DEVELOPMENT OF THE LICHTENBURG 1 PV SOLAR ENERGY FACILITY AND ASSOCIATED INFRASTRUCTURE ON A SITE NEAR LICHTENBURG, NORTH WEST PROVINCE

Avifauna Baseline and Impact Assessment Report

Compiled: October 2018
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EXECUTIVE SUMMARY

Pachnoda Consulting cc was requested by Savannah Environmental (Pty) Ltd to compile an avifauna baseline and impact assessment report for the proposed Lichtenburg 1 PV solar facility and associated infrastructure on Portion 06 of the Farm Zamenkomst No 04 near Lichtenburg, North West Province.

The objectives of the avifaunal study were to: (a) describe the avifauna associations in the project 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 (July 2018 and October 2018).

Four avifaunal habitat types were identified, and consisted of open mixed dolomite grassland with bush clump mosaics, artificial livestock watering points, arable/fallow land and power line pylons which were often used by vultures when roosting. Approximately 204 bird species are expected to occur in the wider study area, of which 100 species were observed in the area with 65 species confined to the study site (infrastructure footprint). The expected richness included 12 threatened or near threatened species, 15 southern African endemics and 21 near-endemic species. The critically endangered White-backed Vulture (*Gyps africanus*) was observed on the study site, although the endangered Cape Vulture (*G. coprotheres*), endangered Lappet-faced Vulture (*Torgos tracheliotos*) and near threatened Black-winged Pratincole (*Glareola nordmanni*) were confirmed from habitat adjacent to the study site. Seven southern African endemics and 13 near-endemic species were confirmed on the study site.

The main impacts associated with the proposed PV solar facility includes 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 low or moderate after mitigation (depending on the type of impact), with the exception of the potential for birds to collide with the associated power lines, which was high without mitigation (and moderate after mitigation). The study site was not located near any prominent wetland system or impoundment, and therefore the

risk of waterbird collisions with the proposed infrastructure was considered to be low. However, in the absence of sufficient information on the occurrence and rate of passing waterbirds, it was recommended that supporting evidence be acquired by means of another follow-up survey during the peak wet season (after the area has received sufficient rains) to inform the final EMPr during operation.

The endangered Cape Vulture (*Gyps coprotheres*), critically endangered White-backed Vulture (*Gyps africanus*) and Lappet-faced Vulture (*Torgos tracheliotos*) were identified as regular foraging visitors to the study site (according to SABAP2 reporting rates and on-site observations). These species are highly prone to power line collisions, whereby the proposed energy facility (especially the proposed overhead power lines) could pose a collision and electrocution risk to vultures. The risk of collision/electrocution was considered likely when vultures feed on a carcass in close proximity to a power line or when attempting to roost on the pylon structures (especially vultures visiting a nearby active vulture restaurant). However, with mitigation the risk of vultures colliding with the associated infrastructure could be reduced from a high to a medium significance.

In addition, a total of 48 collision-prone bird species have been recorded from the wider study area (*sensu* atlas data), of which 23 species were birds of prey.

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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 the Savannah Environmental (Pty) Ltd and ABO Wind Lichtenburg 1 PV (Pty) Ltd;
- I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have no vested financial, personal or any other interest in the application;
- I have no, and will not engage in, conflicting interests in the undertaking of the activity;
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority; and
- All the particulars furnished by me in this form are true and correct.

Lukas Niemand (Pr.Sci.Nat)
21 March 2022

Lukas Niemand is registered with The South African Council for Natural Scientific Professionals (400095/06) with more than 15 years of experience in ecological-related assessments and more than 10 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

The increase in human demand for space and life-supporting resources resulted in a rapid loss of natural open space in South Africa. When natural systems are rezoned for development, indigenous fauna and flora are replaced by exotic species and converted to sterile landscapes with no dynamic propensity or ecological value (Wood *et al.,* 1994). Additionally, development rarely focussed on decisive planning to conserve natural environments, while little thought was given to the consequences on the ecological processes of development in highly sensitive areas.

Transformation and fragmentation are not the only results of unplanned and intended developments, the loss of ecosystem functioning and ultimately the local extinction of species can also occur. Therefore, careful planning will not only preserve rare and endemic fauna and flora, but also the ecological integrity of ecosystems on a landscape level which is imperative for the continuation of natural resources, such as fossil fuels, water and soils with agricultural potential.

In 1992, the Convention of Biological Diversity, a landmark convention, was signed by more than 90 % of all members of the United Nations. The enactment of the National Environmental Management Biodiversity Act, 2004 (Act No. 10 of 2004), together with the abovementioned treaty, focuses on the preservation of all biological diversity in its totality, including genetic variability, natural populations, communities, and ecosystems up to the scale of landscapes. Hence, the local and global focus changed to the sustainable utilisation of biological diversity.

1.1 Background

Pachnoda Consulting cc was requested by Savannah Environmental (Pty) Ltd on behalf of ABO Wind Lichtenburg 1 PV (Pty) Ltd to compile an avifauna baseline and impact assessment report for the proposed Lichtenburg 1 PV solar facility and associated infrastructure on Portion 06 of the Farm Zamenkomst No 04 ("herewith referred to as the "study site") near Lichtenburg, North West Province (Figure 1).

The proposed solar facility has been granted preferred bidder status under a private independent power producer procurement programme and will evacuate power generated from the facility into the Eskom national electricity grid and aid in the diversification and stabilisation of the country's electricity supply . The area under investigation is approximately 428 ha in extent and comprises an agricultural property.

The solar energy facility will have a contracted capacity of up to 100MW, and will make use of either Fixed-tilt, Single-Axis Tracking, or Double-Axis Tracking PV technology. The solar energy facility will comprise the following key infrastructure components:

- Arrays of PV panels (either static or tracking PV systems) with a generation capacity of up to 100MW.
- Mounting structures to support the PV panels.
- On-site inverters to convert the power from Direct Current (DC) to Alternating Current (AC) and a substation to facilitate the connection between the solar energy facility and the Eskom electricity grid.
- A new 132kV power line between the on-site substation and the Eskom grid connection point will be required. Two options are currently being considered for grid connection:
  - Connecting the facility to the existing Watershed Main Transmission Substation (MTS) (preferred option).
  - Connecting the facility (i.e. loop-in-loop-out) to one of the power lines which traverses the property in a north-south direction (dependent on line capacity).
- Cabling between the project components (to be laid underground where practical).
- Offices and workshop areas for maintenance and storage.
- Temporary laydown areas.
- Internal access roads and fencing around the development area.

The full extent of the project site (*c*. 428 ha) will be assessed as part of the EIA process, of which an area of approximately 280 ha (65%) of the total project area would be required for the development of the solar energy facility and associated infrastructure. The PV structures/modules will occupy an area approximately 255 ha in extent, while supporting infrastructure such as internal access roads (18 ha), auxiliary buildings (1 ha), and an onsite substation (1 ha) will occupy the remaining extent. During construction, a temporary laydown area approximately 5 ha in extent will be required.

The project will comprise approximately 300 000 – 400 000 solar panels which once installed will stand 3.5m above ground level. The solar panels will have a maximum of approximately 80 centralised inverter stations at a height of approximately 3 m, or approximately 1120 string inverters mounted at a minimum height of approximately 300 mm above ground.

A 132kV on-site substation is required, and will occupy an area approximately 100m x 100m in extent. A single power line is required to connect the solar energy facility to Eskom's national electricity grid. The power line will have a capacity of 132kV, be approximately 24m in height, and will be developed in a power line servitude of 31 m – 36 m in width (i.e. 15.5m – 18m either side of centre line), and will make use of monopole or lattice tower structures. Generated electricity from the facility substation will feed into a switching station located on the planned Lichtenburg 3 PV facility. All the planned Lichtenburg 1-3 PV facilities will connect at this switching station, and electricity will be evacuated from the switching station via a 132kV power line which will terminate at Watershed Substation. Thus, instead of each project having its own power line and connecting to Watershed, only one 132kV power line will be built and through this power line and the switching station.

1.2 Objectives and Terms of Reference

The main objectives of the avifaunal study were to: (a) describe the avifauna associations in the project 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; sensu IUCN, 2017; 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 study site 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 site;
    - highlight areas of concern or "hotspot" areas;
    - identify and describe impacts that are considered pertinent to the proposed development;
    - highlight gaps of information in terms of the avifaunal environment; and
    - recommend additional surveys and monitoring protocols (*sensu* Jenkins et al., 2017).

1.3 Scope of Work

The following aspects form part of the Scope of Work:

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

The following aspects will be discussed during this avifaunal assessment:

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

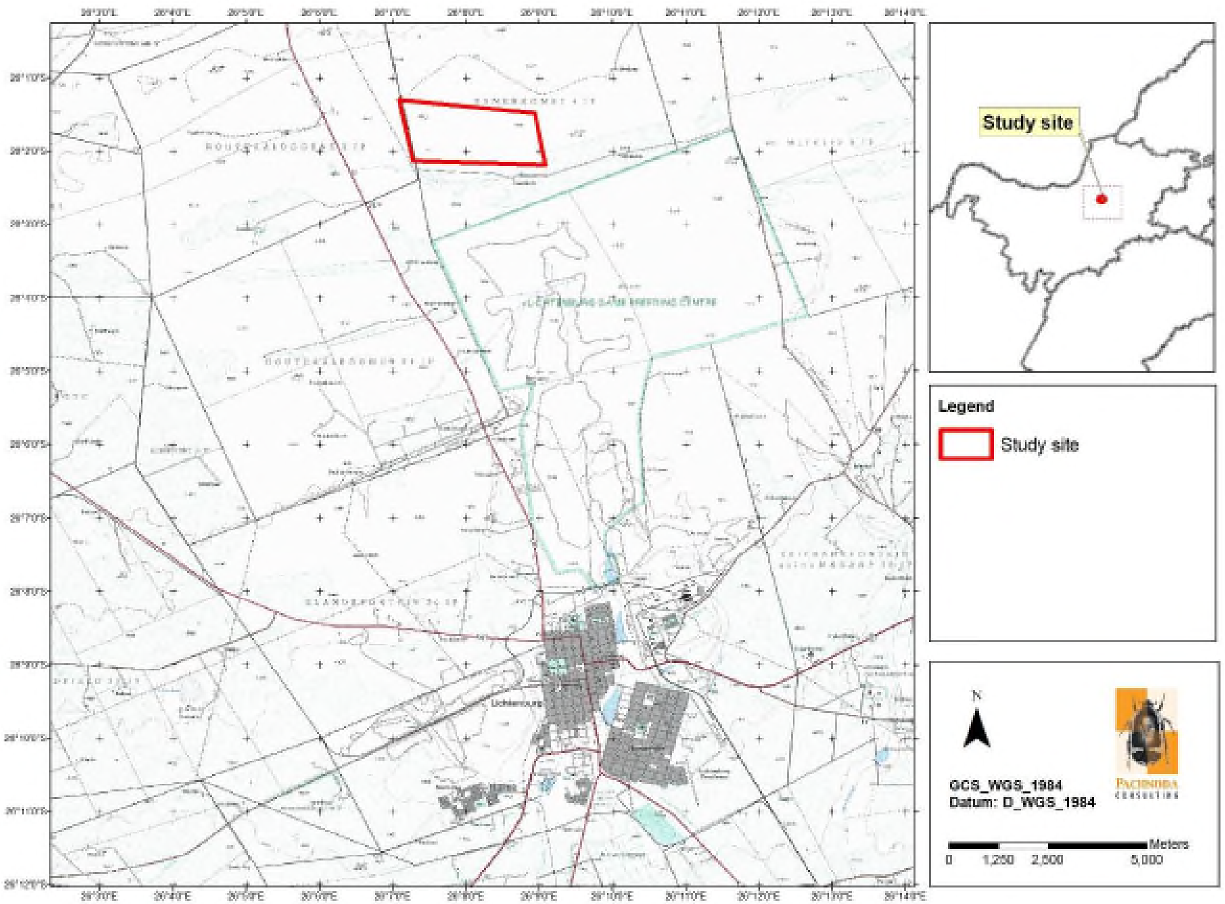

Figure 1: A topo-cadastral image illustrating the geographic position of Lichtenburg 1 PV solar energy facility.

2. METHODS & APPROACH

Take note that the current report places emphasis on the avifaunal community as a key indicator group on the proposed study site, thereby aiming to describe the conservation significance of the ecosystems in the area. Therefore, the occurrence of certain bird species and their relative abundances may determine the outcome of the ecological sensitivity of the area and the subsequent proposed layouts of the solar facility infrastructure.

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

- relevant literature – see section below;
- observations made during two site visits (03 - 06 July 2018 and 15 - 19 October 2018); and
- personal observations from similar habitat types in proximity to the study area, with emphasis on assessments conducted by Pachnoda Consulting (2018) of which the avifauna study was conducted by the author.

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), Harrison *et al.* (1997) and Del Hoyo *et al.* (1992-2011) for general information on bird identification and life history attributes.
- Marnewick *et al.* (2015) was consulted for information regarding the biogeographic affinities (e.g. biome-restricted bird species) of selected bird species that could be present on the study site.
- The conservation status of bird species was categorised according to the global IUCN Red List of threatened species (IUCN, 2017) 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 the quarter-degree grid cell (QDGC) 2626AA (Lichtenburg). The information was then modified according to the prevalent habitat types present on the study site. 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.adu.org.za). The information was then modified according to the prevalent habitat types present on the study site. 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 2600_2605 (although all eight surrounding pentad grid information was also scrutinised; Figure 2).
- The choice of scientific nomenclature, taxonomy and common names were recommended by the International Ornithological Committee (the IOC World Bird List v. 8.2), unless otherwise specified (see www.worldbirdnames.org as assigned by Gill & Donsker, 2018).
- All observations obtained during the site visits (03 - 06 July 2018 and 15 - 19 October 2018) were submitted to the South African Bird Atlas Project (SABAP2).
- Incidental occurrence records for large birds of prey and vulture tracking data were included.
- Data on power line derived bird mortalities were requested from the electrical infrastructure mortality incident register (the dataset was provided by EWT).
- The best practice guidelines for solar facilities by BirdLife South Africa (Jenkins et al., 2017).
- Additional information regarding bird-power line interactions was provided by the author's own personal observations.

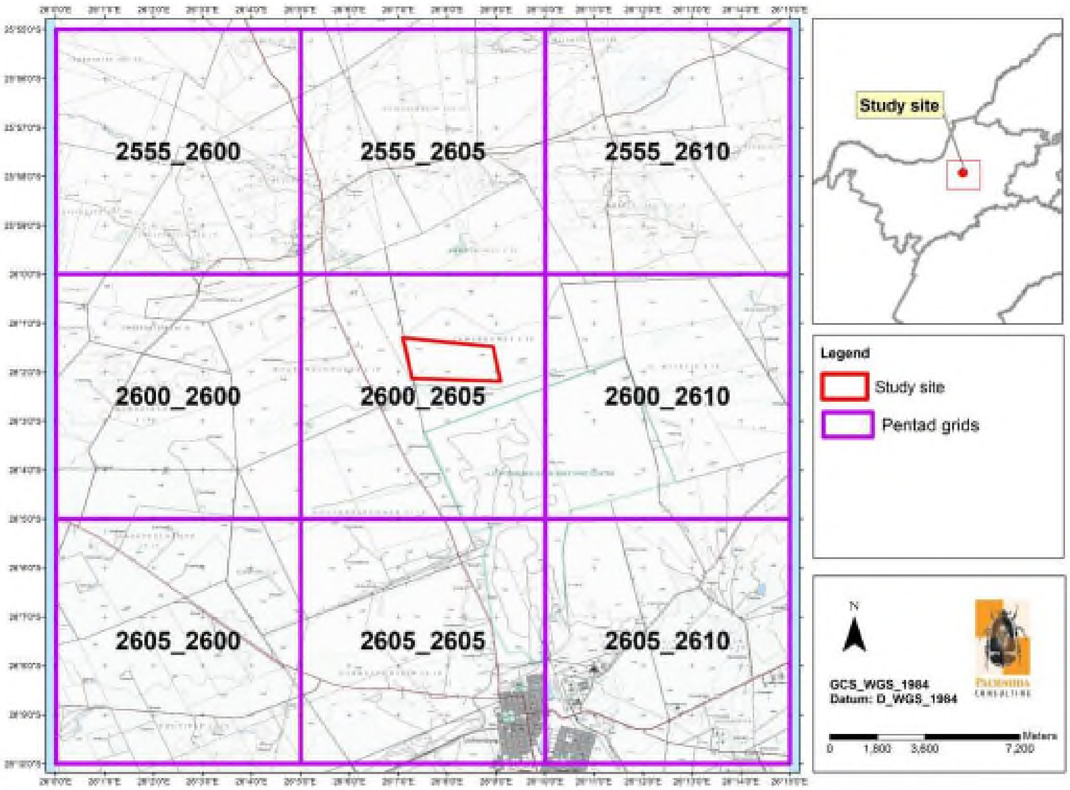

Figure 2: A map illustrating the pentad grids that were investigated for this project.

2.2 Field Methods

The avifauna of the study site was surveyed during two independent site visits representing an austral dry (winter) season survey (03 - 06 July 2018) and an austral wet (summer) season survey (15 - 19 October 2018).

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 20 point counts (as per Buckland et al. 1993), where all birds seen and heard from a specific point over a set period of time was recorded. Data from the point counts has been analysed to determine dominant and indicator bird species (so-called discriminant species), relative densities and to delineate the different bird associations present.

The use of point counts is advantageous since it is the preferred method to use for skulking or elusive species. In addition, it is the preferred method to line transect counts where access is problematic, or when the terrain appears to be complex (e.g. mountainous). It is considered to be a good method to use, and very efficient for gathering a large amount of data in a short period of time (Sutherland, 2006). The spatial position of each point count is illustrated in Figure 3. 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).

Strong winds and a frontal system occurred during the first few days of the dry season survey (July 2018), meaning the majority of birds were perched inside vegetation and the graminoid layer, thereby obscuring detection of the birds by means of conventional static point count sampling. Therefore, the sampling approach was adapted so that all the bird species seen within approximately 100m from the centre of the point were recorded (resulting in an area of 3.14 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 100m 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 diversity of each bird association was analysed by means of rarefaction, while richness measures (such as the total number of species recorded (S) and Shannon Wiener Index) were calculated to compare the associations with each other. The advantage of rarefaction is that it adjusts the number of species expected from each sample if all were reduced to a standard size.

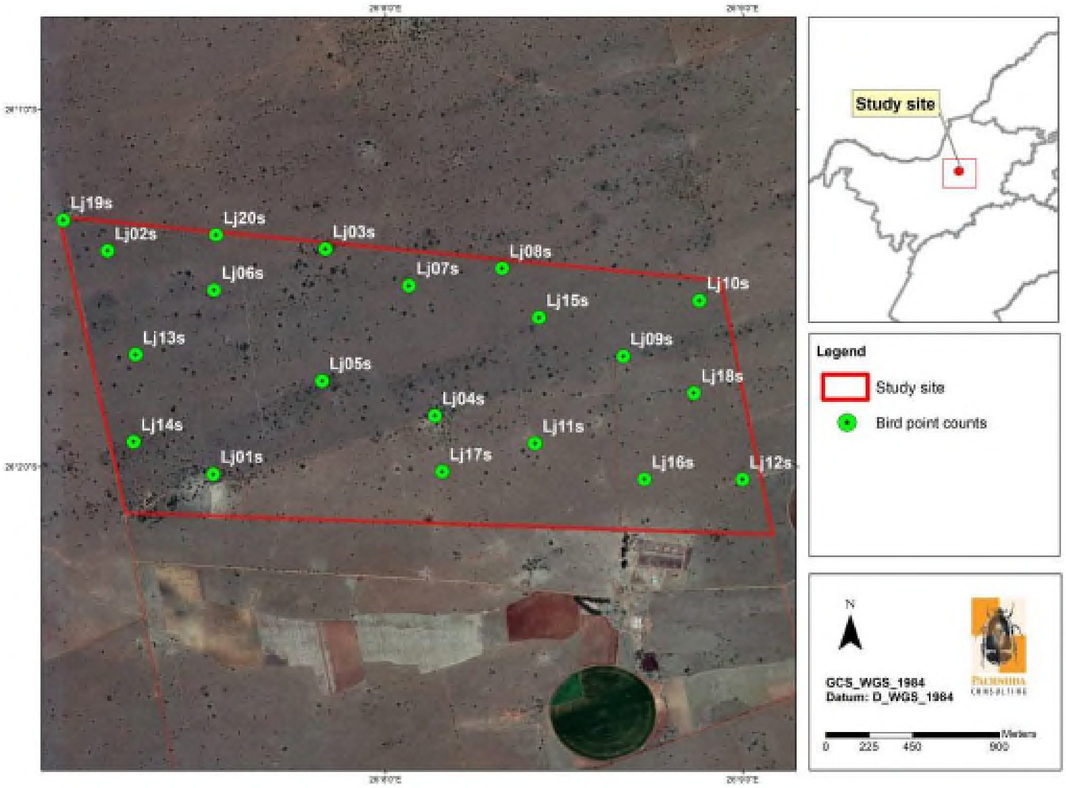

Figure 3: A map illustrating the spatial position of 20 bird point counts.

2.3 Sensitivity Analysis

A sensitivity map was compiled based on the outcome of the baseline results.

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 services (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 contain high numbers of threatened, endemic or rare bird species. These areas should preferably be protected;
- *Moderately high* - Untransformed or productive habitat units (which can also be artificial) which contain high bird numbers and/or bird richness values. These areas are often fragmented OR azonal, and hence of small surface area that are often surrounded by habitat of moderate or low sensitivity. These habitat units also include potential habitat for threatened species. Development is often considered permissible on these areas if there is enough reason to believe that these areas are widespread in the region and future planned developments are unlikely to result in the widespread loss (>50 %) of similar habitat at a regional scale.
- *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 bird species diversity (most species are usually exotic or weeds).

2.4 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.
- The study area was previously poorly surveyed prior to the baseline survey. Therefore, bird richness information for the area is incomplete.
- An important limitation of the assessment is the timing of the austral wet season survey (October 2018), which was commissioned literally a few days after the area received its first major burst of precipitation. It means that the vegetation has not fully recovered from the pending dry season.
- The survey coincides with the early part of October when many Palearctic migrant species have not arrived at their final wintering grounds (e.g. very few Barns Swallows *Hirundo rustica* were observed). Those species that were observed are believed to be early arrivals, thereby implying that the inferred richness index and bird abundance values are biased and may represent an underestimation as benchmark/reference data during additional pre-construction monitoring.

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 study site is located on Portion 06 of the Farm Zamenkomst No 04, approximately 12km north-north-west of Lichtenburg, in Ward 16 of the Ditsobotla Local Municipality, of Ngaka Modiri Molema District, North West Province (see Figure 1).

