DEVELOPMENT OF THE HARMONY TARGET SOLAR PV FACILITY NEAR VIRGINIA, FREE STATE PROVINCE

Avifauna Baseline and Impact Assessment Report

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Compiled by:
Pachnoda Consulting CC
Lukas Niemand Pr.Sci.Nat

PO Box 72847
Lynwood Ridge
Pretoria
0040

Prepared for:
Savannah Environmental (Pty) Ltd

PO Box 148
Sunninghill
Gauteng
2157
0040

EXECUTIVE SUMMARY

Pachnoda Consulting cc was requested by Savannah Environmental (Pty) Ltd on behalf of Avgold Ltd to compile an avifauna baseline report for the proposed Harmony Target Solar PV facility and associated infrastructure with a contracted capacity of up to 30MW located approximately 1km south of the town of Allanridge, 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 area and surroundings, ranging from secondary grassland, inundated pans and ponds (mainly located along the outside periphery of the development area) to transformed and landscape/manicured areas. The study area was also surrounded by a number of pans and Stinkpan, which provided foraging and roosting habitat for a large number of waterbird taxa. Approximately 132 bird species are expected to occur in the wider study area, of which 81 species were observed in the study area (during two surveys). The expected richness included five threatened or near threatened species, 10 southern African endemics and seven near-endemic species. The globally endangered Maccoa Duck (*Oxyura maccoa*), the regionally near threatened Greater flamingo (*Phoenicopterus roseus*) and the globally near threatened Lesser Flamingo (*Phoeniconaias minor*) were observed at the nearby Stinkpan, which could also utilise the inundated pans in the wider study area. Seven southern African endemics and six near-endemic species were confirmed on the study area. In addition, a total of 59 collision-prone bird species have been recorded from the study area (*sensu* atlas data), of which 46 species were waterbird and shorebird taxa, and another seven species were birds of prey. It was evident that the number of potential collision-prone species that could occur in the study area was high.

The main impacts associated with the proposed PV solar facility included 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 colliding with the panels (as they are mistaken for waterbodies).
- Collision with associated infrastructure (mainly overhead power lines).

An evaluation of potential and likely impacts on the avifauna revealed that the impact significance was predicted to be moderate-high to low after mitigation (depending on the type of impact). **However, the risk for waterbirds and shorebirds (including flamingo taxa) colliding with the PV infrastructure remained eminent due to the presence of inundated pans and dams in the study area and a high frequency of passing waterbirds**. **Waterbird interactions with the PV infrastructure was predicted as persistent due to the spatial location of the proposed footprint site (surrounded by water features of which some sustain large numbers of birds).** 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 (e.g. the installation of appropriate bird diverters to minimise the potential risk of collision trauma in birds).

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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 Avgold 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)
25 December 2022

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 Avgold Ltd to compile an avifauna baseline report for the proposed Harmony Target Solar PV facility and associated infrastructure with a contracted capacity of up to 30MW. The Harmony Target Solar PV facility is based approximately 500m south of the Harmony Target mining operations, and approximately 1km south of the town of Allanridge within the Matjhabeng Local Municipality respectively, and within the Lejweleputswa District Municipality, Free State Province.

The solar facility will be located on a 106ha development area, which will include the PV arrays, associated infrastructure and grid connection infrastructure (Figure 2). The infrastructure associated PV facility includes:

- Solar PV arrays comprising of bifacial PV modules and mounting structures, using single axis tracking technology. Once installed, it will stand up to 5m above ground level.
- Inverters and transformers, a SCADA room, and maintenance room.
- Cabling between the project components.
- Balance of Plant:
  - Existing spare switchgear panels, upgraded switchgear circuit breakers or additional switchgear panels.
  - EK self-build works as defined in the CEL.
- Two on-site facility switching/ substations to facilitate the connection between the solar PV facilities and Eskom electricity grid. The Size and Capacity of the on-site stations will be 40MW.
- An onsite Medium voltage (MV) switching station forming part of the collector substation.
- Temporary laydown areas.
- Access roads, internal roads and fencing around the development area.
- Up to 132kV Overhead Power Lines (OHPL) with a maximum of 30m height with a 30m servitude width.
- Underground LV cabling will be used on the PV sites.

The PV facility will be located on the Farm Kromdraai 386.

The facility will tie-in to the Avgold (6.6/44 kV) substation via three grid lines. The grid lines will have a connection capacity of up to 132kV. The lines 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).
    -

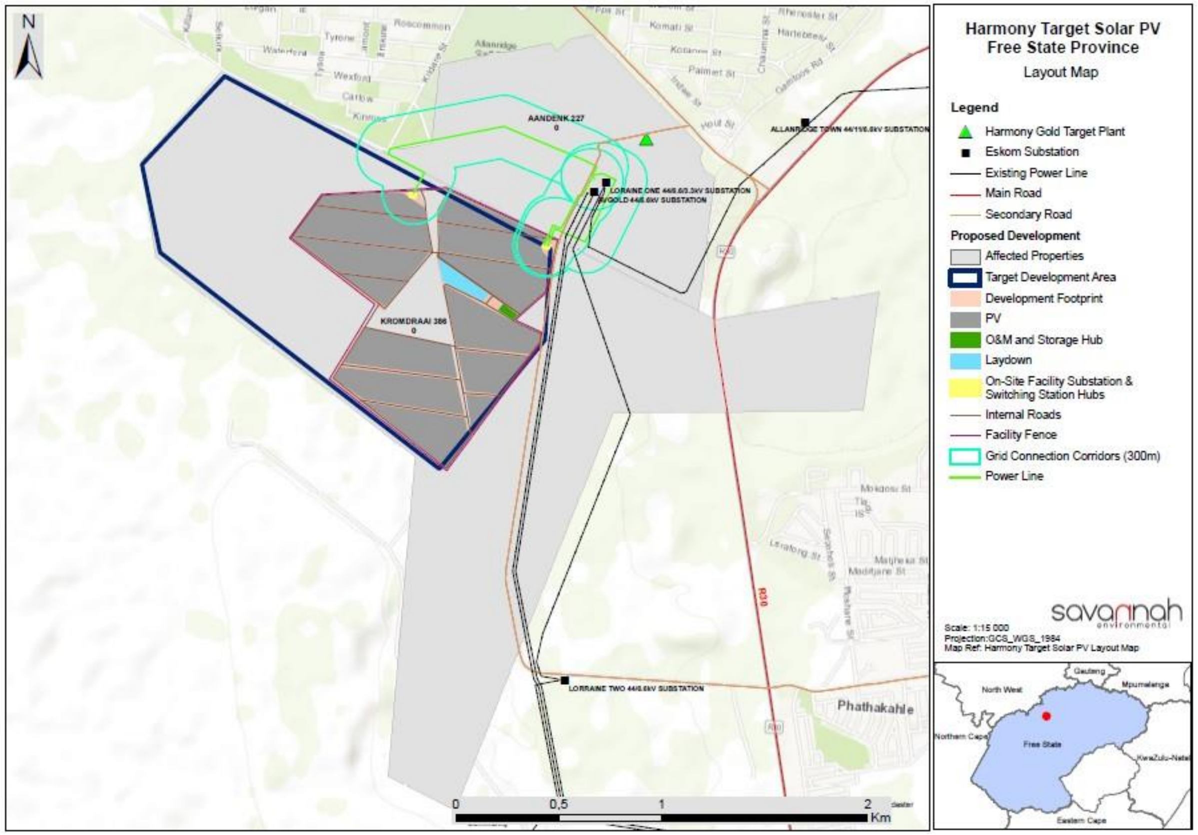


Figure 1: A map illustrating the geographic position of the proposed Harmony Target Solar PV facility.

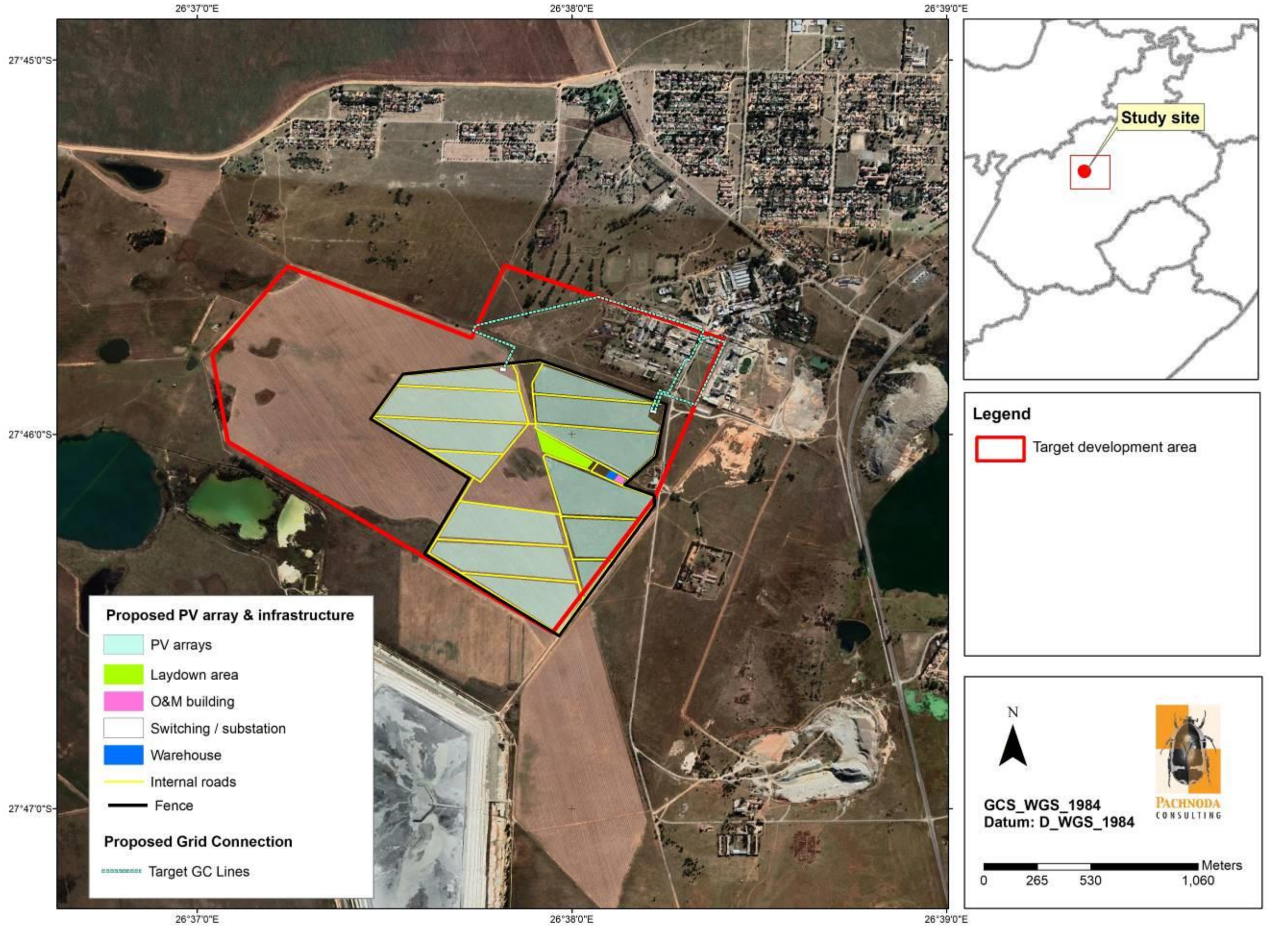


Figure 2: A satellite image illustrating the geographic position of the proposed Harmony Target Solar PV facility.

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.

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 (to be determined during the EIA although herewith deduced from reporting rates) 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 a site visit (06 - 09 June 2022 and 28 – 29 July 2022); and
- personal observations from similar habitat types in close proximity to the study area.

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) 2726DA (Skoonspruit) and 2726DC (Odendaalsrus) (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 grid relevant to the current project is 2745_2635 (although all eight pentad grids surrounding grid 2745_2635 were also scrutinised; 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.

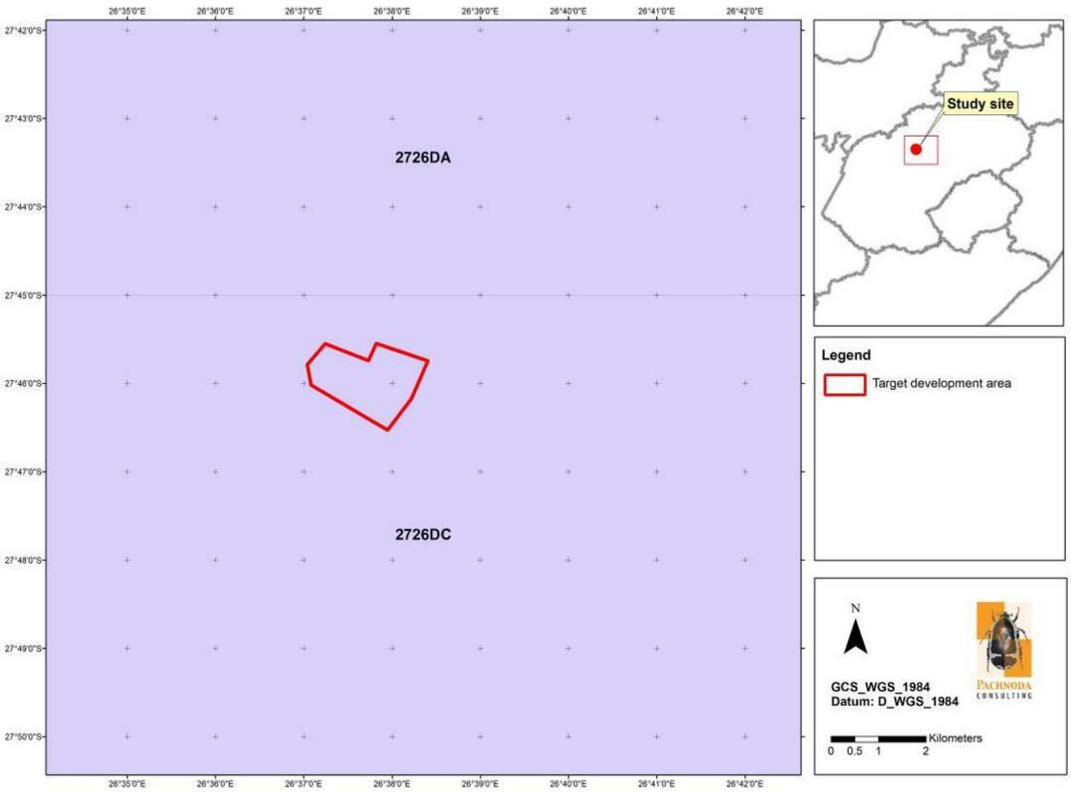


Figure 3: A map illustrating the quarter-degree grid cells that were investigated for this project.

