summary of the cumulative impacts.

1. Nature: Regional losses of natural habitat and subsequent displacement of birds.		
	Overall impact of the proposed project considered in isolation	**Cumulative impact of the project and other projects in the area**
Extent	Local (2)	Local and immediate surroundings (3)
Duration	Long-term (4)	Long-term (4)
Magnitude	Moderate (6)	Moderate (6)
Probability	Highly Probable (4)	Highly Probable (4)
Significance	**Medium (48)**	**Medium (52)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Low
Loss of resources?	Yes	Yes
Can impacts be mitigated?	To some extent	To some extent
Confidence in findings: High.		
Mitigation: It is difficult to mitigate against the loss of habitat without considering alternative sites. The best practicable mitigation will be to consolidate infrastructure (e.g. proposed powerline) to areas where existing impacts occur (e.g. placing the proposed powerline alongside existing powerlines) and to concentrate infrastructure on land with a low biodiversity conservation value.		
2. Nature: Avian collision impacts related to the PV facility during the operational phase (collision with the PV panels).		
	Overall impact of the proposed project considered in isolation	**Cumulative impact of the project and other projects in the area**
Extent	Site and immediate surroundings (3)	Local and immediate surroundings (3)
Duration	Long-term (4)	Long-term (4)
Magnitude	Moderate (6)	High (8)
Probability	Probable (3)	Highly Probable (4)
Significance	**Medium (39)**	**Medium (60)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Low

Irreplaceable loss of resources?	Yes, potential loss of waterfowl and certain shorebird taxa species.	Yes, potential loss of waterfowl and certain shorebird taxa species.
Can impacts be mitigated?	Yes, to some extent	Yes, to some extent
Confidence in findings: Low.		
Mitigation: Apply bird deterrent devices to the panels for birds that may mistake the panels for open water and to prevent them from landing on the panels. To aid post-construction monitoring and/or monitoring of bird mortality rates, it is advised to employ video cameras to document any bird mortalities and to conduct direct observations and carcass searches on a regular and systematic basis. Apply appropriate buffer zones to water features and wetlands.		
3. Nature: Avian collision impacts related to the powerline reticulation and new distribution lines during operation.		

	Overall impact of the proposed project considered in isolation	**Cumulative impact of the project and other projects in the area**
Extent	Local (2)	Local (2)
Duration	Long-term (4)	Long-term (4)
Magnitude	Minor (2)	Moderate (6)
Probability	Probable (3)	Probable (3)
Significance	**Low (24)**	**Medium (36)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Low
Irreplaceable loss of resources?	Yes, potential loss of waterfowl and certain shorebird taxa species.	Yes
Can impacts be mitigated?	Yes, to some extent	Yes, to some extent
Confidence in findings: High.		
Mitigation: Apply bird deterrent devices to the power line and make use of "bird-friendly" pylon structures. Allow for construction of new powerlines parallel to existing lines. To aid post-construction monitoring and/or monitoring of bird mortality rates, it is advised to conduct direct observations and carcass searches on a regular and systematic basis. As a priority, all new power lines should be marked with bird diverters.		
4. Nature: Avian electrocution related to the powerline reticulation and new distribution lines during operation.		

	Without mitigation	**With mitigation**
Extent	Local (2)	Local (2)
Duration	Long-term (4)	Long-term (4)
Magnitude	Minor (2)	Low (4)
Probability	Probable (3)	Probable (3)
Significance	**Low (24)**	**Medium (36)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Low
Irreplaceable loss of resources?	Yes, potential loss of waterfowl and certain shorebird taxa species.	Yes.
Can impacts be mitigated?	Yes, to some extent	Yes, to some extent
Confidence in findings: Moderate.		
Mitigation: Apply bird deterrent devices to the power line and make use of "bird-friendly" pylon structures. As a priority, all		

new power lines should be marked with bird diverters. Make use of bird-friendly pylons and bird guards. Position electrical infrastructure in close proximity to existing infrastructure.

4.12 Recommended avifaunal mitigation

4.12.1 Loss of habitat and displacement bird taxa

It is difficult to mitigate against the loss of habitat when fixed infrastructure is applied. However, proper site selection of the facility is key to reducing the predicted impacts.

The following mitigation measures are proposed:

- Concentrate all surface infrastructure on habitat of medium to low avifaunal sensitivity. The development footprint of the various individual facilities must be kept as small as possible and sensitive habitats must be avoided.
- Where possible, existing access roads should be used and the construction of new roads should be kept to a minimum.
- Prevent an overspill of construction activities into areas that are not part of the proposed construction site.
- Use indigenous plant species native to the study area during landscaping and rehabilitation.
- All internal electrical reticulation should be placed underground, while the alignment of the overhead power lines should be placed parallel to existing powerlines lines.