3.2 Regional Vegetation Description

The study site corresponds to the Grassland Biome and more particularly to the Dry Highveld Grassland Bioregion as defined by Mucina & Rutherford (2006). It consists of an ecological type known as Carletonville Dolomite Grassland (Mucina & Rutherford, 2006) (Figure 4).

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.

Carletonville Dolomite Grassland is confined to the dolomite plains that stretch from Lichtenburg in the North West Province to sections of rocky grassland in Gauteng, especially between altitudes of 1 350m and 1 450m. It occurs on slightly undulating plains dissected by prominent chert ridges, thereby containing a grassland composition rich in floristic species forming a complex mosaic dominated by many plant species.

Currently, only 2% of the remaining 76% of untransformed Carletonville Dolomite Grassland is formally protected within the Cradle of Humankind World Heritage Site and various nature reserves such as Abe Baily and Krugersdorp Nature Reserves.

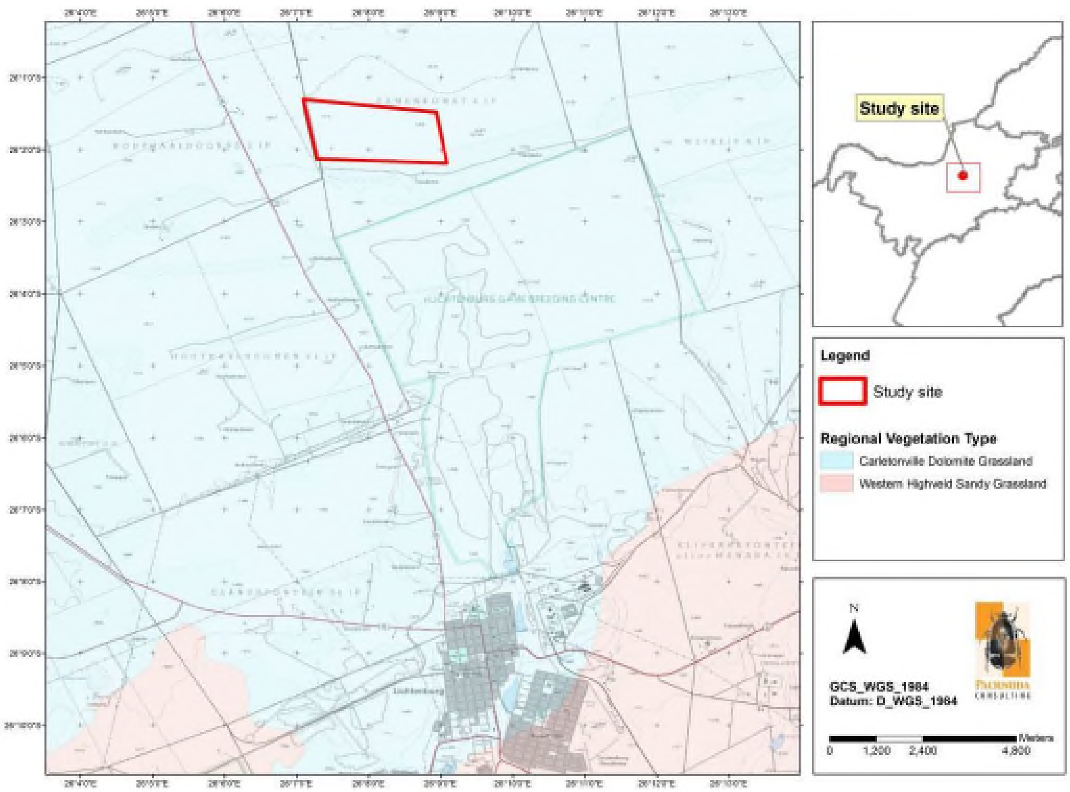

Figure 4: A topographic image illustrating the regional vegetation type corresponding to the study site. Vegetation type categories were identified according to Mucina & Rutherford (2006).

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 5):

Natural areas:

- Grassland;
- Low shrubland; and
- Woodland and open bush.

From the land cover dataset it is evident that the entire study site is covered by natural vegetation consisting of open grassland and bush clumps. The study site is primarily used for livestock grazing. The only existing infrastructure includes artificial livestock watering points and a power line servitude along the western perimeter of the study site.

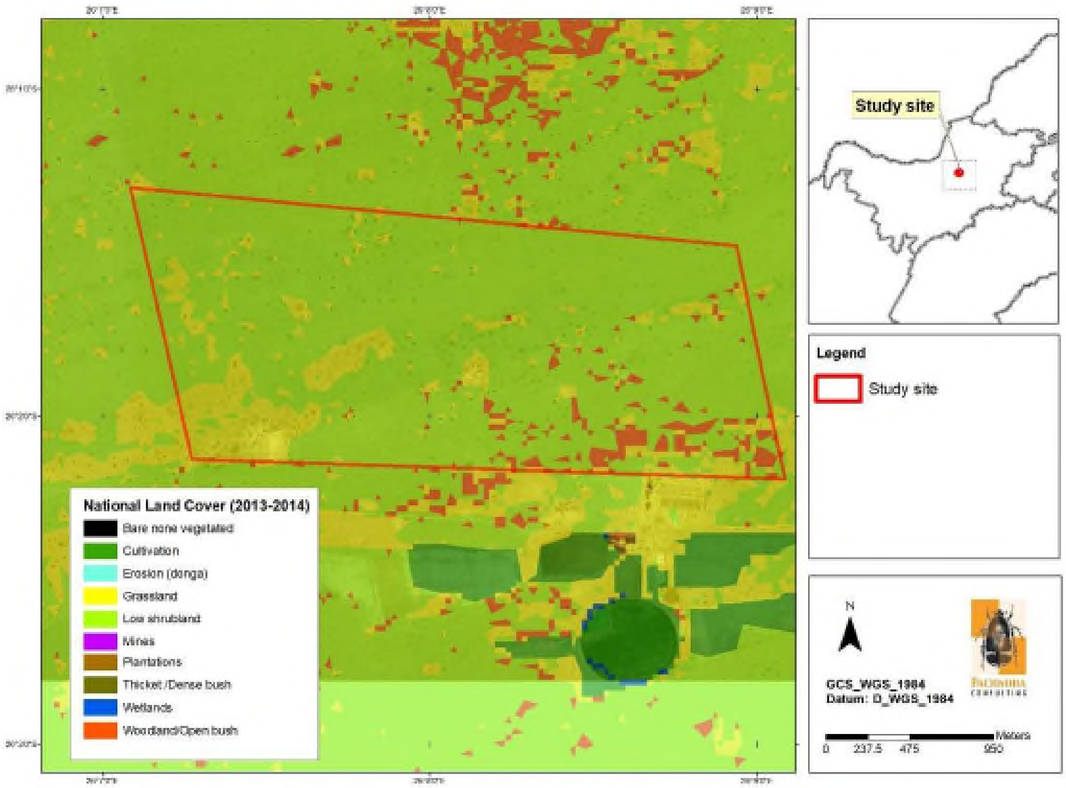

Figure 5: A map illustrating the land cover classes (Geoterrainimage, 2015) corresponding to the proposed study site.

3.4 Conservation Areas, Protected Areas and Important Bird Areas

The study site is situated in close proximity (approx. 670m) to a game farm which was previously known as the Lichtenburg Game Breeding Centre (Figure 6). This area contains a variety of game species, and the facility operates a vulture restaurant (approx. 4.3 km south of the study site) which attracts foraging and roosting vultures (c. three species) to the region. It is currently monitored by VulPro, an NGO, which is actively involved in vulture research, monitoring, rehabilitation and satellite tracking of individuals. This area is currently under new management by lease agreement with the municipality and/ or government. In addition, the reserve manager (pers. comm, Mr N. Lourens) operates a vulture restaurant on the property who also mentioned that foraging vultures are regular visitors to the restaurant and that the birds are fed on a frequent/ regular basis.

There are no formal protected areas or any Important Bird and Biodiversity Areas in close proximity to the study site. The nearest Important Bird Areas (IBAs) to the study site are Baberspan and Leeupan (SA026), and the Botsalano Nature Reserve (SA024) located approximately 70km away to the south-west and north-west respectively.

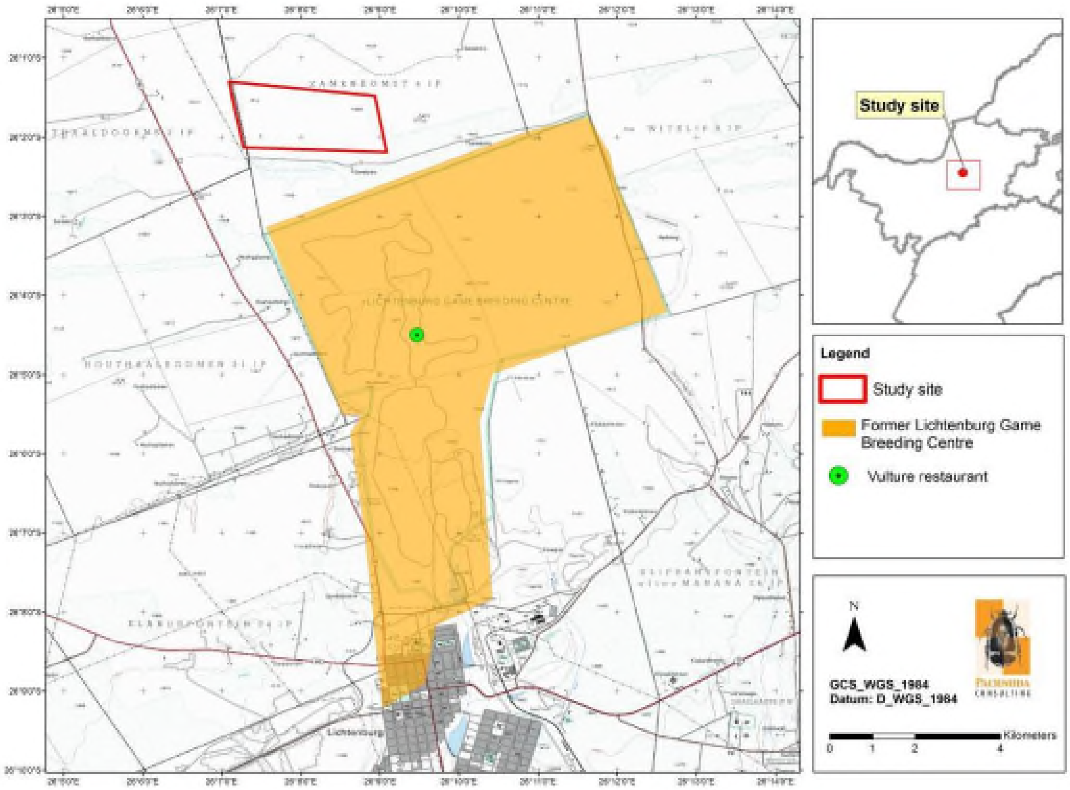

Figure 6: A map illustrating the locality of a game farm facility with a vulture restaurant in close proximity to the proposed study site. Note the locality of an active vulture restaurant in the study region.

4. RESULTS AND DISCUSSION

4.1 Avifaunal habitat types

Four pertinent avifaunal habitat types occur on the study site and are further discussed below (Figure 7, Figure 8 and Figure 9):

1. *Open mixed dolomite grassland with bush clump mosaics:* This unit is prominent on the study site and covers nearly the entire surface area of the study site, the substation options and the proposed corridor alignments. It is represented by two discrete floristic variations which also provide habitat for two discrete avifaunal associations. The first floristic variation consists of open untransformed to semi-transformed mixed dolomite grassland and bush clumps with an eminent woody layer. The grassland variation is represented by untransformed and semi-transformed Carletonville Dolomite Grassland, depending on grazing intensity, and dominated by "late-successional" graminoids such a *Themeda triandra, Cymbopogon caesius, C. pospischilii, Trachypogon spicatus, Elionurus muticus* and *Andropogon schirensis*. It is occupied by a typical grassland bird composition dominated by insectivorous and granivore passerine bird species such as Desert Cisticola, (*Cisticola aridulus*), Melodious Lark (*Mirafra cheniana*)[1], Rufous-naped Lark (*Mirafra africana*), Eastern Clapper Lark (*Mirafra fasciolata*) and Plain-backed Pipit (*Anthus leucophrys*). Prominent non-passerine species include Orange River Francolin (*Scleroptila gutturalis*), Swainson's Spurfowl (*Pternistis swainsonii*), Northern Black Korhaan (*Afrotis afraoides*), Crowned Lapwing (*Vanellus coronatus*) and Black-winged Kite (*Elanus caeruleus*). The omnivorous Pied Crow (*Corvus albus*) is also prominent.

   The bush clumps form a prominent mosaic characterised by the dominance of a woody layer of *Searsia lancea, S. pyroides, Ziziphus mucronata, Gymnosporia buxifolia* and *Asparagus laricinus*. *Celtis africana* and *Olea europaea subsp. africana* are canopy constituents in some areas. The eminent increase in vertical heterogeneity provided by the woody layer is responsible for a "Bushveld" bird association consisting of insectivorous passerines such as Black-chested Prinia (*Prinia flavicans*), Chestnut-vented Warbler (*Sylvia subcoerulea*), Kalahari Scrub Robin (*Cercotrichas paena*), Fiscal Flycatcher (*Melaenornis silens*), Dark-capped Bulbul (*Pycnonotus tricolor*) as well as granivores such as Yellow Canary (*Crithagra flaviventris*), Red-billed Quelea (*Quelea quelea*) and Southern Masked Weaver (*Ploceus velatus*). Passerine bird taxa are represented by Laughing Dove (*Spilopelia senegalensis*), Cape Turtle Dove (*Streptopelia capicola*), Acacia Pied Barbet (*Tricholaema leucomelas*) and White-backed Mousebird (*Colius colius*).

[1] This species represents a new record ("out of range" species) for the area, and probably an indication of range extension or was overlooked in the past. It was observed on the site during July 2018 and October 2018.

2. *Artificial livestock watering points*: These are represented by artificial water troughs and reservoirs with the purpose to provide drinking water to livestock. However, they act as focal congregation areas for many granivore passerine and non-passerine species, including Cape Sparrow (*Passer melanurus*), Laughing Dove (*Spilopelia senegalensis*), Namaqua dove (*Oena capensis*), Scaly-feathered Finch (*Sporopipes squamifrons*) and Wattled Starling (*Creatophora cinerea*). Due to cattle congregating at these features, they also invariably attract scavenger species such as vultures.

3. *Power line servitude and pylons (high voltage)*: A single 132 kV power line consisting of wooden pylons is located along the western boundary of the study site. Three powerline servitudes (c. 132kV) are also located along the western boundary of OHL corridor 2 (including part of OHL corridor 3). Power line pylons are important roosting substrate for large birds of prey and vulture taxa. It is known that Cape Vultures (*Gyps coprotheres*) and White-backed Vultures (*G. africanus*) utilise pylons extensively for roosting purposes (Wolter et al., 2010). Some of the pylons in the study site could be used by vultures for roosting when attracted to carcasses or even by vultures visiting the vulture restaurant located on a nearby game farm. During the winter survey, a single White-backed Vulture (*G. africanus*) was observed roosting on a pylon (04 July 2018 @ 07: 11 AM).

4. *Arable and fallow land:* This habitat is confined to agricultural fields and located on part of OHL corridor 2 and OHL corridor 3. These often attract large congregations of granivore bird species when the land/fields are prepared or during harvesting. Typical bird species that are expected to forage in large numbers include Speckled Pigeon (*Columba guinea*), Red-eyed Dove (*Streptopelia semitorquata*), Red-capped Lark (*Calandrella cinerea*), Chestnut-backed Sparrow-lark (*Eremopterix leucotis*), Red-billed Quelea (*Quelea quelea*), Quailfinch (*Ortygospiza atricollis*) and during the dry season influxes of Capped Wheatear (*Oenanthe pileata*) are also expected. Bird species prone towards collision with electrical infrastructure that may also utilise this habitat during foraging include Helmeted Guineafowl (*Numida meleagris*), Black-headed Heron (*Ardea melanocephala*), large-bodied anseriform species such as Egyptian Goose (*Alopochen aegyptiaca*) and Spurwing Goose (*Plectropterus gambiensis*) and during the austral summer also White Stork (*Ciconia ciconia*).

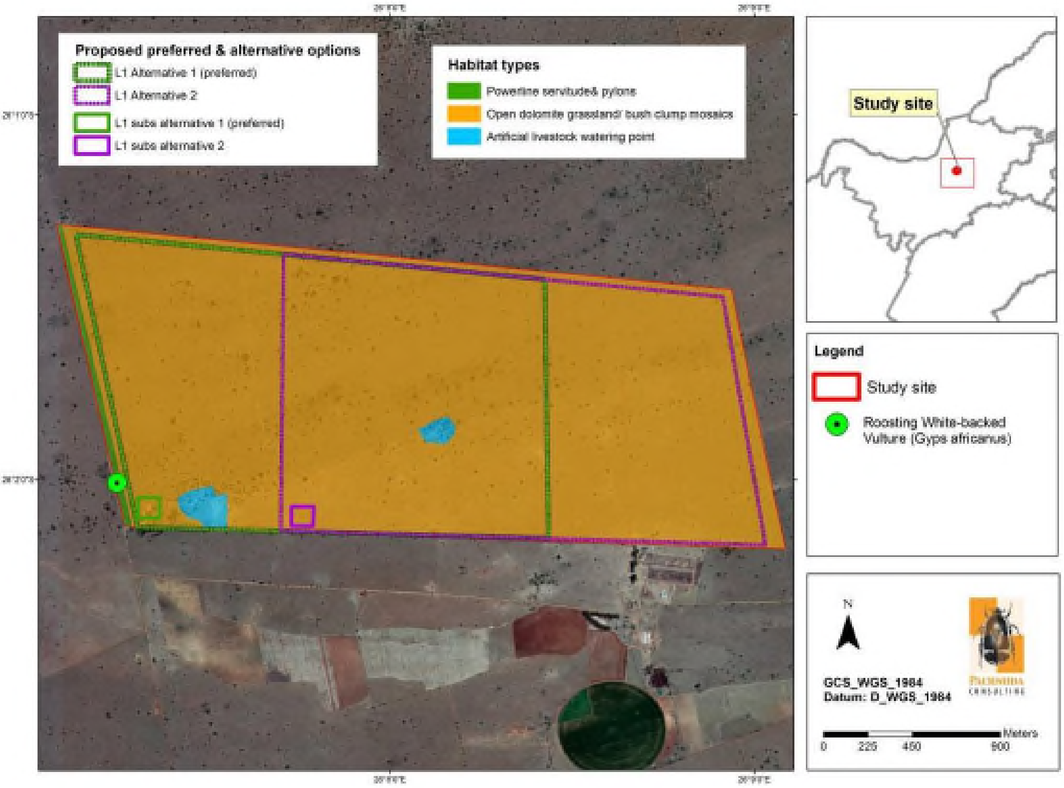

Figure 7: A habitat map illustrating the important avifaunal habitat types on the study site.

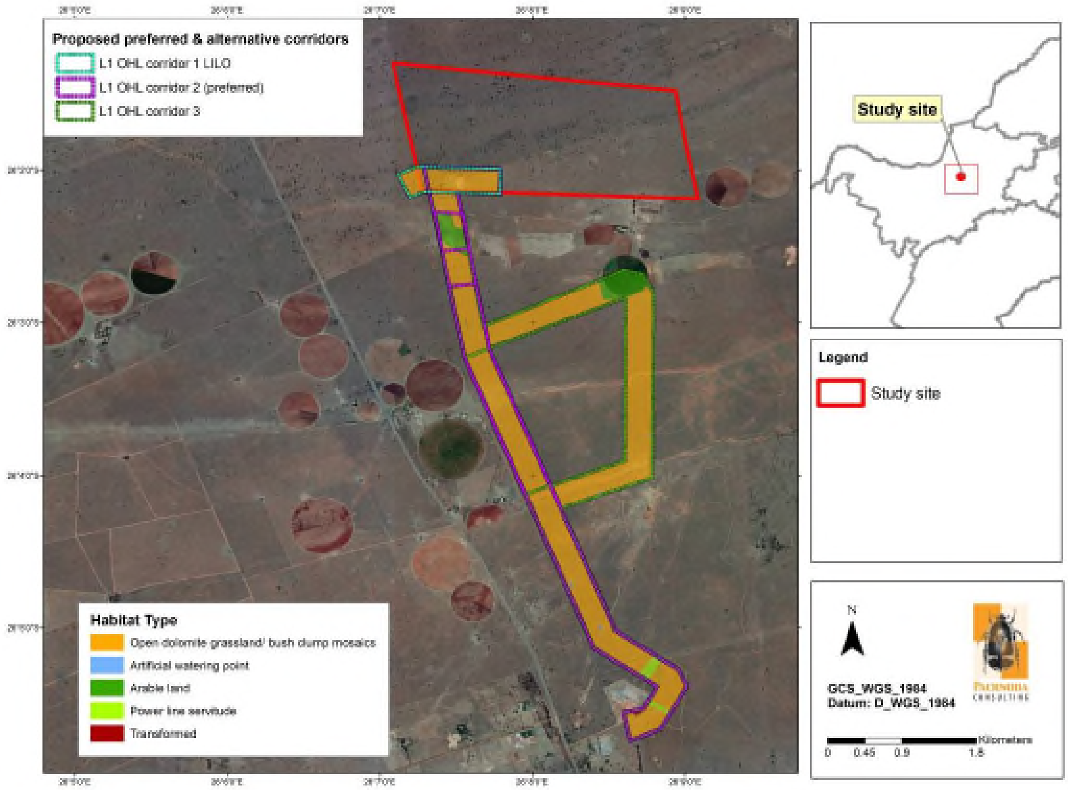

Figure 8: A habitat map illustrating the important avifaunal habitat types along the proposed power line corridor alternatives.