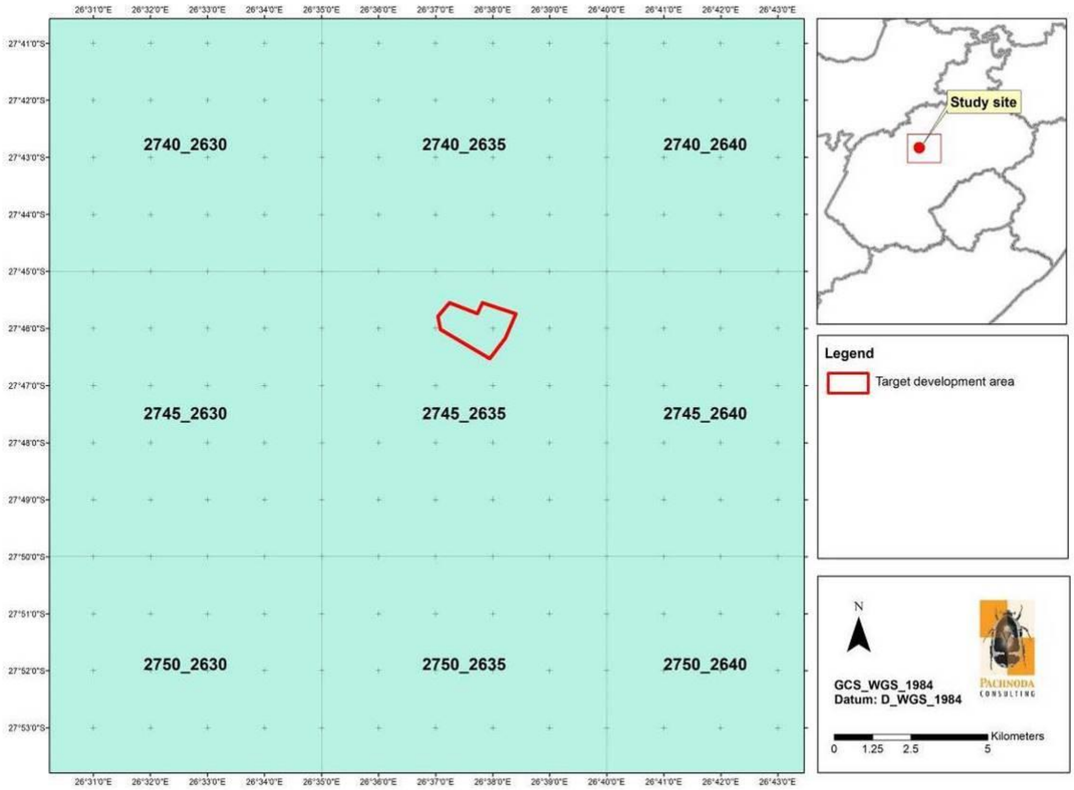


Figure 4: A map illustrating the pentad grids that were investigated for this project.

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 eight point counts (as per Buckland et al. 1993) from the study area[1]. 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

[1] Only eight point counts were required since a large surface area of the study area was covered in agricultural land. These mainly focussed on natural habitat and water features on the site.

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.

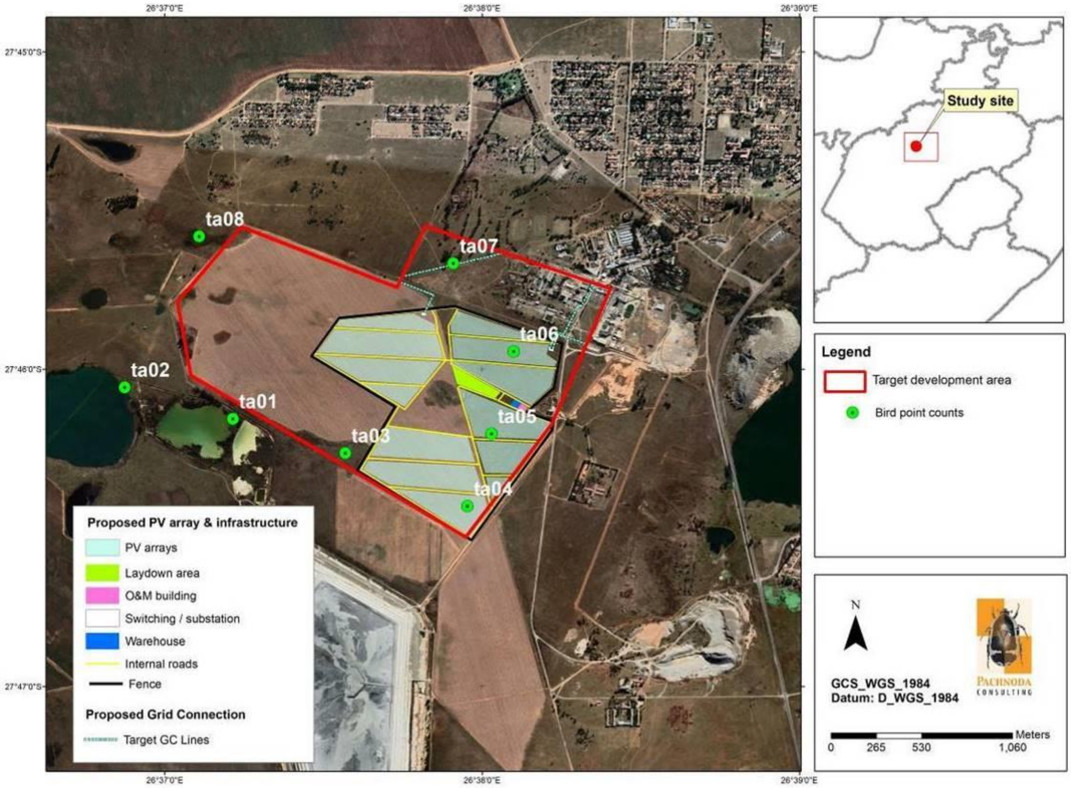


Figure 5: A map illustrating the spatial position of eight bird point counts located within the study area.

2.3 Sensitivity Analysis

A 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. artificial livestock watering points). 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 list of species for the study area 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 is located approximately 500m south of the Harmony Target mining operations, and 1km south of the town of Allanridge, 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 Vaal-Vet Sandy 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.

The Vaal-Vet Sandy Grassland occurs in the Free State and North-West Provinces, where it extends from Lichtenburg and Ventersdorp southwards to Klerksdorp, Leeudoringstad, Bothaville and the Brandfort area north of Bloemfontein. It occurs at an altitude of 1 220-1 560 m and is mainly confined to aeolian and colluvial sand overlying shales and mudstones. The floristic structure of the Vaal-Vet Sandy Grassland is mainly a low tussocky grassland with many karroid elements. In its untransformed condition, *Themeda triandra* is an important dominant graminoid, while intense grazing and erratic rainfall is responsible for an increase of *Elionurus muticus, Cymbopogon pospischilii* and *Aristida congesta*.

The Vaal-Vet Sandy Grassland is a threatened (**Endangered**) ecosystem with only a few remaining patches of untransformed grassland being statutorily conserved (c. 0.3 % at Bloemhof Dam, Schoonspruit, Sandveld, Faan Meintjies, Wolwespruit and Soetdoring Nature Reserves). In addition, the Vaal-Vet Sandy Grassland is a Critically Endangered Ecosystem (as per Section 52 of National Environmental Management Biodiversity Act, (Act No. 10 of 2004)) and a Critical Biodiversity Area as per the Free State Conservation Plan (DESTEA, 2015). More than 63 % of this grassland type is already transformed by cultivation, and intense livestock grazing.

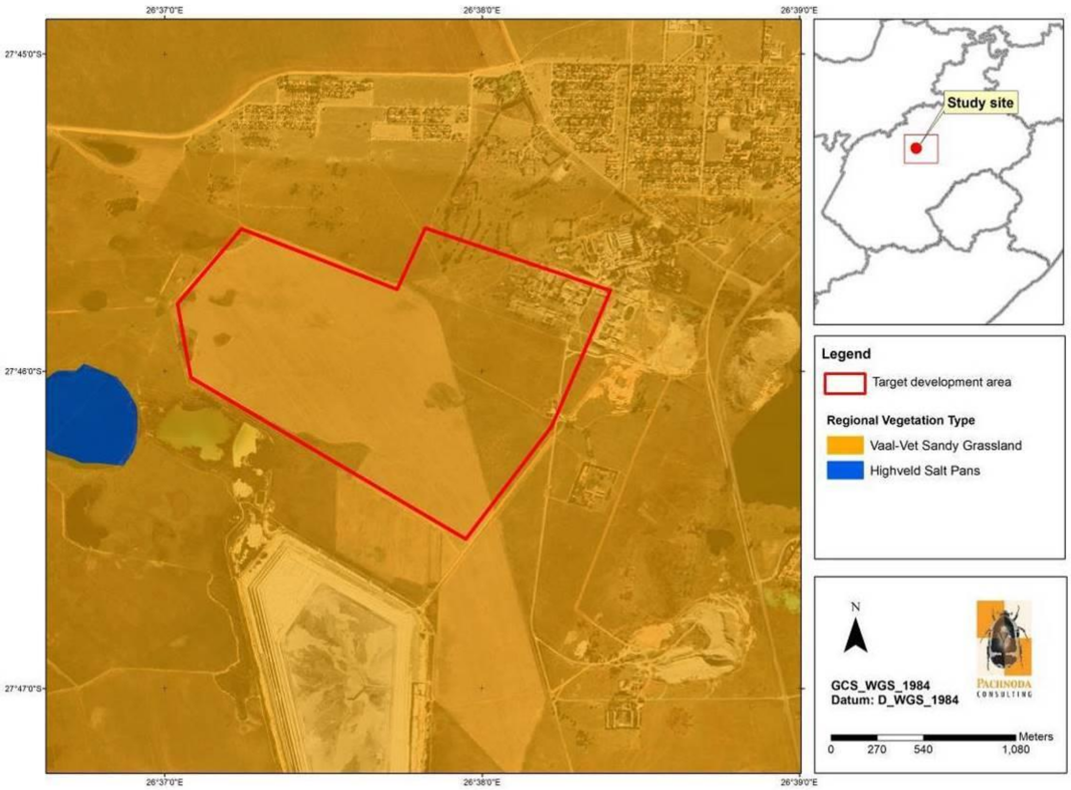


Figure 6: A satellite image illustrating the regional vegetation type corresponding to the study site and immediate surroundings. Vegetation type categories were defined by Mucina & Rutherford (2006; updated 2012).

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;
- small patches of thicket and dense bush; and
- also small surface areas pertaining to wetland habitat.

Transformed areas:

- Mining infrastructure;
- Build-up areas; and
- Cultivation.

From the land cover dataset it is evident that most of the study area is covered by cultivated land and historically ploughed land which consists currently of secondary grassland. However, the north-eastern part of the study area is mainly transformed and consists of mining infrastructure (e.g. the Harmony Target plant) and build-up land which contain manicured parks. A number of small depressions are scattered across the site (most of them contained within cultivated land) which was not digitised by the Geoterrainimage (2015) dataset and should be included as seasonal wetlands. However, some of these are colonised by moist grassland. The study site is also surrounded by numerous endorheic pans, as well as pollution control dams and the large Stinkpan (east of the study site). These pan basins, when inundated provides foraging, roosting and breeding habitat for large congregations of waterbird and shorebird species, including species that are globally and regionally threatened and near threatened.