4.12.2 Creation of "new" avian habitat and bird pollution

The following mitigation measures are proposed:

- Apply bird deterrent devices at selective areas (for example at the corners and middle part of the facility) to the PV panels to discourage birds from colonising the infrastructure or to discourage birds from constructing nests. These could include visual or bio-acoustic deterrents such as highly reflective rotating devices, anti-perching devices such as bird guards, scaring or chasing activities involving the use of trained dogs or raptors and/or netting. Nests should be removed when nest-building attempts are noticed under the guidance of the ECO.
- Reduce or minimise the use of outdoor lighting to avoid attracting birds to the lights or to reduce potential disorientation to migrating birds.
- Use indigenous plant species native to the study area during landscaping and rehabilitation.

4.12.3 Collision trauma caused by photovoltaic panels (the "lake-effect")

The following mitigation measures are proposed:

- Apply bird deterrent devices to the panels at selective areas (for example at the corners and middle part of the facility) to discourage birds from colonising/colliding with the infrastructure. Bird deterrent devices should especially be placed at panels nearest to ("facing") wetland features and rivers/streams. These could include visual or bio-acoustic deterrents such as highly reflective rotating devices, flashers, anti-perching devices such as bird guards, scaring or chasing activities involving the use of trained dogs or raptors and/or netting. An option is to employ video cameras at selected areas to document bird mortalities.
- Buffer all wetland-associated habitat and rivers/streams by at least 500m.
- Apply systematic reflective/dynamic markers to the boundary fence to increase the visibility of the fence for approaching birds (e.g. korhaan taxa) and to avoid potential bird collisions with the fence structure.
- Reduce or minimise the use of outdoor lighting to avoid attracting birds to the lights or to reduce potential disorientation to migrating birds.

4.12.4 Power line interaction: collision and electrocution with power lines

The following mitigation measures are proposed:

- All internal electrical infrastructure and cabling should be placed underground.
- Position the proposed grid connection alongside existing powerline servitudes.
- EWT should be consulted on an appropriate pylon design to be used for the project (if pylons are to be used). In general, the proposed pylon design must incorporate the following design parameters:
  - The clearances between the live components should be as wide as possible within the design limitations/capabilities of the power line.
  - The height of the tower should allow for unrestricted movement of terrestrial birds between successive pylons.
  - The live components should be “bundled” to increase the visibility for approaching birds.
  - “Bird streamers” should be eliminated by discouraging birds from perching above the conductors. In addition, conductors should be strung below the pole to avoid bridging the air gap by perching birds of prey.

It is therefore recommended that the pylon design incorporates "features as illustrated in Figure 20[10].

[10] Please note that these are examples of recommended pylon designs. These are taken from steel monopole pylons.

From Figure 20 it is clear that perching by birds is discouraged by the addition of diagonal crossbars or by doing away with the crossbars that holds the conductors in place. Bird “streamers” are also eliminated by fitting the poles with bird guards/spikes above the conductors. However, safe perching is facilitated by the fitment of a horizontal bar on top of the pole structure without the risk of electrocution (due to the perpendicular orientation of the bar relative to the conductors).

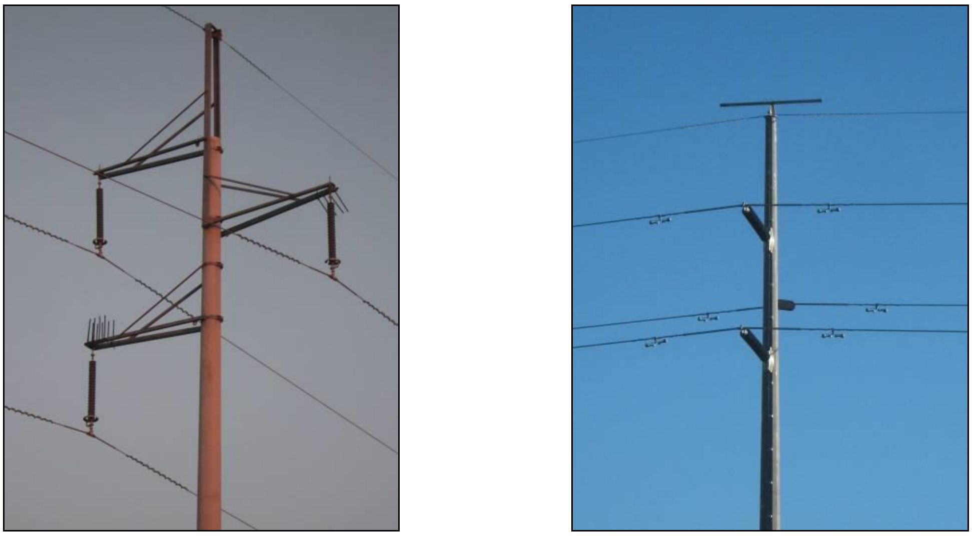


Figure 20: Two bird-friendly tower designs to be considered for the current project.

- All new and planned power lines should be fitted with bird flight diverters (see Figure 21). The maximum distance between the diverters should not exceed 5 m. For dynamic devices (e.g. Viper live bird flapper), flappers should be applied to earth wires while alternating between different colours (e.g. between black and yellow or black and red) and should be fitted to the middle 60 % of the span (corresponding to the lower part of the span). All flappers should be spaced at 5 m intervals from each other.
- It is recommended that existing powerlines be retrofitted with bird flight diverters, especially when a wetland/seep/stream/dam/pollution control dam is crossed. The actual crossover span as well as one span on either side of the wetland/seep/stream/dam/pollution control dam should be marked.

