Lichtenburg PV Solar Park Projects

Specialist Avifaunal Impact Assessment

Prepared for

Africa Geo-Environmental Engineering and Science (AGES)

By

Mr Ryno Kemp
Pr. Sci. Nat
ryno@kempoperations.com

And

Prof Derek Engelbrecht
Pr. Sci. Nat
faunagalore@gmail.com

DECLARATION OF PROFESSIONAL STANDING AND INDEPENDENCE

I, Ryno Kemp (SACNASP # 117462/17) declare that:

- I hold higher degrees in the biological sciences, which allowed registration by the South African Council for Natural Scientific Professions (SACNASP) that sanctions us to function independently as specialist scientific consultants;
- as per prerequisites of the Natural Scientific Professions Act No. 27 of 2003, this project was our work from inception and reflected my observations and unbiased scientific interpretations exclusively, and executed to the best of my abilities;
- I abide by the Code of Ethics of SACNASP; I am committed to biodiversity conservation but concomitantly recognise the need for economic development. Whereas I appreciate opportunities to learn through constructive criticism and debate, I reserve the right to form and hold my own opinion within the constraints of my training, experience and results and, therefore, will not submit willingly to the interests of other parties or change our statements to appease or unduly benefit them;
- I am subcontracted as a specialist consultant for the project "Specialist Avifaunal Impact Assessment – Lichtenburg Solar Park development", as described in this report;
- I have no financial interest in the proposed development other than remuneration for the work performed;
- I do not have, and will not have in the future, any vested or conflicting interests in the proposed development;
- I undertake to disclose to the consultant and its client(s) as well as to the competent authority any material information that may have the potential to influence any decisions by the competent authority, as required in terms of the Environmental Impact Assessment Regulations 2006;
- I reserve the right to transfer our intellectual property in this report only to the client(s) (party or company that commissioned the work) on full payment of the contract fee. Upon transfer of the intellectual property, we recognise that written consent from the client will be required to release any part of this report to third parties.
- In addition, remuneration for services provided by me is not subjected to or based on approval of the proposed project by the relevant authorities responsible for authorising this proposed project.

Ryno Kemp Pretoria, 21 April 2022

And

I, Derek Engelbrecht (SACNASP #400120/01) declare that:

- I hold higher degrees in the biological sciences, which allowed registration by the South African Council for Natural Scientific Professions (SACNASP) that sanctions us to function independently as specialist scientific consultants;
- as per prerequisites of the Natural Scientific Professions Act No. 27 of 2003, this project was our work from inception and reflects exclusively our observations and unbiased scientific interpretations, and executed to the best of our abilities;
- I abide by the Code of Ethics of SACNASP; I am committed to biodiversity conservation but concomitantly recognise the need for economic development. Whereas I appreciate opportunities to learn through constructive criticism and debate, I reserve the right to form and hold our own opinions within the constraints of our training, experience and results, and therefore will not submit willingly to the interests of other parties or change our statements to appease or unduly benefit them;
- Specialist Avifaunal Impact Assessment – Lichtenburg Solar Park development", as described in this report;
- I have no financial interest in the proposed development other than remuneration for the work performed;
- I do not have, and will not have in the future, any vested or conflicting interests in the proposed development;
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- In addition, remuneration for services provided by us are not subjected to or based on approval of the proposed project by the relevant authorities responsible for authorising this proposed project.

Derek Engelbrecht Polokwane, 22 April 2022

Disclaimer:

Even though every care is taken to ensure the accuracy of this report, faunal and environmental assessment studies are limited in scope, time and budget. Discussions and proposed mitigations are made, to some extent, on reasonable and informed assumptions built on *bona fide* information sources and deductive reasoning. Based on field collecting and observations, a more factual report can only be derived over several years and seasons of research to account for fluctuating environmental conditions and animal migrations. Since ecological impact studies deal with dynamic natural systems, additional information may come to light later. Therefore, the specialist cannot accept responsibility for conclusions and mitigation measures made in good faith, based on their own databases and on the information provided at the time of the directive. Although the authors exercised due care and diligence in rendering services and preparing documents, he accepts no liability and the client, by accepting this document, indemnifies the authors against all actions, claims, demands, losses, liabilities, costs, damages and expenses that arise from or in connection with services rendered, directly or indirectly, by the authors and use of this document. Therefore, this report should be viewed and acted upon with these limitations.

Executive Summary

AGES Limpopo (Pty) LTD appointed Kemp Operations (Pty) LTD to conduct an avifaunal assessment based on the EIA guideline for renewable energy projects (Department of Environmental Affairs 2015) and the Best Practice Guidelines Birds & Solar Energy (Jenkins et al. 2017) on portion 25 of the Farm Houthaalboomen 31 IP and Portion 10 of the Farm Lichtenburg Town and Townlands 27 IP to develop a renewable energy generation facility (Photovoltaic [PV] Power Plant) with associated infrastructure and structures, and a power line within the Ditsobotla Local Municipality, Ngaka Modiri Molema District Municipality, North West.

The significant potential avifaunal impacts associated with the proposed development include the permanent displacement of the avifauna through habitat loss and human activity, collision risk with solar panels, collision and electrocution risk with power lines, and disturbance during the construction and operation phase, electromagnetic fields and roosting and breeding on panels. The proposed site for the Lichtenburg Solar Park does not fall in any protected areas. However, the proposed development is near Molemane Eye Nature Reserve (~ 27 km), and the closest Important Bird and Biodiversity Area (IBA's) is ~70 km away at Botsolano Nature Reserve.

This study consisted of a field survey, a desktop study, an impact assessment of the impacts of the proposed development on the area's avifauna, and recommendations for possible mitigation. The desktop analysis recorded a total of 236 bird species that have been recorded during SABAP2 in the general area of the proposed Lichtenburg Solar Park. Of these, 32 were confirmed during the point survey count or are very likely to occur within the study area, and a further 40 are likely to occur as described in the Best Practice Guidelines Birds & Solar Energy (Jenkins et al. 2017). The species accumulation curve supported the low species richness recorded during the desktop analysis and estimated that the proposed site holds ~35 ± 7 species based on the point counts. During the field investigation, various flight paths were observed from non-priority species as well as priority species such as African White-backed and Cape Vultures over the proposed solar park and power lines. However, there are no distinct flight paths across the site, making it difficult to mitigate. A total of 12 threatened or near-threatened species have been recorded in the greater region during the desktop survey, but only two were confirmed during the field survey.

The findings of this report and the relevant impact assessment concluded that the development of the proposed Lichtenburg Solar Park would have a medium impact on the bird communities and will cause a slight impact on the ecological process of the overall bird community. The biggest concern is the threat the power lines within this area hold to threatened species such as the three vulture species present in the area. Therefore, careful considerations need to be taken regarding the proposed power line as the impact can be catastrophic. Still, the issuing authority must consider all prescribed mitigation measures and recommendations.

TABLE OF CONTENTS

Figures

Tables

1. INTRODUCTION

AGES Limpopo (Pty) LTD appointed Kemp Operations (Pty) LTD to conduct an avifaunal assessment based on the EIA guideline for renewable energy projects (Department of Environmental Affairs 2015) and the Best Practice Guidelines Birds & Solar Energy (Jenkins et al. 2017) on portion 25 of the Farm Houthaalboomen 31 IP and Portion 10 of the Farm Lichtenburg Town and Townlands 27 IP to develop a renewable energy generation facility (Photovoltaic [PV] Power Plant) with associated infrastructure and structures, and a power line within the Ditsobotla Local Municipality, Ngaka Modiri Molema District Municipality, North West (Figure 1). The proposed solar park will have a maximum generation capacity of up to 120 MW at the point of connection with the Eskom connection infrastructure. The proposed development will consist of ~240 ha of the Lichtenburg Game Breeding Centre.