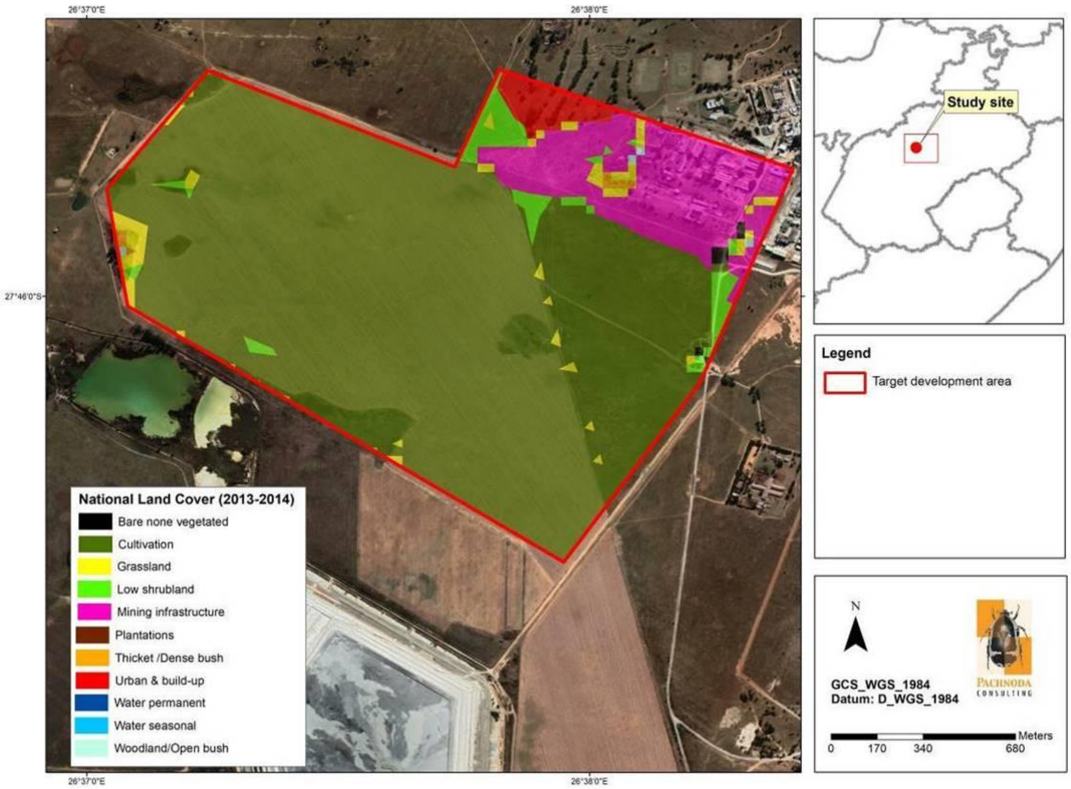


Figure 7: A map illustrating the land cover classes (Geoterrainimage, 2015) corresponding to the proposed study area and immediate surroundings.

3.4 Conservation Areas, Protected Areas and Important Bird Areas

The study area does not coincide with any formal conservation area or Important Bird and Biodiversity Area (IBA). The nearest legal conservation area to the proposed study site is the Sandveld and Bloemhof Dam Nature Reserves, which is located 45 km north-west of the study site. The Sandveld and Bloemhof Dam Nature Reserves are also a recognised IBA (SA039).

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 area and immediate surroundings hold a **medium** sensitivity with respect to the relative animal species protocol (Figure 8) (report generated 05/08/2022):

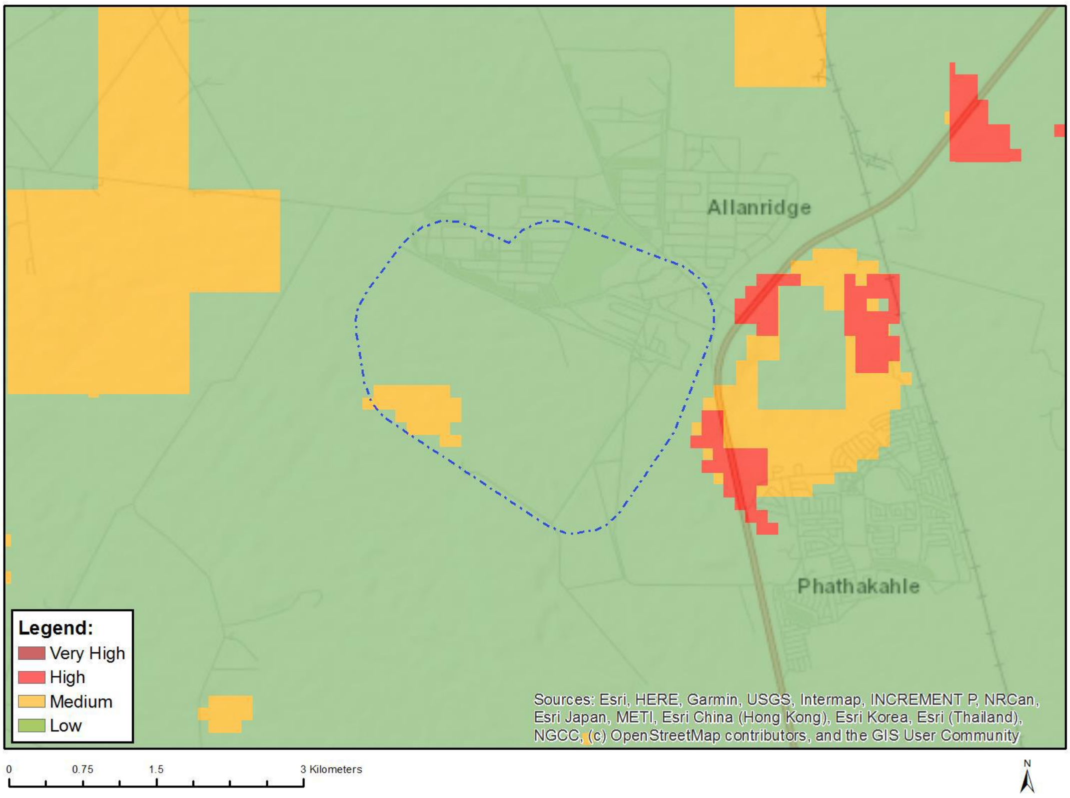


Figure 8: The animal species sensitivity of the study area and immediate surroundings (a 500m buffer was added to the site boundary) according to the Screening Tool.

Sensitive features include the following:

Sensitivity	Feature(s)
Low	Subject to confirmation
Medium	Aves-*Hydroprogne caspia*

According to the results of the screening tool, a medium probability of occurrence is evident for the vulnerable Caspian Tern (*Hydroprogne caspia*), which could potentially occur at the pan and pollution control dams located at the south-western part of the study area. In addition, the nearby Stinkpan has a high probability for the occurrence of the endangered African Marsh Harrier (*Circus ranivorus*) and Yellow-billed Stork (*Mycteria ibis*).

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

Figure 9: The relative avian sensitivity of the study area and immediate surroundings (a 500m buffer was 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):

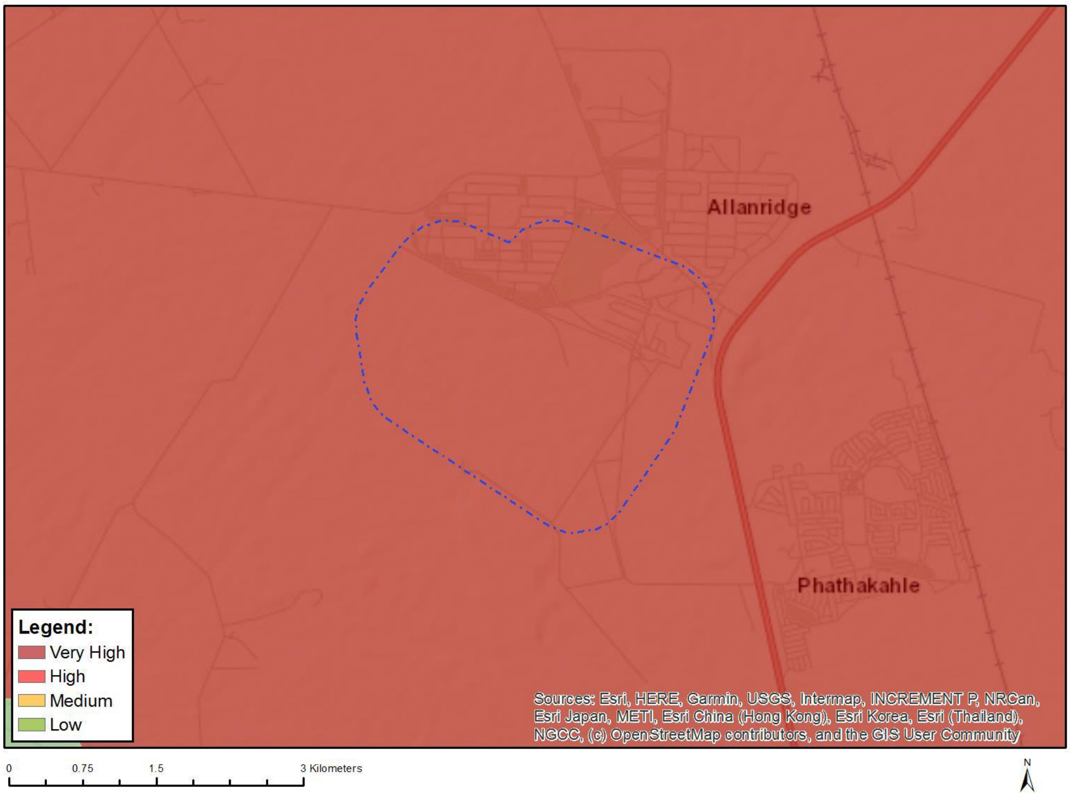


Figure 10: The relative terrestrial biodiversity sensitivity of the study area and immediate surroundings (a 500m buffer was added to the site boundary) according to the Screening Tool.

Sensitive features include the following:

Sensitivity	Feature(s)
Very High	Critical Biodiversity Area 1
Very High	Ecological Support Area 1
Very High	Ecological Support Area 2
Very High	Endangered Ecosystem

It is evident from the results of the Screening Tool report the entire study area coincides with a Critical Biodiversity Area 1 (CBA 1) and Ecological Support Area 1 and 2 (ESA 1 & 2) as per the Free State Biodiversity Plan (DESTEA, 2015). In addition, the study site also coincides with an Endangered ecosystem which is represented by the Vaal-Vet Sandy Grassland.

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 site and immediate surroundings are a consequence of a combination of factors simulated by geomorphology, presence of wetland features and past land use practice which have culminated in a number of habitat types that deserve further discussion (Figure 11 and Figure 12):

1. *Secondary grassland:* This unit is prominent on the eastern part of the study site of which most were historically under cultivation in the past. It represents a grassland sere with a secondary graminoid composition that is dominated by *Cynodon dactylon* and graminoid species of the genus *Eragrostis*. The expected bird composition is represented by widespread cryptic grassland species. Typical bird species expected to be present include Desert Cisticola (*Cisticola aridulus*), Red-capped Lark (*Calandrella cinerea*), Ant-eating Chat (*Myrmecocichla formicivora*) and Double-banded Courser (*Rhinoptilus africanus*). It also provides foraging and breeding habitat for the collision-prone species, the Northern Black Korhaan (*Afrotis afraoides*).

2. *Pans, depressions, pollution control dams and Stinkpan*: These habitat features include a number of mainly endorheic pan basins which becomes seasonally inundated during the austral wet season. They provide foraging, roosting and also breeding habitat for a diversity of waterbird species, of which the richness is proportional to the surface area and depth of the pans. Thereby, large, shallow pans are more likely to sustain larger congregations of waterbird numbers and waterbird species. Most of these pans occur along the periphery of the study site, but are regarded as an "inter-connected" system of pans, meaning that none of the pans within the local catchment are similar to each, thereby providing a continuous supply of resources for waterbirds which tend to commute on a daily basis over the study site. Furthermore, the large and nearby Stinkpan also provides important foraging habitat for two near threatened flamingo species as well as the globally engendered Maccoa Duck (*Oxyura maccoa*) (pers. obs.).

   Most of the basins of depressions on the study site is colonised by moist grassland, and these are more likely to provide habitat for a unique bird composition represented by smaller wetland-associated passerine species, such as Zitting Cisticola (*C. juncidis*), Levaillant's Cisticola (*C. tinniens*) and Quailfinch (*Ortygospiza atricollis*).

   A series of pollution control dams are located near the south-western boundary of the study site and these also provide ephemeral habitat for a variety of waterbird species, most notably Cape Teal (*Anas capensis*), Black-winged Stilt (*Himantopus himantopus*), Cape Shoveller (*A. smithii*), Red-billed Teal (*A. erythrorhyncha*) and Black-necked Grebe (*Podiceps nigricollis*).

3. *Transformed, landscaped (manicured) areas and cultivation*: These areas are represented by build-up land and landscaped areas as well as areas under active commercial cultivation. The manicured park are earmarked by a distinct tree dominated by *Searsia lancea* which was artificially planted. These "parks" area colonised by a high number of bird species which favour the vertical heterogeneity provided by the tree canopy. The bird composition is expected to be represented by a "bushveld" composition which is often present in semi-

urban landscaped (manicured) gardens and parks (c. Ring-necked Dove *Streptopelia capicola*, Rattling Cisticola *Cisticola cheniana*, Red-eyed Dove *S. semitorquata*, Cape Starling *Lamprotornis nitens*), Chestnut-vented Warbler *Curruca subcaerulea*, Blue Waxbill *Uraeginthus angolensis* and Green Wood-hoopoe (*Phoeniculus purpureus*).