Figure 21: Examples of bird flight diverters to be used on the power lines: Double loop bird flight diverter (left) and Viper live bird flapper (right).

4.12.5 General mitigation measures

- All construction sites/areas must be demarcated on site layout plans (preferably), and no construction personnel or vehicles may leave the demarcated area except those authorised to do so. Those areas surrounding the construction sites that are not part of the demarcated development area should be considered as “no-go” areas for employees, machinery or even visitors.
- All road networks must be planned with care to minimise dissection or fragmentation of important avifaunal habitat type. Where possible, the use of existing roads is encouraged.
- Open fires is strictly prohibited and only allowed at designated areas.
- Killing or poaching of any bird species should be avoided by means of awareness programs presented to the labour force. The labour force should be made aware of the conservation issues pertaining to the bird taxa occurring on the study site. Any person found deliberately harassing any bird species in any way should face disciplinary measures, following the possible dismissal from the site.
- Checks must be carried out at regular intervals to identify areas where erosion is occurring. Appropriate remedial action, including the rehabilitation of eroded areas should be undertaken.

4.13 Suggested monitoring and Environmental Management Plan

Information on collision trauma (bird mortalities) and the displacement of birds caused by PV solar facilities is insufficient. Therefore, as per the guidelines of Jenkins *et al.* (2017) it is highly recommended that additional monitoring be implemented to augment existing data:

- At least one additional pre-construction survey is recommended, consisting of a minimum of two days which is necessary to inform the final EMPr during operation. The survey should coincide with the peak wet season when most of the nearby wetland features in the wider study region are inundated.
- A post-construction survey during operation with a minimum of 3 x 3-5 day surveys over a six month period (including the peak wet season). The surveys aim to obtain mortality data from birds colliding with the panels to advise on appropriate mitigation measures to be implemented to reduce potential bird mortalities. The surveys should be conducted in a regular and systematic manner by means of direct observations (and the use of installed video cameras) and carcass searches. A management programme must be compiled to assess the efficacy of applied mitigation measures and consult or change measures to reduce on-going mortalities when detected. Additional mitigation measures should be tested or applied, especially if mortalities include species of conservation concern.
- It is possible that mortalities due to collision will occur at the powerlines even after mitigation. The post-construction monitoring (during operation) should also quantify mortalities caused by the powerline network. Monitoring should be implemented once a month for at least one year. All searches should be done on foot. A management programme must be compiled to assess the efficacy of applied mitigation measures and consult or change measures to reduce on-going mortalities when detected. Additional mitigation measures should be tested or applied, especially if mortalities include species of conservation concern.

OBJECTIVE 1: Minimize potential collision trauma with infrastructure and augmenting existing information on bird interactions with solar infrastructure

Project Component/s	» PV panel arrays
Potential Impact	» Collision trauma caused by photovoltaic panels (the "lake-effect")
Activity/Risk Source	» Construction and operation of PV infrastructure
Mitigation: Target/Objective	» Zero bird mortalities due to collision trauma caused by PV panels

Mitigation: Action/Control	**Responsibility**	**Timeframe**
• Apply bird deterrent devices to the PV panels to discourage birds from colonising the infrastructure or to discourage birds from constructing nests. These could include visual or bio-acoustic deterrents such as highly reflective rotating devices, flashers, anti-perching devices such as bird guards, scaring or chasing activities involving the use of trained dogs or raptors and/or netting. Nests	ECO & OM	Operation (on-going)

should be removed when nest-building attempts are noticed.		
• Reduce or minimise the use of outdoor lighting to avoid attracting birds to the lights or to reduce potential disorientation to migrating birds.	ECO & OM	Operation (on-going)
• Use indigenous plant species native to the study area during landscaping and rehabilitation.	CER & ECO	Construction phase
• Implement post-construction monitoring and carcass surveys	OM & CER	Directly after construction and during operation - At least 3 surveys, each 3-5 days for a 6 month period
• Implement pre-construction monitoring protocols (as per Jenkins et al., 2017)	OM & CER	Prior to construction - At least 1 survey of 2 days (during wet season)
• Compile management programme to assess efficacy of mitigation and on-going research/trials	EM & OM	Operation (on-going)

Performance Indicator	Reduced statistical detection/observation of bird mortalities
Monitoring	• Implement at least one pre-construction survey consisting of a minimum of 2 days. • Implement post-construction surveys during operation with a minimum of 3 x 3-5 day surveys over a six month period (including the peak wet season). • Surveys should coincide with the peak wet season when most of the wetland features in the wider study region are inundated. • Obtain quantified data on waterbird richness and potential flyways, which will contribute towards our understanding of impacts related to collision trauma with the panels. • Obtain mortality data from birds colliding with the panels and advise on appropriate mitigation measures to be implemented to reduce potential bird mortalities. • Conduct post-construction monitoring in a systematic manner by means of direct observations and the use of installed video cameras and carcass searches. • Implement management programme to assess the efficacy of applied mitigation measures and consult or change measures to reduce on-going mortalities when detected. Additional mitigation measures should be tested or applied, especially if mortalities include birds of prey and species of conservation concern.