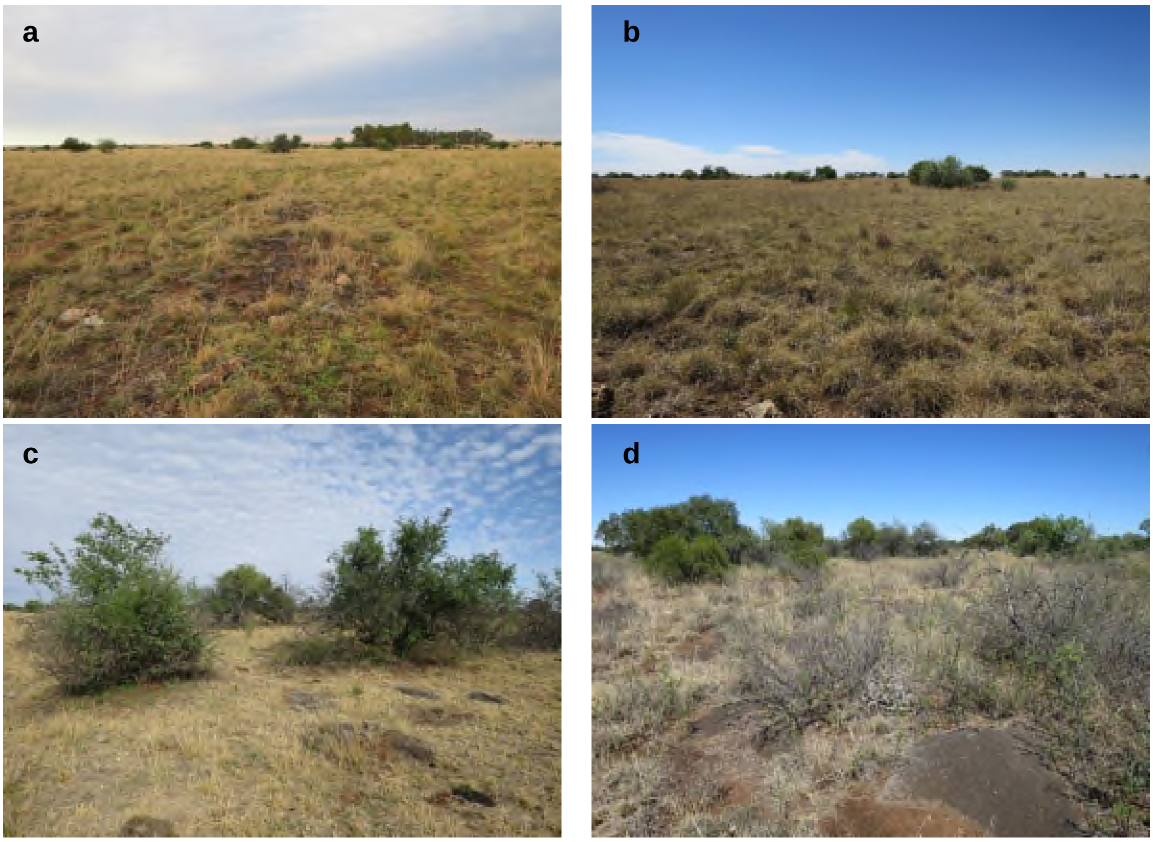

Figure 9: A collage of images illustrating examples of avifaunal habitat types on the study site (observed during October 2018): (a - d) open mixed dolomite grassland and bush clump mosaics, (e - f) artificial livestock watering points and (g - h) power line servitude and pylons.

4.2 Species Richness and Summary statistics

Approximately 204 bird species are expected to occur on the wider study area (refer Appendix 1 and Table 1). The expected richness was inferred from the South African Bird Atlas Project (SABAP1 & SABAP2)[2] (Harrison et al., 1997; www.sabap2.org) and the presence of suitable habitat in the study area. The expected richness is also strongly correlated with favourable environmental conditions (e.g. during good rains) and seasonality (e.g. when migratory species are present). This equates to 21 % of the approximate 976[3] species listed for the southern African subregion[4] (and approximately 24 % of the 855 species recorded within South Africa[5]). However, the species richness obtained[6] from the pentad grid 2600_2605 corresponding to the study site was significantly lower with 117 species recorded. According to field observations, the average number of species observed per pentad grid is *ca*. 100 species (77 species during the austral dry season and 100 during the austral summer) of which 65 species were confirmed on the Lichtenburg PV 1 study site[7] during the surveys (with 49 species observed during the July 2018 survey and 55 species during the October 2018 survey; see Appendix 2). The statistic obtained for the pentad grid described approximately 50 % of the expected richness, and the lower observed richness value is best explained by the monotonous habitat structure that is prevalent across the study site. On a national scale, the species richness per pentad on the study area is considered moderate (refer to Figure 10).

According to Table 1, the study site is poorly represented by biome-restricted[8] (see Table 2) and local endemic bird species. It does support *ca*. 34 % of the near - endemic species present in the subregion. Of the 204 bird species recorded in the study region, 12 are threatened or near threatened species, 15 are southern African endemics and 21 are near-endemic species. In addition, one critically endangered species (White-backed Vulture *Gyps africanus*) was observed on the study site, although two threatened (Cape Vulture *G. coprotheres* and Lappet-faced Vulture *Torgos tracheliotos*) and one near threatened species (Black-winged Pratincole *Glareola nordmanni*) were confirmed from habitat adjacent to the study site (Table 3). Furthermore, seven southern African endemics and 13 near-endemic species were confirmed on the study site (Table 3).

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2 The expected richness statistic was derived from the QDS 2626AA (Lichtenburg) with a total of 271 bird species recorded (according to 142 cards submitted) and pentad grid 2600_2605 (including adjacent grids) totalling 317 bird species (based on 66 full protocol cards). The SABAP2 statistic was corrected by excluding erroneous submissions of species "splits", including White-browed Coucal (*Centropus superciliosus*), the Clapper and Long-billed Lark complex (splits emanating from *Mirafra apiata* and *Certhilauda curvirostris*), Orange River White-eye (*Zosterops pallidus*), Olive Thrush (*Turdus olivaceus*) and Northern Grey-headed Sparrow (*Passer griseus*).

3 *sensu* www.zestforbirds.co.za (Hardaker, 2018)

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

5 With reference to South Africa (including Lesotho and Swaziland (BirdLife South Africa, 2018).

6 Including observations made during the July 2018 and October 2018 surveys.

7 With reference to Portion 06 of the Farm Zamenkomst No 04.

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

Prominent wetland features and waterbodies are absent from the study site and surroundings, thereby explaining the absence of waterfowl, wading birds and shorebird taxa.

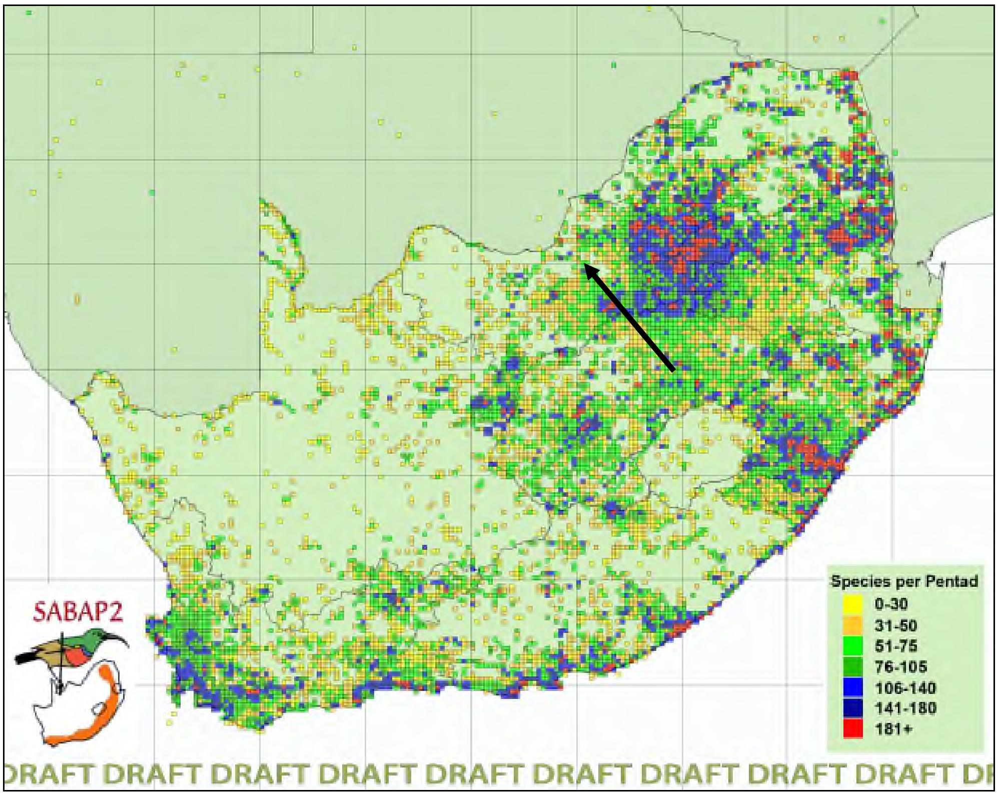

Figure 10: The bird species richness per pentad grid in comparison to the broader study area (see arrow) (map courtesy of SABAP2 and the Animal Demography Unit). According to the SABAP2 database, the study area hosts between 76 - 105 species.

Table 1: A summary table of the total number of species, Red listed species (according to Taylor *et al*., 2015 and the IUCN, 2017), endemics and biome-restricted species (Marnewick *et al*., 2015) expected (*sensu* SABAP1 and SABAP2) to occur in the study site.

Description	Expected Richness Value (study area and surroundings)***	Observed Richness Value (Portion 06 of the Farm Zamenkomst No 04)****
Total number of species*	204 (24 %)	65 (32 %)
Number of Red Listed species*	12 (9 %)	1 (8 %)
Number of biome-restricted species – Zambezian and Kalahari-Highveld Biomes*	2 (1.5 %)	2 (100 %)
Number of local endemics (BirdLife SA, 2018)*	2 (5 %)	0 (0 %)
Number of local near-endemics (BirdLife SA, 2018)*	7 (2 %)	4 (57 %)
Number of regional endemics (Hockey *et al*., 2005)**	15 (15 %)	7 (47 %)

Description	Expected Richness Value (study area and surroundings)***	Observed Richness Value (Portion 06 of the Farm Zamenkomst No 04)****
Number of regional near-endemics (Hockey *et al.,* 2005)**	21 (34 %)	13 (62 %)

* only species in the geographic boundaries of South Africa (including Lesotho and Swaziland) 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, 2018).
**** Percentage values in brackets refer to totals compared against the expected number of species in the study area.

Table 2: Expected biome-restricted species (Marnewick *et al*, 2015) observed on the study site.

Species	Kalahari-Highveld	Zambezian	Expected Frequency of occurrence
Kalahari Scrub-robin (*Cercotrichas paena)*	X		Abundant
White-bellied Sunbird (*Cinnyris talatala*)		X	Uncommon

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

Common Name	Scientific name	Regional Status	Global Status	Observed (July & October 2018)	Collision with power lines	Displacement (disturbance & loss of habitat)
Vulture, White-backed	*Gyps africanus*	CR	CR	1	1	1
Vulture, Cape	*Gyps coprotheres*	EN	EN	1*	1	1
Vulture, Lappet-faced	*Torgos tracheliotos*	EN	EN	1*	1	1
Eagle, Martial	*Polemaetus bellicosus*	EN	VU		1	1
Eagle, Tawny	*Aquila rapax*	EN			1	1
Barbet, Acacia Pied	*Tricholaema leucomelas*	End		1		1
Boubou, Southern	*Laniarius ferrugineus*	End				1
Chat, Anteating	*Myrmecocichla formicivora*	End		1		1
Cliff-swallow, South African	*Hirundo spilodera*	End				1
Flycatcher, Fairy	*Stenostira scita*	End				1
Flycatcher, Fiscal	*Melaenornis silens*	End		1		1
Korhaan, Northern Black	*Afrotis afraoides*	End		1	1	1
Lark, Melodious	*Mirafra cheniana*	End		1		1
Longclaw, Cape	*Macronyx capensis*	End		1		1
Mousebird, White-backed	*Colius colius*	End		1		1
Starling, Pied	*Lamprotornis bicolor*	End				1
Thrush, Karoo	*Turdus smithi*	End		1*		1
Weaver, Cape	*Ploceus capensis*	End				1
White-eye, Cape	*Zosterops virens*	End		1		1
Bokmakierie	*Telophorus zeylonus*	N-end		1		1
Bulbul, African Red-eyed	*Pycnonotus nigricans*	N-end				1
Bunting, Lark-like	*Emberiza impetuani*	N-end				1
Canary, Yellow	*Crithagra flaviventris*	N-end		1		1
Cisticola, Cloud	*Cisticola textrix*	N-end		1		1

Common Name	Scientific name	Regional	Global	Observed	Collision	Displacement
Finch, Red-headed	*Amadina erythrocephala*	N-end				1
Finch, Scaly-feathered	*Sporopipes squamifrons*	N-end		1		1
Flycatcher, Marico	*Bradornis mariquensis*	N-end				1
Francolin, Orange River	*Scleroptila levaillantoides*	N-end		1	1	1
Goshawk, Southern Pale Chanting	*Melierax canorus*	N-end		1	1	1
Lark, Eastern Clapper	*Mirafra fasciolata*	N-end		1		1
Penduline-tit, Cape	*Anthoscopus minutus*	N-end		1		1
Scrub-robin, Kalahari	*Cercotrichas paena*	N-end		1		1
Shrike, Crimson-breasted	*Laniarius atrococcineus*	N-end		1		1
Sparrow, Cape	*Passer melanurus*	N-end		1		1
Sparrowlark, Grey-backed	*Eremopterix verticalis*	N-end				1
Spurfowl, Natal	*Pternistis natalensis*	N-end			1	1
Warbler, Chestnut-vented	*Sylvia subcaerulea*	N-end		1		1
Wheatear, Mountain	*Oenanthe monticola*	N-end		1*		1
Whydah, Shaft-tailed	*Vidua regia*	N-end				1
Falcon, Red-footed	*Falco vespertinus*	NT	NT		1	
Pratincole, Black-winged	*Glareola nordmanni*	NT	NT	1*	1	
Crane, Blue	*Anthropoides paradiseus*	NT	VU		1	1
Stork, Abdim's	*Ciconia abdimii*	NT			1	
Stork, Marabou	*Leptoptilos crumeniferus*	NT			1	
Secretarybird	*Sagittarius serpentarius*	VU	VU		1	1
Falcon, Lanner	*Falco biarmicus*	VU			1	
	Totals:	**46**	**8**	**26**	**16**	**41**

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
* - denotes a species which was observed from habitat adjacent to the site, but has a high probability to occur on the study site.

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

The species accumulation curve (SAC) reached an asymptote at approximately 12-13 point counts (Figure 11). The sampling sufficiency captured approximately 78-80% of the number of species predicted by the Michaelis-Menten model, while 90% of the predicted species was captured at 29 counts. Therefore, sampling was considered sufficient and captured most of the species present on the study site during the respective survey sessions.

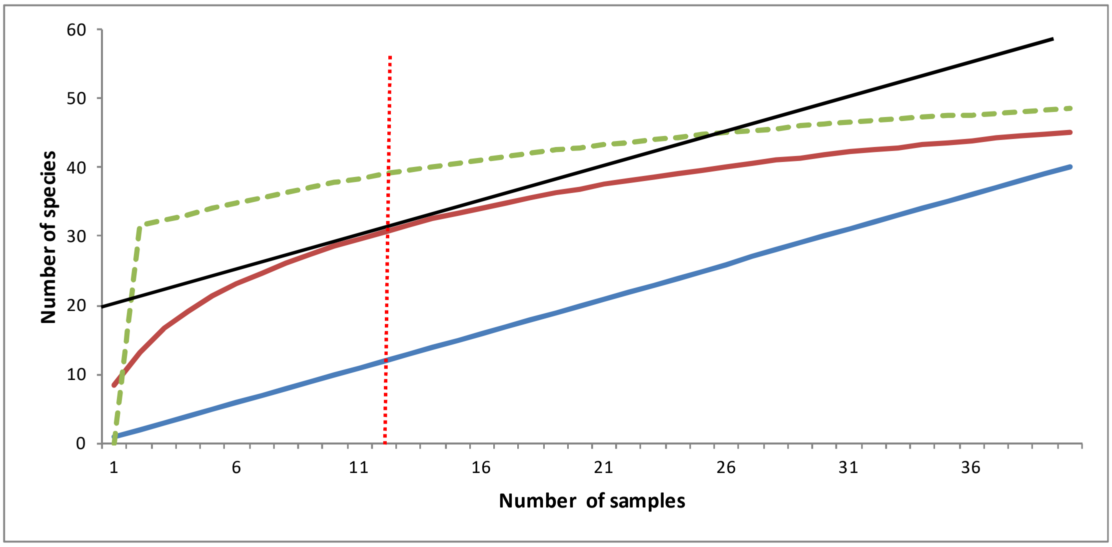

Figure 11: The species accumulation curve (SAC) (red line) for bird points sampled during the July 2018 and October 2018 survey sessions. The blue line represents an accumulation of one species for every additional point count. The black line is parallel to the blue one and is tangent to the SAC approximately after 12-13 counts (as represented by the vertical red stippled line). The green stippled line represents the Michaelis-Menten curve.

4.3 Bird species of conservation concern

Table 4 provides an overview of bird species of conservation concern that could occur on the study site based on their historical distribution ranges and the presence of suitable habitat. According to Table 4, a total of 12 species have been recorded in the broader study area (sensu SABAP1 & SABAP2) which include six globally threatened species, two globally near threatened species, two regionally threatened species and two regionally near-threatened species.

It is evident from Table 4 that the highest reporting rates (>5%) were observed for the globally endangered Cape Vulture (*Gyps coprotheres*), the globally critically endangered White-backed Vulture (*Gyps africanus*), the globally endangered Lappet-faced Vulture (*Torgos tracheliotos*) and the globally near threatened Black-winged Pratincole (*Glareola nordmanni*) (Figure 12). These species have a high likelihood of occurrence pending the presence of suitable food (livestock carcasses) and seasonality (e.g. the pratincoles are non-breeding summer visitors to the area).

The regionally vulnerable Lanner Falcon (*Falco biarmicus*) and globally near threatened Red-footed Falcon (*Falco vespertinus*) show reporting rates between 3 % and 5 %. These species have a moderate probability of occurrence and are regarded as occasional foraging visitors to the area.

The remaining species have low reporting rates (<2%) and are regarded as irregular foraging visitors with low probabilities of occurrence. However, during the site visits it was noticed that extensive areas of suitable foraging habitat persists for some of these species (e.g. Secretarybird *Sagittarius serpentarius*) despite being ominously absent from the area. It is possible that the low reporting rates reflect the poor coverage of the study area by citizen scientists (e.g. birdwatchers), and some of these species could occur in higher numbers due to being overlooked. As an example, Red-footed Falcons (*F. vespertinus*) often occur in flocks of the similar-looking Amur Falcon (*F. amurensis*), which based on reporting rates appear to be a common summer visitor to the area. Therefore, it is highly possible that Red-footed Falcons were previously overlooked or misidentified. The October 2018 survey took place during the early part of the wet season, and it is possible that the timing of the survey has not coincided with the arrival of species such as the Red-footed Falcon (*F. vespertinus*) and Abdim's Stork (*Ciconia abdimii*). This emphasises the importance of additional pre-construction surveys at different times of the season.

Table 4: Bird species of conservation concern that could utilise the study site based on their historical distribution range and the presence of suitable habitat. Red list categories according to the IUCN (2017)* and Taylor et al. (2015)**.

Species	Global Conservation Status*	National Conservation Status**	Mean Reporting rate: SABAP1 (n=142)	Mean Reporting rate: SABAP2 (n=66)	Preferred Habitat	Potential Likelihood of Occurrence
Anthropoides paradiseus (Blue Crane)	Vulnerable	Near threatened	47.18	-	Prefers open grasslands. Also forages along wetlands, pastures and agricultural land.	Potential vagrant or highly irregular foraging visitor. Not recorded post-2007 on the study area (pentad grid scale).
Aquila rapax (Tawny Eagle)	-	Endangered	2.11	-	Lowveld and Kalahari savannas, especially game farming areas and reserves	An irregular foraging visitor or vagrant to the study site. Not recorded post-2007 on the study area (pentad grid scale).
Ciconia abdimii (Abdim's Stork)	-	Near threatened	7.75	-	Open stunted grassland, fallow land and agricultural fields.	An uncommon summer foraging visitor to areas consisting of secondary grassland or arable land. It was not

Species	Global Conservation Status*	National Conservation Status**	Mean Reporting rate: SABAP1 (n=142)	Mean Reporting rate: SABAP2 (n=66)	Preferred Habitat	Potential Likelihood of Occurrence
						observed post-2007 on the study area (pentad grid scale).
Falco vespertinus (Red-footed Falcon)	Near threatened	Near threatened	2.11	3.03	Varied, prefers to hunt open arid grassland and savannoid woodland, often in company with Amur Falcons (*F. amurensis*).	An occasional summer foraging visitor to the area. Not recorded post-2007 from the study area (pentad grid scale), although known from two observations made in 2009 from neighbouring pentad grid 2605_2610.
Falco biarmicus (Lanner Falcon)	-	Vulnerable	2.82	4.55	Varied, but prefers to breed in mountainous areas.	An occasional foraging visitor to the study area. It is known from a single observation on the study area during 01 Dec 2016, and another two observations from the pentad 2605_2605 south of the study site during the same period.
Glareola nordmanni (Black-winged Pratincole)	Near threatened	Near threatened	0.70	~11.11	Varied, but forages over open short grassland, pastures and agricultural lands (especially when being tilled)	A regular foraging visitor to the study area. A flock of approx. 35 birds were observed on 15 October 2018 from habitat adjacent to the study site.
Gyps coprotheres (Cape Vulture)	Endangered	Endangered	17.16	9.09	Mainly confined to mountain ranges, especially	A regular foraging/scavengin g visitor to the study area pending the presence of food

Species	Global Conservation Status*	National Conservation Status**	Mean Reporting rate: SABAP1 (n=142)	Mean Reporting rate: SABAP2 (n=66)	Preferred Habitat	Potential Likelihood of Occurrence
					near breeding site. Ventures far afield in search of food.	(e.g. livestock carcasses). It was confirmed from habitat adjacent to the study site (soaring overhead) during the July 2018 site visit, and from another observation corresponding to pentad grid 2600_2605. It is regarded as a regular passage visitor (soaring overhead) to the nearby vulture restaurant.
Gyps africanus (White-backed Vulture)	Critically Endangered	Critically Endangered	16.18	12.12	Breed on tall, flat-topped trees. Mainly restricted to large rural or game farming areas.	A regular foraging/scavenging visitor to the study site pending the presence of food (e.g. livestock carcasses). It was confirmed from the site (roosting on pylons) during the July 2018 site visit, and from at least another five observations corresponding to pentad grid 2600_2605. It is regarded as a regular passage visitor (soaring overhead) to the nearby vulture restaurant.
Leptoptilos crumeniferus (Marabou Stork	-	Near threatened	0.70	1.52	Varied, from savanna to wetlands, pans and	An irregular scavenging visitor to the area. Only known from a

Species	Global Conservation Status*	National Conservation Status**	Mean Reporting rate: SABAP1 (n=142)	Mean Reporting rate: SABAP2 (n=66)	Preferred Habitat	Potential Likelihood of Occurrence
					floodplains – dependant of game farming areas	single observation on 10 Jan 2010.
Polemaetus bellicosus (Martial Eagle)	Vulnerable	Endangered	-	1.52	Varied, from open karroid shrub to lowland savanna.	An irregular foraging visitor. It was last recorded from pentad 2605_2605 south of the study site on 28 Jan 2012.
Sagittarius serpentarius (Secretarybird)	Vulnerable	Vulnerable	2.45	1.52	Prefers open grassland or lightly wooded habitat.	Regarded as an irregular foraging visitor to the study site despite the widespread presence of suitable foraging habitat. It was last recorded from pentad 2605_2605 south of the study site on 25 April 2011.
Torgos tracheliotos (Lappet-faced Vulture)	Endangered	Endangered	5.63	6.06	Lowveld and Kalahari savanna; mainly on game farms and reserves	A regular foraging/scavenging visitor to the study site pending the presence of food (e.g. livestock carcasses). It was confirmed from habitat adjacent to the study site (soaring over the study site) during the July 2018 site visit, and from at least another three observations corresponding to pentad grid 2600_2605. It is regarded as a regular passage

Species	Global Conservation Status*	National Conservation Status**	Mean Reporting rate: SABAP1 (n=142)	Mean Reporting rate: SABAP2 (n=66)	Preferred Habitat	Potential Likelihood of Occurrence
						visitor (soaring overhead) to the nearby vulture restaurant.