The necessary application for environmental authorisation has been registered under the terms of the EIA Regulations published on 4 December 2014 under sections 24(5) and 44 of the National Environmental Management Act (NEMA, Act No. 107 of 1998). As part of the Environmental Impact Assessment process for this proposed development, several specialist surveys are required, including an avifaunal assessment which will form part of the final scoping phase of the EIA and is based on the EIA guideline for renewable energy projects (Department of Environmental Affairs 2015) and the Best Practice Guidelines Birds & Solar Energy (Jenkins et al. 2017). This report thus details the modus operandi and the findings of an avifaunal investigation at the proposed site and the results of the relevant avifaunal impact assessments.

The proposed development consists of the installation of the following equipment:

- Photovoltaic modules (mono-crystalline, poly-crystalline, or bi-facial modules)
- Mounting systems for the PV arrays will be secured in concrete foundations.
- Electrical infrastructure includes internal cabling, string boxes, DC/AC inverters, power transformers, medium voltage receiving stations, high-voltage substations with power transformers, switching stations, electrical systems, and UPS devices.
- Other significant infrastructures that will be constructed include lighting systems, grounding systems, internal roads, perimeter fencing and alarm systems, water supply pipelines and water treatment facilities.
- Sewage system
- Interventions on the Eskom Watershed Substation
- During the construction phase, additional activities (water access points, water supply pipelines, water treatment facilities, prefabricated buildings, and workshops) might occur but will be removed at the end of construction.

The proposed power line of 132 kV links the solar plant (on-site substation) and the Eskom Watershed Substation located on the Remainder Portion of the Lichtenburg Town and Townlands 27 IP.

Figure 1. Location of the proposed Lichtenburg Solar Park (Red).

1.1. OBJECTIVES AND SCOPE OF THE STUDY

The objective of this study was to carry out a preliminary avifaunal assessment of the greater area outside the footprint of the study area and data collection of the footprint area of the proposed Lichtenburg Solar Park as described in the Best Practice Guidelines Birds & Solar Energy (Jenkins et al. 2017). To assess the potential impacts that the proposed development may hold along with mitigating actions that can be implemented to limit or revoke these threats, the guidelines and recommendations as suggested by the EIA guideline for renewable energy projects (Department of Environmental Affairs 2015), as well as the Best Practice Guidelines Birds & Solar Energy (Jenkins et al. 2017), were followed.

The specific aims of this study were thus to:

- Compile a species list through desktop analysis and a field investigation
    - Produce species richness analysis from the point count surveys using EstimateS software
    - Produce a detailed bird list recorded during field surveys from published data and online databases such as the South African Bird Atlas Project 2 (SABAP2)
    - Use available online databases such as SABAP2 to compile a season list due to budget constraints

- Identify “priority“ species of conservation concern occurring within the study area and provide a detailed SABAP map of these birds for the greater area,
- Identify specific regions and avian habitats in the study area that could be regarded as sensitive or which may harbour species of conservation concern,
- Identify significant bird breeding, roosting or feeding sites and possible avian flight paths or migratory routes,
- Identify potential impacts on avifauna that the proposed activity may hold,
- List mitigating actions that can be implemented to limit or revoke these threats.
- Should the proposed activity be approved, make appropriate management recommendations regarding bird and habitat conservation on the site.
- Identify No-Go areas.

1.2. DESKTOP ANALYSIS OF POTENTIAL IMPACTS

The significant potential avifaunal impacts associated with the proposed development, in general, include the following:

- Displacement through habitat loss and human activity
- Collision risk with solar panels
- Collision and electrocution risk with power lines
- Disturbance during the construction and operation phase
- Electromagnetic fields
- Roosting and breeding on panels

Below, each category of impact is discussed in more detail.

1.2.1. DISPLACEMENT THROUGH HABITAT LOSS AND HUMAN ACTIVITY

Ground-disturbing activities affect various ecological processes (e.g. risk of erosion, plant invasion or secondary succession, soil density), which ultimately influence habitat quality. Avian populations require suitable habitats to remain stable over generations. However, human population growth and the associated increase in human actiity (e.g. mining, agriculture, urbanisation) result in many habitats becoming fragmented and unsuitable for long-term, sustainable occupation by birds, especially among threatened species (Friesen et al. 1995; Kluza et al. 2000). The North West Province is home to several endangered species such as the Vulnerable Cape Vulture, Critically Endangered African White-backed Vulture and Endangered Lappet-faced Vulture. These are just three species dependent on suitable habitats to breed and forage. However, increased habitat fragments have led to recent population declines (Taylor et al. 2015). Any development involving clearing natural vegetation risks placing additional pressure on already threatened species, and the presence of such species must be thoroughly investigated during the EIA process. Significant adverse impacts can be caused during different stages of development, e.g. the construction, operational and decommissioning phases. During the breeding season, for instance, many bird species are susceptible to human or other disturbances that can cause significant problems

for reproductive success (e.g., Griffin & DeGraaf 2000; Müllner et al. 2004; Kluza; Phillips *et al.* 2005; Tewksbury *et al.* 2006). Solar energy parks usually result in substantial site preparation, which includes the removal of vegetation influencing the ecosystem stability and increasing the threat of soil erosion.

1.2.2. COLLISION RISK WITH SOLAR PANELS

There are currently two known types of direct solar-related bird fatalities (McCrary *et al*. 1986; Hernandez *et al*. 2014; Kagan *et al*. 2014):

- Collision-related fatality—fatality resulting from the direct contact of the bird with a project structure(s). The fatality has been documented in solar projects of all technology types.
- Solar-flux-related fatal resulting from the burning/singeing effects of exposure to concentrated sunlight. Passing through the area of solar flux may result in (a) direct fatality; (b) singeing of flight feathers that cause loss of flight ability, leading to impact with other objects; or (c) impairment of flight capability to reduce the ability to forage or avoid predators, resulting in starvation or predation of the individual (Kagan *et al*. 2014). Solar-flux-related fatality has been observed only at facilities employing power tower technologies.

A study by Harvey et al. (2014a and 2014b) at the 1300 ha California Valley Solar Ranch PV conducted weekly mortality searches during two 3-month periods in 2014. They estimated that 1030 mortalities occur at this site per year. Even though they did not determine the cause of death, the risk of collisions with reflective surfaces is a proven cause of death at solar plants worldwide, making this the most likely mortality recorded at this site. The cause of death is based on opportunistic carcasses collection. Kegan et al. (2014) showed that collisions with reflective surfaces are the highest threat of any form at a solar plant.

These studies showed that collisions with reflective surfaces (impact trauma) emerge as the highest single identifiable cause of avian mortality. Another problem is where birds, especially waterbirds, mistake these large sheets of dark blue photovoltaic panels for water bodies (the so-called “lake effect”) (Kagan et al. 2014). Slight modifications of panels and design can significantly reduce the number of avian mortalities.