OBJECTIVE 2: Minimize collisions and electrocution associated with powerlines

Project Component/s	» Overhead powerlines
Potential Impact	» Collision and electrocution caused by powerlines
Activity/Risk Source	» Overhead powerlines
Mitigation: Target/Objective	» Reduced bird mortalities due to collision/electrocution

Mitigation: Action/Control	Responsibility	Timeframe
• Apply bird deterrent devices to all new powerlines	ECO & CER	Construction
• Implement post-construction monitoring and carcass surveys	OM & CER	Operation - once a month for at least one year
• Compile management programme to assess efficacy of mitigation and on-going research/trials	OM	Operation (on-going)
• Report mortalities (number, locality and species) to Electrical Energy Mortality Register at EWT	OM	Operation (on-going)

Performance Indicator	Reduced statistical detection/observation of bird mortalities
Monitoring	• Implement post-construction monitoring to quantify bird mortalities caused by the powerline network. All searches should be done on foot. • Compile a management programme to assess the efficacy of applied mitigation measures and consult or change measures to reduce on-going mortalities when detected. Additional mitigation measures should be tested or applied, especially if mortalities include birds of prey and species of conservation concern.

4.14 Opinion regarding the feasibility of the project

Pachnoda Consulting cc was requested by Savannah Environmental (Pty) Ltd on behalf of Freegold Harmony (Pty) Ltd to compile an avifauna baseline report for the proposed Harmony Joel Solar PV facility and associated infrastructure with a contracted capacity of up to 18MW located on a site 20km north east of the town of Theunissen in the Free State Province.

Three avifaunal habitat types were identified on the study site and surroundings, consisting of open grassland with bush clump mosaics, the doring river system with riverine woodland and transformed units (ranging from build-up land and mining infrastructure). The study site was also surrounded by slimes dams and the doring River system, which provided additional habitat for waterbird and shorebird taxa. Approximately 162 bird species are expected to occur in the wider study area, of which 91 species were observed in the study area (during two independent surveys). The expected richness included four threatened or near threatened species, 15 southern African endemics and 19 near-endemic species. However, the occurrence of threatened and near threatened bird species was predicted to be low, although the natural broad-scale habitat units provided foraging habitat for the occasional occurrence of the vulnerable Lanner Falcon (*Falco biarmicus*) and endangered Secretarybird (*Sagittarius serpentarius*). Eleven southern African endemics and 13 near-endemic species were confirmed on the study site.

An evaluation of potential and likely impacts on the avifauna revealed that the impact significance was moderate to low after mitigation (depending on the type of impact). However, the risk for certain waterbirds (mainly large-bodied waterfowl such as the South African Shelduck *Tadorna cana* and Egyptian Goose *Alopochen aegyptiacus*) colliding with the PV infrastructure remained eminent due to the presence of wetland-associated features and the nearby Doring river system. Post-construction monitoring was recommended along with the installation of appropriate bird diverters to minimise the potential risk of collision trauma in birds.

No fatal-flaws were identified during the assessment, although it was strongly recommended that the proposed mitigation measures and monitoring protocols (e.g. post construction monitoring) be implemented during the construction and operational phase of the project.

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www.sabap2.birdmap.africa

Appendix 1: A shortlist of bird species recorded on the development area and immediate surroundings. The list provides an indication of the species occurrence according to SABAP2 reporting rates. The list was derived (and modified) from species observed in pentad grids 2810_2645, 2810_2650, 2815_2645 and 2815_2650 (the eight surrounding grids were also consulted) and from personal observations. The reporting rates include submissions made during the June and July 2022 surveys.

#	Common Name	Scientific Name	Observed (Jun/Jul 2022)	SABAP2 Reporting Rate			
				Full Protocol (%)	Number of cards	Ad hoc Protocol (%)	Number of cards
432	Acacia Pied Barbet	*Tricholaema leucomelas*	1	65.22	15	10.53	2
95	African Black Duck	*Anas sparsa*	1	8.70	2	5.26	1
52	African Darter	*Anhinga rufa*		8.70	2	0.00	0
149	African Fish Eagle	*Haliaeetus vocifer*		4.35	1	0.00	0
418	African Hoopoe	*Upupa africana*	1	4.35	1	10.53	2
167	African Marsh Harrier	*Circus ranivorus*		0.00	0	5.26	1
387	African Palm Swift	*Cypsiurus parvus*	1	39.13	9	0.00	0
692	African Pipit	*Anthus cinnamomeus*	1	56.52	13	21.05	4
544	African Red-eyed Bulbul	*Pycnonotus nigricans*	1	78.26	18	15.79	3
81	African Sacred Ibis	*Threskiornis aethiopicus*		8.70	2	0.00	0
576	African Stonechat	*Saxicola torquatus*	1	78.26	18	15.79	3
208	African Swamphen	*Porphyrio madagascariensis*		0.00	0	5.26	1
119	Amur Falcon	*Falco amurensis*		4.35	1	0.00	0
575	Ant-eating Chat	*Myrmecocichla formicivora*	1	73.91	17	15.79	3
514	Ashy Tit	*Melaniparus cinerascens*	1	13.04	3	5.26	1
493	Barn Swallow	*Hirundo rustica*		34.78	8	5.26	1
159	Black Sparrowhawk	*Accipiter melanoleucus*		4.35	1	0.00	0
650	Black-chested Prinia	*Prinia flavicans*	1	86.96	20	15.79	3
69	Black-crowned Night Heron	*Nycticorax nycticorax*		8.70	2	0.00	0
841	Black-faced Waxbill	*Brunhilda erythronotos*	1	17.39	4	5.26	1