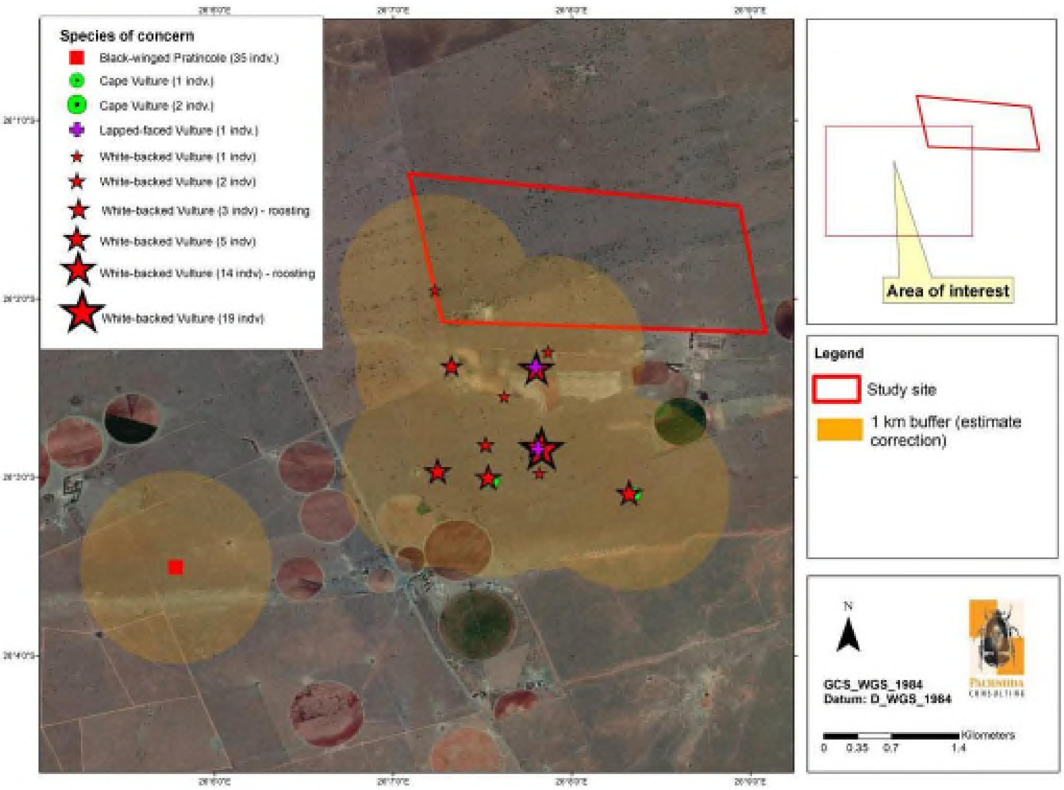

Figure 12: A map illustrating the occurrence of threatened and near threatened species observed on the study site during surveys conducted in July 2018 and October 2018.

4.4 Novelties and "Out of range" species

Three of the bird species observed on the study site represent new records for the broader study area or at least part of the study area. They are regarded as "full out of range" species according to their respective known distribution ranges (Figure 13).

Most of these species have simply not been observed in the region owing to the paucity of dedicated citizen scientists (e.g. the birding fraternity) visiting the area.

- Cardinal Woodpecker (*Dendropicos fuscescens*) - Two independent observations from bush clump habitat. It was observed during July 2018 and October 2018.

- Southern Pale chanting Goshawk (*Melierax canorus*) - A single observation (October 2018) representing an immature bird recorded on the northern part of the study site.

- Melodious Lark (*Mirafra cheniana*) - At least seven observations (both July and October 2018) of birds recorded in open grassland.

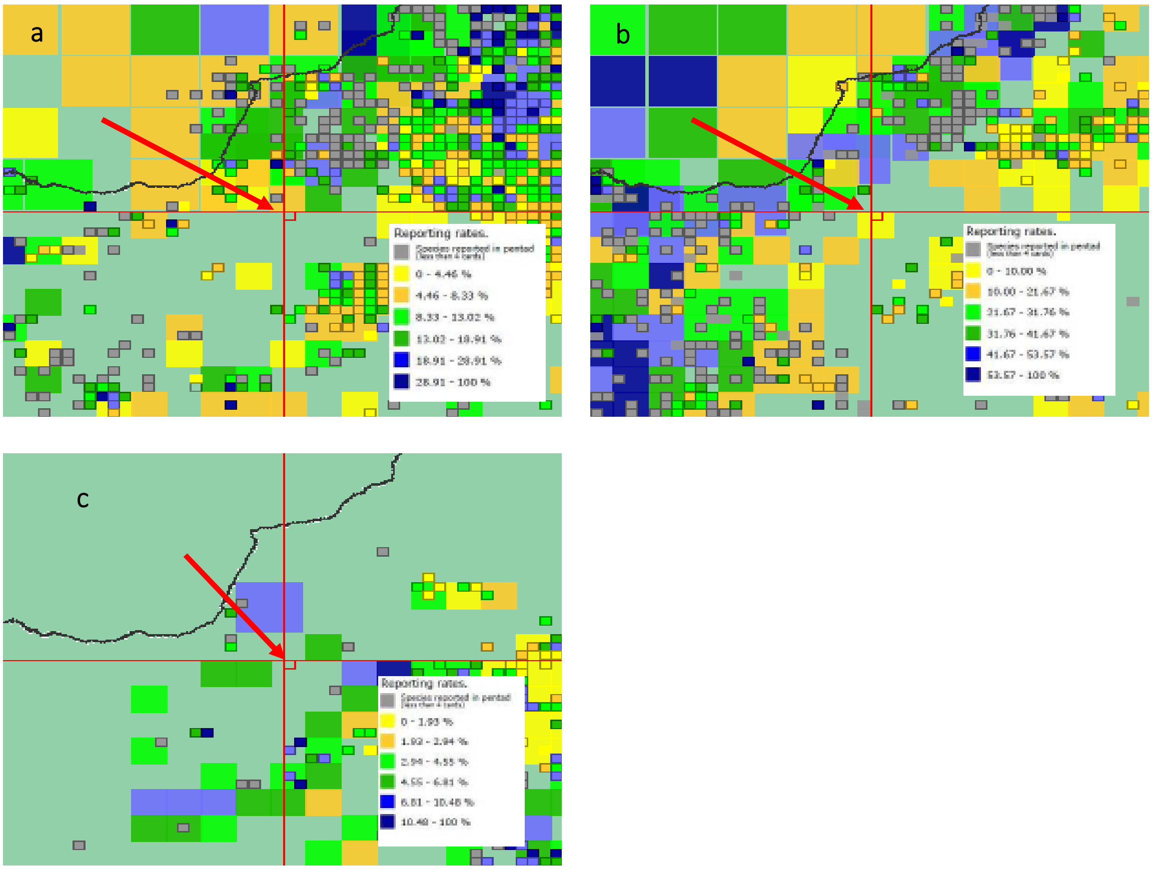

Figure 13: An example of distribution maps representing "full out of range" bird species observed during the respective surveys. Large squares represent quarter degree grids (SABAP1) and small squares are pentad grids (SABAP2): (a) Cardinal Woodpecker (*Dendropicos fuscescens*), (b) Southern Pale-chanting Goshawk (*Melierax canorus*) and (c) Melodious Lark (*Mirafra cheniana*).

4.5 Bird Assemblage Structure and Composition

4.5.1 Summary of point counts

A total of 45 bird species and an average abundance of 430.5 individuals were recorded from 20 bird points (according to two replicative counts). The data provides an estimate of the bird richness and their numbers on the study site obtained during an austral dry and wet season survey. A mean of 12.9 species and 21.5 individuals were recorded per point count. The highest number of species recorded from a point count was 20 species observed from areas of dense *Searsia lancea* dominated bush clumps and the lowest was three species from open grazed dolomite grassland. The highest number of individuals recorded per point count was 136 individuals (at an artificial livestock watering point), and the lowest was 2.5 individuals (from open grazed dolomite grassland). The mean frequency of occurrence of a bird species was 28.76% and the median was 15.00%, while the most common value (mode) was 5.00% and 10.00%. The latter represents those species that were encountered in only one and two point counts respectively. Eleven species occurred in 50 % of all the counts (Table 5), while two species (c. Dark-capped Bulbul *Pycnonotus tricolor* and Chestnut-vented Warbler *Sylvia subcaerulea*) occurred in 90 % of all the counts (Table 5).

Table 5: Bird species with a frequency of occurrence greater than 40%, observed on the study site (according to 20 counts).

Species	Frequency (%)	Species	Frequency (%)
Dark-capped Bulbul (*Pycnonotus tricolor*)	90.00	Eastern Clapper Lark (*Mirafra fasciolata*)	70.00
Chestnut-vented Warbler (*Sylvia subcaerulea*)	90.00	Kalahari Scrub-robin (*Cercotrichas paena*)	70.00
Laughing Dove (*Spilopelia senegalensis*)	85.00	Southern Fiscal (*Lanius collaris*)	70.00
Acacia Pied Barbet (*Tricholaema leucomelas*)	75.00	Neddicky (*Cisticola fulvicapilla*)	50.00
Black-chested Prinia (*Prinia flavicans*)	75.00	Rufous-naped Lark (*Mirafra africana*)	50.00
Desert Cisticola (*Cisticola aridulus*)	75.00		

Four species with a frequency of occurrence greater than 50 % are either endemic or near-endemic to southern Africa, of which one is also restricted to the Kalahari-Highveld Biome (Kalahari Scrub-robin *Cercotrichas paena*).

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

Displacement of birds by the proposed infrastructure is one of the impacts that will occur. By mapping the spatial distribution of the number of species and average abundance values obtained from each point count, it is possible to predict where displacement of birds will be more intensive. According to Figure 14 and Figure 15, displacement of birds will be most intensive on the eastern, northern and west-central parts of the study site where the highest number of species and bird numbers were recorded. Most of these areas correspond to large patches of *Searsia lancea*-dominated bush clumps and artificial livestock watering points. The bush clumps promote vertical heterogeneity and bird richness by providing habitat for passerine bird species which are absent from the surrounding grasslands. In addition, surface water is a scarce commodity on the study site, and the only reliable source of surface water for granivore species is the cattle troughs and spilled water from borehole reservoirs. Many of these granivore species have to take water in on a daily basis in order to assist with the digestion of seeds.

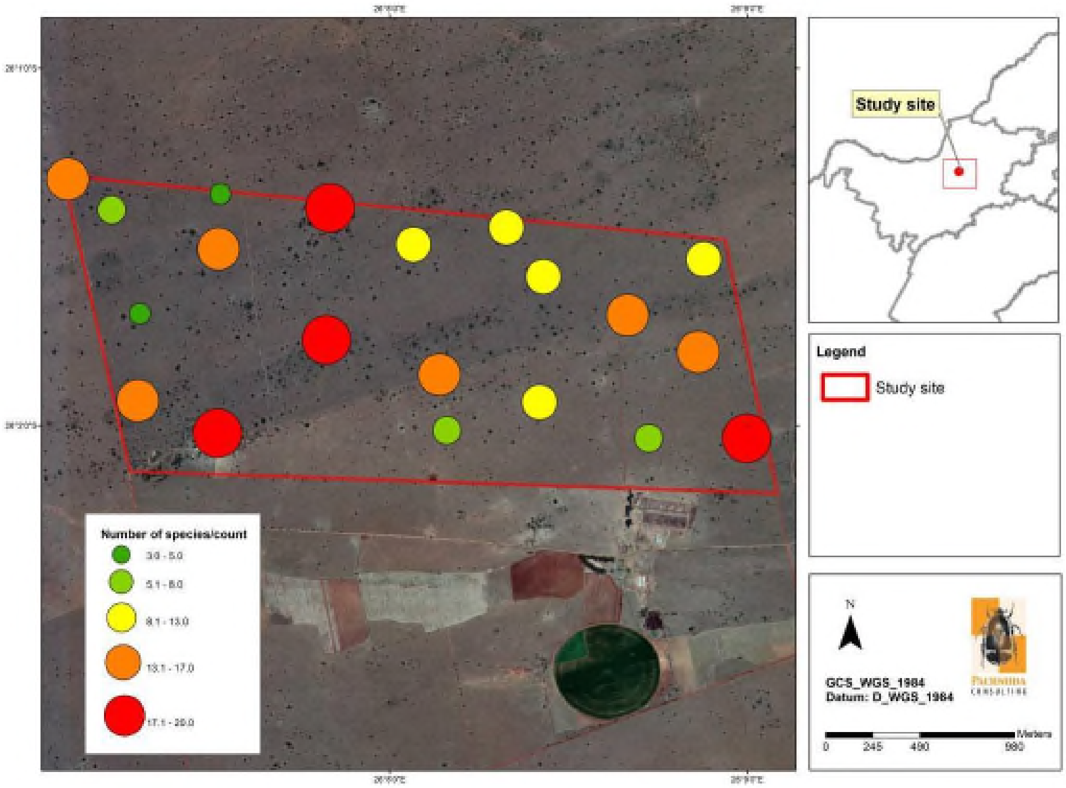

Figure 14: A map of the study site illustrating the spatial distribution of richness values (number of species) obtained for each point count.

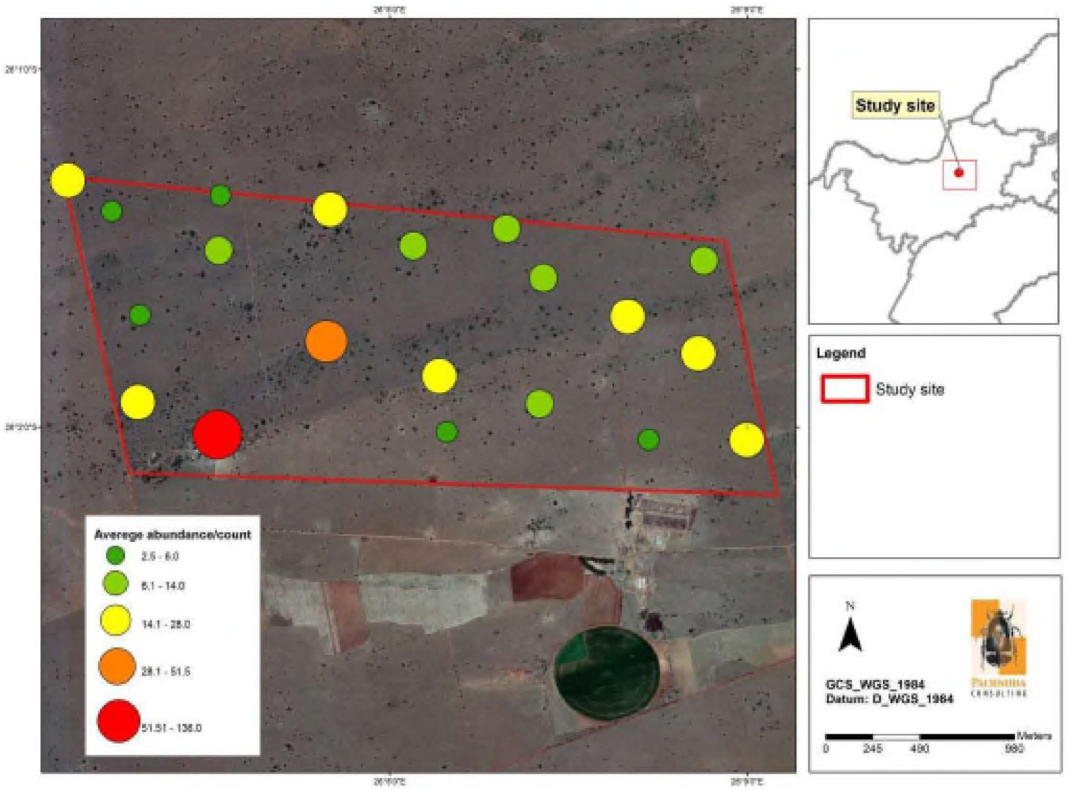

Figure 15: A map of the study site illustrating the distribution of abundance values (average number of individuals) obtained for each point count.

4.5.3 Dominance and typical bird species

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

The three most typical bird species on the study site include the Chestnut-vented Warbler (*Sylvia subcaerulea*), Dark-capped Bulbul (*Pycnonotus tricolor*) and Laughing Dove (*Spilopelia senegalensis*). The typical species forms part of nearly every bird assemblage located in the dolomite grassland with bush clump mosaics. These species are considered widespread species in the broader study area. It is also evident from Table 6 that the typical assemblage is functional and contain all major primary trophic guilds (insectivores, frugivores, carnivores, omnivores and granivores) across all strata (upper to lower canopy and on the ground).

Table 6: Typical bird species on the study site.

Species	Av. Abundance	Consistency (Sim/SD)	Contribution (%)	Primary trophic guild
Chestnut-vented Warbler (*Sylvia subcaerulea*)	1.53	1.72	13.27	Insectivore: upper canopy foliage gleaner
Dark-capped Bulbul (*Pycnonotus tricolor*)	1.70	1.69	13.20	Frugivore: upper canopy gleaner
Laughing Dove (*Spilopelia senegalensis*)	1.85	1.48	10.58	Granivore: ground gleaner
Desert Cisticola (*Cisticola aridulus*)	0.55	0.94	9.79	Insectivore: upper canopy foliage gleaner
Acacia Pied Barbet (*Tricholaema leucomelas*)	0.88	0.96	8.76	Frugivore: upper canopy gleaner
Black-chested Prinia (*Prinia flavicans*)	1.13	1.05	8.30	Insectivore: upper canopy foliage gleaner
Eastern Clapper Lark (*Mirafra fasciolata*)	0.38	0.90	7.19	Granivore: ground gleaner
Southern Fiscal (*Lanius collaris*)	0.48	0.87	6.43	Carnivore: ground hawker
Kalahari Scrub-robin (*Cercotrichas paena*)	0.68	0.93	6.04	Insectivore: lower canopy foliage gleaner
Rufous-naped Lark (*Mirafra africana*)	0.30	0.53	3.43	Granivore: ground gleaner
Neddicky (*Cisticola fulvicapilla*)	0.33	0.55	2.81	Insectivore: upper canopy foliage gleaner
Wattled Starling (*Creatophora cinerea*)	7.38	0.34	1.80	Omnivore

4.5.4 Composition and diversity

Multidimensional scaling and hierarchical agglomerative clustering ordination of bird abundance values obtained from 20 point counts differentiate between two discrete bird associations (Global R= 0.8, p<0.001; Figure 16). These include an (1) association on dolomite grassland containing woody bush clumps and an (2) association pertaining to open dolomite grassland in the absence of any bush clumps. The former association is also represented by two sub-associations: (1.1) an association on open grassland with scattered bush clumps and an (1.2) association pertaining to dense woody bush clumps.

The habitat fidelity between species is illustrated in Figure 16 by plotting the relative abundance values of Desert Cisticola (*Cisticola aridulus*). It shows that Desert Cisticola are more prominent in open grassland and habitat where grassland are dominant (in contrast to habitat consisting only of woody elements e.g. bush clumps). It is also evident that the birds at livestock watering points are similar in composition to those occurring in dense woody bush clumps. Point Ll11 is an outlier since a large flock of Wattled Starlings (*Creatophora cinerea*) was roosting in a low bush.

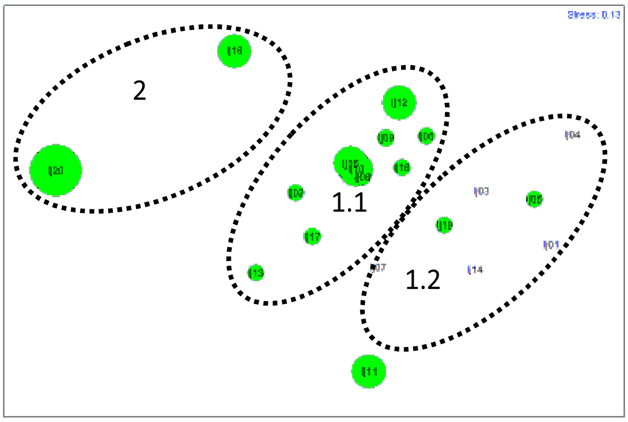

Figure 16: A two-dimensional non-metric multidimensional scaling ordination (stress=0.13) of the relative abundances of bird species based on Bray-Curtis similarities obtained from 20 point counts. It differentiates between two three bird associations/ sub-associations on (1.1) dolomite grassland/bush clump mosaics, (1.2) dense woody bush clumps and (2) open dolomite grassland. The green circles represent the relative abundances of Desert Cisticola (*Cisticola aridulus*).

The composition of each association is described below:

1. Association on Dolomite grassland/bush clump mosaics

- 1.1 Sub-association on dolomite grassland with bush clump mosaics - This is a prominent bird composition on open grassland with scattered bush clump mosaics. It therefore contains both "grassland" and "bushveld" species.

  Dominant species: Dark-capped Bulbul (*Pycnonotus tricolor*), Chestnut-vented Warbler (*Sylvia subcaerulea*), Desert Cisticola (*Cisticola aridulus*), Eastern Clapper Lark (*Mirafra fasciolata*), Acacia Pied Barbet (*Tricholaema leucomelas*) and Rufous-naped Lark (*Mirafra africana*).

  Indicator species [9]: The composition also occurs in other habitat units, hence indicator species are absent. The only species that was observed from this habitat was the Crested Barbet (*Trachyphonus vaillantii*).

- 1.2 Sub-association on dense woody bush clumps - This is a bird composition consisting mainly of "bushveld" species.

  Dominant species: Dark-capped Bulbul (*Pycnonotus tricolor*), Chestnut-vented Warbler (*Sylvia subcaerulea*), Laughing Dove (*Spilopelia

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

senegalensis), Wattled Starling (*Creatophora cinerea*), Kalahari Scrub-robin (*Cercotrichas paena*), Black-chested Prinia (*Prinia flavicans*), Yellow Canary (*Crithagra flaviventris*) and Fiscal Flycatcher (*Melaenornis silens*).