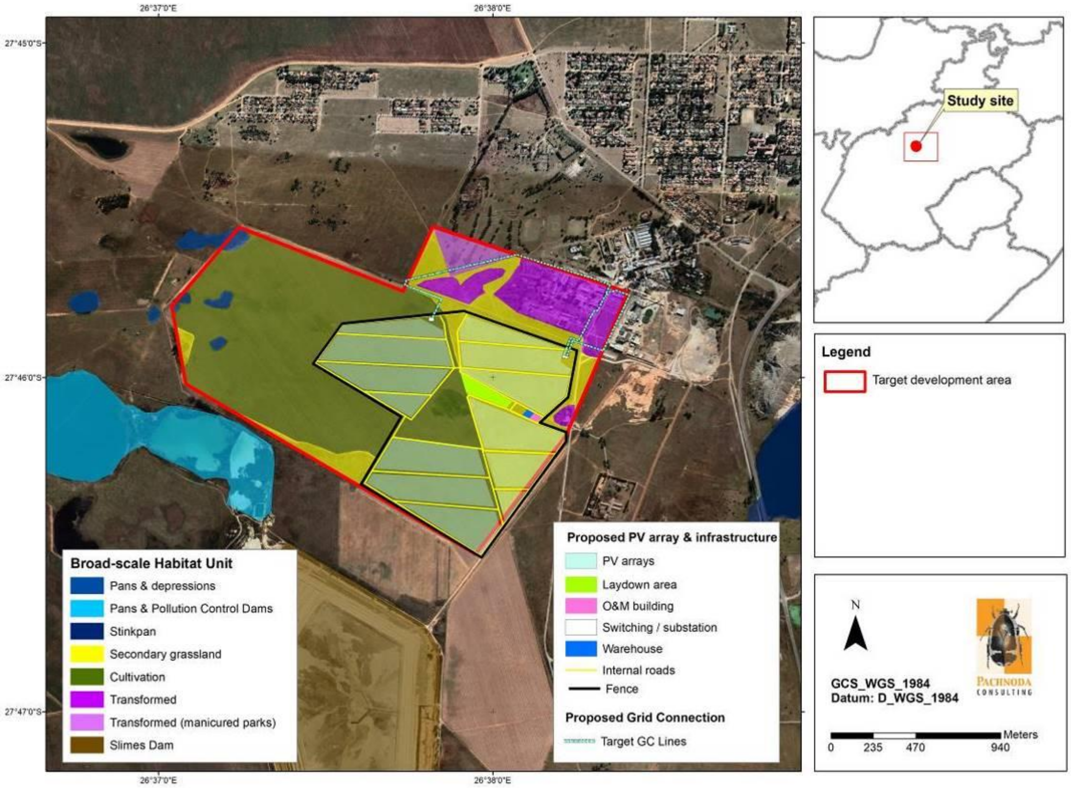
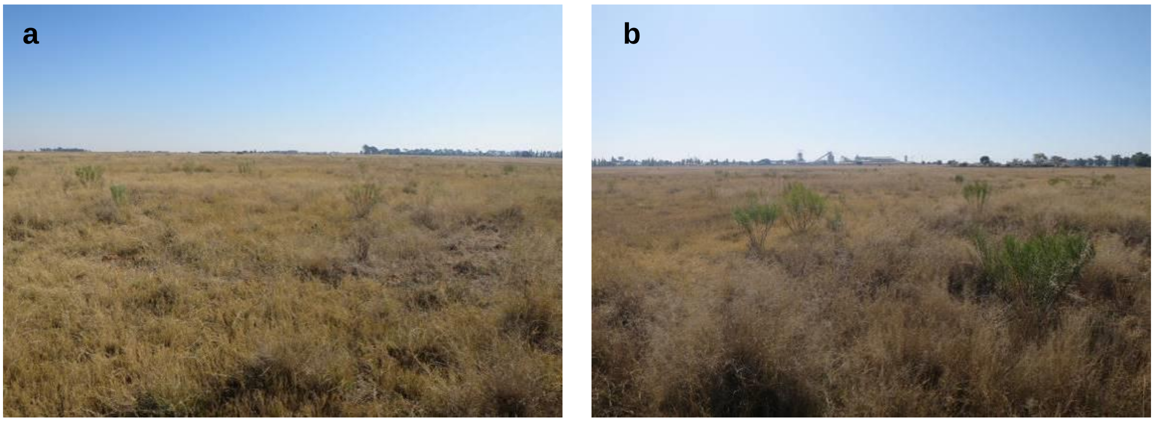


Figure 11: A broad-scale habitat map illustrating the avifaunal habitat types on the study area and immediate surroundings.



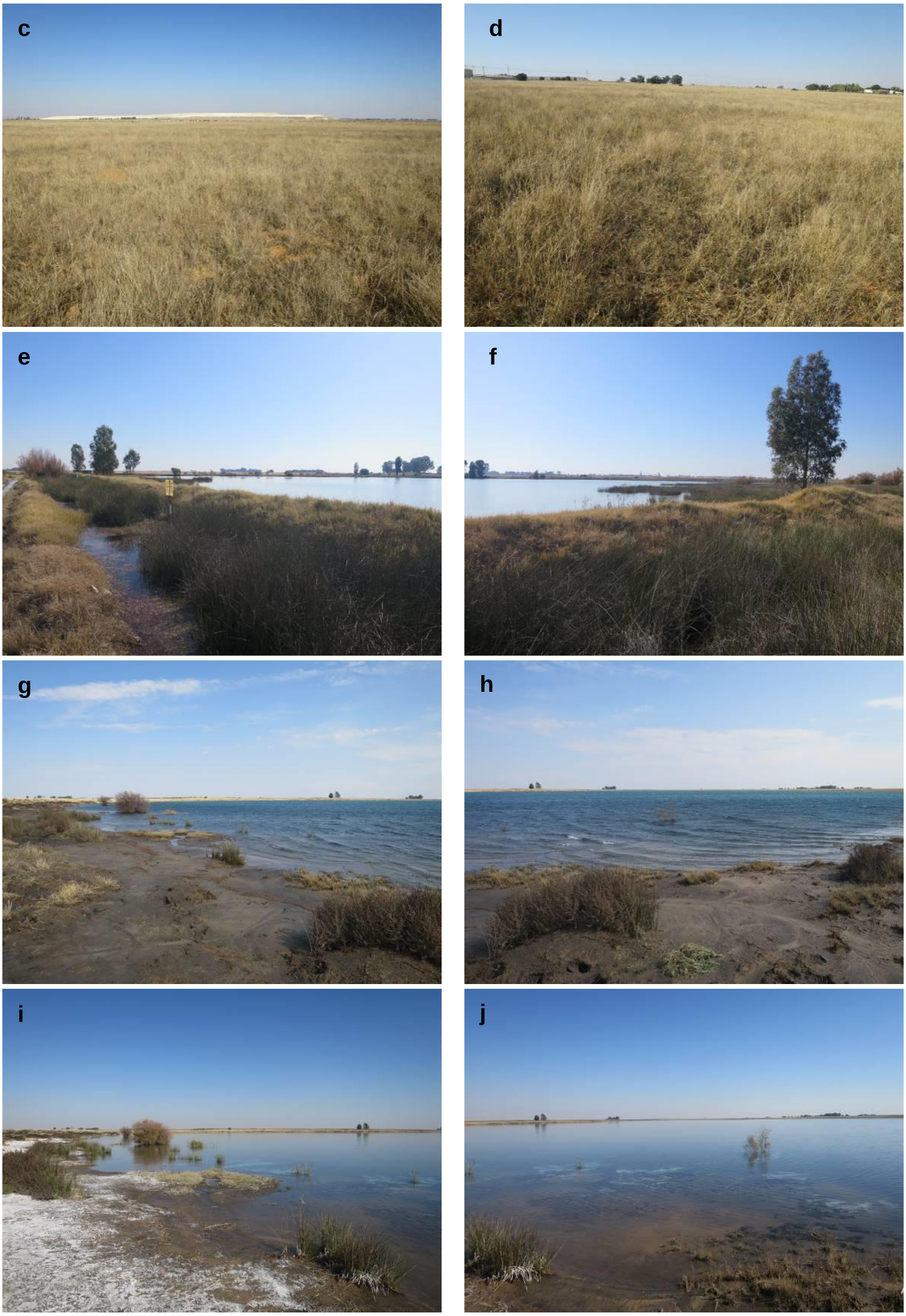

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Figure 12: A collage of images illustrating examples of avifaunal habitat types confined to the development area and immediate surroundings: (a - d) secondary grassland, (e – f) a pollution control dam near the south-western boundary of the development area, (g - j) a large pan near the south-western boundary of the

development area, (k - l) an endorheic pan near the north-western boundary of the development area, (m – p) transformed and landscaped areas with a water feature on the northern part of the development area and (q - r) commercial agricultural land which cover most of the development area.

4.2 Species Richness and Predicted summary statistics

Approximately ~132 bird species have been recorded within the study area (refer to Appendix 1 & Table 1), although it is more likely that between 50-70 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)[2] (Harrison et al., 1997; www.sabap2.birdmap.africa) and the presence of suitable habitat in the study area. This equates to 13 % of the approximate 990[3] species listed for the southern African subregion[4] (and approximately 15 % of the 871 species recorded within South Africa[5]). However, an average number of 48 species for each full protocol card submitted, were recorded for the pentad grid 2745_2635 corresponding to the study area (for observations of two hours or more; range= 1 - 78 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 African Wattled Lapwing (*Vanellus senegallus*), Double-banded Courser (*Rhinoptilus africanus*) and the Green-winged Pytilia (*Pytilia melba*).

According to Table 1, biome-restricted[6] remained to be absent on the study area and the local endemic and near-endemic bird richness were extremely low (Table 2). It also shows a low diversity of regional endemics, with 9 % of the endemic species present in the subregion. In addition, a large percentage of the species recorded in the study area is represented by waterbirds and shorebird taxa (ca. 38% of the total number of recorded bird species, sensu SABAP2).

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*	132 (13 %)	81 (61 %)
Number of Red Listed species**	5 (3.6 %)#	3 (27 %)

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[2] The expected richness statistic was derived from pentad grid 2745_2635 totalling 129 bird species (based on seven full protocol cards).

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

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

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

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

Number of biome-restricted species – Zambezian and Kalahari-Highveld Biomes*	0 (0%)	0 (0 %)
Number of local endemics (BirdLife SA, 2022)*	1 (3 %)	0 (0 %)
Number of local near-endemics (BirdLife SA, 2022)*	3 (10 %)	1 (33 %)
Number of regional endemics (Hockey *et al.*, 2005)**	10 (9 %)	7 (70 %)
Number of regional near-endemics (Hockey *et al.*, 2005)**	7 (11 %)	6 (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: 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)
Greater Flamingo	*Phoenicopterus roseus*	NT		1	1	1	
Lesser Flamingo	*Phoeniconaias minor*	NT	NT	1	1	1	
Maccoa Duck	*Oxyura maccoa*	VU	EN	1	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
Ant-eating Chat	*Myrmecocichla formicivora*	End		1			1
Rufous-eared Warbler	*Malcorus pectoralis*	End					11
Fiscal Flycatcher	*Melaenornis silens*	End					1
Cape Longclaw	*Macronyx capensis*	End		1			1
Orange River White-eye	*Zosterops pallidus*	End		1			1
Pied Starling	*Lamprotornis bicolor*	End					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			1
Chestnut-vented Warbler	*Curruca subcoerulea*	N-end		1			1
Cape Sparrow	*Passer melanurus*	N-end		1			1
Yellow Canary	*Crithagra*	N-end					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)
	flaviventris						
Cloud Cisticola	*Cisticola textrix*	N-end					1
African Marsh Harrier	*Circus ranivorus*	EN			1		1
Yellow-billed Stork	*Mycteria ibis*	EN			1		
	Totals:	**22**	**2**	**15**	**8**	**5**	**16**

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 3 provides an overview of bird species of conservation concern that could occur on the study area and immediate surroundings based on their historical distribution ranges and the presence of suitable habitat. According to Table 3, a total of five species could occur on the study area which includes one globally threatened species, one globally near threatened species, two regionally threatened species and one regionally near-threatened species.

It is evident from Table 3 that the highest reporting rates (>50%) were observed for the globally near threatened Lesser Flamingo (*Phoeniconaias minor*) and regionally near threatened Greater Flamingo (*Phoenicopterus roseus*). These two species are regarded as regular foraging visitors to the nearby pans (including the pollution control dams) and Stinkpan which is located adjacent to the study area. At least 10 individuals of Greater Flamingo and 50 individuals of Lesser flamingo were counted on Stinkpan during the July survey (Figure 13). However, these species are probably absent on the physical study site due to the absence of any suitable habitat on the study site. *Nevertheless, birds dispersing or commuting between the nearby pans and Stinkpan, will have to fly over the study area and could potentially interact (collide) with the PV panels and associated electrical infrastructure*. In addition, *the close proximity of these water features to the study site will also increase the risk of these species interacting with the PV infrastructure.*

The remaining species have low reporting rates (<20%) and are regarded as irregular foraging visitors to the study site with the exception of the globally endangered Maccoa Duck (*Oxyura maccoa*). The latter species was probably overlooked in the past and is regarded as regular foraging visitors (and probably also breeding visitors) to the nearby Stinkpan. At least four individuals were observed on Stinkpan during the July survey (Figure 13).