#	Common Name	Scientific Name	Observed (Jun/Jul 2022)	SABAP2 Reporting Rate			
				Full Protocol (%)	Number of cards	Ad hoc Protocol (%)	Number of cards
55	Black-headed Heron	*Ardea melanocephala*		30.43	7	5.26	1
5	Black-necked Grebe	*Podiceps nigricollis*		4.35	1	5.26	1
245	Blacksmith Lapwing	*Vanellus armatus*	1	65.22	15	15.79	3
860	Black-throated Canary	*Crithagra atrogularis*	1	21.74	5	15.79	3
130	Black-winged Kite	*Elanus caeruleus*	1	56.52	13	21.05	4
270	Black-winged Stilt	*Himantopus himantopus*		0.00	0	5.26	1
839	Blue Waxbill	*Uraeginthus angolensis*	1	39.13	9	15.79	3
99	Blue-billed Teal	*Spatula hottentota*		0.00	0	5.26	1
722	Bokmakierie	*Telophorus zeylonus*	1	26.09	6	10.53	2
714	Brown-crowned Tchagra	*Tchagra australis*	1	30.43	7	15.79	3
402	Brown-hooded Kingfisher	*Halcyon albiventris*	1	8.70	2	5.26	1
509	Brown-throated Martin	*Riparia paludicola*	1	26.09	6	10.53	2
4131	Burchell's Coucal	*Centropus burchellii*		4.35	1	0.00	0
703	Cape Longclaw	*Macronyx capensis*	1	47.83	11	21.05	4
581	Cape Robin-Chat	*Cossypha caffra*	1	43.48	10	15.79	3
94	Cape Shoveler	*Spatula smithii*	1	4.35	1	5.26	1
786	Cape Sparrow	*Passer melanurus*	1	82.61	19	15.79	3
737	Cape Starling	*Lamprotornis nitens*	1	43.48	10	0.00	0
316	Ring-necked Dove	*Streptopelia capicola*	1	86.96	20	21.05	4
686	Cape Wagtail	*Motacilla capensis*	1	34.78	8	5.26	1
1172	Cape White-eye	*Zosterops virens*	1	4.35	1	0.00	0
531	Cape Penduline Tit	*Anthoscopus minutus*	1	4.35	1	0.00	0
568	Capped Wheatear	*Oenanthe pileata*		4.35	1	0.00	0
450	Cardinal Woodpecker	*Dendropicos fuscescens*	1	13.04	3	5.26	1
484	Chestnut-backed Sparrow-Lark	*Eremopterix leucotis*		4.35	1	0.00	0

#	Common Name	Scientific Name	Observed (Jun/Jul 2022)	SABAP2 Reporting Rate			
				Full Protocol (%)	Number of cards	Ad hoc Protocol (%)	Number of cards
658	Chestnut-vented Warbler	*Curruca subcoerulea*	1	82.61	19	21.05	4
872	Cinnamon-breasted Bunting	*Emberiza tahapisi*		21.74	5	5.26	1
631	Cloud Cisticola	*Cisticola textrix*		17.39	4	0.00	0
154	Common (Steppe) Buzzard	*Buteo buteo vulpinus*		8.70	2	5.26	1
210	Common Moorhen	*Gallinula chloropus*	1	13.04	3	5.26	1
734	Common Myna	*Acridotheres tristis*	1	26.09	6	0.00	0
421	Common Scimitarbill	*Rhinopomastus cyanomelas*	1	13.04	3	10.53	2
843	Common Waxbill	*Estrilda astrild*	1	21.74	5	10.53	2
439	Crested Barbet	*Trachyphonus vaillantii*	1	34.78	8	10.53	2
242	Crowned Lapwing	*Vanellus coronatus*	1	82.61	19	21.05	4
630	Desert Cisticola	*Cisticola aridulus*	1	30.43	7	15.79	3
352	Diederik Cuckoo	*Chrysococcyx caprius*		39.13	9	0.00	0
278	Double-banded Courser	*Rhinoptilus africanus*		13.04	3	0.00	0
89	Egyptian Goose	*Alopochen aegyptiaca*	1	47.83	11	21.05	4
404	European Bee-eater	*Merops apiaster*		21.74	5	10.53	2
678	Fairy Flycatcher	*Stenostira scita*	1	21.74	5	5.26	1
570	Familiar Chat	*Oenanthe familiaris*	1	21.74	5	5.26	1
665	Fiscal Flycatcher	*Melaenornis silens*	1	73.91	17	21.05	4
162	Gabar Goshawk	*Micronisus gabar*	1	4.35	1	0.00	0
83	Glossy Ibis	*Plegadis falcinellus*		13.04	3	5.26	1
502	Greater Striped Swallow	*Cecropis cucullata*	1	43.48	10	5.26	1
419	Green Wood Hoopoe	*Phoeniculus purpureus*		8.70	2	0.00	0
830	Green-winged Pytilia	*Pytilia melba*	1	21.74	5	10.53	2
288	Grey-headed Gull	*Chroicocephalus cirrocephalus*	1	13.04	3	5.26	1
84	Hadada Ibis	*Bostrychia hagedash*	1	82.61	19	15.79	3