Indicator species: Fiscal Flycatcher (*Melaenornis silens*), Brown-crowned Tchagra (Tchagra australis), Little Bee-eater (Merops pusillus), Streaky-headed Seed-eater (Crithagra gularis), Cape White-eye (Zosterops virens) and Grey-go-away-bird (C*orythaixoides concolor*).

2. Association on open dolomite grassland

This is a bird composition on open grassland and contains mainly "grassland" species.

Dominant species: Desert Cisticola (*Cisticola aridulus*) and Melodious Lark (*Mirafra cheniana*).

Indicator species: Cape Longclaw (*Macronyx capensis*).

The highest number of bird species and bird numbers were observed from the dense bush clumps followed by the grassland/bush clump mosaics (Table 7). The lowest number of bird species was recorded from open grassland. However, rarefaction curves showed that the equitability (evenness) of bird numbers for each species is slightly higher at the grassland/bush clump mosaics, meaning that this association is potentially more stable and at a more advanced successional stage (Figure 17).

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

Bird Association	Number of species	Number of Individuals	H'(loge)
Dense bush clumps	34.00	46.00	2.14
Grassland/bush clump mosaics	31.00	12.32	2.89
Open grassland	8.00	3.50	1.87

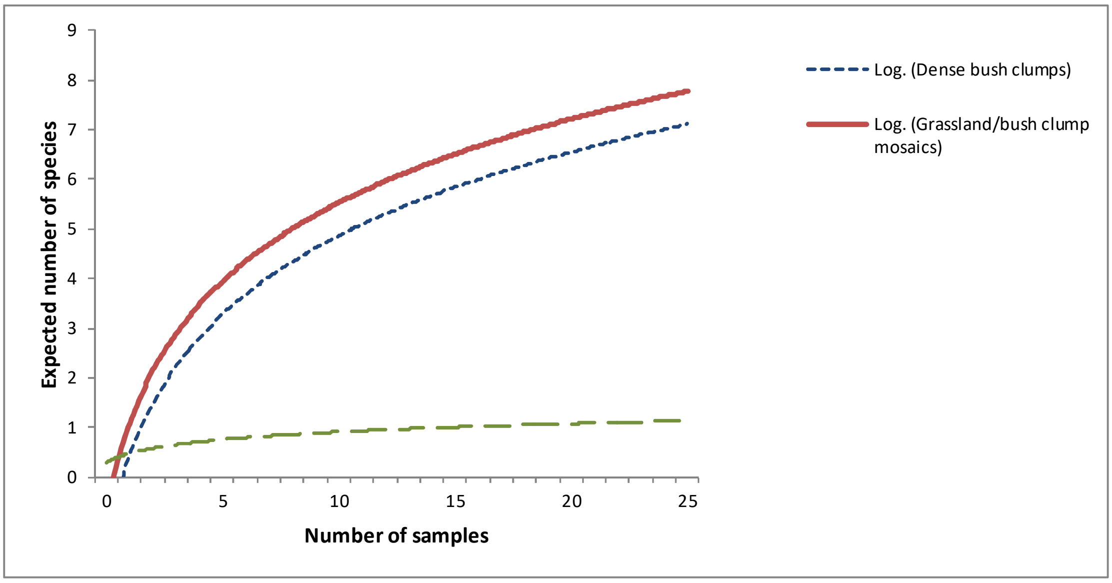

Figure 17: Rarefaction curves for the bird associations on the respective habitat units on the study site.

4.6 Passerine and non-passerine densities

Forty-five bird species, representing 16 non-passerine species and 29 passerines were recorded from 20 point counts on the study site. The study site comprises of approximately 4.11 species.ha^{-1} (Appendix 3). The average density per hectare is 6.86 birds.ha^{-1} and ranges between 0.8 birds.ha^{-1} on open grassland to 43.31 birds.ha^{-1} at livestock watering points.

4.7 Movements/dispersal of Collision-prone birds

Frequent daily dispersal of birds was not observed apart from foraging Pied Crows (*Corvus albus*) and perched small-bodied birds of prey such as Black-winged Kite (*Elanus caeruleus*) and Southern Pale-chanting Goshawk (*Melierax canorus*). The birds of prey were mainly confined to the northern section of the study site (Table 8 and Figure 18). The flight routes of the crows were random and haphazard and no predicted/deterministic pattern could be established. Therefore, the crows utilise searching as a means to find potential food during foraging excursions. A roosting White-backed Vulture individual was also observed during the July 2018 survey on the western part of the study site corresponding to an existing power line servitude.

The absence of any nearby water bodies, dams and drainage lines explains the absence of waterbirds passing in the area.

Table 8: A summary of the occurrence and movements of collision-prone bird species observed during July 2018 and October 2018 on the study site.

Date	Time	Obs Period	No	Species	Movement/Activity
07/05/2018	9h23	July 2018	2	Black-winged Kite	2 birds perched in tree
10/17/2018	7h21	October 2018	1	Pale-chanting Goshawk	1 immature bird perched in tree
10/17/2018	5h41	October 2018	1	Northern Black Korhaan	Displaying
07/04/2018	7h11	July 2018	1	White-backed Vulture	Perched on pylon
07/04/2018	12h46	July 2018	6	Orange River Francolin	Foraging group
07/05/2018	8h02	July 2018	2	Orange River Francolin	Foraging group
07/05/2018	7h21	July 2018	1	Pied Crow	Flying northwards
	12h47		1	Pied Crow	Flying east
	12h54		2	Pied Crow	Flying west
	13h48		2	Pied Crow	Flying west
10/17/2018	7h07	October 2018	1	Pied Crow	Flying northwards
	5h37		5	Pied Crow	Perched near carcass
	7h15		6	Pied Crow	Perched in tree

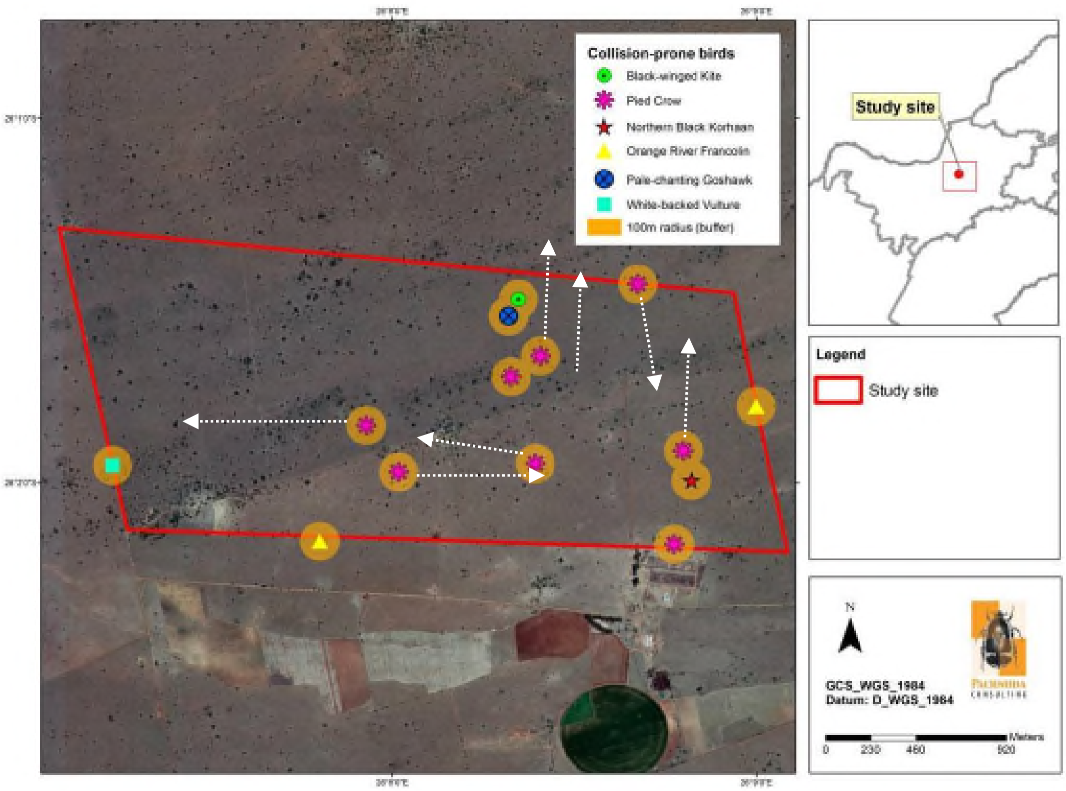

Figure 18: A map of the study site illustrating the occurrence of collision prone birds.

4.8 Avifaunal sensitivity

A sensitivity map was compiled, illustrating habitat units comprising of potential sensitive elements based on the following arguments (Figure 19 and Figure 20):

Areas of moderately high sensitivity

These represent habitat or areas where a high number of bird species were recorded although also direct observations of collision-prone bird species. Therefore, displacement potential of birds at these areas is regarded to be higher when compared to other areas. It includes mainly dense bush clumps, some artificial livestock watering points and the power line servitude where the pylon structures are often used as roosting platforms for vultures.

In addition, the artificial livestock watering points attract large numbers of granivore passerine and non-passerine bird species, of which many need to drink water on a daily basis. The placement of electrical infrastructure in close proximity to these areas could increase potential avian collisions with the infrastructure. These areas are therefore considered to be of moderately high sensitivity. These habitat units are widespread in the broader study region and the livestock watering points and power line servitudes are artificial in origin, therefore the displacement of birds at these habitat units are not regarded as a fatal flaw nor are any of these units considered to be no-go areas.

Areas of medium sensitivity

These represent habitat units of extensive dolomite grassland and bush clump mosaics. It also includes some of the artificial watering points. These habitat types provide suitable foraging habitat for certain threatened and near threatened bird species, including large terrestrial bird species (e.g. Northern Black Korhaan) with the potential to interact (e.g. collide) with the proposed electrical infrastructure. However, reporting rates for threatened and near threatened bird species was relatively low, thereby suggesting a medium sensitivity rating instead of a high sensitivity even though the majority of the habitat is natural. In addition, the dolomite grassland and bush clump mosaics are widespread in the region and with large surface areas prevalent in the North West Province, therefore the displacement of birds at these habitat units is not regarded as a fatal flaw nor are any of these units considered to be no-go areas.

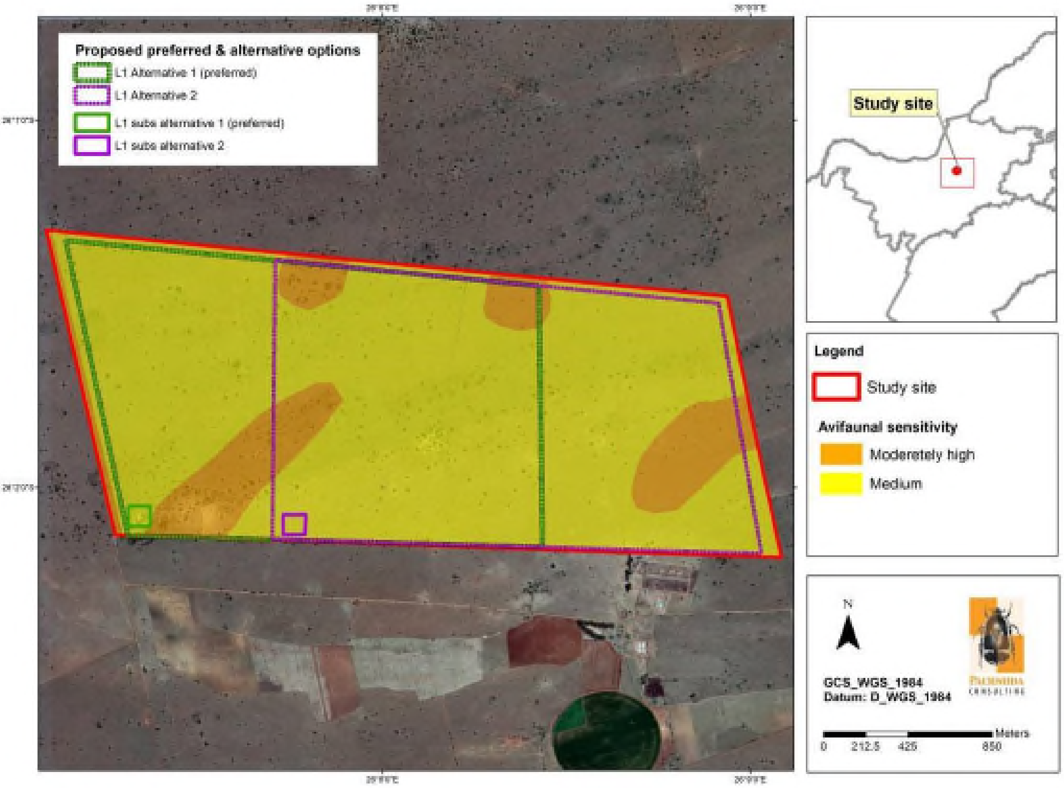

Figure 19: A map illustrating the avifaunal sensitivity of the study site (including the preferred and alternative options) based on the ecological condition of habitat types, the occurrence of collision prone species and areas with high avian richness.

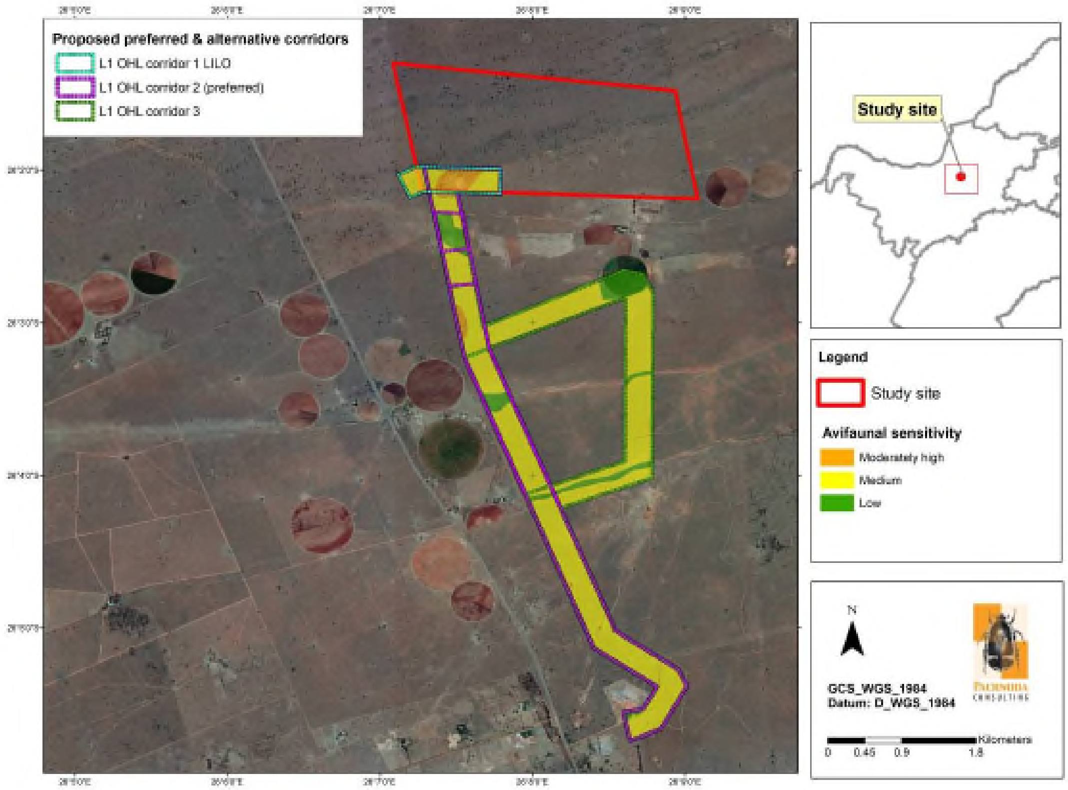

Figure 20: A map illustrating the avifaunal sensitivity of the proposed corridor alternatives based on the ecological condition of habitat types.

4.9 Overview of Avian Impacts at Solar Facilities

4.9.1 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. mammals). 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 of 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 (due to solar flux-based mortalities associated with CSP sites).
- 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.

4.9.2 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 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 power lines 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.

4.10 Impacts associated with the Lichtenburg 1 PV Solar Energy Facility

Table 9 provides a summary of the impacts anticipated and quantification thereof.

4.10.1 Loss of habitat and displacement of birds

Approximately 280 ha of the site will be cleared of vegetation and habitat to accommodate the panel arrays and associated infrastructure. Clearing of vegetation will inevitably result in the loss of habitat and displacement of bird species. From the results approximately 4.11 species.ha^{-1} and 6.86 birds.ha^{-1} will become displaced by the activity (as per Jenkins et al., 2017). If it is assumed that all birds are evenly distributed across the study site and the study site is represented by a single homogenous habitat, then the activity will result in the displacement of 1,928 birds. It is particularly biome-restricted, endemics and conservation important species that are likely to become displaced, as well as habitat specialists (e.g. grassland specialists) which will disappear from the area. These include mainly passerine and smaller non-passerine species inhabiting the untransformed dolomite grasslands and bush clump mosaics.

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

- Northern Black Korhaan (*Afrotis afraoides*);
- Melodious Lark (*Mirafra cheniana*);
- Kalahari Scrub Robin (*Cercotrichas paena*);
- Orange River Francolin (*Scleroptila gutturalis*) and potentially also small to medium birds of prey such as:
- Black-winged Kite (*Elanus caeruleus*) and
- Southern Pale-chanting Goshawk (*Melierax canorus*).

When considering the number of displaced bird species and their widespread occurrence in the region, the predicted impact due to the overall displacement and habitat loss is moderate without mitigation measures.

Two PV layout options are proposed (preferred and alternative option), including two options for the internal substation (preferred and alternative option) (Figure 19). It is unlikely that the significance of the impact will differ should the PV facility be constructed at the preferred or alternative layout options. Both PV layout options contain the same habitat types and share similar sensitivity ratings. In addition, the proposed substation covers a small surface area, which will result in a reduced impact significance rating (when compared to the PV layout).

However, it is recommended to consolidate infrastructure to areas containing existing infrastructure. Therefore, the preferred options (L1 Alternative 1 and L1 substation Alternative 1) are located proximal to an existing power line (on the western boundary of the study site) which will reduce the distance of the overhead powerline corridor.

4.10.2 Creation of "new" avian habitat and bird pollution

It is possible that the 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*); and

- Speckled Pigeon (*Columba guinea*).

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 impact is manageable and will result in a low significance.

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

The study site is not located in close proximity to any major wetland system or water body. The nearest large wetland systems are 10 km from the study site, which explain the low occurrence of waterbird taxa at the study site. These wetland habitat types are often utilised by waterbirds which could accidentally mistake the reflective panels for waterbodies, thereby resulting in bird collisions with the panel surfaces. At this stage the impact is considered to be low although it is unknown what the significance of it will be during the peak summer season depending on subsequent site visits (e.g. pre-construction monitoring) during the peak wet season when most of the wetland features in the region are inundated. This makes predictions regarding the occurrence of waterbird species and their numbers (e.g. density) in the area inconceivable.

However, desktop results and site observations show that the following species could interact with the panel infrastructure:

- Yellow-billed Duck (*Anas undulata*);
- Spur-winged Goose (*Plectropterus gambiensis*);
- Egyptian Goose (*Alopochen aegyptiaca*);
- Black-headed Heron (*Ardea melanocephala*); and probably also
- Grey Heron (*Ardea cinerea*) and
- White-faced Duck (*Dendrocygna viduata*).

In the absence of sufficient information on the occurrence of waterbird taxa in the area, as well as the lack of data on bird mortalities caused by collisions, the precautionary principle was applied which results in an impact of moderate significance (in the absence of any mitigation measures).

4.10.4 Interaction with overhead power lines and reticulation

A number of overhead power lines are proposed. These include a short loop-in loop out corridor alternative at the internal substation (L1 OHL corridor 1 LILO) which will terminate at a switching station on the Lichtenburg 3 PV facility, and two overhead power line alternatives feeding into the Watershed substation near Lichtenburg (preferred L1 OHL corridor 2 or alternative L1 OHL corridor 3). Birds are impacted in three ways by means of overhead power lines. 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 power lines. 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. However, electrocution is proportional to the spatial position of carcasses, and will probably only occur when a carcass is located underneath or in close proximity to an overhead distribution power line.

- *Collision*

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

Areas where bird collisions are likely to be high could be ameliorated by marking the lines with appropriate bird deterrent devices such as "bird diverters" and "flappers" to increase the visibility of the lines. In addition, the length of L1 OHL corridor 1 LILO is significantly shorter than OHL corridor 2 or OHL corridor 3, thereby reducing the impact of potential avian collisions significantly. The OHL corridor 2 (preferred) is located alongside existing power line servitudes (in contrast to a section of OHL corridor 3 which deviated from the existing powerline servitudes), and the advantage of OHL corridor 2 is that the placement of the OHL corridor 2 along an existing power line will greatly increase the visibility of the overhead cables to passing birds (during daylight), thereby reducing avian collision with the overhead cabling structures.

Therefore, the impact of avian collisions at OHL corridor 2 (preferred) is predicted to be lower when compared to OHL corridor 3 (alternative).

This may be true for most other bird species that are prone towards power line collisions, although the risk of Cape Vultures colliding with the power line will persist due to the foraging behaviour and ecological requirements of this species. Cape Vultures feed communally and congregate in large numbers at a carcass; therefore any power line in close proximity could result in this species colliding with the earth wires, often resulting in more than a single mortality.

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

It is anticipated that access roads need to be constructed, including the clearing of vegetation as part of the power line servitude. 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.

The artificial livestock watering points also deserve special consideration since these features are often overlooked or neglected during the construction of power lines and as they often attract large numbers of small passerine birds and birds of prey (the latter often include falconiform taxa which hunt small passerines). Construction activities in close proximity to these features could possibly displace these individuals from the area or increase the risk of collision.

Table 9: 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.		
Layout (Alternative 1 & 2)	**Without mitigation**	**With mitigation**
Extent	Local (2)	Local (2)
Duration	Long-term (4)	Long-term (4)
Magnitude	Moderate (6)	Moderate (6)
Probability	Definite (5)	Probable (3)
Significance	**Medium (60)**	**Medium (36)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Low
Irreplaceable loss of resources?	Yes	Yes
Can impacts be mitigated?	Yes, to some extent	Yes
Substation (Alternative 1 & 2)	**Without mitigation**	**With mitigation**
Extent	Local (1)	Local (1)
Duration	Long-term (4)	Long-term (4)
Magnitude	Low (4)	Minor (2)

Probability	Definite (5)	Probable (3)
Significance	**Medium (45)**	**Low (21)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Low
Irreplaceable loss of resources?	Yes	Yes
Can impacts be mitigated?	Yes, to some extent	Yes

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. It is unlikely that the significance of the impact will change should the facility be constructed on the preferred or alternative layout options. Both layout options and substations contain the same habitat types and share similar sensitivity ratings. The PV facility will cover approximately 65 % of the total surface area representing primarily habitat of medium sensitivity. The best practicable mitigation will be to consolidate infrastructure to areas where existing impacts occur (e.g. placing the proposed power line alongside existing power lines). The proposed substation covers a small surface area, which will result in a reduced impact significance rating.