Table 3: Bird species of conservation concern that could utilise the study area 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	16.67	Restricted to permanent wetlands with extensive reedbeds.	Probably absent from the physical development area, although it could occur along the well-vegetated margins of the nearby Stinkpan. Only known from a single observation during 2011 in the study region. (sensu SABAP2).
Oxyura maccoa (Maccoa Duck)	Endangered	Vulnerable	16.67	Large saline pans and shallow impoundments.	A regular foraging visitor and possibly also breeding visitor to the pans and impounds adjacent to the development area. It was observed on Stinkpan (July 2022; pers. obs.). Probably absent on the physical development area due to the absence of suitable habitat. Birds dispersing between pans could potentially fly over the site and may interact with the PV panels en electrical infrastructure.
Mycteria ibis (Yellow-billed Stork)	-	Endangered	16.67	Wetlands, pans and flooded grassland.	Probably an irregular foraging visitor

Species	Global Conservation Status*	National Conservation Status**	SABAP2 reporting rate	Preferred Habitat	Potential Likelihood of Occurrence
					to the pans in the region. It is currently only known from a single recent record obtained during 03 March 2022 (sensu SABAP2). Probably absent on the physical development area due to the absence of suitable habitat. Birds dispersing between pans could potentially fly over the site and may interact with the PV panels en electrical infrastructure.
Phoeniconaias minor (Lesser Flamingo)	Near-threatened	Near-threatened	66.67	Restricted to large saline pans and other inland water bodies containing cyanobacteria.	A regular foraging visitor to the shallow margins of Stinkpan (pers. obs.) and probably also the nearby smaller pans. Probably absent on the physical development area due to the absence of suitable habitat. Birds dispersing between the pans and dams in the area could potentially fly over the site and may interact with the PV panels en electrical infrastructure.
Phoenicopterus roseus (Greater Flamingo)	-	Near-threatened	83.33	Restricted to large saline pans and other inland water bodies.	A highly regular foraging visitor to the shallow margins of Stinkpan (pers. obs.) and probably also

Species	Global Conservation Status*	National Conservation Status**	SABAP2 reporting rate	Preferred Habitat	Potential Likelihood of Occurrence
					the nearby smaller pans. Probably absent on the physical development area due to the absence of suitable habitat. Birds dispersing between the pans and dams in the area could potentially fly over the site and may interact with the PV panels en electrical infrastructure.

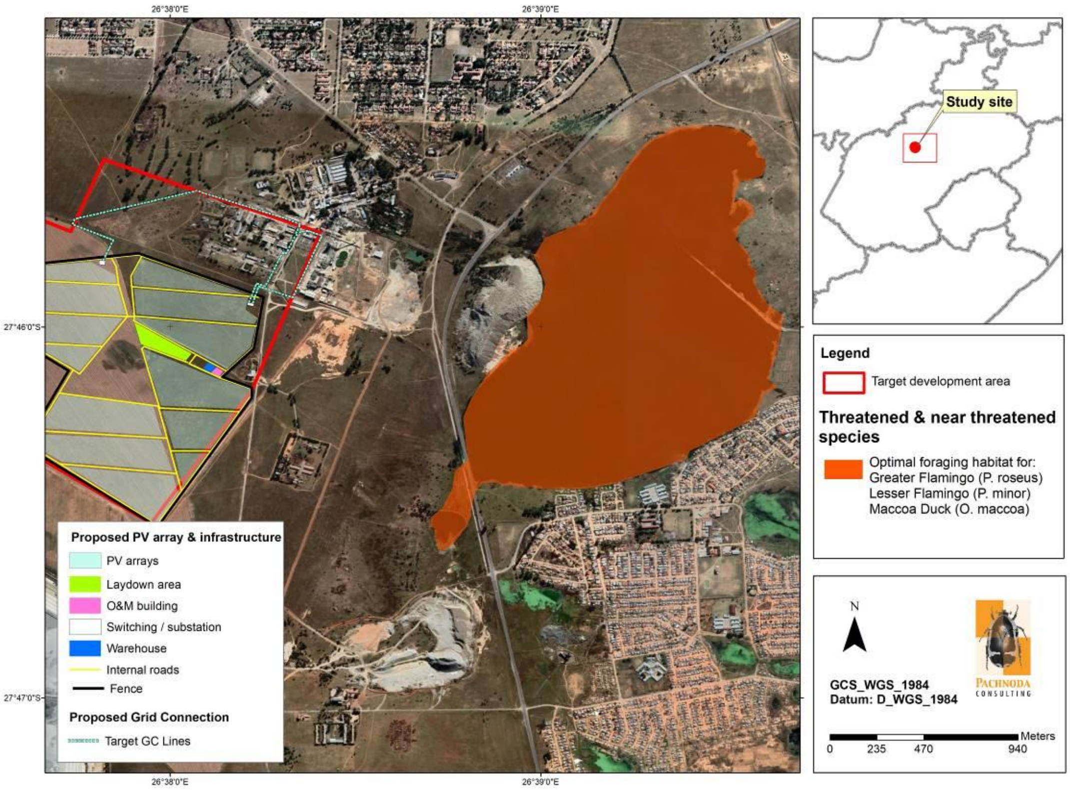

Figure 13: A map illustrating the occurrence of threatened and near threatened bird species observed on the development area and immediate surroundings during the June/July 2022 surveys.

4.3.1 *Notes on the occurrence of the Caspian Tern (Hydroprocne caspia)*

According to the results of the Screening Tool: Animal theme, the regionally vulnerable Caspian Tern (*Hydroprogne caspia*) has a medium probability to occur on the proposed study area. However, from the SABAP2 data it was evident that the Caspian Tern has not been observed from within the study area, with the nearest recent record stemming from the Odendaalsrus area (approximately 12 km south-east of the study area). High reporting rates occur mainly from the Vaal River and Bloemhof Dam (approximately 55 km northwest of the study area) which comprises of dispersing/foraging individuals which disperse between Bloemhof Dam and the Vaal Dam (this species has previously bred at both sites; see Figure 14) as well as at the Erfenis Dam near Winburg (approximately 80 km south of the study area). In addition, the probability that this species could occur on physical development area is low, but the nearby Stinkpan provides optimal foraging habitat for non-breeding birds when dispersing between national breeding sites (e.g. Bloemhof Dam).

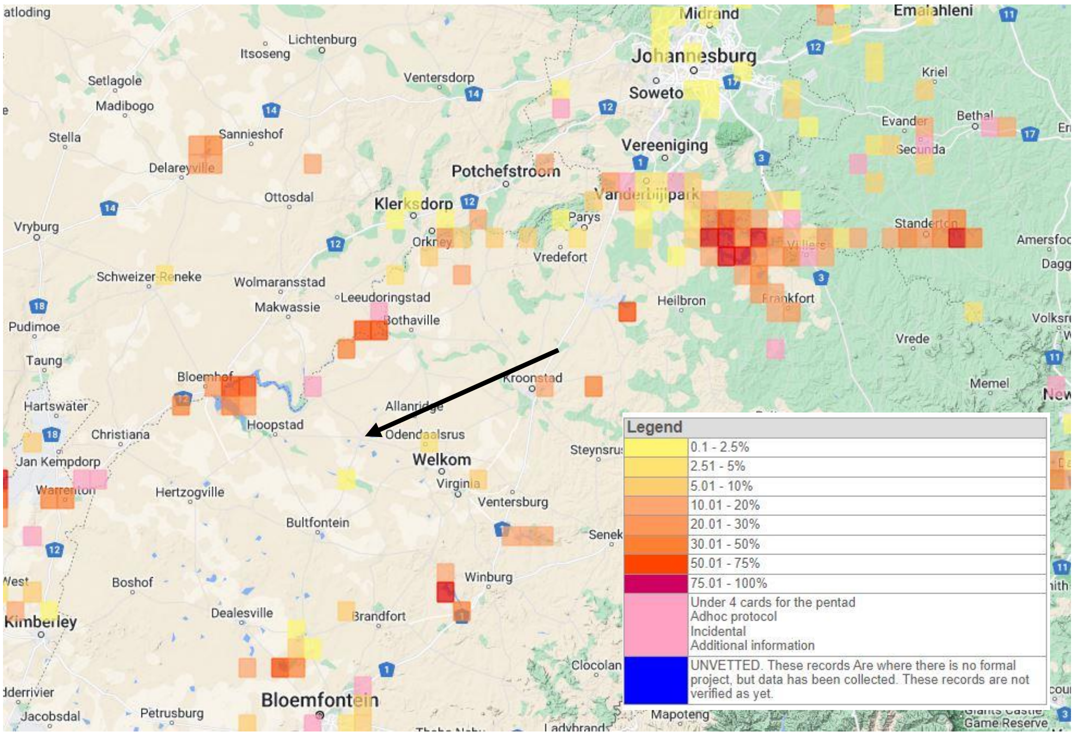

Figure 14: The extant (current) occurrence of Caspian Tern (*Hydroprogne caspia*) on the study area according to SABAP2 reporting rates (the arrow indicates the position of the study area) (map courtesy and copyright of SABAP2 and Animal Demography Unit).

4.4 Bird Assemblage Structure and Composition

4.4.1 Summary of point counts

A total of 48 bird species and an average abundance of 243 individuals were recorded from eight bird points (representing two replicative counts) located on the development area. The data provides an estimate of the bird richness and their numbers on the study area and immediate surroundings obtained during two independent survey sessions. A mean of 9.57 species and 30.38 individuals were recorded per point count. The highest number of species and individuals recorded from point count was respectively 22 species and 113 bird individuals (from landscaped and manicured areas). The lowest number of species and individuals was respectively three species and 4.5 individuals (from secondary grassland).

The mean frequency of occurrence of a bird species in the study area was 19.27 % and the median was 12.50%, while the most common value (mode) was 12.50%. The latter represents those species that were encountered in only one point count. Three species occurred in 50% or more of the point counts (Table 4) being African Pipit (*Anthus cinnamomeus*), Crowned Lapwing (*Vanellus coronatus*) and Red-capped Lark (*Calandrella cinerea*). In addition, 25% of the observed species are waterbird species.

Table 4: Bird species with a frequency of occurrence greater than 30% observed on the study area (according to eight counts).

Species	Frequency (%)	Species	Frequency (%)
African Pipit (*Anthus cinnamomeus*)	62.50	Desert Cisticola (*Cisticola aridulus*)	37.50
Crowned Lapwing (*Vanellus coronatus*)	50.00	Ring-necked Dove (*Streptopelia capicola*)	37.50
Red-capped Lark (Calandrella cinerea)	50.00	Zitting Cisticola (*Cisticola juncidis*)	37.50

4.4.2 Dominance and typical bird species

The dominant (typical) species on the study area are presented in Table 5. 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 included the African Pipit (*Anthus cinnamomeus*), Crowned Lapwing (*Vanellus coronatus*) and Red-capped Lark (*Calandrella cinerea*). 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 5 that the typical bird assemblage is predominantly represented by 70% terrestrial/ ground -foraging insectivores (insect-eating), 20% granivores (seed-eating taxa) and 10% being freshwater foraging herbivores (mainly waterfowl).

Table 5: Typical (high frequency of occurrence) bird species on the study area.

Species	Av. Abundance	Consistency (Sim/SD)	Contribution (%)	Primary Trophic Guild
African Pipit (*Anthus cinnamomeus*)	1.06	0.63	23.32	Insectivore: ground gleaner
Red-capped Lark (*Calandrella cinerea*)	1.25	0.49	19.38	Insectivore: ground gleaner
Crowned Lapwing (*Vanellus coronatus*)	0.94	0.45	14.53	Insectivore: ground gleaner
Desert Cisticola (*Cisticola aridulus*)	0.38	0.32	11.99	Insectivore: upper canopy foliage gleaner
Ring-necked Dove (*Streptopelia capicola*)	1.63	0.33	6.40	Granivore: ground gleaner
Zitting Cisticola (*Cisticola juncidis*)	0.44	0.33	5.24	Insectivore: upper canopy foliage gleaner
Northern Black Korhaan (*Afrotis afraoides*)	0.31	0.19	3.04	Insectivore: ground gleaner
Ant-eating Chat (*Myrmecocichla formicivora*)	0.44	0.19	2.97	Insectivore: ground gleaner
Yellow-billed Duck (*Anas undulata*)	0.81	0.19	2.08	Herbivore: freshwater forager
Cape Sparrow (*Passer melanurus*)	0.50	0.19	1.94	Granivore: ground gleaner

4.4.3 Diversity and species richness

The highest number of bird species on the study area was observed from pans and ponds where surface water accumulates, followed by the bird association on landscaped areas (Table 6). The lowest number of bird species was recorded from the active cultivated land. The highest number of bird individuals on the study area was observed from the landscaped areas (Table 6), followed by the pans and ponds. The lowest number of bird numbers was recorded from the secondary grassland habitat.

Table 6: 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	Number of Individuals	Shannon Wiener Index H'(log_e)
Secondary grassland	10	7.00	2.19
Pans and ponds	24	31.33	2.46
Transformed: Manicured/landscaped areas	22	113.00	2.03
Transformed: Cultivation	6	15.00	1.71

4.5 Passerine bird densities

Twenty-eight passerine bird species were recorded from eight point counts on the development area. The development area accommodates approximately 7.05 species.ha^{-1} (Appendix 2). The average density per hectare is 22.28 birds.ha^{-1} and ranges between 3.21 birds.ha^{-1} to 120.51 birds.ha^{-1}.

4.6 Movements/dispersal of Collision-prone birds

The spatial location of water features (e.g. pans, dams and ponds) on the wider study area emphasises a high probability that waterbirds, especially waterfowl such as ducks, geese and flamingo species, could daily disperse across part of the proposed PV arrays when visiting nearby water features in the area (Figure 15). These species are predicted to commute between Stinkpan and the pans and dams located on the south-western section of the study area.

In addition, the home ranges of approximately five pairs of Northern Black Korhaan (*Afrotis afraoides*) correspond to the development area (Figure 15). These individuals could become displaced from the study area during the construction phase of the PV arrays.