#	Common Name	Scientific Name	Observed (Jun/Jul 2022)	SABAP2 Reporting Rate			
				Full Protocol (%)	Number of cards	Ad hoc Protocol (%)	Number of cards
72	Hamerkop	*Scopus umbretta*		4.35	1	0.00	0
192	Helmeted Guineafowl	*Numida meleagris*	1	65.22	15	15.79	3
784	House Sparrow	*Passer domesticus*	1	47.83	11	0.00	0
835	Jameson's Firefinch	*Lagonosticta rhodopareia*	1	13.04	3	5.26	1
586	Kalahari Scrub Robin	*Cercotrichas paena*	1	65.22	15	10.53	2
583	Karoo Scrub Robin	*Cercotrichas coryphoeus*		4.35	1	0.00	0
1104	Karoo Thrush	*Turdus smithi*	1	13.04	3	0.00	0
317	Laughing Dove	*Spilopelia senegalensis*	1	86.96	20	31.58	6
706	Lesser Grey Shrike	*Lanius minor*		8.70	2	0.00	0
125	Lesser Kestrel	*Falco naumanni*		8.70	2	0.00	0
604	Lesser Swamp Warbler	*Acrocephalus gracilirostris*	1	8.70	2	5.26	1
646	Levaillant's Cisticola	*Cisticola tinniens*	1	43.48	10	5.26	1
413	Lilac-breasted Roller	*Coracias caudatus*		4.35	1	0.00	0
6	Little Grebe	*Tachybaptus ruficollis*	1	21.74	5	10.53	2
385	Little Swift	*Apus affinis*		65.22	15	10.53	2
621	Long-billed Crombec	*Sylvietta rufescens*	1	4.35	1	0.00	0
852	Long-tailed Paradise Whydah	*Vidua paradisaea*		17.39	4	0.00	0
818	Long-tailed Widowbird	*Euplectes progne*		47.83	11	10.53	2
103	Maccoa Duck	*Oxyura maccoa*		0.00	0	5.26	1
397	Malachite Kingfisher	*Corythornis cristatus*		8.70	2	5.26	1
361	Marsh Owl	*Asio capensis*		4.35	1	10.53	2
564	Mountain Wheatear	*Myrmecocichla monticola*		8.70	2	5.26	1
318	Namaqua Dove	*Oena capensis*	1	60.87	14	15.79	3
183	Natal Spurfowl	*Pternistis natalensis*	1	13.04	3	10.53	2
637	Neddicky	*Cisticola fulvicapilla*	1	56.52	13	21.05	4

#	Common Name	Scientific Name	Observed (Jun/Jul 2022)	SABAP2 Reporting Rate			
				Full Protocol (%)	Number of cards	Ad hoc Protocol (%)	Number of cards
1035	Northern Black Korhaan	*Afrotis afraoides*	1	43.48	10	15.79	3
179	Orange River Francolin	*Scleroptila gutturalis*	1	0.00	0	10.53	2
1171	Orange River White-eye	*Zosterops pallidus*	1	43.48	10	5.26	1
838	Orange-breasted Waxbill	*Amandava subflava*		4.35	1	0.00	0
165	Pale Chanting Goshawk	*Melierax canorus*		13.04	3	5.26	1
498	Pearl-breasted Swallow	*Hirundo dimidiata*	1	8.70	2	0.00	0
522	Pied Crow	*Corvus albus*		8.70	2	0.00	0
394	Pied Kingfisher	*Ceryle rudis*		8.70	2	5.26	1
746	Pied Starling	*Lamprotornis bicolor*		34.78	8	5.26	1
846	Pin-tailed Whydah	*Vidua macroura*		13.04	3	5.26	1
694	Plain-backed Pipit	*Anthus leucophrys*		4.35	1	0.00	0
674	Pririt Batis	*Batis pririt*	1	17.39	4	10.53	2
57	Purple Heron	*Ardea purpurea*		4.35	1	0.00	0
844	Quailfinch	*Ortygospiza atricollis*	1	26.09	6	10.53	2
642	Rattling Cisticola	*Cisticola chiniana*	1	8.70	2	5.26	1
708	Red-backed Shrike	*Lanius collurio*		4.35	1	0.00	0
837	Red-billed Firefinch	*Lagonosticta senegala*	1	26.09	6	5.26	1
805	Red-billed Quelea	*Quelea quelea*	1	78.26	18	21.05	4
97	Red-billed Teal	*Anas erythrorhyncha*		17.39	4	5.26	1
488	Red-capped Lark	*Calandrella cinerea*		26.09	6	5.26	1
314	Red-eyed Dove	*Streptopelia semitorquata*	1	52.17	12	15.79	3
392	Red-faced Mousebird	*Urocolius indicus*	1	47.83	11	10.53	2
820	Red-headed Finch	*Amadina erythrocephala*		17.39	4	0.00	0
212	Red-knobbed Coot	*Fulica cristata*	1	17.39	4	5.26	1
50	Reed Cormorant	*Microcarbo africanus*	1	43.48	10	5.26	1