1.2.3. COLLISION AND ELECTROCUTION RISK WITH POWER LINES

Power lines are known to negatively impact birds through either collisions or electrocutions. Power lines are categorised into transmission and distribution lines (Luzenski et al. 2016), providing elevated nesting for species such as crows. Electrocution risk can be reduced by the pole design, whereas collision risk is more difficult to mitigate for all species successfully. Collision risk poses a real threat to orders that have a high wing load (higher body mass per wing area), limiting their manoeuvrability to change direction, which put them at higher risk of colliding with power lines (Bevanger 1998, Janss 2000), such as vultures (Cathartiformes), storks (Ciconiiformes), bustards (Druiformes), etc. (Bevanger 1995). Electrocution victims range from small species (e.g. starlings) to larger species (e.g. vultures, storks) (Bevanger 1998, Janss 2000, Mañosa 2001, Sergio et al. 2004). The pylon structure plays a considerable role in the risk of electrocution (Manosa 2001). In South Africa, storks and vultures have been severely affected by electrocution (Ledger and Annegarn 1981, Hobbs and Ledger 1986, van Rooyen 2000). Over the last two decades, more than 1530 birds have been impacted negatively by power lines over the last 2 decades (VulPro, www.vulpro.com). However, more and more research has been

done to reduce the impact of this threat (Jenkins et al. 2010, 2011, 2016; Dixon et al. 2018; Hermandez-Lambrano *et al*. 2018), but still, a large portion of birds admitted to rehabilitation centres are due to power line interactions, especially vultures (Howard *et al*. 2020)

1.2.4. DISTURBANCE DURING THE CONSTRUCTION PHASE

The impact on birds is sometimes more significant during the construction phase, with increasingly higher levels of activity resulting in increased disturbance. During the construction phase, the number of personnel and vehicles drastically increase. These activities increase the probability of other impacts such as fuel spills and illegal hunting of birds or mammals by construction workers. For these reasons, mitigation of effects during the construction phase needs to feature prominently in the environmental management plan, and due care must be taken to avoid excessive impacts.

1.2.5. ELECTROMAGNETIC FIELDS

Electromagnetic fields (EMFs) are generated from power lines that negatively impact bird behaviour (Fernie and Reynolds 2005). Furthermore, EMFs can interfere with the navigation capability of migrant birds (Engels et al., 2014).

1.2.6. ROOSTING AND BREEDING ON PANELS

Fixed Photovoltaic panels will create nest/perching/roosting areas for various birds from small to big. One such example for the proposed site is sparrows, starlings and crows, as the panels and infrastructure can be used for a suitable breeding site.

1.3. DESCRIPTION OF STUDY AREA

1.3.1. LAND USES AND INFRASTRUCTURE IN AND AROUND THE SURVEY SITE

The proposed Lichtenburg Solar Park is located north of the Lichtenburg suburbs in the North West Province within the Licthenburg Game Breeding Centre (Figure 2). The proposed habitat is classified as natural grasslands (Figure 3). The major infrastructure consists of various power lines adjacent to the proposed development site (Figure 4) and the Eskom Watershed Substation (Figure 5). Other infrastructures in the Lichtenburg Game Breeding Centre include buildings, game fences, numerous internal service roads and tracks, several lion camps and a vulture supplementary feeding site of approximately 1.9km (Figure 6).

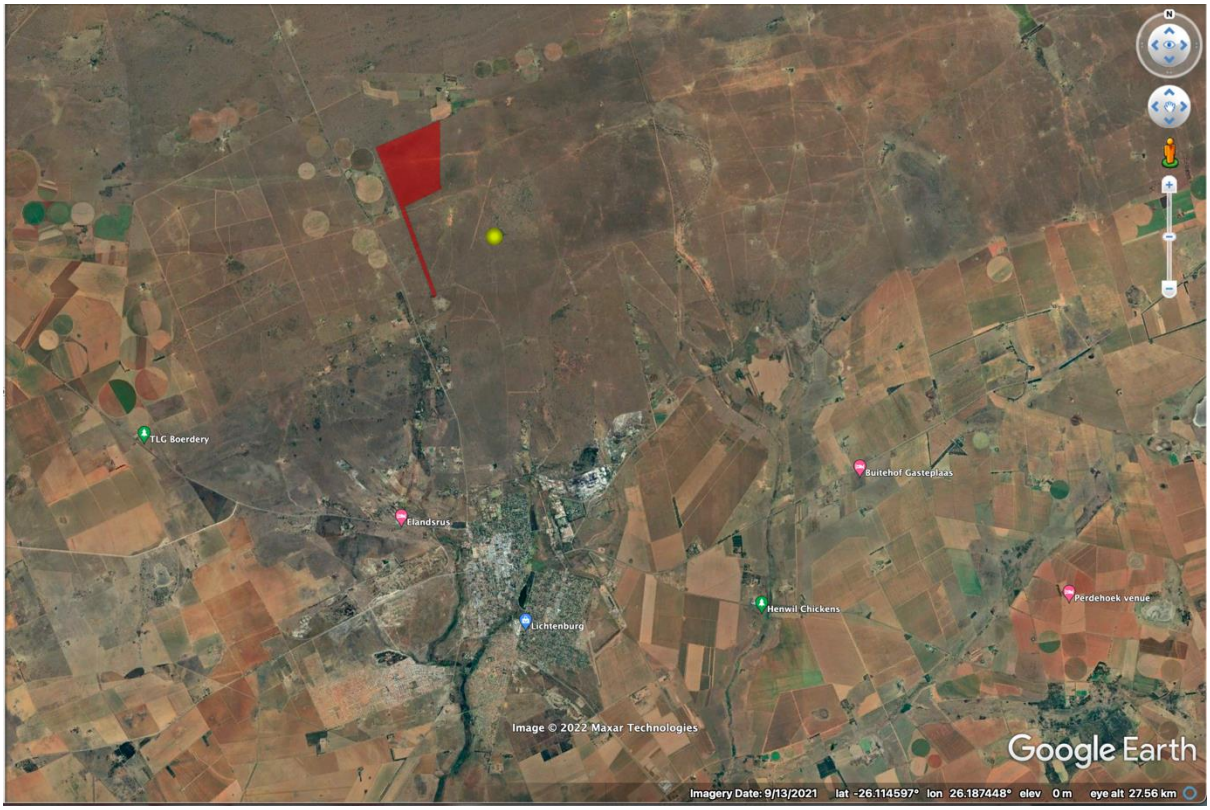

Figure 2. Location of the proposed Lichtenburg Solar Park (Red) and vulture restaurant (yellow) north of Lichtenburg.

Figure 3. Natural grasslands at the proposed solar park.

Figure 4. Vultures roosting on power lines adjacent to the proposed power line (red line)

Figure 5. Eskom Watershed Substation.

Figure 6. An active vulture supplementary feeding site provides food to African White-backed, Cape and Lappet-faced Vultures from Magaliesburg, Thabazimbi region and western and southern parts of North West.

1.3.2. CONSERVATION STATUS

The North-West Province of South Africa contains various small privately-owned and government-owned nature reserves. The proposed Lichtenburg Solar Park does not fall into a protected area (Figure 7). However, the proposed development is near Molemane Eye Nature Reserve (~ 27 km), and the closest Important Bird and Biodiversity Area (IBA's) is ~70 km away at Botsolano Nature Reserve.