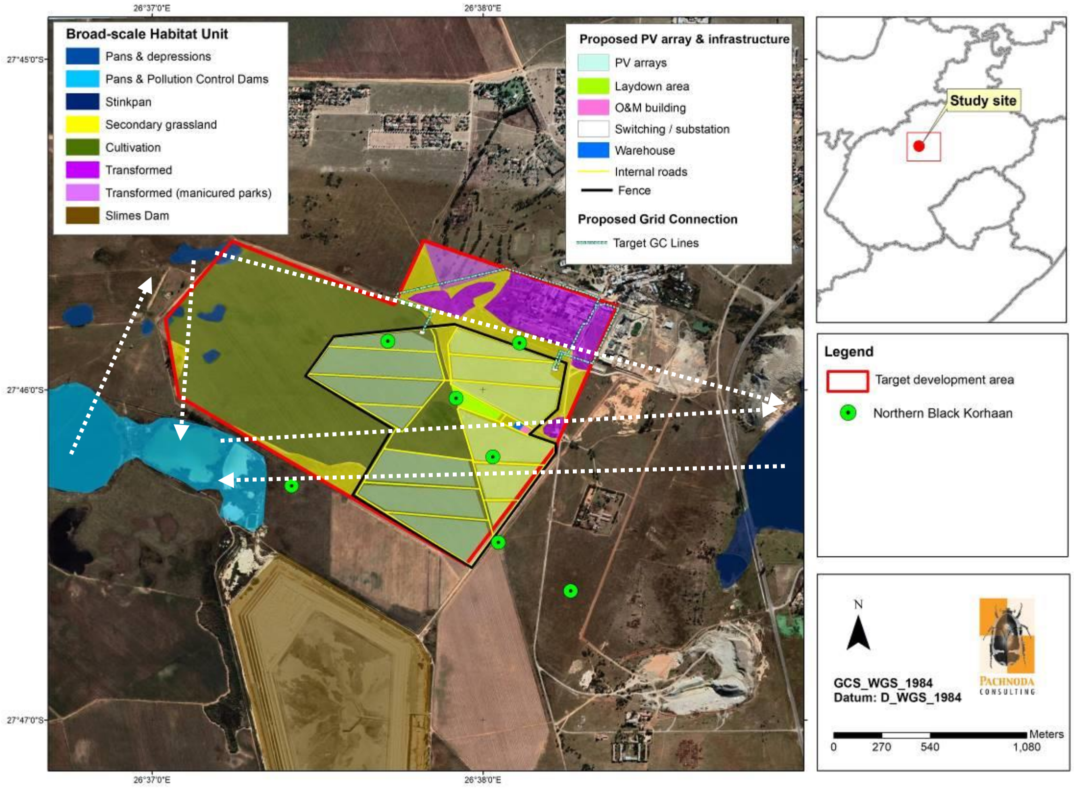

Figure 15: A map of the study area illustrating the occurrence and predicted movements of collision prone birds.

4.7 Avifaunal sensitivity

A sensitivity map was compiled, illustrating habitat units comprising of potential sensitive elements based on the following arguments (Figure 16):

Areas of high sensitivity

It includes the pans, pollution control dams, and all the adjacent pans and buffer zones.

The pans have the potential to attract passerine bird species with high affinities for wetland-associated habitat units. It thereby contribute towards the local avian richness in supporting bird species that are otherwise absent from the surrounding terrestrial "dryland" grassland units.

Nevertheless, all the nearby pans, including Stinkpan and some of the pollution control dams support congregations of waterfowl and shorebirds taxa. These include globally and regionally threatened and near threatened species (e.g. flamingo taxa and Maccoa Duck). The pans are also important from a functional and dynamic perspective at the landscape level since they are part of an "inter-connected" system of "stepping stones" within the local catchment, meaning that environmental conditions at these pans (e.g. water levels, salinity, food availability, availability of shoreline habitat) are constantly changing. Therefore, none of the pans within catchment are similar to each, thereby providing a continuous supply of resources for waterbirds which tend to commute on a daily basis over the study site and along the edges of the slimes dams (which are often inundated). The placement of electrical infrastructure and PV panels in close proximity to these areas, as well as on areas where the frequency of fly-overs by waterbirds are high could elevate potential avian collisions with the infrastructure. Nevertheless, the pollution control dams are of artificial origin, and could be removed or relocated.

Areas of low sensitivity

These habitat units are represented by transformed types and include the secondary grasslands, cultivated land, build-up areas and landscaped/manicured areas.

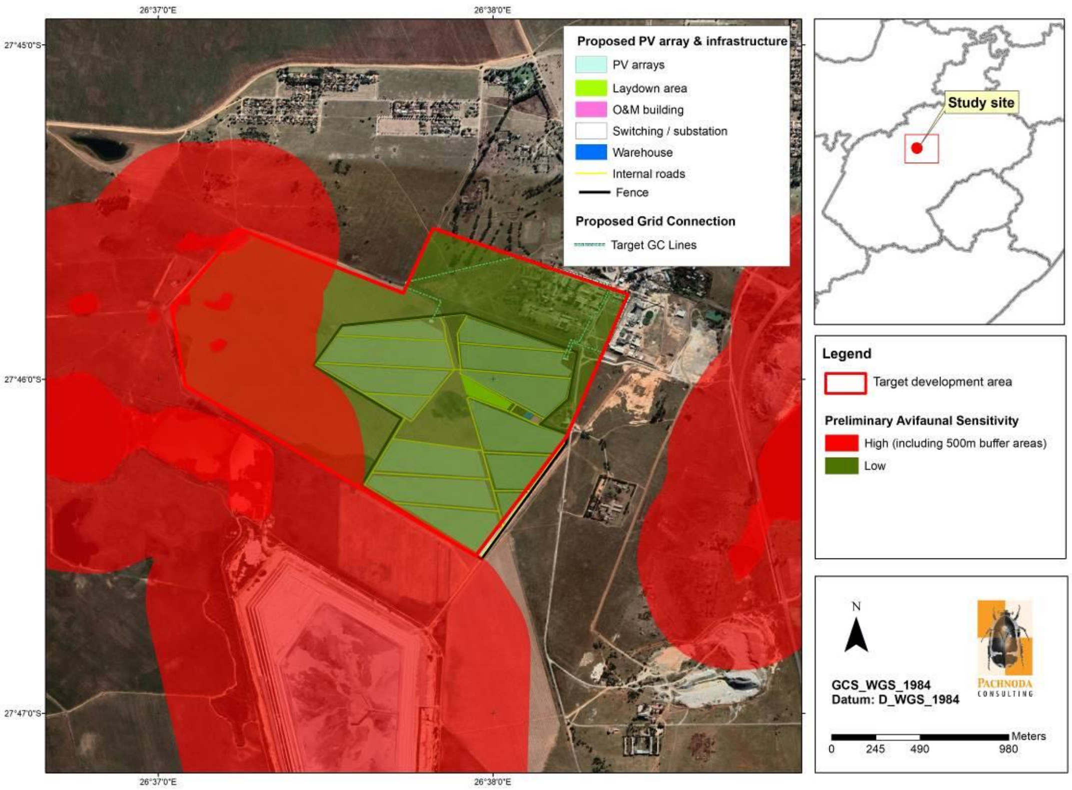

Figure 16: A map illustrating the avifaunal sensitivity of the area based on habitat types supporting bird taxa of conservation concern and important ecological function.

4.8 Overview of Avian Impacts at Solar Facilities

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 Impacts associated with the Harmony Target Solar PV Facility

Table 7 provides a summary of the impacts anticipated and a quantification thereof.

4.9.1 Loss of habitat and displacement of birds

Approximately 106ha of the study site will 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 7.05 species.ha^{-1} and 66.79 birds.ha^{-1} will become displaced should the activity occur (as per Jenkins et al., 2017). However, the predicted loss in bird densities is low and the number of endemics species that occur on the study area is also regarded as low. Nevertheless, at least five pairs of Northern Black Korhaan (*Afrotis afraoides*) may become displaced.

- Cloud Cisticola (Cisticola textrix); and
- 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 proximity of pans, inundated ponds and the large Stinkpan to the study area increases the risk of waterbirds and shorebird taxa interacting with the PV panels. A number of waterbird species occurs on the study area with a high frequency of traversing the study area on a daily basis (bird dispersing between the water features) which could interact with the PV panels.

Appropriate application of bird deterrent devices is highly recommended, which may include a combination of rotating flashers/reflectors, including diverters which emit light during nigh time to increase the visibility of the infrastructure for birds such as flamingos which tend to disperse during the night. Post construction monitoring to quantify mortalities will be important during to early operational phase in order to determine "hotspot" areas which may require additional mitigation measures.

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*);
- Yellow-billed Duck (*Anas undulata*);
- White-faced Duck (*Dendrocygna viduata*);
- Red-billed Teal (*Anas erythrorhynchus*);
- Cape Teal (*Anas capensis*);
- Cape Shoveller (*Anas smithii*);
- Glossy Ibis (*Plegadis falcinellus*);
- Black-winged Stilt (*Himantopus himantopus*);
- Three-banded Plover (*Charadrius tricollaris*); and potentially also
- Greater Flamingo (*Phoenicopterus roseus*);
- Lesser Flamingo (*Phoeniconaias minor*);
- Maccoa Duck (*Oxyura maccoa*);
- White-breasted Cormorant (*Phalacrocorax lucidus*)
- Reed Cormorant (*Microcarbo africanus*);
- African Sacred Ibis (*Threskiornis aethiopicus*) and potentially also
- Little Grebe (*Tachybaptus ruficollis*);
- Black-headed Heron (*Ardea melanocephala*);
- Red-knobbed Coot (*Fulica cristata*);
- Grey Heron (*Ardea cinerea*);
- Little Egret (*Egretta garzetta*);
- Great Egret (*Ardea alba*);
- African Darter (*Anhinga rufa*);
- Common Moorhen (*Gallinula chloropus*) and
- African Swamphen (*Porphyrio madagascariensis*).

4.9.4 Interaction with overhead powerlines and reticulation

At least three 132kV overhead powerlines are proposed to tie-in to the Avgold (6.6/44 kV) substation. Almost the entire corridors of these will traverse transformed/manicured land occupied by mining infrastructure. 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” (BFD) to increase the visibility of the lines. It is proposed that the overhead powerlines (including existing lines) consider the fitment of dynamic devices such as the "Viper live bird flapper" and nocturnal LED solar-charged bird diverters owing to the potential nocturnal flyovers by flamingo taxa.

- *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 7: 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	Low (4)	Minor (2)
Probability	Definite (5)	Probable (3)
Significance	**Medium (50)**	**Low (24)**
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 low sensitivity. 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).

Residual:
Decreased bird species richness, low evenness values and subsequent loss of avian diversity on a local scale. The impact will also result in 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 competitive 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 (4)
Duration	Long-term (4)	Long-term (4)
Magnitude	High (8)	Medium (6)
Probability	Highly Probable (4)	Highly Probable (4)
Significance	**High (64)**	**Medium-High (56)**
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: It is difficult to mitigate against the potential for waterbird species to collide with the PV infrastructure owing to the spatial location of the footprint area (being located in close proximity to a number of wetland features). 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 be placed at panels nearest (facing) to pans and other water features. Bird deterrent devices should also include light-emitting devices to increase the visibility of the PV infrastructure for waterbird species that migrate at night (e.g. flamingo species). Security/CCTV cameras may be installed to quantify mortalities (cameras are also installed along the perimeter fence for security measures and may also prove to be effective to quantify mortalities). Buffer pans/depressions by at least 500m (arrays should be positioned at least 500m away from pans). If post-construction monitoring predicts and/or confirms any 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 the overhead power lines during operation.		
Grid Corridor	**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 collision-prone 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 corridor is 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.		
Grid Corridor	**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 collision-prone waterbird species.	Yes (to some extent), owing to the potential loss of collision-prone 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 tailings facilities. 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 59 collision-prone bird species have been recorded from the study area, of which 46 species are waterbirds and seven 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 high (c. 45% of the total number of bird species recorded in the area).