Residual:

It is anticipated that during rehabilitation (after removal of the panels) that the vegetation will revert to secondary grassland resulting in a decreased bird species richness with low evenness values on a local scale. The residual impact of the PV facility will be medium. The residual impact of the substation will be low due to the small surface area of habitat loss.

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.

Layout (Alternative 1 & 2)	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.

Residual:

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

3. Nature:

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

Layout (Alternative 1 & 2)	Without mitigation	With mitigation
Extent	Local (2)	Local (2)
Duration	Long-term (4)	Long-term (4)
Magnitude	Low (4)	Minor (2)
Probability	Probable (3)	Improbable (2)

Significance	**Medium (30)**	**Low (16)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Low
Irreplaceable loss of resources?	No, although threatened species are present in the area, these are likely to become displaced while waterbirds are uncommon due to the absence of prominent water/wetland features in the area.	No
Can impacts be mitigated?	Yes, to some extent	Yes, to some extent
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. If pre-construction and 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 low.		

4. Nature: Avian collision impacts related to the overhead power line during operation.		
L1 OHL corridor (LILO)	**Without mitigation**	**With mitigation**
Extent	Local (1)	Local (1)
Duration	Long-term (4)	Long-term (4)
Magnitude	Moderate (6)	Low (4)
Probability	Probable (3)	Probable (3)
Significance	**Medium (33)**	**Low (27)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Low
Irreplaceable loss of resources?	Yes, owing to the potential loss of critically endangered or endangered bird species	Yes
Can impacts be mitigated?	Yes	Yes
L1 OHL corridor 2	**Without mitigation**	**With mitigation**
Extent	Regional (4)	Regional (4)
Duration	Long-term (4)	Long-term (4)
Magnitude	High (8)	High (8)
Probability	Highly Probable (4)	Probable (3)
Significance	**High (64)**	**Medium (48)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Low
Irreplaceable loss of resources?	Yes, owing to the potential loss of critically endangered or endangered bird species	Yes, impact could still occur irrespective of mitigation.
Can impacts be mitigated?	Yes, to some extent	Yes, to some extent
L1 OHL corridor 3	**Without mitigation**	**With mitigation**

Extent	Regional (4)	Regional (4)
Duration	Long-term (4)	Long-term (4)
Magnitude	Very High (10)	High (8)
Probability	Highly Probable (4)	Highly Probable (4)
Significance	**High (72)**	**High (64)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Low
Irreplaceable loss of resources?	Yes, owing to the potential loss of critically endangered or endangered bird species	Yes, impact could still occur irrespective of mitigation.
Can impacts be mitigated?	Yes, to some extent	Yes, to some extent
Mitigation: Apply bird deterrent devices to the power line and make use of "bird-friendly" pylon structures. Avoid the placement of cattle feedlots, kraals and watering points in close proximity to overhead electrical infrastructure. 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. In addition, the impact significance (after mitigation) will be reduced if the proposed corridor is placed alongside an existing power line servitude. It is advised that artificial livestock watering points corresponding to OHL corridors be removed or relocated to prevent collisions with birds that are attempting to drink water from the watering points.		
Residual: Direct mortality is possible and may still happen irrespective of applied mitigation measures. The residual impact will be medium.		

5. Nature: Avian electrocution related to the overhead power lines.		
All proposed corridors	**Without mitigation**	**With mitigation**
Extent	Regional (4)	Immediate area (3)
Duration	Long-term (4)	Long-term (4)
Magnitude	Very High (10)	High (8)
Probability	Highly Probable (4)	Probable (3)
Significance	**High (72)**	**Medium (45)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Low
Irreplaceable loss of resources?	Yes, owing to the potential loss of critically endangered or endangered bird species	Yes, impact could still occur irrespective of mitigation.
Can impacts be mitigated?	Yes, to some extent	Yes, to some extent
Mitigation: Electrocution is proportional to the spatial position of carcasses (with reference to scavenging birds of prey), and will probably only occur when a carcass is located underneath or in close proximity to an overhead distribution power line. Apply bird deterrent devices to the power line. Avoid the placement of cattle feedlots and watering points near electrical infrastructure. Grazing of cattle at or in close proximity to distribution lines should be monitored at all times and preferably be avoided (to minimise potential livestock carcasses near distribution lines). Make use of bird-friendly pylons and bird guards as recommended by EWT. Position electrical infrastructure in close proximity to existing infrastructure.		
Residual: Direct mortality is possible and may still happen irrespective of applied mitigation measures. The residual impact will be medium.		

4.10.5 Collision-prone bird species

A total of 48 collision-prone bird species have been recorded in the wider study area, of which 23 species are birds of prey (Table 10). Three of these species are vulture species (Cape Vulture *Gyps coprotheres*, White-backed Vulture *Gyps africanus* and Lappet-faced Vulture *Torgos tracheliotos*). Those species with SABAP2 reporting rates higher than 5% are regarded to be regular in the area and include the highly collision-prone and threatened White-backed Vulture, Cape Vulture and Lappet-faced Vulture.

Table 10: Collision-prone bird species and Red listed species (in red) expected to be present on the study site inferred from the South African Atlas Project (SABAP1 & SABAP2).

Common Name	Scientific name	National conservation status (*sensu* Taylor *et al.*, 2015)	SABAP2 reporting rate (%)	SABAP1 reporting rate (%)
Pigeon, Speckled	*Columba guinea*		63.64	69.12
Ibis, Hadeda	*Bostrychia hagedash*		57.58	81.86
Egret, Western Cattle	*Bubulcus ibis*		45.45	78.92
Spurfowl, Swainson's	*Pternistis swainsonii*		43.94	36.27
Crow, Pied	*Corvus albus*		42.42	85.78
Guineafowl, Helmeted	*Numida meleagris*		42.42	59.80
Duck, Yellow-billed	*Anas undulata*		34.85	63.73
Kite, Black-winged	*Elanus caeruleus*		33.33	59.80
Korhaan, Northern Black	*Afrotis afraoides*		33.33	52.94
Falcon, Amur	*Falco amurensis*		21.21	13.38
Heron, Black-headed	*Ardea melanocephala*		19.70	47.06
Ibis, Glossy	*Plegadis falcinellus*		19.70	14.71
Francolin, Orange River	*Scleroptila levaillantoides*		18.18	15.20
Goose, Egyptian	*Alopochen aegyptiacus*		16.67	60.78
Kestrel, Lesser	*Falco naumanni*		16.67	14.22
Kite, Yellow-billed	*Milvus aegyptius*		12.12	7.84
Vulture, White-backed	*Gyps africanus*	CR	12.12	16.18
Ibis, African Sacred	*Threskiornis aethiopicus*		10.61	60.29
Vulture, Cape	*Gyps coprotheres*	EN	9.09	17.16
Goose, Spur-winged	*Plectropterus gambensis*		7.58	43.14
Vulture, Lappet-faced	*Torgos tracheliotos*	EN	6.06	5.63
Falcon, Lanner	*Falco biarmicus*	VU	4.55	2.82
Hamerkop	*Scopus umbretta*		4.55	12.75
Snake-eagle, Black-chested	*Circaetus pectoralis*		4.55	1.47
Owl, Western Barn	*Tyto alba*		3.03	6.37
Spurfowl, Natal	*Pternistis natalensis*		3.03	4.41
Kestrel, Greater	*Falco rupicoloides*		3.03	27.94
Francolin, Coqui	*Peliperdix coqui*		3.03	2.45
Falcon, Red-footed	*Falco vespertinus*	NT	3.03	2.11
Buzzard, Steppe	*Buteo (buteo) vulpinus*		3.03	10.29
Eagle-owl, Spotted	*Bubo africanus*		3.03	1.47
Harrier-Hawk, African	*Polyboroides typus*		3.03	0.00

Common Name	Scientific name	National conservation status (*sensu* Taylor *et al.*,	SABAP2 reporting rate (%)	SABAP1 reporting rate (%)
Crow, Cape	*Corvus capensis*		1.52	20.59
Secretarybird	*Sagittarius serpentarius*		1.52	2.45
Kite, Black	*Milvus migrans*		1.52	0.70
Stork, Marabou	*Leptoptilos crumeniferus*	NT	1.52	0.70
Eagle, Martial	*Polemaetus bellicosus*	EN	1.52	0.00
Snake-eagle, Brown	*Circaetus cinereus*		1.52	0.00
Stork, Abdim's	*Ciconia abdimii*	NT		7.75
Stork, White	*Ciconia ciconia*			6.34
Owl, Marsh	*Asio capensis*			5.63
Crane, Blue	*Anthropoides paradiseus*	NT		47.18
Courser, Temminck's	*Cursorius temminckii*			2.94
Courser, Double-banded	*Rhinoptilus africanus*			2.82
Eagle, Tawny	*Aquila rapax*	EN		2.11
Eagle, Wahlberg's	*Aquila wahlbergi*			11.29
Goshawk, Southern Pale Chanting	*Melierax canorus*		Full out of range observation (15/10/2018)	0.70
Pratincole, Black-winged	*Glareola nordmanni*	NT	Full out of range observation (15/10/2018)	0.70

The study site does not coincide with any prominent wetland system or impoundment which will lower the risk of waterbird collisions with the proposed electrical infrastructure.

4.10.6 Vultures

Three species of vulture occur in the study area, which are prone towards electrocution and collision with power lines. These include the globally critically endangered White-backed Vulture (*Gyps africanus*), the globally endangered Cape Vulture (*G. coprotheres*) and the globally endangered Lappet-faced Vulture (*Torgos tracheliotos*). These species are of international significance and any mortality of adult individuals could have a negative effect on its species' population recruitment. Most of these suffer from a shortage of food supplies which is responsible for low reproductive rates, especially for Cape Vultures (Taylor *et al*., 2015). In addition, most of these species also tend to congregate at mammalian carcasses, where they feed in large groups, especially Cape Vultures. In addition, Cape Vultures also typically search for food in groups. It is such congregations which increase the risk of mortalities whenever these individuals forage or roost in close proximity to power lines. In addition, the proposed study site is also in close proximity to the foraging rangeland of Cape Vultures as evidenced by dispersal data obtained from vulture individuals fitted with satellite tracking devices (Figure 21).

The highest number of mortalities due to electrocution and collision recorded in the study region pertains to Cape Vultures (*Gyps coprotheres*) and White-backed Vultures (*Gyps africanus*) (according to the electrical infrastructure mortality incident register) (Figure 22). Most of the mortalities were caused by electrocution from smaller distribution lines in the area, although a significant number of Cape Vulture mortalities (*c*. 30 %) were also the result of collisions with transmission lines (Figure 23). There is a definite correlation between the size (in terms of voltage) of the power line and the type of mortality, whereby electrocution incidents were prominent at distribution lines while collisions occur at transmission lines. Therefore, it is postulated that the proposed power line network could contribute towards the rate of collision mortalities in vulture species in the area. Most of the power line interactions also occurred in the Ventersdorp and Lichtenburg area (Figure 24), with a single mass mortality involving 10 Cape Vultures and eight White-backed Vultures on 09 March 2009. **It clearly shows that when these species congregate (for example when feeding from a carcass in close proximity to a power line or when roosting on pylons or nearby structures in close proximity to power lines), the risk of mortality due to both electrocution and collision is greatly increased**. It was also evident from the mortality data that incidents are continuous with a recent mortality recorded during 06 February 2018 and 13 incidents recorded during the last two years. Most of the recent incidents pertain to collisions, which are an indication that mitigation measures such as the application of bird diverters tend to be ineffective.

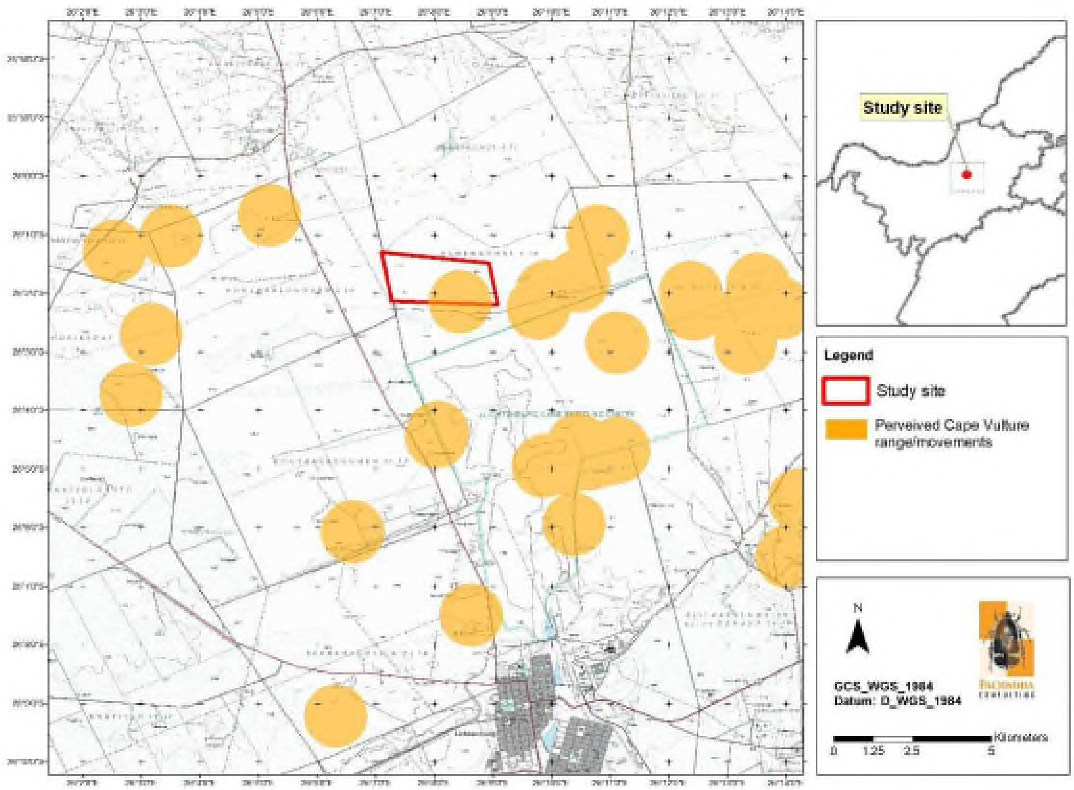

Figure 21: The occurrence of Cape Vultures (*Gyps coprotheres*) within the study region fitted with satellite trackers.

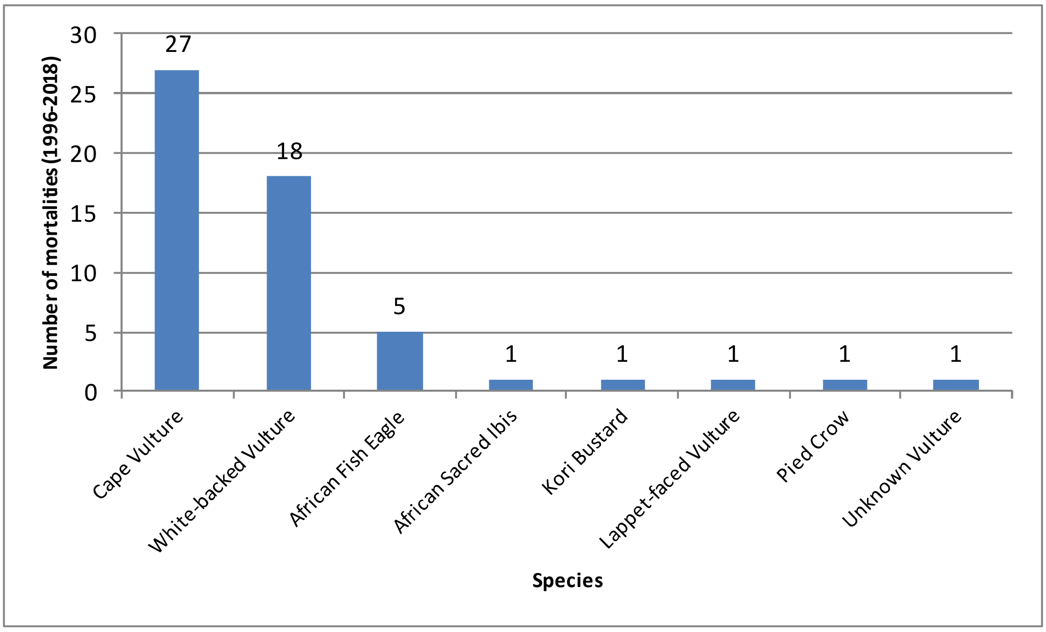

Figure 22: The number of mortalities (electrocutions and collisions) per bird species due to transmission and distribution lines in the study area (1996-2018).

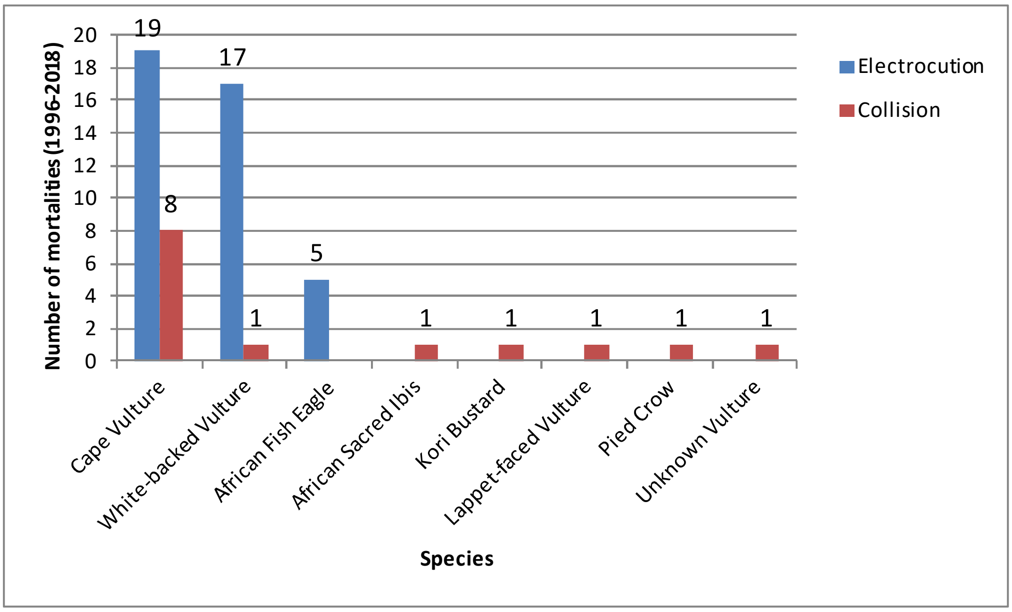

Figure 23: The number of mortalities per bird species caused by electrocutions (distribution lines) and collisions (transmission lines) in the study area (1996-2018).

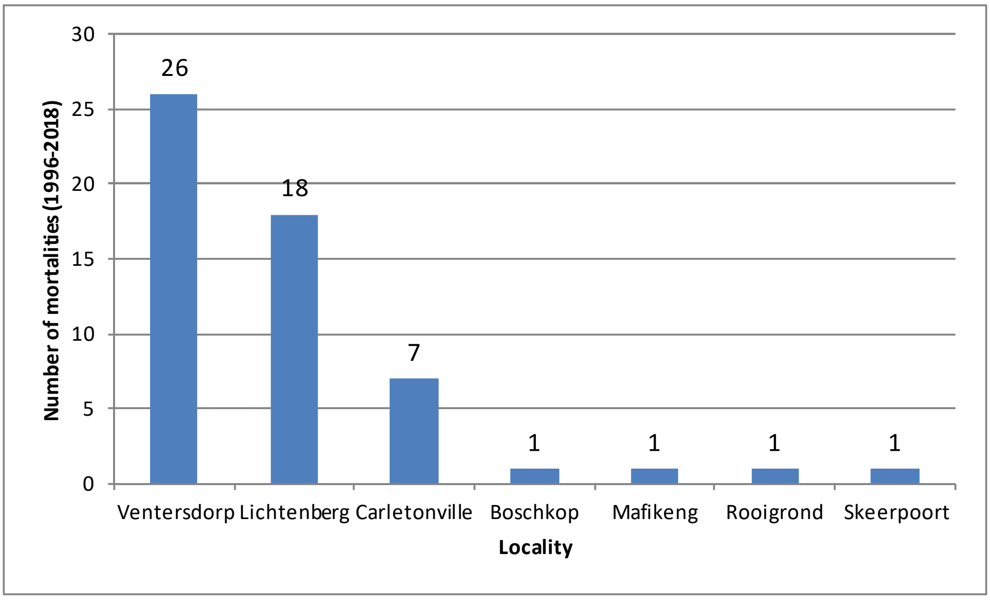

Figure 24: The number of bird mortalities caused by power lines per geographic locality (1996-2018), including the Lichtenburg area.

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 in the study area due to other planned solar farm projects and electrical infrastructure in the region.

The Lichtenburg 1 PV facility is one of three similar facilities located within 500 m of each other. The other two facilities include the Lichtenburg 2 and Lichtenburg 3 PV facilities which are located on Portion 23 of the Farm Houthaalboomen No 31 and the Remaining Extent of Portion 02 of the Farm Zamenkomst No 04 respectively. These three solar facilities will cumulatively occupy an area of approximately 784 ha (Figure 25).

In addition, other solar projects are also proposed in the region which include the two 75MW Tlisiteng PV Facilities (covering a maximum of 600 ha in total on Portion 25 of the Farm Houthaalboomen No. 31), the Watershed Solar Energy Facility and the Lichtenburg Solar Park (Table 11 and Figure 25). In addition, the new 400 kV Pluto - Mahikeng transmission line is planned for construction approximately 4 km south of the Lichtenburg 3 PV facility.

The cumulative impacts are likely to exacerbate the displacement and loss of habitat. In addition, the grid connection (via overhead power lines) of these facilities with high voltage lines south of the study area will increase the probability of bird strikes with power lines and avian mortalities due to collision and electrocution. *It is especially* *vulture species that are at risk of colliding or electrocution by the proposed additional electrical infrastructure*.

Table 11: A summary of proposed solar projects in the area.