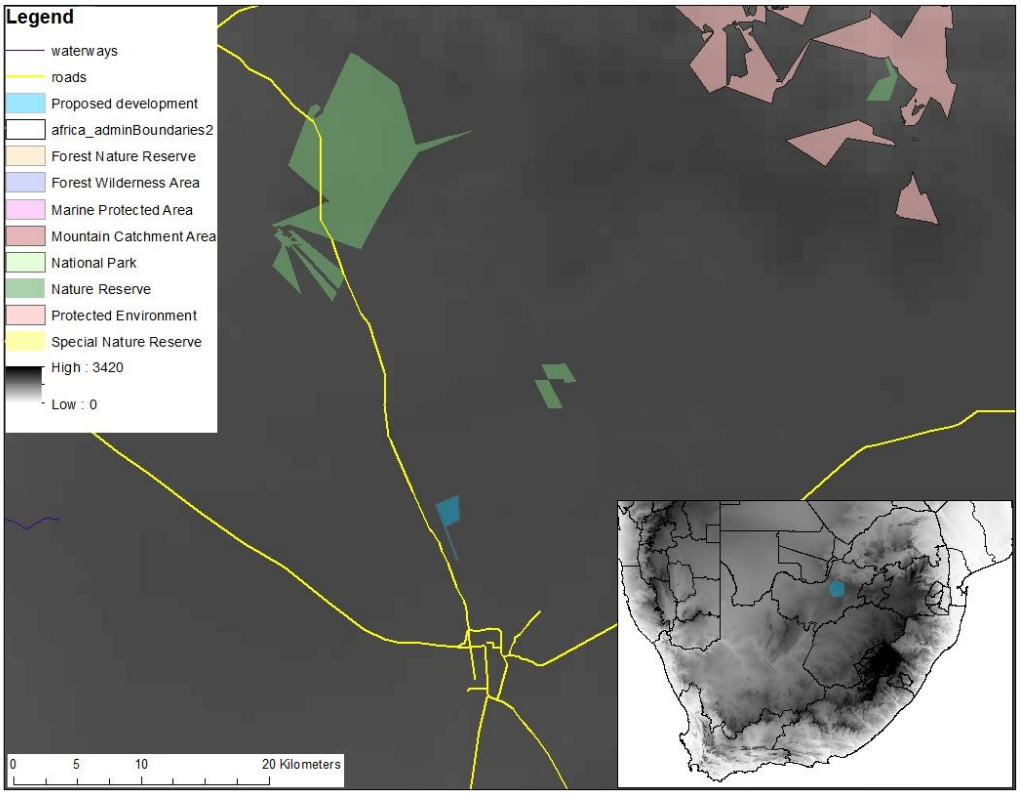

Figure 7. Conservation status of the area surrounding the proposed Lichtneburg Solar Park (blue) in the North West. Data obtained from South Africa National Land Cover (SANLC) 2018.

1.3.3. VEGETATION AND LANDFORMS

According to Mucina and Rutherford (2006), the proposed Lichtenburg Solar Park development falls within the Carletonville Dolomite Grassland and are found predominantly in the North West Province of South Africa (Figure 8) and species richness, dominated by plant species. A fine-scale 2018 Land-Use map was generated from South Africa National Land-Cover (SANLC) 2018, suggesting that most of the proposed Solar Park development land is classified as natural grassland surrounded by agricultural activities (Figure 9).

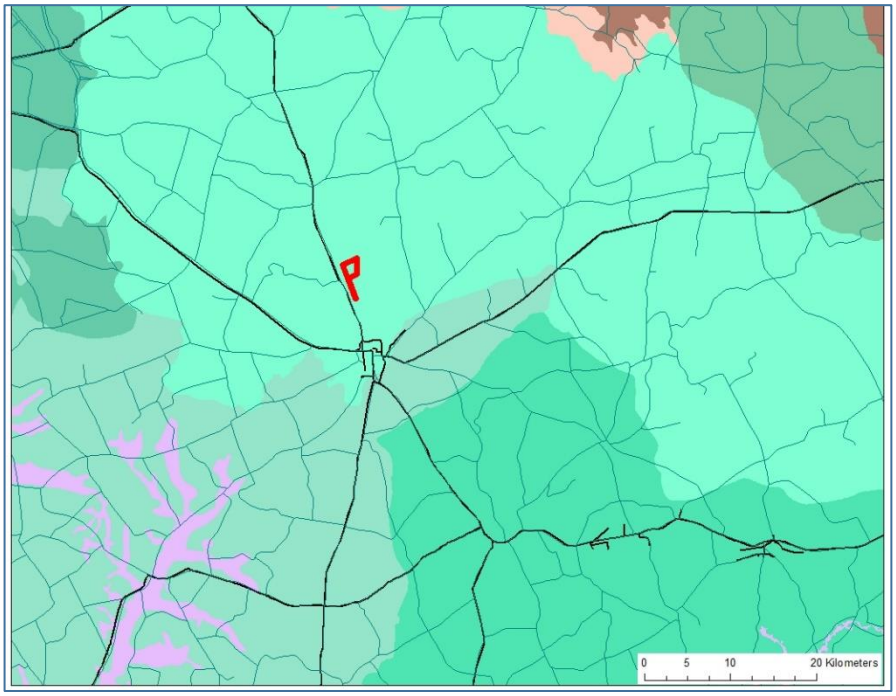

Figure 8. A map extracted from Mucina & Rutherford (2006) shows the position of the proposed Lichtenburg Solar Park development (red) in an area dominated by Carletonville Dolomite Grassland (light sea green).

Figure 9. The vegetation classification for the proposed Lichtenburg Solar Park development (red) is based on the South Africa National Land-Cover (SANLC) 2018 and is classified as natural grasslands.

2. METHODS

This study consisted of a desktop study, an on-site impact assessment assessing the impacts of the proposed development on the area's avifauna, and recommendations for possible mitigation. Furthermore, bird movements, nest and roost sites were determined, and large terrestrial species and raptors surveys were conducted as stipulated in the Best Practice Guidelines Birds & Solar Energy (Jenkins et al. 2017). Red-listed species were identified using the most recent red list assessment for the region (Taylor *et al.* 2015), the National Environmental Management: Biodiversity Act, 2004 list of Threatened or Protected Species (2007 version) and Schedule 2 “Specially Protected Species” in North West Biodiversity Management Act No. 4 (2016 version).

2.1. DESKTOP STUDY

Before the study, various maps and satellite images (1:50 000 topo-cadastral maps, Google Earth imagery) were studied to identify unique landscape features within the study area (e.g. drainage lines, thickets, pans, wooded areas, rocky outcrops). A detailed bird list recorded in the region of the study site was compiled using published (bird atlas reports and dissertations), and unpublished literature (previous EIA reports, bird club reports, etc.) but most of the region’s data was sourced from the second South African Bird Atlas Project (SABAP2).

Historically, the avian distribution database that was often used for desktop studies was based on the quarter-degree grid square (QDGS), which was also the unit area used in the first South African Bird Atlas Project (SABAP 1) conducted between 1987 and 1991 (Harrison et al. 1997). The survey scale for the current national bird atlas project (SABAP2) was reduced to the pentad grid cell, which covers 5 minutes of latitude by 5 minutes of longitude (5” X 5”). Each pentad is approximately 9 × 8 km and is a smaller survey unit, revealing more detailed and accurate bird range data (Figure 10).

Other avian distribution and conservation publications consulted for this study included: Important Bird Areas of Southern Africa (Barnes 1998, 2000), Important Bird and Biodiversity Areas of South Africa (Marnewick *et al.* 2015), The Atlas of Southern African Birds (Harrison et al. 1997), The ESKOM Red Data Book of Birds of South Africa, Lesotho and Swaziland (Taylor et al. 2015). Large terrestrial bird data was sourced from the Coordinated Avifaunal Road Count (CAR) project (Young *et al.* 2003) online database and waterbird count data from the Coordinated Waterbird Counts (CWAC) project (Taylor *et al.* 1999), both available from the Animal Demography Unit, University of Cape Town.