#	Common Name	Scientific Name	Observed (Jun/Jul 2022)	SABAP2 Reporting Rate			
				Full Protocol (%)	Number of cards	Ad hoc Protocol (%)	Number of cards
940	Rock Dove	*Columba livia*	1	30.43	7	5.26	1
506	Rock Martin	*Ptyonoprogne fuligula*		4.35	1	0.00	0
256	Ruff	*Calidris pugnax*		0.00	0	5.26	1
458	Rufous-naped Lark	*Mirafra africana*		30.43	7	0.00	0
460	Sabota Lark	*Calendulauda sabota*	1	17.39	4	15.79	3
789	Scaly-feathered Weaver	*Sporopipes squamifrons*		47.83	11	5.26	1
105	Secretarybird	*Sagittarius serpentarius*		8.70	2	0.00	0
847	Shaft-tailed Whydah	*Vidua regia*		4.35	1	0.00	0
572	Sickle-winged Chat	*Emarginata sinuata*		4.35	1	0.00	0
504	South African Cliff Swallow	*Petrochelidon spilodera*		47.83	11	10.53	2
90	South African Shelduck	*Tadorna cana*	1	34.78	8	15.79	3
707	Southern Fiscal	*Lanius collaris*	1	78.26	18	21.05	4
4142	Southern Grey-headed Sparrow	*Passer diffusus*		43.48	10	5.26	1
803	Southern Masked Weaver	*Ploceus velatus*	1	91.30	21	31.58	6
102	Southern Pochard	*Netta erythrophthalma*		8.70	2	5.26	1
808	Southern Red Bishop	*Euplectes orix*	1	56.52	13	15.79	3
390	Speckled Mousebird	*Colius striatus*		13.04	3	0.00	0
311	Speckled Pigeon	*Columba guinea*	1	65.22	15	10.53	2
474	Spike-heeled Lark	*Chersomanes albofasciata*		26.09	6	0.00	0
654	Spotted Flycatcher	*Muscicapa striata*		4.35	1	0.00	0
88	Spur-winged Goose	*Plectropterus gambensis*		26.09	6	10.53	2
185	Swainson's Spurfowl	*Pternistis swainsonii*	1	73.91	17	15.79	3
277	Temminck's Courser	*Cursorius temminckii*		4.35	1	0.00	0
238	Three-banded Plover	*Charadrius tricollaris*	1	30.43	7	10.53	2
851	Village Indigobird	*Vidua chalybeata*		13.04	3	0.00	0

#	Common Name	Scientific Name	Observed (Jun/Jul 2022)	SABAP2 Reporting Rate			
				Full Protocol (%)	Number of cards	Ad hoc Protocol (%)	Number of cards
840	Violet-eared Waxbill	*Granatina granatina*	1	13.04	3	10.53	2
735	Wattled Starling	*Creatophora cinerea*	1	56.52	13	5.26	1
61	Western Cattle Egret	*Bubulcus ibis*	1	60.87	14	21.05	4
305	Whiskered Tern	*Chlidonias hybrida*		8.70	2	0.00	0
391	White-backed Mousebird	*Colius colius*	1	56.52	13	15.79	3
763	White-bellied Sunbird	*Cinnyris talatala*	1	4.35	1	5.26	1
47	White-breasted Cormorant	*Phalacrocorax lucidus*		4.35	1	0.00	0
780	White-browed Sparrow-Weaver	*Plocepasser mahali*	1	95.65	22	10.53	2
100	White-faced Whistling Duck	*Dendrocygna viduata*		17.39	4	0.00	0
409	White-fronted Bee-eater	*Merops bullockoides*		4.35	1	0.00	0
383	White-rumped Swift	*Apus caffer*	1	21.74	5	10.53	2
495	White-throated Swallow	*Hirundo albigularis*		21.74	5	5.26	1
814	White-winged Widowbird	*Euplectes albonotatus*		13.04	3	0.00	0
866	Yellow Canary	*Crithagra flaviventris*	1	56.52	13	10.53	2
96	Yellow-billed Duck	*Anas undulata*	1	30.43	7	15.79	3
812	Yellow-crowned Bishop	*Euplectes afer*		8.70	2	0.00	0
629	Zitting Cisticola	*Cisticola juncidis*	1	8.70	2	0.00	0

Appendix 2: Preliminary density estimates of birds recorded from the study area and immediate surroundings during two independent surveys conducted during June and July 2022.