Project Name	DEA Reference Number(s)	Location	Approximate distance from proposed Lichtenburg 1	Project Status
Lichtenburg Solar Park (1 x 70MW project)	14/12/16/3/3/2/270	A Portion of Portion 10 of the Farm Lichtenburg Town and Townlands No. 27	~1.6km south	EIA in process
Tlisitseng PV 1 Solar Energy Facility (1 x 75MW projects)	14/12/16/3/3/2/9	Portion 25 of the Farm Houthaalboomen No. 31	~ 2.8km south-south-west	EA awarded
Tlisitseng PV 2 Solar Energy Facility (1 x 75MW projects)	14/12/16/3/3/2/975	Portion 25 of the Farm Houthaalboomen No. 31	~ 2.8km south-south-west	EA awarded
Watershed Solar Energy Facility (Phase 1) (1 x 75MW project)	14/12/16/3/3/2/556	Portions 1, 9, 10 and 18 of the Farm Houthaalboomen No. 31	~6.7km south-west	EIA in process
Watershed Solar Energy Facility (Phase 2) (1 x 75MW project)	14/12/16/3/3/2/557	Portions 1, 9, 10 and 18 of the Farm Houthaalboomen No. 31	~6.7km south-west	EIA in process
Lichtenburg 2 PV Facility (1 x 100MW project)	4/12/16/3/3/2/1092	Portion 23 of the Farm Houthaalboomen No. 31	~600m south-west	EIA in process
Lichtenburg 3 PV Facility (1 x 100MW project)	14/12/16/3/3/2/1093	Remaining Extent of Portion 02 of the Farm Zamenkomst No. 04	Adjacent (south)	EIA in process

A summary of the cumulative impacts is provided in Table 12.

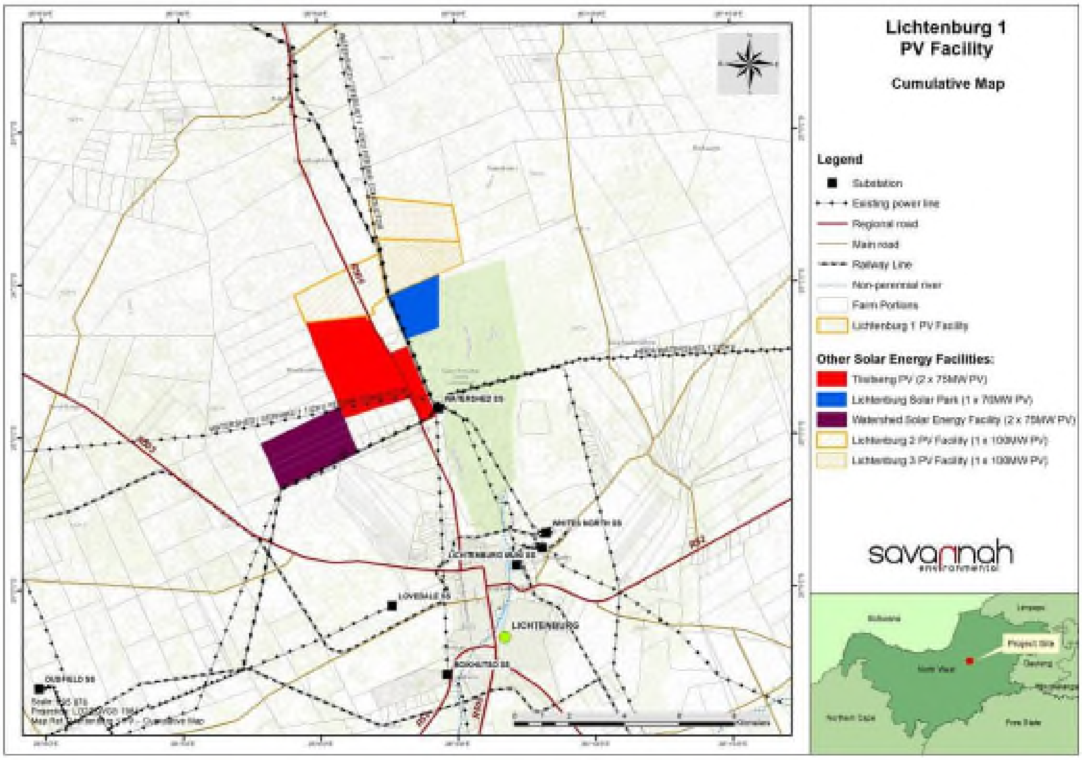

Figure 25: Proposed or planned solar energy facilities in the study area.

Table 12: 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)	Regional (4)
Duration	Long-term (4)	Long-term (4)
Magnitude	Moderate (6)	Moderate (6)
Probability	Probable (3)	Probable (3)
Significance	**Medium (36)**	**Medium (42)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Low
Loss of resources?	Yes	Yes
Can impacts be mitigated?	Yes, to some extent	Yes
Confidence in findings: High.		
Mitigation: The best practicable mitigation will be to consolidate infrastructure (e.g. proposed power line) to areas where existing impacts occur (e.g. placing the proposed power line alongside existing power lines). The development footprint of the various individual facilities must be kept as small as possible and sensitive habitats must be avoided.		

2. Nature: Avian collision impacts related to the PV facility during the operation 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	Local (2)	Local and immediate surroundings (3)
Duration	Long-term (4)	Long-term (4)
Magnitude	Minor (2)	Moderate (6)
Probability	Improbable (2)	Probable (2)
Significance	**Low (16)**	**Low (26)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Low
Irreplaceable loss of resources?	No, although threatened species are present in the area, these are likely to become displaced while waterbirds are uncommon due to the absence of prominent water/wetland features in the area.	No, although threatened species are present in the area, these are likely to become displaced while waterbirds are uncommon due to the absence of prominent water/wetland features in the area
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.		

3. Nature: Avian collision impacts related to the overhead power lines during operation.		
	Overall impact of the proposed project considered in isolation	**Cumulative impact of the project and other projects in the area**
Extent	Regional (4)	Regional (4)
Duration	Long-term (4)	Long-term (4)
Magnitude	High (8)	High (8)
Probability	Probable (3)	Highly Probable (4)
Significance	**Medium (48)**	**High (64)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Low
Irreplaceable loss of resources?	Yes, owing to the potential loss of critically endangered or endangered bird species	Yes, owing to the potential loss of critically endangered or endangered bird species
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 power lines 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 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	Immediate area (3)	Regional (4)
Duration	Long-term (4)	Long-term (4)
Magnitude	High (8)	High (8)
Probability	Probable (3)	Highly Probable (4)
Significance	**Medium (45)**	**High (64)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Low
Irreplaceable loss of resources?	Yes, owing to the potential loss of critically endangered or endangered bird species	Yes, owing to the potential loss of critically endangered or endangered bird species.
Can impacts be mitigated?	Yes, to some extent	Yes, to some extent
Confidence in findings: Moderate.		
Mitigation: Make use of bird-friendly pylons and bird guards. As far as possible, position electrical infrastructure in close proximity to existing similar infrastructure.		

4.12 Recommended avifaunal mitigation

4.12.1 Loss of habitat and displacement bird taxa (including threatened and near threatened birds)

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

The following mitigation measures are proposed:

- Concentrate all surface infrastructure on habitat of medium to low avifaunal sensitivity. The development footprint of the various individual facilities must be kept as small as possible and sensitive habitats must be avoided.
- Where possible, existing access roads should be used and the construction of new roads should be kept to a minimum.
- Prevent an overspill of construction activities into areas that are not part of the proposed construction site;
- Use indigenous plant species native to the study site 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 lines.
- Where possible, retain dense bush clump habitat as part of an open space system to provide refugia and perching platforms for "bushveld" bird species.

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.
- 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:

- Implement at least an additional bird survey (pre-construction surveys - see section dealing with monitoring and EMP) during the peak wet season to obtain quantified data on the occurrence or flyways of waterbird taxa. The data will enable informed decisions regarding the use of deterrent devices.
- Apply bird deterrent devices to the panels at selective areas (for example at the corners and middle part of the facility) to discourage birds from colonising/colliding with the infrastructure. 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.
- 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.
- The **proposed power line servitude and substation should be placed adjacent to existing power lines (e.g. L1 OHL corridor 2)**. This will increase the visibility of the lines and concentrate impacts rather than segregating impacts onto areas consisting of untransformed habitat.
- The footprint of this corridor is small and it is spatially situated in close proximity to existing power lines. If the LILO corridor is found to be unsuitable, then corridor 2 (L1 OHL corridor 2) is preferred since this alignment will run parallel to a number of existing power lines.
- It is advised that the artificial livestock watering points corresponding to the L1 OHL corridor 1 (LILO) and L1 OHL corridor 2 be removed or relocated to prevent collisions with birds that are attempting to drink water from the watering point.
- It is advised that all infrastructure be fenced to prevent cattle from accessing the facility. Avoid the placement of cattle feedlots, kraals and watering points in close proximity to overhead electrical infrastructure. A safe distance of at least 100 m (preferably 200 m) from any overhead powerline is recommended. It is advised that grazing cattle at or in close proximity to distribution lines (*c*. 100 m) be monitored (to avoid the risk of livestock carcasses near distribution lines, which may attract vultures and increase the

risk of collision or electrocution by overhead lines). In the event that a carcass is located, it should immediately be removed from the area. If livestock carcasses are considered safe for consumption by vultures, it may be donated to the nearby vulture restaurant.

- EWT should be consulted on an appropriate pylon design to be used for the project. 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 26[10].

From Figure 26 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).

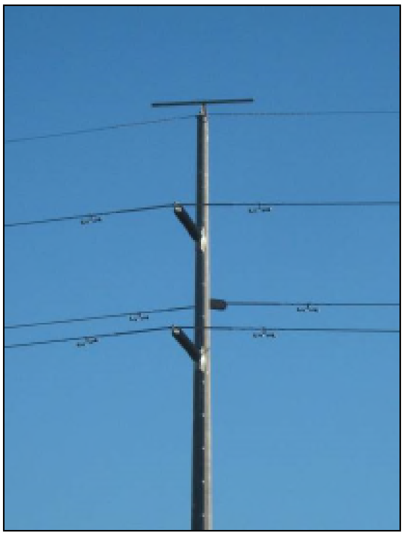

Figure 26: Two bird-friendly tower designs to be considered for the current project.

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

- All new and planned power lines should be fitted with bird flight diverters (see Figure 27).

Figure 27: Examples of bird flight diverters to be used on the power lines: Double loop bird flight diverter (left) and Viper live bird flapper (right).

4.12.5 General mitigation measures

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

4.13 Suggested monitoring and Environmental Management Plan

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

- At least one additional pre-construction survey is recommended, consisting of a minimum of 1-2 days which is necessary to inform the final EMPr during operation. The survey should coincide with the peak wet season when most of the drainage lines and wetland features in the wider study region are inundated. This will enable the observer to obtain quantified data on waterbird richness and potential flyways, which will contribute towards the understanding of impacts related to collision trauma with the panels.
- A post-construction survey during operation (with a minimum of 2 x 3 day surveys during 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 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 birds of prey and species of conservation concern.
- It is possible that bird mortalities due to collision will occur at the power lines even after mitigation. The post-construction monitoring (during operation) should also quantify mortalities (especially vulture mortalities) caused by the power line network. The information could then be used to inform the electrical infrastructure mortality incident register. It is suggested that monitoring should be implemented once a month for at least one year when in operation. 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 birds of prey and species of conservation concern.

OBJECTIVE 1: *Minimise 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	» 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, 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 pre-construction monitoring protocols (as per Jenkins et al., 2017).	ECO & EM	Prior to construction - At least 1 survey of 1-2 days (during wet season)
• Implement post-construction monitoring and carcass surveys (as per Jenkins et al., 2017).	OM & CER	Post- construction - At least 2 surveys, each 3 days during a 6 month period
• Compile management programme to assess efficacy of mitigation and on-going research/trials.	EM & OM	Operation (on-going)

Performance Indicator	Reduced statistical detection/observation of bird mortalities
Monitoring	• Implement at least one pre-construction survey consisting of a minimum of 1-2 days. • Surveys should coincide with the peak wet season when most of the

	drainage lines and wetland features in the wider study region are inundated. • Obtain quantified data on waterbird richness and potential flyways, which will contribute towards the understanding of impacts related to collision trauma with the panels. • Monitor terrestrial birds at the fixed point counts by using the exact protocol applied during this report. • Implement post-construction survey during operation with a minimum of 2 x 3 day surveys during a six month period (including the peak wet season). • 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 (an option is the use of installed video cameras at selected areas) 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: Minimise collisions and electrocution associated with power lines

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

Mitigation: Action/Control	Responsibility	Timeframe
• Apply bird deterrent devices to all new power lines power line	ECO & CER	Construction
• Implement post-construction monitoring and carcass surveys	OM	Operation - daily
• Compile management programme to assess efficacy of mitigation and on-going research/trials	OM & CER	Operation - monthly for at least one year
• Report mortalities (number, locality and species) to Electrical Energy Mortality Register at EWT	OM	Operation (on-going)
• Relocate/remove artificial livestock watering points that are to be spanned by OHL	ECO	Construction

corridors.		

Performance Indicator	Reduced statistical detection/observation of bird mortalities
Monitoring	• Implement surveys for livestock carcasses. • Implement post-construction monitoring to quantify bird mortalities caused by the power line 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 Conclusion and an opinion regarding the feasibility of the project

Pachnoda Consulting cc was requested by Savannah Environmental (Pty) Ltd to compile an avifauna baseline and impact assessment report for the proposed Lichtenburg 1 PV solar facility and associated infrastructure on Portion 06 of the Farm Zamenkomst No 04 near Lichtenburg, North West Province.

Four avifaunal habitat types were identified, and consisted of open mixed dolomite grassland with bush clump mosaics, artificial livestock watering points, arable/fallow land and power line pylons which were often used by vultures when roosting. Approximately 204 bird species are expected to occur in the wider study area, of which 100 species were observed in the area with 65 species confined to the study site (infrastructure footprint). The expected richness included 12 threatened or near threatened species, 15 southern African endemics and 21 near-endemic species. The critically endangered White-backed Vulture (*Gyps africanus*) was observed on the study site, although the endangered Cape Vulture (*G. coprotheres*), endangered Lappet-faced Vulture (*Torgos tracheliotos*) and near threatened Black-winged Pratincole (*Glareola nordmanni*) were confirmed from habitat adjacent to the study site. Seven southern African endemics and 13 near-endemic species were confirmed on the study site.

An evaluation of potential and likely impacts on the avifauna revealed that the impact significance was low or moderate after mitigation (depending on the type of impact), with the exception of the potential for birds to collide with the associated power lines, which was high without mitigation (and moderate after mitigation). The study site was not located near any prominent wetland system or impoundment, and therefore the risk of waterbird collisions with the proposed infrastructure was considered to be low.

The endangered Cape Vulture (*Gyps coprotheres*), critically endangered White-backed Vulture (*Gyps africanus*) and Lappet-faced Vulture (*Torgos tracheliotos*) were identified as regular foraging visitors to the study site (according to SABAP2 reporting rates and on-site observations). These species are highly prone to power line collisions, whereby the proposed energy facility (especially the proposed overhead power lines) could pose a collision and electrocution risk to vultures. The risk of collision/electrocution was considered likely when vultures feed on a carcass in close proximity to a power line or when attempting to roost on the pylon structures (especially vultures visiting a nearby active vulture restaurant).

No fatal-flaws were identified during the assessment, and irrespective of the layout options proposed for the PV facility and the internal substation (preferred vs. alternative), the significance of the avifaunal impacts were regarded as identical. Impacts related to avian collision and electrocution with overhead power lines will be reduced when the preferred L1 OHL corridor 2 were to be considered instead of L1 OHL corridor 3. Nevertheless, it is strongly recommended that the proposed mitigation measures and monitoring protocols (additional with pre- and post construction monitoring) be implemented during the construction and operational phase of the project.

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www.sabap2.adu.org.za

Appendix 1: A shortlist of bird species expected to be present on the study region and immediate surroundings. The list provides an indication of the species occurrence according to SABAP1 and SABAP2 reporting rates. The list was derived (and modified) from species observed in pentad grid 2600_2605 and the eight surrounding grids. The reporting rates include submissions made during the July and October 2018 surveys.

Ref	Common Name	Scientific name	SABAP2 reporting rate (%)			SABAP1 reporting rate (%)
			Full protocol	Adhoc protocol	Incidentals	
533	Babbler, Arrow-marked	*Turdoides jardineii*	3.03			27.45
432	Barbet, Acacia Pied	*Tricholaema leucomelas*	39.39		5	56.37
431	Barbet, Black-collared	*Lybius torquatus*	31.82		3	58.33
439	Barbet, Crested	*Trachyphonus vaillantii*	65.15		5	76.96
673	Batis, Chinspot	*Batis molitor*	1.52		1	38.71
404	Bee-eater, European	*Merops apiaster*	27.27		4	16.67
410	Bee-eater, Little	*Merops pusillus*	7.58		1	11.27
411	Bee-eater, Swallow-tailed	*Merops hirundineus*	1.52			3.52
409	Bee-eater, White-fronted	*Merops bullockoides*	12.12			4.90
808	Bishop, Southern Red	*Euplectes orix*	60.61		9	40.20
722	Bokmakierie	*Telophorus zeylonus*	46.97		5	50.49
709	Boubou, Southern	*Laniarius ferrugineus*	3.03			25.49
731	Brubru, Brubru	*Nilaus afer*	1.52		1	1.41
544	Bulbul, African Red-eyed	*Pycnonotus nigricans*	42.42		2	63.73
545	Bulbul, Dark-capped	*Pycnonotus tricolor*	37.88		10	46.57
872	Bunting, Cinnamon-breasted	*Emberiza tahapisi*	13.64		2	10.29
874	Bunting, Golden-breasted	*Emberiza flaviventris*				7.35
871	Bunting, Lark-like	*Emberiza impetuani*	1.52			0.70
723	Bush-shrike, Grey-headed	*Malaconotus blanchoti*	1.52			0.00
196	Buttonquail, Kurrichane	*Turnix sylvaticus*	Full out of range observation (15/10/2018)			0.70
154	Buzzard, Steppe	*Buteo (buteo) vulpinus*	3.03	14.29	1	10.29
860	Canary, Black-throated	*Crithagra atrogularis*	40.91		3	41.18
866	Canary, Yellow	*Crithagra flaviventris*	62.12		8	37.25
859	Canary, Yellow-fronted	*Crithagra mozambicus*	1.52			8.82
575	Chat, Anteating	*Myrmecocichla formicivora*	45.45	28.57	7	63.73
570	Chat, Familiar	*Oenanthe familiaris*	4.55			2.94
631	Cisticola, Cloud	*Cisticola textrix*	19.70			2.45
630	Cisticola, Desert	*Cisticola aridulus*	18.18		1	3.43
642	Cisticola, Rattling	*Cisticola chiniana*	10.61			1.47
629	Cisticola, Zitting	*Cisticola juncidis*	39.39		3	4.90
504	Cliff-swallow, South African	*Hirundo spilodera*	28.79		6	34.80
4131	Coucal, Burchell's	*Centropus burchellii*	19.70			46.08
278	Courser, Double-banded	*Rhinoptilus africanus*				2.82
277	Courser, Temminck's	*Cursorius temminckii*				2.94
216	Crane, Blue	*Anthropoides paradiseus*				47.18
621	Crombec, Long-billed	*Sylvietta rufescens*	6.06		1	0.70
523	Crow, Cape	*Corvus capensis*	1.52			20.59
522	Crow, Pied	*Corvus albus*	42.42		8	85.78
344	Cuckoo, Black	*Cuculus clamosus*				1.61

Ref	Common Name	Scientific name	SABAP2 reporting rate (%)			SABAP1 reporting rate (%)
352	Cuckoo, Diderick	*Chrysococcyx caprius*	33.33		6	32.35
346	Cuckoo, Great Spotted	*Clamator glandarius*				0.70
348	Cuckoo, Jacobin	*Clamator jacobinus*				4.84
351	Cuckoo, Klaas's	*Chrysococcyx klaas*				2.45
347	Cuckoo, Levaillant's	*Clamator levaillantii*				1.61
343	Cuckoo, Red-chested	*Cuculus solitarius*				24.19
317	Dove, Laughing	*Spilopelia senegalensis*	93.94	14.29	13	90.69
318	Dove, Namaqua	*Oena capensis*	12.12	14.29	3	33.82
314	Dove, Red-eyed	*Streptopelia semitorquata*	72.73	14.29	7	78.92
940	Dove, Rock	*Columba livia*	16.67		3	7.84
517	Drongo, Fork-tailed	*Dicrurus adsimilis*	1.52	14.29		77.42
96	Duck, Yellow-billed	*Anas undulata*	34.85		4	63.73
142	Eagle, Martial	*Polemaetus bellicosus*	1.52			0.00
134	Eagle, Tawny	*Aquila rapax*				2.11
137	Eagle, Wahlberg's	*Aquila wahlbergi*				11.29
368	Eagle-owl, Spotted	*Bubo africanus*	3.03		2	1.47
61	Egret, Western Cattle	*Bubulcus ibis*	45.45		7	78.92
600	Eremomela, Yellow-bellied	*Eremomela icteropygialis*				0.70
119	Falcon, Amur	*Falco amurensis*	21.21		4	13.38
114	Falcon, Lanner	*Falco biarmicus*	4.55		2	2.82
120	Falcon, Red-footed	*Falco vespertinus*	3.03			2.11
820	Finch, Red-headed	*Amadina erythrocephala*	28.79		1	61.97
789	Finch, Scaly-feathered	*Sporopipes squamifrons*	22.73		4	6.37
835	Firefinch, Jameson's	*Lagonosticta rhodopareia*	3.03			3.23
837	Firefinch, Red-billed	*Lagonosticta senegala*	16.67		2	7.84
707	Fiscal, Southern	*Lanius collaris*	71.21	14.29	7	87.75
678	Flycatcher, Fairy	*Stenostira scita*				3.92
665	Flycatcher, Fiscal	*Melaenornis silens*	45.45		8	58.82
661	Flycatcher, Marico	*Bradornis mariquensis*	6.06		4	5.88
654	Flycatcher, Spotted	*Muscicapa striata*	16.67			11.76
173	Francolin, Coqui	*Peliperdix coqui*	3.03			2.45
179	Francolin, Orange River	*Scleroptila gutturalis*	18.18		7	15.20
339	Go-away-bird, Grey	*Corythaixoides concolor*	21.21	14.29	4	41.18
89	Goose, Egyptian	*Alopochen aegyptiacus*	16.67		3	60.78
88	Goose, Spur-winged	*Plectropterus gambensis*	7.58		1	43.14
165	Goshawk, Southern Pale Chanting	*Melierax canorus*	Full out of range observation (15/10/2018)			0.70
192	Guineafowl, Helmeted	*Numida meleagris*	42.42	14.29	9	59.80
288	Gull, Grey-headed	*Larus cirrocephalus*	3.03			2.11
72	Hamerkop	*Scopus umbretta*	4.55		1	12.75
171	Harrier-Hawk, African	*Polyboroides typus*	3.03			0.00
55	Heron, Black-headed	*Ardea melanocephala*	19.70		4	47.06
440	Honeyguide, Greater	*Indicator indicator*	4.55		2	2.45
442	Honeyguide, Lesser	*Indicator minor*	4.55			0.98
418	Hoopoe, African	*Upupa africana*	43.94	14.29	6	77.45
424	Hornbill, African Grey	*Lophoceros nasutus*				12.75
81	Ibis, African Sacred	*Threskiornis aethiopicus*	10.61			60.29
83	Ibis, Glossy	*Plegadis falcinellus*	19.70		3	14.71
84	Ibis, Hadeda	*Bostrychia hagedash*	57.58		5	81.86
851	Indigobird, Village	*Vidua chalybeata*				4.90