2.2. FIELD SURVEYS

A detailed field survey was carried out on the 29th and 30th of March 2022. However, based on the National Screening Tool (https://screening.environment.gov.za/screeningtool/#/pages/welcome), the proposed site is classified as high sensitivity as it is close to an extremely important and active supplementary feeding site for vultures and is bigger than 150 ha resulted in the proposed project falling within regime 3 that requires multiple surveys. A field survey aid in filling in any information gaps identified from pilot investigations and published data. Bird communities were surveyed on the proposed development area as stipulated in the Best Practice Guidelines Birds & Solar Energy (Jenkins et al. 2017) using the point count and line transect surveying techniques. ArcGIS was used to create random points across the surveying area for the proposed Solar Park area and line transect for the proposed Power Line development, as seen in Figure 11, which was located using a GPS. Twenty-six random points were plotted on the proposed Solar Park development with a minimum distance of 150 m apart to ensure sufficient bird assemblage coverage. Furthermore, seventeen points were plotted in a line transect 150 m apart to better understand the bird assemblage at the proposed power line section.

Each point was visited during the morning survey (06:30-10:30) or the afternoon survey (14:00 - 18:00). Surveys were restricted to early mornings and late afternoons to avoid midday air temperatures known to reduce bird activity (Kemp et al. 2020). During the survey, only one observer was used. Upon arrival at the survey point, the observer waited for 2 minutes before the start of the 10-minute survey as stipulated in the Best Practice Guidelines Birds & Solar Energy (Jenkins et al. 2017).

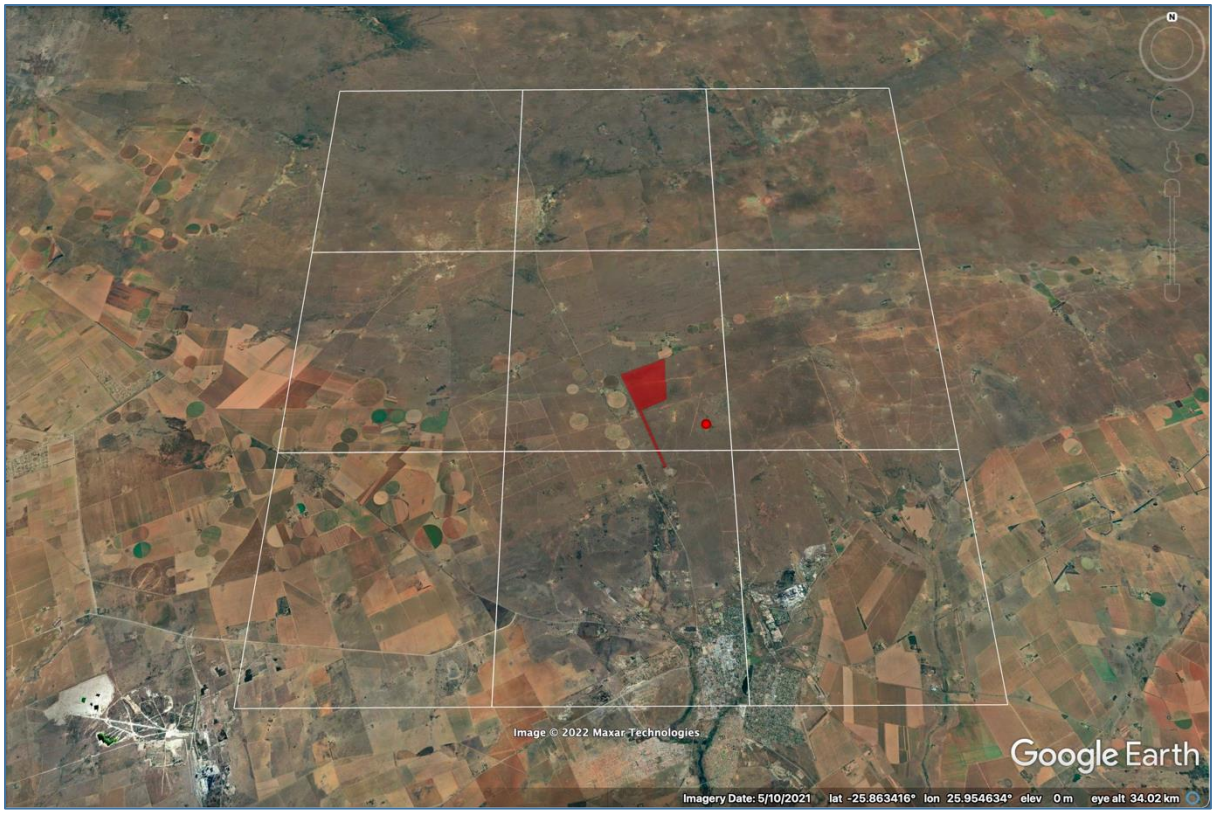

Figure 10. A satellite image shows the nine South African Bird Atlas Project 2 pentads surrounding the study area (red) for a more comprehensive desktop analysis. *Image courtesy of Google Earth.*

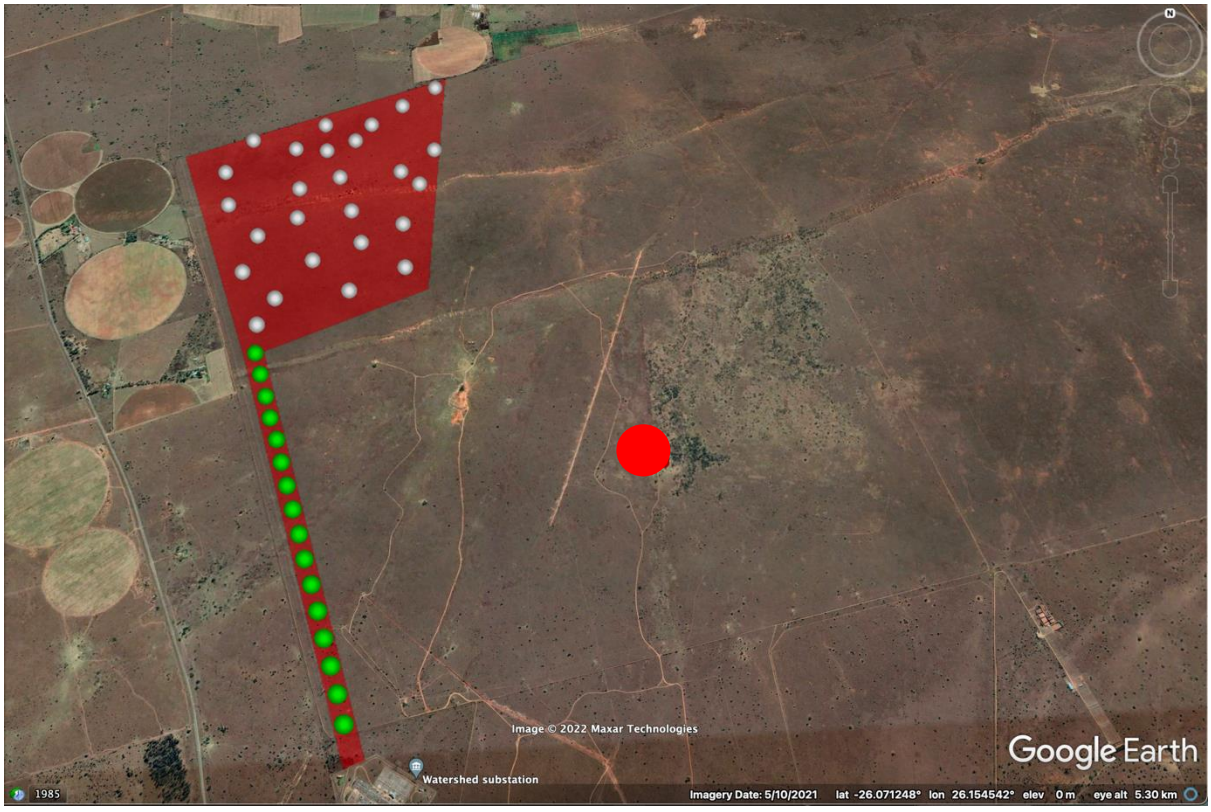

Figure 11. Twenty-six random points (grey) were plotted on the proposed Solar Park development. Seventeen (green) points were plotted in a line transect to better understand the bird assemblage at the proposed power line section—image *courtesy of Google Earth.*