Table 8: Collision-prone bird species and Red listed species (in red) expected to be present on the study area 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
African Darter	*Anhinga rufa*	16.67	1	0.00	0
African Fish Eagle	*Haliaeetus vocifer*	16.67	1	0.00	0
African Marsh Harrier	*Circus ranivorus*	16.67	1	0.00	0
African Sacred Ibis	*Threskiornis aethiopicus*	16.67	1	0.00	0
African Spoonbill	*Platalea alba*	50.00	3	0.00	0
African Swamphen	*Porphyrio madagascariensis*	16.67	1	0.00	0
Amur Falcon	*Falco amurensis*	16.67	1	0.00	0
Black Heron	*Egretta ardesiaca*	16.67	1	0.00	0
Black-crowned Night Heron	*Nycticorax nycticorax*	16.67	1	0.00	0
Black-headed Heron	*Ardea melanocephala*	66.67	4	0.00	0
Black-necked Grebe	*Podiceps nigricollis*	33.33	2	12.50	1
Black-winged Kite	*Elanus caeruleus*	50.00	3	0.00	0
Black-winged Stilt	*Himantopus himantopus*	66.67	4	37.50	3
Blue-billed Teal	*Spatula hottentota*	33.33	2	0.00	0
Cape Shoveler	*Spatula smithii*	33.33	2	0.00	0
Cape Teal	*Anas capensis*	33.33	2	12.50	1
Common Buzzard	*Buteo buteo*	33.33	2	0.00	0
Common Moorhen	*Gallinula chloropus*	33.33	2	0.00	0
Common Sandpiper	*Actitis hypoleucos*	16.67	1	12.50	1
Egyptian Goose	*Alopochen aegyptiaca*	50.00	3	0.00	0
Glossy Ibis	*Plegadis falcinellus*	83.33	5	12.50	1
Goliath Heron	*Ardea goliath*	33.33	2	0.00	0
Great Crested Grebe	*Podiceps cristatus*	0.00	0	12.50	1
Great Egret	*Ardea alba*	33.33	2	0.00	0
Greater Flamingo	*Phoenicopterus roseus*	83.33	5	62.50	5
Grey Heron	*Ardea cinerea*	33.33	2	0.00	0
Grey-headed Gull	*Chroicocephalus cirrocephalus*	83.33	5	12.50	1
Hadada Ibis	*Bostrychia hagedash*	50.00	3	0.00	0
Helmeted Guineafowl	*Numida meleagris*	83.33	5	0.00	0

Common Name	Scientific Name	SABAP2 Reporting Rate			
		Full Protocol (%)	Number of cards	Ad Hoc Protocol (%)	Number of cards
Lesser Flamingo	*Phoeniconaias minor*	66.67	4	50.00	4
Lesser Kestrel	*Falco naumanni*	16.67	1	12.50	1
Little Bittern	*Ixobrychus minutus*	16.67	1	0.00	0
Little Egret	*Egretta garzetta*	16.67	1	0.00	0
Little Grebe	*Tachybaptus ruficollis*	66.67	4	0.00	0
Little Stint	*Calidris minuta*	16.67	1	12.50	1
Maccoa Duck	*Oxyura maccoa*	16.67	1	0.00	0
Marsh Sandpiper	*Tringa stagnatilis*	16.67	1	0.00	0
Northern Black Korhaan	*Afrotis afraoides*	50.00	3	0.00	0
Pied Crow	*Corvus albus*	16.67	1	0.00	0
Purple Heron	*Ardea purpurea*	16.67	1	0.00	0
Red-billed Teal	*Anas erythrorhyncha*	50.00	3	0.00	0
Red-knobbed Coot	*Fulica cristata*	83.33	5	25.00	2
Reed Cormorant	*Microcarbo africanus*	33.33	2	0.00	0
Rock Kestrel	*Falco rupicolus*	16.67	1	0.00	0
Ruff	*Calidris pugnax*	16.67	1	12.50	1
South African Shelduck	*Tadorna cana*	16.67	1	0.00	0
Southern Pochard	*Netta erythrophthalma*	16.67	1	0.00	0
Speckled Pigeon	*Columba guinea*	100.00	6	12.50	1
Spur-winged Goose	*Plectropterus gambensis*	50.00	3	0.00	0
Squacco Heron	*Ardeola ralloides*	16.67	1	0.00	0
Swainson's Spurfowl	*Pternistis swainsonii*	33.33	2	0.00	0
Three-banded Plover	*Charadrius tricollaris*	50.00	3	0.00	0
Western Cattle Egret	*Bubulcus ibis*	83.33	5	12.50	1
Whiskered Tern	*Chlidonias hybrida*	16.67	1	0.00	0
White-breasted Cormorant	*Phalacrocorax lucidus*	16.67	1	0.00	0
White-faced Whistling Duck	*Dendrocygna viduata*	33.33	2	0.00	0
White-winged Tern	*Chlidonias leucopterus*	16.67	1	0.00	0
Yellow-billed Duck	*Anas undulata*	83.33	5	0.00	0
Yellow-billed Stork	*Mycteria ibis*	16.67	1	0.00	0

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.

At least four approved solar PV facilities occur within a 17 km radius of the proposed Target Solar facility (as per the results of the Screening Tool; Table 9).

Table 9: Solar developments with an approved Environmental Authorisation or applications under consideration within 30 km of the proposed area.

No	EIA Reference No	Classification	Status of application	Distance from proposed area (km)
1	14/12/16/3/3/3/1/644	Solar PV	Approved	13.7
2	14/12/16/3/3/1/1472	Solar PV	Approved	15.1
3	14/12/16/3/3/1/1444	Solar PV	Approved	12.8
4	14/12/16/3/3/1/1471	Solar PV	Approved	16.7

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 10.

Table 10: 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	Minor (2)	Low (4)
Probability	Probable (3)	Probable (3)
Significance	**Low (24)**	**Medium (33)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Low
Loss of resources?	Yes	Yes
Can impacts be mitigated?	No	
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 (4)	Site and immediate surroundings (4)
Duration	Long-term (4)	Long-term (4)
Magnitude	Medium (6)	High (8)
Probability	Highly Probable (4)	Highly Probable (4)

Significance	**Medium-High (56)**	**High (64)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Low
Irreplaceable loss of resources?	Yes (to some extent), owing to the potential loss of waterbird taxa.	Yes (to some extent), owing to the potential loss of waterbird taxa and potential threatened and near threatened waterbird taxa
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 (to some extent), owing to the potential loss of waterbird taxa.	Yes (to some extent), owing to the potential loss of waterbird taxa and potential threatened and near threatened waterbird taxa
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.		
	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)	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 (to some extent), owing to the potential loss of waterbird taxa.	Yes (to some extent), owing to the potential loss of waterbird taxa and potential threatened and near threatened waterbird taxa
Can impacts be mitigated?	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 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 power line and substation 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 as well as arrays facing in the direction of pans and other water features) to discourage birds from colonising/colliding with the infrastructure. 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. The devices should also include light-emitting devices to increase the visibility of the PV infrastructure for waterbird species that migrate at night (e.g. flamingo species). An option is to employ video cameras at selected areas to document bird mortalities.
- Buffer pans by at least 500m (arrays should be positioned at least 500m away from pans/dams/ponds).
- 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.
- Where possible, position the proposed grid connection lines 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 17[7].

From Figure 17 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).

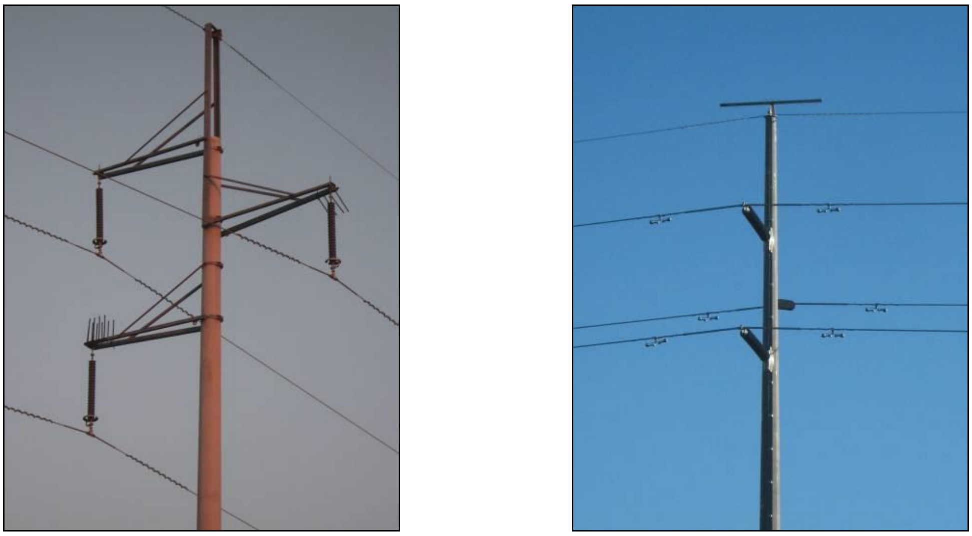

Figure 17: Two bird-friendly tower designs to be considered for the current project.

- All new and planned power lines should be fitted with bird flight diverters (see Figure 10). For the current project it is proposed that the overhead powerlines consider the fitment of dynamic devices such as the "Viper live bird flapper" and nocturnal LED solar-charged bird diverters owing to potential nocturnal flyovers by flamingo taxa. 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.

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

Figure 18: Examples of bird flight diverters to be used on the power lines: Nocturnal LED solar-charged bird 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 post construction monitoring be implemented to augment existing data:

- At least two additional pre-construction survey is recommended, consisting of one day each which is necessary to inform the final EMPr during operation.

The surveys 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 3-4 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 should be removed when nest-building attempts are noticed.	ECO & OM	Operation (on-going)
• 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 3-4 days for a 6 month period
• Implement pre-construction monitoring protocols (as per Jenkins et al., 2017)	OM & CER	Prior to construction - At least 2 surveys of 1 day each (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 two pre-construction surveys. • Implement post-construction surveys during operation with a minimum of 3

	x 3-4 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 Avgold Ltd to compile an avifauna baseline report for the proposed Harmony Target Solar PV facility and associated infrastructure with a contracted capacity of up to 30MW located approximately 1km south of the town of Allanridge, Free State Province.

Three avifaunal habitat types were identified on the study area and surroundings, ranging from secondary grassland, inundated pans and ponds (mainly located along the outside periphery of the development area) to transformed and landscape/manicured areas. The study area was also surrounded by a number of pans and Stinkpan, which provided foraging and roosting habitat for a large number of waterbird taxa. Approximately 132 bird species are expected to occur in the wider study area, of which 81 species were observed in the study area (during two surveys). The expected richness included five threatened or near threatened species, 10 southern African endemics and seven near-endemic species. The globally endangered Maccoa Duck (*Oxyura maccoa*), the regionally near threatened Greater flamingo (*Phoenicopterus roseus*) and the globally near threatened Lesser Flamingo (*Phoeniconaias minor*) were observed at the nearby Stinkpan, which could also utilise the inundated pans in the wider study area. Seven southern African endemics and six near-endemic species were confirmed on the study area.

An evaluation of potential and likely impacts on the avifauna revealed that the impact significance was predicted to be moderate-high to low after mitigation (depending on the type of impact). **However, the risk for waterbirds and shorebirds (including flamingo taxa) colliding with the PV infrastructure remained eminent due to the presence of inundated pans and ponds in the study area and dispersal routes coinciding with the study area**. **Waterbird interactions with the PV infrastructure was predicted as persistent due to the spatial location of the proposed footprint site (surrounded by water features of which some sustain large numbers of birds).** 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 (e.g. the installation of appropriate bird diverters to minimise the potential risk of collision trauma in birds).

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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 grid 2745_2635 (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	66.67	4.00	0.00	0.00
52	African Darter	*Anhinga rufa*	1	16.67	1.00	0.00	0.00
149	African Fish Eagle	*Haliaeetus vocifer*	1	16.67	1.00	0.00	0.00
418	African Hoopoe	*Upupa africana*		50.00	3.00	11.11	1.00
167	African Marsh Harrier	*Circus ranivorus*		16.67	1.00	0.00	0.00
387	African Palm Swift	*Cypsiurus parvus*		0.00	0.00	11.11	1.00
692	African Pipit	*Anthus cinnamomeus*	1	50.00	3.00	0.00	0.00
544	African Red-eyed Bulbul	*Pycnonotus nigricans*	1	33.33	2.00	0.00	0.00
81	African Sacred Ibis	*Threskiornis aethiopicus*	1	16.67	1.00	0.00	0.00
85	African Spoonbill	*Platalea alba*	1	50.00	3.00	0.00	0.00
576	African Stonechat	*Saxicola torquatus*	1	66.67	4.00	0.00	0.00
208	African Swamphen	*Porphyrio madagascariensis*		16.67	1.00	0.00	0.00
247	African Wattled Lapwing	Vanellus senegallus	1	n/a	1.00	0.00	0.00
119	Amur Falcon	*Falco amurensis*		16.67	1.00	0.00	0.00
575	Ant-eating Chat	*Myrmecocichla formicivora*	1	83.33	5.00	0.00	0.00
493	Barn Swallow	*Hirundo rustica*		16.67	1.00	0.00	0.00
64	Black Heron	*Egretta ardesiaca*		16.67	1.00	0.00	0.00
650	Black-chested Prinia	*Prinia flavicans*	1	83.33	5.00	11.11	1.00
69	Black-crowned Night Heron	*Nycticorax nycticorax*		16.67	1.00	0.00	0.00
55	Black-headed Heron	*Ardea melanocephala*	1	66.67	4.00	0.00	0.00

#	Common Name	Scientific Name	Observed (Jun/Jul, 2022)	SABAP2 Reporting Rate			
				Full Protocol (%)	Number of cards	Ad Hoc Protocol (%)	Number of cards
5	Black-necked Grebe	*Podiceps nigricollis*	1	33.33	2.00	22.22	2.00
245	Blacksmith Lapwing	*Vanellus armatus*	1	100.00	6.00	11.11	1.00
860	Black-throated Canary	*Crithagra atrogularis*		33.33	2.00	11.11	1.00
130	Black-winged Kite	*Elanus caeruleus*	1	50.00	3.00	0.00	0.00
270	Black-winged Stilt	*Himantopus himantopus*	1	66.67	4.00	33.33	3.00
839	Blue Waxbill	*Uraeginthus angolensis*	1	16.67	1.00	0.00	0.00
99	Blue-billed Teal	*Spatula hottentota*		33.33	2.00	0.00	0.00
714	Brown-crowned Tchagra	*Tchagra australis*	1	16.67	1.00	0.00	0.00
703	Cape Longclaw	*Macronyx capensis*	1	50.00	3.00	0.00	0.00
94	Cape Shoveler	*Spatula smithii*	1	33.33	2.00	0.00	0.00
786	Cape Sparrow	*Passer melanurus*	1	100.00	6.00	11.11	1.00
737	Cape Starling	*Lamprotornis nitens*	1	33.33	2.00	0.00	0.00
98	Cape Teal	*Anas capensis*	1	33.33	2.00	11.11	1.00
316	Ring-necked Dove	*Streptopelia capicola*	1	100.00	6.00	11.11	1.00
686	Cape Wagtail	*Motacilla capensis*	1	50.00	3.00	0.00	0.00
484	Chestnut-backed Sparrow-Lark	*Eremopterix leucotis*	1	16.67	1.00	0.00	0.00
658	Chestnut-vented Warbler	*Curruca subcoerulea*	1	33.33	2.00	0.00	0.00
631	Cloud Cisticola	*Cisticola textrix*		16.67	1.00	0.00	0.00
154	Common (Ssteppe) Buzzard	*Buteo buteo vulpinus*		33.33	2.00	0.00	0.00
210	Common Moorhen	*Gallinula chloropus*	1	33.33	2.00	0.00	0.00
734	Common Myna	*Acridotheres tristis*	1	100.00	6.00	0.00	0.00
258	Common Sandpiper	*Actitis hypoleucos*		16.67	1.00	11.11	1.00
439	Crested Barbet	*Trachyphonus vaillantii*	1	50.00	3.00	11.11	1.00
242	Crowned Lapwing	*Vanellus coronatus*	1	100.00	6.00	0.00	0.00
630	Desert Cisticola	*Cisticola aridulus*	1	50.00	3.00	0.00	0.00