Species	jo01	jo02	jo03	jo04	jo05	jo06	jo07	jo08	jo09	jo10	jo11	jo12	Mean birds/ha
Ant-eating Chat	0	1	0	0	0	0	0	0	0	0	0	0	**0.009**
African Pipit	0	0	0	0	0	0	0	0.5	0	0	0	0	**0.004**
African Red-eyed Bulbul	2	1.5	0.5	1.5	0	0	2	0	2	0.5	1.5	0.5	**0.107**
Ashy Tit	0.5	1	0	0	0	0	0	0	0	0	0	0	**0.013**
Black-chested Prinia	2	2	2	2	0	0	2	0	2	2	2	2	**0.160**
Bokmakierie	0	1	1	1	0	0	0	0	0	0	0	0	**0.027**
Brown-crowned Tchagra	0	1	1	0	0	0	1	0	1.5	0	0.5	1	**0.053**
Black-throated Canary	2	1	0	0	0	0	0	0	1	0	0	0	**0.036**
Blue Waxbill	5	1	1	0	1	0	0	0	1	1	2	1	**0.116**
Cape Longclaw	0	0	0	0	1.5	0	0	0	0	0	0	0	**0.013**
Common Waxbill	0	0	0	0	0	0	0	0	0	0	2	0.5	**0.022**
Cape Robin-chat	2	2	0	0.5	0	0	0	0	2	0	0	1.5	**0.071**
Cape Sparrow	0	1.5	0	0	0	0	0	0	1.5	0	2	1	**0.053**
Chestnut-vented Warbler	2	3	3	2	0	0	2	0	2	2	2	3	**0.187**
Cape White-eye	0	0	0	0	0	0	0	0	2	0	0	1	**0.027**
Desert Cisticola	0	0	0	0.5	1.5	2	0	1.5	0	0	0	0	**0.049**
Fiscal Flycatcher	0.5	1	0.5	1.5	0	0	1	0	1	0	0	0	**0.049**
Green-winged Pytilia	0	0	1	0	0	0	0	0	0	0	0	1	**0.018**
Jameson's Firefinch	1	0	0	0	0	0	0	0	0	0	0	0	**0.009**
Kalahari Scrub Robin	0.5	1.5	0.5	2	0	0	1.5	0	1	0.5	0.5	1	**0.080**
Long-billed Crombec	0.5	0	0	0	0	0	0	0	0	0	0	0	**0.004**
Neddicky	1	1	2	1.5	0	0	2	0	2	1.5	1	1.5	**0.120**
Orange River White-eye	3	3	1	3	0	0	0	0	3	0	0	1	**0.125**

Species	jo01	jo02	jo03	jo04	jo05	jo06	jo07	jo08	jo09	jo10	jo11	jo12	Mean birds/ha
Pririt Batis	0	0	0	0	0	0.5	0.5	0	0	0	0	0	**0.009**
Quailfinch	0	1	0	0	0	0	0	0	0	0	0	0	**0.009**
Rattling Cisticola	0	0	0	0	0	0	0	0	0	0	0.5	0	**0.004**
Red-billed Firefinch	1	0	0	0	0	0	0	0	1	0	0	0	**0.018**
Sabota Lark	0	0	1	1	0	0	1	0	1	0	0.5	0	**0.040**
Southern Fiscal	0	0	0.5	0.5	0.5	0.5	0.5	1.5	0	0	0	0	**0.036**
Southern Masked Weaver	1.5	2	0	1	0	0	2	0	2	0	1.5	0.5	**0.093**
African Stonechat	0	0	0	0	0.5	0	0	0	0	0	0.5	0	**0.009**
Violet-eared Waxbill	0	0	0	1	0	0	0	0	3	0	0	2	**0.053**
Wattled Starling	0	0	0	0	0	0	0	0	4	0	0	8	**0.107**
White-bellied Sunbird	0	0	0	0	0	0	0	0	0	0	0.5	0	**0.004**
White-browed Sparrow-weaver	0	0	0	2	0	0	0	0	0	0	0	0	**0.018**
Number of individuals	24.5	25.5	15	21	5	3	15.5	3.5	33	7.5	17	26.5	
Number of species	15	17	13	15	5	3	11	3	18	6	14	16	
Number of birds/ha	**31.41**	**32.69**	**19.23**	**26.92**	**6.41**	**3.85**	**19.87**	**4.49**	**42.31**	**9.62**	**21.79**	**33.97**	
Number of species/ha	**19.23**	**21.79**	**16.67**	**19.23**	**6.41**	**3.85**	**14.10**	**3.85**	**23.08**	**7.69**	**17.95**	**20.51**	
Average number of birds/ha	**21.05**												
Average number of species/ha	**14.53**												