2.2.1. ASSUMPTIONS AND LIMITATIONS OF BASELINE DATA

- The environmental consultant and client received adequate background information regarding the proposed activity. It is assumed that the relevant information received is accurate and correct. Sufficient information regarding the region's avifauna was sourced from published, unpublished and online datasets.
- The findings expressed in this report are based on a two-day field survey at the end of March. It is also likely that certain species that show seasonal and nomadic movements or altitudinal migration may have also been absent from the area during the field study. However, the information obtained from online bird atlas data for the site included winter and summer observations and was deemed sufficient to mitigate this constraint.
- During the field survey, the entire study site was freely accessible by vehicle and on foot. The terrain was flat with mainly open grassland vegetation cover making for easy bird observation.
- There were no confidentially constraints.
- There were no financial constraints.
- The assumptions made and prevalent constraints did not pose any significant negative implications for the study.
- Bird behaviour and ecology are unpredictable, like any other organisms. However, the proposed project's impact can reliably be predicted by conducting an in-depth site visit, desktop analysis, and further research based on effects observed elsewhere. Still, it is essential to understand that specific and local factors can modify interactions between birds and humans.

3. RESULTS

3.1. AVIAN HABITATS

The proposed site is classified as mixed grasslands with only a few roads running through the proposed area. The eastern part of the proposed site has various power lines running from north to south to the Eskom Watershed Substation substation. Habitat at the proposed site is dominated by grasslands resulting in low species richness, as shown by the species accumulation curve that estimates that the proposed site holds ~35 ± 7 species (Figure 12).

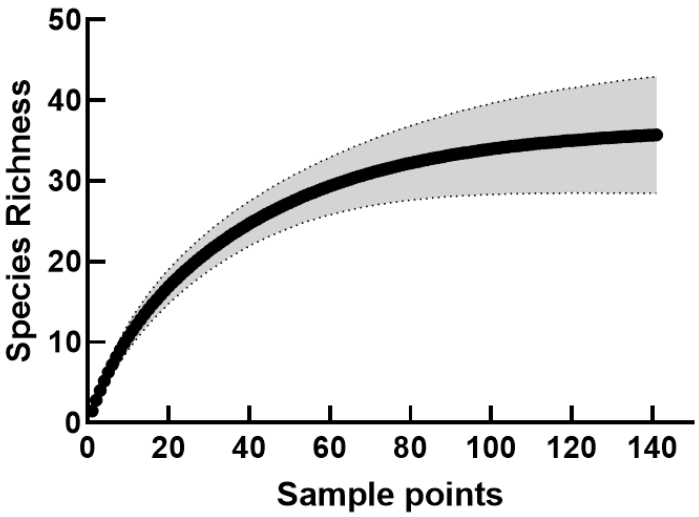

Figure 12. Species accumulation curve for all the points surveyed. The species accumulation curve estimates that the proposed site will hold ~35 ± 7 species.

Table 1. *Bird species were recorded in the area considered for the desktop survey (see Figure 6). The current (2015) regional red data status ("RD" column) of each red-listed species is provided (NT = Near Threatened; VU = Vulnerable; EN = Endangered; CR = Critically Endangered), and the likelihood of each species occurring at the greater surveyed area of the Lichtenburg Solar Park is rated as Confirmed/Very Likely (Green), Likely (Orange) and Unlikely (Red). The table also provides insight into the bird species occurring at the proposed site for each month of the year.*

	Common Name	Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Likelihood at site	RD	South African Endemic
1	Avocet Pied	Recurvirostra avosetta											1		Unlikely		
2	Babbler Arrow-marked	Turdoides jardineii				1							1	1	Unlikely		
3	Barbet Acacia Pied	Tricholaema leucomelas	1	1	1	1	1	1	1	1		1	1	1	Very Likely		*
4	Barbet Black-collared	Lybius torquatus	1	1	1	1		1	1	1		1	1	1	Unlikely		
5	Barbet Crested	Trachyphonus vaillantii	1	1	1	1	1	1	1	1		1	1	1	Unlikely		
6	Batis Chinspot	Batis molitor							1	1		1	1		Unlikely		
7	Bee-eater Blue-cheeked	Merops persicus	1	1		1							1	1	Unlikely		
8	Bee-eater European	Merops apiaster	1	1								1	1	1	Likely		
9	Bee-eater Little	Merops pusillus	1		1	1			1			1		1	Likely		
10	Bee-eater Swallow-tailed	Merops hirundineus				1									Unlikely		
11	Bee-eater White-fronted	Merops bullockoides	1		1	1	1							1	Unlikely		
12	Bishop Southern Red	Euplectes orix	1	1	1	1			1	1		1	1	1	Very Likely		

13	Bishop Yellow-crowned	Euplectes afer		1											Unlikely	
14	Bittern Little	Ixobrychus minutus										1	1		Unlikely	
15	Bokmakierie	Telophorus zeylonus	1	1	1	1	1	1	1	1		1	1	1	Very Likely	*
16	Boubou Southern	Laniarius ferrugineus				1								1	Unlikely	*
17	Brubru	Nilaus afer		1	1										Unlikely	
18	Bulbul African Red-eyed	Pycnonotus nigricans	1	1	1	1		1	1	1		1	1	1	Unlikely	
19	Bulbul Dark-capped	Pycnonotus tricolor	1	1	1	1		1	1	1		1	1	1	Very Likely	
20	Bunting Cinnamon-breasted	Emberiza tahapisi		1	1	1				1				1	Unlikely	
21	Bunting Golden-breasted	Emberiza flaviventris			1										Unlikely	
22	Bunting Lark-like	Emberiza impetuani				1									Unlikely	*
23	Bushshrike Grey-headed	Malaconotus blanchoti												1	Unlikely	
24	Buzzard Common	Buteo buteo	1	1								1			Unlikely	
25	Canary Black-throated	Crithagra atrogularis	1	1	1	1			1	1		1	1	1	Likely	
26	Canary Yellow	Crithagra flaviventris	1	1	1	1		1	1	1		1	1	1	Likely	*
27	Canary Yellow-fronted	Crithagra mozambica										1			Unlikely	
28	Chat Ant-eating	Myrmecocichla formicivora	1	1	1	1	1	1	1	1		1	1	1	Very Likely	*
29	Chat Familiar	Oenanthe familiaris				1			1						Unlikely	