#	Common Name	Scientific Name	Observed (Jun/Jul, 2022)	SABAP2 Reporting Rate			
				Full Protocol (%)	Number of cards	Ad Hoc Protocol (%)	Number of cards
352	Diederik Cuckoo	*Chrysococcyx caprius*		16.67	1.00	0.00	0.00
849	Dusky Indigobird	*Vidua funerea*		16.67	1.00	0.00	0.00
278	Double-banded Courser	*Rhinoptilus africanus*	1	n/a	1.00	0.00	0.00
66	Dwarf Bittern	*Ixobrychus sturmii*		16.67	1.00	0.00	0.00
89	Egyptian Goose	*Alopochen aegyptiaca*	1	50.00	3.00	0.00	0.00
404	European Bee-eater	*Merops apiaster*		16.67	1.00	11.11	1.00
570	Familiar Chat	*Oenanthe familiaris*		33.33	2.00	0.00	0.00
665	Fiscal Flycatcher	*Melaenornis silens*		33.33	2.00	0.00	0.00
83	Glossy Ibis	*Plegadis falcinellus*	1	83.33	5.00	11.11	1.00
56	Goliath Heron	*Ardea goliath*		33.33	2.00	0.00	0.00
4	Great Crested Grebe	*Podiceps cristatus*		0.00	0.00	11.11	1.00
58	Great Egret	*Ardea alba*		33.33	2.00	0.00	0.00
86	Greater Flamingo	*Phoenicopterus roseus*	1	83.33	5.00	66.67	6.00
502	Greater Striped Swallow	*Cecropis cucullata*	1	66.67	4.00	11.11	1.00
419	Green Wood Hoopoe	*Phoeniculus purpureus*	1	33.33	2.00	0.00	0.00
830	Green-winged Pytilia	Pytilia melba	1	n/a	1.00	0.00	0.00
54	Grey Heron	*Ardea cinerea*		33.33	2.00	0.00	0.00
288	Grey-headed Gull	*Chroicocephalus cirrocephalus*	1	83.33	5.00	11.11	1.00
84	Hadada Ibis	*Bostrychia hagedash*	1	50.00	3.00	0.00	0.00
192	Helmeted Guineafowl	*Numida meleagris*	1	83.33	5.00	11.11	1.00
784	House Sparrow	*Passer domesticus*	1	83.33	5.00	11.11	1.00
1104	Karoo Thrush	*Turdus smithi*	1	50.00	3.00	0.00	0.00
317	Laughing Dove	*Spilopelia senegalensis*	1	100.00	6.00	11.11	1.00
87	Lesser Flamingo	*Phoeniconaias minor*	1	66.67	4.00	55.56	5.00
125	Lesser Kestrel	*Falco naumanni*		16.67	1.00	11.11	1.00

#	Common Name	Scientific Name	Observed (Jun/Jul, 2022)	SABAP2 Reporting Rate			
				Full Protocol (%)	Number of cards	Ad Hoc Protocol (%)	Number of cards
604	Lesser Swamp Warbler	*Acrocephalus gracilirostris*	1	16.67	1.00	0.00	0.00
646	Levaillant's Cisticola	*Cisticola tinniens*	1	83.33	5.00	0.00	0.00
67	Little Bittern	*Ixobrychus minutus*		16.67	1.00	0.00	0.00
59	Little Egret	*Egretta garzetta*		16.67	1.00	0.00	0.00
6	Little Grebe	*Tachybaptus ruficollis*	1	66.67	4.00	0.00	0.00
253	Little Stint	*Calidris minuta*		16.67	1.00	11.11	1.00
385	Little Swift	*Apus affinis*		16.67	1.00	11.11	1.00
818	Long-tailed Widowbird	*Euplectes progne*		66.67	4.00	0.00	0.00
103	Maccoa Duck	*Oxyura maccoa*	1	16.67	1.00	0.00	0.00
397	Malachite Kingfisher	*Corythornis cristatus*		16.67	1.00	0.00	0.00
262	Marsh Sandpiper	*Tringa stagnatilis*		16.67	1.00	0.00	0.00
564	Mountain Wheatear	*Myrmecocichla monticola*	1	16.67	1.00	11.11	1.00
318	Namaqua Dove	*Oena capensis*		50.00	3.00	0.00	0.00
637	Neddicky	*Cisticola fulvicapilla*	1	33.33	2.00	0.00	0.00
1035	Northern Black Korhaan	*Afrotis afraoides*	1	50.00	3.00	0.00	0.00
1171	Orange River White-eye	*Zosterops pallidus*	1	50.00	3.00	0.00	0.00
522	Pied Crow	*Corvus albus*	1	16.67	1.00	0.00	0.00
746	Pied Starling	*Lamprotornis bicolor*		50.00	3.00	0.00	0.00
846	Pin-tailed Whydah	*Vidua macroura*		16.67	1.00	0.00	0.00
57	Purple Heron	*Ardea purpurea*		16.67	1.00	0.00	0.00
844	Quailfinch	*Ortygospiza atricollis*	1	83.33	5.00	0.00	0.00
642	Rattling Cisticola	*Cisticola chiniana*	1	33.33	2.00	0.00	0.00
805	Red-billed Quelea	*Quelea quelea*	1	66.67	4.00	0.00	0.00
97	Red-billed Teal	*Anas erythrorhyncha*	1	50.00	3.00	0.00	0.00
488	Red-capped Lark	*Calandrella cinerea*	1	66.67	4.00	0.00	0.00

#	Common Name	Scientific Name	Observed (Jun/Jul, 2022)	SABAP2 Reporting Rate			
				Full Protocol (%)	Number of cards	Ad Hoc Protocol (%)	Number of cards
314	Red-eyed Dove	*Streptopelia semitorquata*	1	66.67	4.00	0.00	0.00
392	Red-faced Mousebird	*Urocolius indicus*		50.00	3.00	0.00	0.00
212	Red-knobbed Coot	*Fulica cristata*	1	83.33	5.00	22.22	2.00
50	Reed Cormorant	*Microcarbo africanus*	1	33.33	2.00	0.00	0.00
940	Rock Dove	*Columba livia*		33.33	2.00	11.11	1.00
123	Rock Kestrel	*Falco rupicolus*		16.67	1.00	0.00	0.00
256	Ruff	*Calidris pugnax*		16.67	1.00	11.11	1.00
619	Rufous-eared Warbler	*Malcorus pectoralis*		0.00	0.00	11.11	1.00
458	Rufous-naped Lark	*Mirafra africana*		50.00	3.00	0.00	0.00
90	South African Shelduck	*Tadorna cana*	1	16.67	1.00	0.00	0.00
707	Southern Fiscal	*Lanius collaris*	1	83.33	5.00	0.00	0.00
4142	Southern Grey-headed Sparrow	*Passer diffusus*		16.67	1.00	0.00	0.00
803	Southern Masked Weaver	*Ploceus velatus*	1	83.33	5.00	22.22	2.00
102	Southern Pochard	*Netta erythrophthalma*	1	16.67	1.00	0.00	0.00
808	Southern Red Bishop	*Euplectes orix*	1	100.00	6.00	11.11	1.00
311	Speckled Pigeon	*Columba guinea*	1	100.00	6.00	11.11	1.00
474	Spike-heeled Lark	*Chersomanes albofasciata*	1	66.67	4.00	0.00	0.00
654	Spotted Flycatcher	*Muscicapa striata*		16.67	1.00	0.00	0.00
88	Spur-winged Goose	*Plectropterus gambensis*	1	50.00	3.00	0.00	0.00
62	Squacco Heron	*Ardeola ralloides*		16.67	1.00	0.00	0.00
185	Swainson's Spurfowl	*Pternistis swainsonii*	1	33.33	2.00	0.00	0.00
238	Three-banded Plover	*Charadrius tricollaris*	1	50.00	3.00	0.00	0.00
851	Village Indigobird	*Vidua chalybeata*		16.67	1.00	0.00	0.00
735	Wattled Starling	*Creatophora cinerea*	1	50.00	3.00	0.00	0.00
61	Western Cattle Egret	*Bubulcus ibis*	1	83.33	5.00	11.11	1.00

#	Common Name	Scientific Name	Observed (Jun/Jul, 2022)	SABAP2 Reporting Rate			
				Full Protocol (%)	Number of cards	Ad Hoc Protocol (%)	Number of cards
305	Whiskered Tern	*Chlidonias hybrida*		16.67	1.00	0.00	0.00
47	White-breasted Cormorant	*Phalacrocorax lucidus*	1	16.67	1.00	0.00	0.00
780	White-browed Sparrow-Weaver	*Plocepasser mahali*	1	100.00	6.00	22.22	2.00
100	White-faced Whistling Duck	*Dendrocygna viduata*	1	33.33	2.00	0.00	0.00
383	White-rumped Swift	*Apus caffer*		16.67	1.00	22.22	2.00
495	White-throated Swallow	*Hirundo albigularis*		83.33	5.00	0.00	0.00
304	White-winged Tern	*Chlidonias leucopterus*		16.67	1.00	0.00	0.00
866	Yellow Canary	*Crithagra flaviventris*	1	33.33	2.00	0.00	0.00
96	Yellow-billed Duck	*Anas undulata*	1	83.33	5.00	0.00	0.00
76	Yellow-billed Stork	*Mycteria ibis*		16.67	1.00	0.00	0.00
812	Yellow-crowned Bishop	*Euplectes afer*		33.33	2.00	0.00	0.00
629	Zitting Cisticola	*Cisticola juncidis*	1	33.33	2.00	0.00	0.00

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	ta04	ta05	ta03	ta01	ta02	ta06	ta07	ta08b	Mean number/ha
Ant-eating Chat	2	1.5	0	0	0	0	0	0	**0.070**
African Pipit	2	1.5	2	0	0	0	1	2	**0.170**
African Red-eyed Bulbul	0	0	0	0	0	0	0.5	0	**0.010**
Black-chested Prinia	0	0	0	0	1	0	2	0	**0.060**
Brown-crowned Tchagra	0	0	0	0	0	0	0.5	0	**0.010**
Blue Waxbill	0	0	0	0	0	0	8	0	**0.160**
Cape Longclaw	0	0	0	0	1	0	0	0	**0.020**
Cape Sparrow	2	0	0	0	2	0	0	0	**0.080**
Cape Starling	0	0	0	0	0	0	1	0	**0.020**
Chestnut-vented Warbler	0	0	0	0	0	0	2	0	**0.040**
Desert Cisticola	0	1	1	0	0	1	0	0	**0.060**
Green-winged Pytilia	0	0	0	0	0	0	0.5	0	**0.010**
Karoo Thrush	0	0	0	0	0	0	0.5	0	**0.010**
Levaillant's cisticola	0	0	0	2	2	0	0	0	**0.080**
Mountain Wheatear	0	0.5	0	0	0	0	0	0	**0.010**
Neddicky	0	0	0	0	0	0	0.5	0	**0.010**
Orange River White-eye	0	0	0	0	0	0	1	0	**0.020**
Quailfinch	0	1.5	0	0	0	0	0	0	**0.030**
Rattling Cisticola	0	0	0	0	0	0	1.5	0	**0.030**
Red-billed Quelea	0	0	0	0	0	0	54	0	**1.082**
Red-capped Lark	5	1	2	0	0	0	0	2	**0.200**
Spike-heeled Lark	0	0	0	0	0	1.5	0	0	**0.030**

Species	ta04	ta05	ta03	ta01	ta02	ta06	ta07	ta08b	Mean number/ha
Southern Masked Weaver	0	0	0	2	0	0	3	0	**0.100**
African Stonechat	0	0	0	2	0	0	0	0	**0.040**
Wattled Starling	0	0	0	0	0	0	7.5	0	**0.150**
White-browed Sparrow-weaver	0	0	0	0	0	0	9.5	0	**0.190**
Yellow Canary	0	0	0	0	0	0	1	0	**0.020**
Zitting Cisticola	0	1	0	1.5	1	0	0	0	**0.070**
Number of individuals	11.00	8.00	5.00	7.50	7.00	2.50	94.00	4.00	
Number of species	4	7	3	4	5	2	17	2	
Number of birds/ha	**14.10**	**10.26**	**6.41**	**9.62**	**8.97**	**3.21**	**120.51**	**5.13**	
Number of species/ha	**5.13**	**8.97**	**3.85**	**5.13**	**6.41**	**2.56**	**21.79**	**2.56**	
Average number of birds/ha	**22.28**								
Average number of species/ha	**7.05**								