Ref	Common Name	Scientific name	SABAP2 reporting rate (%)			SABAP1 reporting rate (%)
122	Kestrel, Greater	*Falco rupicoloides*	3.03			27.94
125	Kestrel, Lesser	*Falco naumanni*	16.67		3	14.22
402	Kingfisher, Brown-hooded	*Halcyon albiventris*				18.63
128	Kite, Black	*Milvus migrans*	1.52			0.70
130	Kite, Black-winged	*Elanus caeruleus*	33.33	42.86	6	59.80
129	Kite, Yellow-billed	*Milvus aegyptius*	12.12	14.29	3	7.84
1035	Korhaan, Northern Black	*Afrotis afraoides*	33.33		7	52.94
247	Lapwing, African Wattled	*Vanellus senegallus*	1.52			3.43
245	Lapwing, Blacksmith	*Vanellus armatus*	69.70		5	73.53
242	Lapwing, Crowned	*Vanellus coronatus*	65.15		7	72.06
1183	Lark, Eastern Clapper	*Mirafra fasciolata*	18.18		5	24.02
488	Lark, Red-capped	*Calandrella cinerea*	4.55		1	6.34
456	Lark, Melodious	*Mirafra cheniana*	Full out of range observation (numerous observations, July & October 2018)			0.00
458	Lark, Rufous-naped	*Mirafra africana*	31.82		3	33.33
460	Lark, Sabota	*Calendulauda sabota*	6.06		1	4.93
474	Lark, Spike-heeled	*Chersomanes albofasciata*	22.73		6	25.98
703	Longclaw, Cape	*Macronyx capensis*	27.27		2	36.27
510	Martin, Banded	*Riparia cincta*	12.12		2	4.41
509	Martin, Brown-throated	*Riparia paludicola*	7.58			30.99
803	Masked-weaver, Southern	*Ploceus velatus*	77.27		10	69.12
392	Mousebird, Red-faced	*Urocolius indicus*	51.52	14.29	5	51.47
390	Mousebird, Speckled	*Colius striatus*	15.15		2	14.71
391	Mousebird, White-backed	*Colius colius*	50.00		9	54.90
734	Myna, Common	*Acridotheres tristis*	66.67	14.29	8	0.00
637	Neddicky	*Cisticola fulvicapilla*	18.18		2	12.75
371	Nightjar, European	*Caprimulgus europaeus*				0.70
372	Nightjar, Rufous-cheeked	*Caprimulgus rufigena*	Full out of range observation (15/10/2018)			4.84
521	Oriole, Black-headed	*Oriolus larvatus*	4.55			25.98
359	Owl, Western Barn	*Tyto alba*	3.03		1	6.37
361	Owl, Marsh	*Asio capensis*				5.63
365	Owlet, Pearl-spotted	*Glaucidium perlatum*				2.94
387	Palm-swift, African	*Cypsiurus parvus*	37.88		5	21.08
682	Paradise-flycatcher, African	*Terpsiphone viridis*	9.09		4	11.76
852	Paradise-whydah, Long-tailed	*Vidua paradisaea*	1.52			2.11
531	Penduline-tit, Cape	*Anthoscopus minutus*	3.03			0.00
311	Pigeon, Speckled	*Columba guinea*	63.64	14.29	10	69.12
692	Pipit, African	*Anthus cinnamomeus*	37.88		4	21.57
695	Pipit, Buffy	*Anthus vaalensis*				2.11
694	Pipit, Plain-backed	*Anthus leucophrys*	1.52			0.00
238	Plover, Three-banded	*Charadrius tricollaris*	33.33		2	25.98
282	Pratincole, Black-winged	*Glareola nordmanni*	Full out of range observation (15/10/2018)			0.70
650	Prinia, Black-chested	*Prinia flavicans*	66.67		7	31.37
649	Prinia, Tawny-flanked	*Prinia subflava*	7.58			3.92
830	Pytilia, Green-winged	*Pytilia melba*	4.55		1	2.82
189	Quail, Common	*Coturnix coturnix*				0.98
844	Quailfinch	*Ortygospiza atricollis*	12.12		3	4.90
805	Quelea, Red-billed	*Quelea quelea*	42.42		7	29.90

Ref	Common Name	Scientific name	SABAP2 reporting rate (%)			SABAP1 reporting rate (%)
606	Reed-warbler, African	*Acrocephalus baeticatus*	19.70			1.96
581	Robin-chat, Cape	*Cossypha caffra*	19.70		2	61.27
412	Roller, European	*Coracias garrulus*	1.52			1.96
413	Roller, Lilac-breasted	*Coracias caudatus*	1.52			14.08
421	Scimitarbill, Common	*Rhinopomastus cyanomelas*	15.15		7	20.97
586	Scrub-robin, Kalahari	*Cercotrichas paena*	31.82		7	18.14
588	Scrub-robin, White-browed	*Cercotrichas leucophrys*	1.52			1.47
105	Secretarybird	*Sagittarius serpentarius*	1.52			2.45
867	Seedeater, Streaky-headed	*Crithagra gularis*	1.52			5.88
711	Shrike, Crimson-breasted	*Laniarius atrococcineus*	16.67	14.29	1	28.92
706	Shrike, Lesser Grey	*Lanius minor*	16.67		3	7.35
708	Shrike, Red-backed	*Lanius collurio*	25.76		4	16.67
146	Snake-eagle, Black-chested	*Circaetus pectoralis*	4.55		2	1.47
145	Snake-eagle, Brown	*Circaetus cinereus*	1.52			0.00
786	Sparrow, Cape	*Passer melanurus*	72.73	14.29	9	71.57
784	Sparrow, House	*Passer domesticus*	53.03	14.29	7	51.47
4142	Sparrow, Southern Grey-headed	*Passer diffusus*	19.70		2	6.86
780	Sparrow-weaver, White-browed	*Plocepasser mahali*	69.70		8	60.78
484	Sparrowlark, Chestnut-backed	*Eremopterix leucotis*	3.03		1	9.15
485	Sparrowlark, Grey-backed	*Eremopterix verticalis*				5.63
183	Spurfowl, Natal	*Pternistis natalensis*	3.03			4.41
185	Spurfowl, Swainson's	*Pternistis swainsonii*	43.94		7	36.27
737	Starling, Cape Glossy	*Lamprotornis nitens*	30.30		5	82.35
746	Starling, Pied	*Lamprotornis bicolor*	7.58			39.22
735	Starling, Wattled	*Creatophora cinerea*	43.94		8	51.96
576	Stonechat, African	*Saxicola torquatus*	40.91		5	57.84
78	Stork, Abdim's	*Ciconia abdimii*				7.75
73	Stork, Marabou	*Leptoptilos crumeniferus*	1.52			0.70
80	Stork, White	*Ciconia ciconia*				6.34
772	Sunbird, Amethyst	*Chalcomitra amethystina*	6.06		1	18.63
755	Sunbird, Marico	*Cinnyris mariquensis*	1.52			0.00
763	Sunbird, White-bellied	*Cinnyris talatala*	10.61		1	35.29
493	Swallow, Barn	*Hirundo rustica*	31.82		4	35.78
502	Swallow, Greater Striped	*Crecopis cucullata*	48.48		8	36.76
498	Swallow, Pearl-breasted	*Hirundo dimidiata*				0.70
501	Swallow, Red-breasted	*Crecopis semirufa*	3.03	14.29		3.92
378	Swift, Common	*Apus apus*	Full out of range observation (15/10/2018)			0.00
384	Swift, Horus	*Apus horus*				2.11
385	Swift, Little	*Apus affinis*	33.33		5	31.86
383	Swift, White-rumped	*Apus caffer*	28.79		1	18.63
714	Tchagra, Brown-crowned	*Tchagra australis*	10.61		3	6.86
275	Thick-knee, Spotted	*Burhinus capensis*	6.06		1	19.12
557	Thrush, Groundscraper	*Turdus litsipsirupa*	7.58		3	24.02
1104	Thrush, Karoo	*Turdus smithi*	57.58		6	66.18
658	Warbler, Chestnut-vented	*Sylvia subcaerulea*	42.42		7	30.88
316	Turtle-dove, Cape	*Streptopelia capicola*	19.70	14.29	3	58.82
106	Vulture, Cape	*Gyps coprotheres*	9.09		1	17.16
108	Vulture, Lappet-faced	*Torgos tracheliotos*	6.06		1	5.63

Ref	Common Name	Scientific name	SABAP2 reporting rate (%)			SABAP1 reporting rate (%)
107	Vulture, White-backed	*Gyps africanus*	12.12		3	16.18
686	Wagtail, Cape	*Motacilla capensis*	59.09		7	86.27
607	Warbler, Marsh	*Acrocephalus palustris*	4.55			0.00
599	Warbler, Willow	*Phylloscopus trochilus*	10.61		1	5.39
839	Waxbill, Blue	*Uraeginthus angolensis*	21.21		2	4.41
843	Waxbill, Common	*Estrilda astrild*	18.18			6.37
838	Waxbill, Orange-breasted	*Amandava subflava*	3.03			1.96
840	Waxbill, Violet-eared	*Granatina granatina*	1.52			6.34
799	Weaver, Cape	*Ploceus capensis*	6.06		1	30.88
568	Wheatear, Capped	*Oenanthe pileata*	10.61		2	9.80
564	Wheatear, Mountain	*Oenanthe monticola*	3.03		1	11.76
1172	White-eye, Cape	*Zosterops virens*	27.27		4	66.18
594	Whitethroat, Common	*Sylvia communis*				0.70
846	Whydah, Pin-tailed	*Vidua macroura*	27.27		2	22.55
847	Whydah, Shaft-tailed	*Vidua regia*				0.70
818	Widowbird, Long-tailed	*Euplectes progne*	37.88	14.29	6	56.37
813	Widowbird, Red-collared	*Euplectes ardens*	3.03			2.11
814	Widowbird, White-winged	*Euplectes albonotatus*	19.70		4	4.41
419	Wood-hoopoe, Green	*Phoeniculus purpureus*	12.12		4	16.18
450	Woodpecker, Cardinal	*Dendropicos fuscescens*	Full out of range observation (15/10/2018 & 03/07/2018)			8.06
447	Woodpecker, Golden-tailed	*Campethera abingoni*	1.52			4.41

Appendix 2: A shortlist of bird species observed during July 2018 and October 2018 on Portion 06 of the Farm Zamenkomst No 04 (Lichtenburg 1 PV solar facility). The initial position (datum WGS 84) of each species is also provided.

Common Name	Scientific Name	Initial Observation	
		Latitude	Longitude
Acacia Pied Barbet	*Tricholaema leucomelas*	-26.0339	26.1455
African Hoopoe	*Upupa africana*	-26.0364	26.1458
African Pipit	*Anthus cinnamomeus*	-26.0339	26.1455
Ant-eating Chat	*Myrmecocichla formicivora*	-26.0339	26.1455
Barn Swallow	*Hirundo rustica*	-26.0283	26.1386
Black-chested Prinia	*Prinia flavicans*	-26.0339	26.1455
Black-winged Kite	*Elanus caeruleus*	-26.0239	26.1391
Bokmakierie	*Telophorus zeylonus*	-26.0339	26.1455
Brown-crowned Tchagra	*Tchagra australis*	-26.0303	26.1307
Cape Glossy Starling	*Lamprotornis nitens*	-26.0228	26.1291
Cape Longclaw	*Macronyx capensis*	-26.0239	26.1391
Cape Penduline Tit	*Anthoscopus minutus*	-26.0284	26.1443
Cape Sparrow	*Passer melanurus*	-26.0363	26.1457
Cape Turtle Dove	*Streptopelia capicola*	-26.0339	26.1455
Cape White-eye	*Zosterops virens*	-26.0249	26.1345
Cardinal Woodpecker	*Dendropicos fuscescens*	-26.0305	26.1360
Chestnut-vented Tit-Babbler	*Sylvia subcoerulea*	-26.0339	26.1455
Cloud Cisticola	*Cisticola textrix*	-26.0250	26.1244
Common Scimitarbill	*Rhinopomastus cyanomelas*	-26.0296	26.1464
Crested Barbet	*Trachyphonus vaillantii*	-26.0339	26.1455
Crimson-breasted Shrike	*Laniarius atrococcineus*	-26.0341	26.1368
Crowned Lapwing	*Vanellus coronatus*	-26.0244	26.1310
Dark-capped Bulbul	*Pycnonotus tricolor*	-26.0339	26.1454
Desert Cisticola	*Cisticola aridulus*	-26.0339	26.1455
Diederik Cuckoo	*Chrysococcyx caprius*	-26.0240	26.1289
Eastern Clapper Lark	*Mirafra fasciolata*	-26.0363	26.1457
European Bee-eater	*Merops apiaster*	-26.0249	26.1345
Fiscal Flycatcher	*Melaenornis silens*	-26.0244	26.1310
Grey Go-away-bird	*Corythaixoides concolor*	-26.0314	26.1355
Hadeda Ibis	*Bostrychia hagedash*	-26.0339	26.1454
Helmeted Guineafowl	*Numida meleagris*	-26.0339	26.1455
Kalahari Scrub Robin	*Cercotrichas paena*	-26.0339	26.1455
Laughing Dove	*Spilopelia senegalensis*	-26.0339	26.1454
Lesser Honeyguide	*Indicator minor*	-26.0249	26.1345
Little Bee-eater	*Merops pusillus*	-26.0294	26.1306
Little Swift	*Apus affinis*	-26.0249	26.1345
Long-billed Crombec	*Sylvietta rufescens*	-26.0296	26.1473
Melodious Lark	*Mirafra cheniana*	-26.0339	26.1455
Namaqua Dove	*Oena capensis*	-26.0339	26.1454

Common Name	Scientific Name	Initial Observation	
Neddicky	*Cisticola fulvicapilla*	-26.0244	26.1310
Northern Black Korhaan	*Afrotis afraoides*	-26.0339	26.1454
Orange River Francolin	*Scleroptila gutturalis*	-26.0339	26.1455
Pale Chanting Goshawk	*Melierax canorus*	-26.0256	26.1386
Pied Crow	*Corvus albus*	-26.0339	26.1454
Plain-backed Pipit	*Anthus leucophrys*	-26.0356	26.1470
Quailfinch	*Ortygospiza atricollis*	-26.0268	26.1400
Red-billed Quelea	*Quelea quelea*	-26.0286	26.1215
Red-eyed Dove	*Streptopelia semitorquata*	-26.0339	26.1454
Red-faced Mousebird	*Urocolius indicus*	-26.0256	26.1471
Rufous-naped Lark	*Mirafra africana*	-26.0281	26.1456
Sabota Lark	*Calendulauda sabota*	-26.0216	26.1184
Southern Fiscal	*Lanius collaris*	-26.0297	26.1485
Southern Masked Weaver	*Ploceus velatus*	-26.0323	26.1403
Speckled Mousebird	*Colius striatus*	-26.0323	26.1400
Spike-heeled Lark	*Chersomanes albofasciata*	-26.0339	26.1454
Streaky-headed Seedeater	*Crithagra gularis*	-26.0298	26.1306
Swainson's Spurfowl	*Pternistis swainsonii*	-26.0339	26.1455
Wattled Starling	*Creatophora cinerea*	-26.0356	26.1470
Western Cattle Egret	*Bubulcus ibis*	-26.0250	26.1476
White-backed Mousebird	*Colius colius*	-26.0296	26.1473
White-backed Vulture	*Gyps africanus*	-26.0326	26.1205
White-bellied Sunbird	*Cinnyris talatala*	-26.0327	26.1213
White-browed Sparrow-Weaver	*Plocepasser mahali*	-26.0356	26.1470
Willow Warbler	*Phylloscopus trochilus*	-26.0356	26.1470
Yellow Canary	*Crithagra flaviventris*	-26.0296	26.1473

Appendix 3: Preliminary density estimates of birds recorded from the study site during two independent surveys conducted during July 2018 and October 2018.

Species	lj01	lj02	lj03	lj04	lj05	lj06	lj07	lj08	lj09	lj10	lj11	lj12	lj13	lj14	lj15	lj16	lj17	lj18	lj19	lj20	Birds/ha
Acacia Pied Barbet	0.5	1	0.5	0.5	0	0	1	0.5	4	2	0	1	1	1.5	1	0	0	1	1.5	0.5	0.28
African Pipit	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0	0.01
Black-chested Prinia	1	0.5	3	1	2	2	0.5	1.5	2	1	0	2	0	0	1	1	0	2	2	0	0.36
Bokmakierie	0	0	1	0	1	0	0	0.5	1	1	0	0	0	0	0	0	0	1	0	0	0.09
Brown-crowned Tchagra	1	0	0	0	1	0	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0.04
Black-winged Kite	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0.02
Cardinal Woodpecker	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01
Cape Longclaw	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0.02
Cape Turtle Dove	0	0	0.5	0	0	1	0	0	0.5	0	0	0.5	0	0	0	0	0	0	0	0	0.04
Crested Barbet	0	0	0	0	0	0.5	0	0	0.5	0	0	0	0	0	0.5	0	0	0.5	0	0	0.03
Chestnut-vented Warbler	2	1.5	2.5	1.5	3	0.5	0.5	1	2.5	1.5	1	1.5	1	3.5	1.5	0	1	2.5	2	0	0.49
Cape White-eye	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.03
Dark-capped Bulbul	6	1	1.5	1	1.5	2.5	2	0.5	1.5	1	0.5	1.5	2.5	4.5	1	0	1	3	1.5	0	0.54
Desert Cisticola	0	0.5	0	0	0.5	0.5	0	0.5	0.5	1	1	1	0.5	0	1	1	0.5	0.5	0.5	1.5	0.18
Eastern Clapper Lark	0	0.5	0.5	0	0	0.5	0.5	0.5	1	0.5	0.5	0.5	0	0.5	0.5	0.5	0.5	0.5	0	0	0.12
Fiscal Flycatcher	1	0	1.5	0.5	0.5	0	0	0	0	0	0	0	0	0.5	0	0	0	0	2	0	0.10
Grey-go-away-bird	0.5	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.02
Helmeted Guineafowl	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.03
African Hoopoe	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0	0.01
Kalahari Scrub-robin	1.5	0	1.5	1.5	1	0.5	0	0.5	1	0.5	0	1.5	0	1.5	0.5	0	0.5	0.5	1	0	0.21
Long-billed Crombec	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0.05
Little Bee-eater	0	0	0	1.5	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.04
Laughing Dove	8.5	0	2	2	4	1	0.5	2	2	1.5	0.5	1.5	0	2	1	0.5	0.5	7	0.5	0	0.59
Lesser Honeyguide	0.5	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0.02
Melodious Lark	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0.5	0.02
Namaqua Dove	2	0	0	0	2.5	0.5	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0.11

Species	lj01	lj02	lj03	lj04	lj05	lj06	lj07	lj08	lj09	lj10	lj11	lj12	lj13	lj14	lj15	lj16	lj17	lj18	lj19	lj20	Birds/ha
Neddicky	0	0	1	0	0.5	1	0	0.5	0.5	0.5	0	1	0	0.5	0.5	0	0	0	0.5	0	0.10
Orange River Francolin	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0.03
Plain-backed Pipit	0	0	0	0	0	0	0	0	0.5	0	0	0.5	0	0	0	0	0	0	0	0	0.02
Red-billed Quelea	0	0	0	0	0	0	0	0	0	0	0.5	0	0	1.5	0	0	0	0	0	0	0.03
Red-eyed Dove	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0.01
Red-faced Mousebird	2.5	0	1.5	0	1	2.5	0	0	0	0	0.5	0.5	0	0	0	0	0	0	0.5	0	0.14
Rufous-naped Lark	0	0.5	1	0	0	0	0.5	0.5	1	0.5	0	0.5	0	0	0.5	0.5	0	0.5	0	0	0.10
Sabota Lark	0.5	0	0.5	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0.05
Southern Fiscal	0.5	0.5	0.5	0	0.5	0.5	0.5	1	1.5	0	0	0.5	0.5	1	0	0	0.5	1	0.5	0	0.15
Streaky-headed Seed-eater	0	0	0	2	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.04
Southern Masked Weaver	1	0	1	0.5	0.5	0	0.5	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0.06
Speckled Mousebird	0	0	0	0	0	0	0	0	0	0	0.5	1	0	0	0	0	0	0	0	0	0.02
Swainson's Spurfowl	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0.01
Wattled Starling	100	0	2.5	0	27.5	0	0.5	0	0	0	5.5	0	0	9	0	0	0	0	2.5	0	2.35
White-backed Mousebird	0.5	0	0	0.5	0	0	0	0	2.5	0	0	0	0	0	0	0	0	1	0	0	0.07
White-bellied Sunbird	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0.01
Western Cattle Egret	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.02
Willow Warbler	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0.5	0	0.02
Yellow Canary	5.5	0	1	1.5	1	0.5	0	0	0	0	0	0	0	1	0	0	0	1	1.5	0	0.21
Number of individuals	**136**	**6**	**24.5**	**18**	**51.5**	**14**	**8.5**	**10.5**	**22.5**	**11**	**12**	**20.5**	**5.5**	**28**	**9**	**4.5**	**4.5**	**23.5**	**18**	**2.5**	
Number of species	**19**	**8**	**19**	**17**	**20**	**14**	**12**	**13**	**16**	**11**	**11**	**20**	**5**	**14**	**11**	**7**	**7**	**16**	**15**	**3**	
Number of birds/ha	**43.31**	**1.91**	**7.80**	**5.73**	**16.40**	**4.46**	**2.71**	**3.34**	**7.17**	**3.50**	**3.82**	**6.53**	**1.75**	**8.92**	**2.87**	**1.43**	**1.43**	**7.48**	**5.73**	**0.80**	
Number of species/ha	**6.05**	**2.55**	**6.05**	**5.41**	**6.37**	**4.46**	**3.82**	**4.14**	**5.10**	**3.50**	**3.50**	**6.37**	**1.59**	**4.46**	**3.50**	**2.23**	**2.23**	**5.10**	**4.78**	**0.96**	
Average number of birds/ha	**6.86**																				
Average number of species/ha	**4.11**																				