30	Cisticola Cloud	Cisticola textrix	1	1	1	1							1	1	1	Very Likely	*
31	Cisticola Desert	Cisticola aridulus		1	1	1			1	1			1	1	1	Very Likely	
32	Cisticola Levaillant's	Cisticola tinniens	1	1	1	1			1	1			1	1		Unlikely	
33	Cisticola Rattling	Cisticola chiniana	1			1				1			1	1		Unlikely	
34	Cisticola Zitting	Cisticola juncidis	1	1	1	1			1	1			1	1	1	Very Likely	
35	Coot Red-knobbed	Fulica cristata	1	1	1	1	1	1	1	1			1	1	1	Unlikely	
36	Cormorant Reed	Microcarbo africanus	1	1	1	1	1	1	1	1			1	1	1	Unlikely	
37	Cormorant White-breasted	Phalacrocorax lucidus	1		1		1		1	1			1	1	1	Unlikely	
38	Coucal Burchell's	Centropus burchellii	1						1	1			1	1	1	Unlikely	
39	Crake Black	Zapornia flavirostra	1							1			1			Unlikely	
40	Crombec Long-billed	Sylvietta rufescens			1			1	1	1			1	1		Unlikely	
41	Crow Cape	Corvus capensis											1			Unlikely	
42	Crow Pied	Corvus albus	1	1	1	1		1	1	1			1	1	1	Very Likely	
43	Cuckoo Diederik	Chrysococcyx caprius	1	1	1	1							1	1	1	Likely	
44	Cuckooshrike Black	Campephaga flava				1										Unlikely	
45	Darter African	Anhinga rufa	1			1		1					1	1		Unlikely	
46	Dove Cape Turtle	Streptopelia capicola		1	1	1		1	1	1			1	1	1	Likely	
47	Dove Emerald-spotted Wood	Turtur chalcospilos													1	Unlikely	

48	Dove Laughing	Spilopelia senegalensis	1	1	1	1	1	1	1	1		1	1	1	Very Likely	
49	Dove Namaqua	Oena capensis				1			1	1		1	1	1	Likely	
50	Dove Red-eyed	Streptopelia semitorquata	1	1	1	1	1	1	1	1		1	1	1	Very Likely	
51	Dove Rock	Columba livia	1	1				1	1	1		1	1	1	Unlikely	
52	Drongo Fork-tailed	Dicrurus adsimilis												1	Unlikely	
53	Duck African Black	Anas sparsa	1	1						1		1			Unlikely	
54	Duck Fulvous Whistling	Dendrocygna bicolor			1										Unlikely	
55	Duck White-faced Whistling	Dendrocygna viduata	1	1	1							1	1	1	Unlikely	
56	Duck Yellow-billed	Anas undulata	1	1	1	1	1	1		1		1	1	1	Unlikely	
57	Eagle Black-chested Snake	Circaetus pectoralis								1		1			Unlikely	
58	Eagle Brown Snake	Circaetus cinereus	1												Unlikely	
59	Eagle Martial	Polemaetus bellicosus	1												Unlikely	EN
60	Eagle-Owl Spotted	Bubo africanus								1					Unlikely	
61	Egret Little	Egretta garzetta	1	1									1	1	Unlikely	
62	Egret Western Cattle	Bubulcus ibis	1	1	1	1		1		1		1	1	1	Likely	
63	Falcon Amur	Falco amurensis	1	1	1									1	Unlikely	
64	Falcon Lanner	Falco biarmicus	1											1	Unlikely	VU
65	Falcon Peregrine	Falco peregrinus											1		Unlikely	

66	Falcon Red-footed	Falco vespertinus	1									1			Unlikely	NT	
67	Finch Red-headed	Amadina erythrocephala	1	1	1	1		1	1	1		1	1		Unlikely		*
68	Firefinch Jameson's	Lagonosticta rhodopareia							1	1					Unlikely		
69	Firefinch Red-billed	Lagonosticta senegala	1	1		1				1		1			Unlikely		
70	Fiscal Southern	Lanius collaris	1	1	1	1		1	1	1		1	1	1	Very Likely		
71	Flamingo Greater	Phoenicopterus roseus			1										Unlikely	NT	
72	Flamingo Lesser	Phoeniconaias minor											1		Unlikely	NT	
73	Flycatcher African Paradise	Terpsiphone viridis	1	1									1	1	Unlikely		
74	Flycatcher Fiscal	Melaenornis silens	1	1		1		1	1	1		1	1	1	Unlikely		*
75	Flycatcher Marico	Melaenornis mariquensis	1	1											Unlikely		*
76	Flycatcher Spotted	Muscicapa striata	1	1	1	1							1	1	Unlikely		
77	Francolin Coqui	Peliperdix coqui			1					1		1	1	1	Unlikely		
78	Francolin Crested	Dendroperdix sephaena										1		1	Unlikely		
79	Francolin Orange River	Scleroptila gutturalis	1	1	1	1		1	1	1		1	1	1	Very Likely		*
80	Go-away-bird Grey	Crinifer concolor	1	1	1	1		1	1	1		1	1	1	Unlikely		
81	Goose Egyptian	Alopochen aegyptiaca	1	1	1	1		1				1	1	1	Unlikely		
82	Goose Spur-winged	Plectropterus gambensis		1								1	1		Unlikely		

83	Grebe Little	Tachybaptus ruficollis	1		1	1	1	1	1	1		1	1	1	Unlikely
84	Greenshank Common	Tringa nebularia										1	1	1	Unlikely
85	Guineafowl Helmeted	Numida meleagris	1	1	1	1		1	1	1		1	1	1	Likely
86	Gull Grey-headed	Chroicocephalus cirrocephalus								1					Unlikely
87	Hamerkop	Scopus umbretta	1	1								1			Unlikely
88	Harrier-Hawk African	Polyboroides typus			1		1								Unlikely
89	Helmetshrike White-crested	Prionops plumatus	1												Unlikely
90	Heron Black	Egretta ardesiaca	1									1	1		Unlikely
91	Heron Black-crowned Night	Nycticorax nycticorax										1			Unlikely
92	Heron Black-headed	Ardea melanocephala		1	1	1		1	1	1		1	1		Unlikely
93	Heron Goliath	Ardea goliath	1											1	Unlikely
94	Heron Grey	Ardea cinerea	1		1	1		1	1			1		1	Unlikely
95	Heron Purple	Ardea purpurea	1		1				1	1		1	1		Unlikely
96	Heron Striated	Butorides striata				1							1		Unlikely
97	Honeyguide Greater	Indicator indicator						1		1					Unlikely
98	Honeyguide Lesser	Indicator minor						1	1			1			Unlikely
99	Hoopoe African	Upupa africana	1	1		1	1	1	1	1		1	1	1	Unlikely
100	Ibis African Sacred	Threskiornis aethiopicus	1		1			1		1		1	1	1	Unlikely
101	Ibis Glossy	Plegadis falcinellus	1	1			1	1		1		1	1	1	Unlikely
102	Ibis Hadada	Bostrychia hagedash	1	1	1	1	1	1	1	1		1	1	1	Unlikely

103	Kestrel Greater	Falco rupicoloides	1		1	1									Likely	
104	Kestrel Lesser	Falco naumanni	1	1								1	1	1	Likely	
105	Kingfisher Giant	Megaceryle maxima				1								1	Unlikely	
106	Kingfisher Malachite	Corythornis cristatus	1	1	1	1		1	1			1	1		Unlikely	
107	Kingfisher Pied	Ceryle rudis	1	1	1	1	1	1		1		1	1	1	Unlikely	
108	Kite Black	Milvus migrans		1											Unlikely	
109	Kite Black-winged	Elanus caeruleus	1	1	1	1			1	1		1	1	1	Likely	
110	Kite Yellow-billed	Milvus aegyptius	1	1											Unlikely	
111	Korhaan Northern Black	Afrotis afraoides	1	1	1	1		1	1	1		1	1	1	Very Likely	*
112	Lapwing African Wattled	Vanellus senegallus						1							Likely	
113	Lapwing Blacksmith	Vanellus armatus	1	1	1	1	1	1	1	1		1	1	1	Likely	
114	Lapwing Crowned	Vanellus coronatus	1	1	1	1		1	1	1		1	1	1	Likely	
115	Lark Eastern Clapper	Mirafra fasciolata	1	1	1				1	1		1	1	1	Very Likely	*
116	Lark Red-capped	Calandrella cinerea			1				1			1			Likely	
117	Lark Rufous-naped	Mirafra africana	1	1	1	1			1	1		1	1	1	Likely	
118	Lark Sabota	Calendulauda sabota		1	1				1			1		1	Likely	*
119	Lark Spike-heeled	Chersomanes albofasciata	1		1	1			1	1		1	1	1	Likely	*
120	Longclaw Cape	Macronyx capensis	1	1	1	1			1	1		1	1	1	Likely	*

121	Martin Banded	Riparia cincta	1	1	1	1						1	1	1	Likely		
122	Martin Brown-throated	Riparia paludicola		1					1	1			1		Unlikely		
123	Martin Rock	Ptyonoprogne fuligula				1		1		1		1			Unlikely		
124	Moorhen Common	Gallinula chloropus	1	1	1	1	1	1	1	1		1	1		Unlikely		
125	Mousebird Red-faced	Urocolius indicus	1	1	1	1			1	1		1	1	1	Likely		
126	Mousebird Speckled	Colius striatus		1	1	1		1	1			1			Likely		
127	Mousebird White-backed	Colius colius	1	1	1	1		1	1	1		1	1	1	Likely		*
128	Myna Common	Acridotheres tristis	1	1	1	1	1	1	1	1		1	1	1	Unlikely		
129	Neddicky	Cisticola fulvicapilla	1	1	1	1			1	1		1	1	1	Likely		
130	Oriole Black-headed	Oriolus larvatus				1								1	Unlikely		
131	Ostrich Common	Struthio camelus	1	1		1	1	1				1	1	1	Likely		
132	Owl Western Barn	Tyto alba										1	1		Unlikely		
133	Painted-snipe Greater	Rostratula benghalensis	1										1		Unlikely	NT	
134	Pigeon Speckled	Columba guinea	1	1	1	1	1	1	1	1		1	1	1	Unlikely		
135	Pipit African	Anthus cinnamomeus	1	1	1	1		1	1	1		1	1		Likely		
136	Pipit Buffy	Anthus vaalensis			1										Unlikely		
137	Pipit Plain-backed	Anthus leucophrys			1							1			Unlikely		
138	Plover Three-banded	Charadrius tricollaris	1			1	1	1	1	1		1	1	1	Unlikely		

139	Pochard Southern	Netta erythrophthalma			1	1		1							Unlikely		
140	Prinia Black-chested	Prinia flavicans	1	1	1	1	1	1	1	1		1	1	1	Very Likely		
141	Prinia Tawny-flanked	Prinia subflava		1		1		1				1	1		Likely		
142	Pytilia Green-winged	Pytilia melba			1	1			1	1		1	1		Unlikely		
143	Quailfinch	Ortygospiza atricollis			1	1			1	1		1		1	Likely		
144	Quelea Red-billed	Quelea quelea	1	1		1			1	1		1	1	1	Likely		
145	Robin-Chat Cape	Cossypha caffra		1				1	1	1		1	1		Likely		
146	Robin-Chat White-throated	Cossypha humeralis				1									Unlikely		*
147	Roller European	Coracias garrulus												1	Unlikely	NT	
148	Roller Lilac-breasted	Coracias caudatus												1	Unlikely		
149	Ruff	Calidris pugnax	1	1		1						1	1		Unlikely		
150	Sandpiper Common	Actitis hypoleucos	1	1								1	1		Unlikely		
151	Sandpiper Curlew	Calidris ferruginea	1												Unlikely		
152	Sandpiper Marsh	Tringa stagnatilis	1										1		Unlikely		
153	Sandpiper Wood	Tringa glareola	1			1						1	1	1	Unlikely		
154	Scimitarbill Common	Rhinopomastus cyanomelas	1	1					1	1		1	1	1	Unlikely		
155	Scrub Robin Kalahari	Cercotrichas paena	1	1	1	1		1	1	1		1	1	1	Likely		
156	Scrub Robin White-browed	Cercotrichas leucophrys												1	Unlikely		

157	Secretarybird	Sagittarius serpentarius				1									Unlikely	VU	
158	Seedeater Streaky-headed	Crithagra gularis								1		1			Unlikely		
159	Shelduck South African	Tadorna cana	1		1	1	1	1	1			1			Unlikely		*
160	Shoveler Cape	Spatula smithii								1					Unlikely		*
161	Shrike Crimson-breasted	Laniarius atrococcineus	1		1	1		1	1	1		1	1	1	Unlikely		*
162	Shrike Lesser Grey	Lanius minor	1	1	1								1	1	Unlikely		
163	Shrike Red-backed	Lanius collurio	1	1	1	1							1	1	Likely		
164	Snipe African	Gallinago nigripennis	1				1						1	1	Unlikely		
165	Sparrow Cape	Passer melanurus	1	1	1	1	1	1	1	1		1	1	1	Very Likely		*
166	Sparrow Great	Passer motitensis				1							1		Unlikely		*
167	Sparrow House	Passer domesticus	1	1	1	1		1	1	1		1	1	1	Likely		
168	Sparrow Southern Grey-headed	Passer diffusus	1	1	1	1			1	1		1	1		Likely		
169	Sparrow-Lark Chestnut-backed	Eremopterix leucotis				1			1	1					Unlikely		
170	Sparrow-Weaver White-browed	Plocepasser mahali	1	1	1	1		1	1	1		1	1	1	Likely		
171	Sparrowhawk Black	Accipiter melanoleucus								1					Unlikely		
172	Spoonbill African	Platalea alba	1			1		1				1	1	1	Unlikely		

173	Spurfowl Natal	Pternistis natalensis				1								1	Unlikely		*
174	Spurfowl Swainson's	Pternistis swainsonii	1	1	1	1			1	1		1	1	1	Likely		
175	Starling Cape	Lamprotornis nitens	1	1	1	1		1	1			1	1	1	Likely		
176	Starling Pied	Lamprotornis bicolor			1	1				1					Unlikely		*
177	Starling Wattled	Creatophora cinerea	1	1		1	1	1	1	1		1	1		Likely		
178	Stilt Black-winged	Himantopus himantopus	1	1	1	1	1	1							Unlikely		
179	Stint Little	Calidris minuta	1											1	Unlikely		
180	Stonechat African	Saxicola torquatus	1	1		1		1	1	1		1	1	1	Likely		
181	Stork Marabou	Leptoptilos crumenifer	1												Unlikely	NT	
182	Sunbird Amethyst	Chalcomitra amethystina	1									1		1	Unlikely		
183	Sunbird Marico	Cinnyris mariquensis				1									Unlikely		
184	Sunbird White-bellied	Cinnyris talatala		1		1		1	1	1		1	1	1	Unlikely		
185	Swallow Barn	Hirundo rustica	1	1	1	1						1	1	1	Likely		
186	Swallow Greater Striped	Cecropis cucullata	1	1	1	1						1	1	1	Likely		
187	Swallow Red-breasted	Cecropis semirufa				1								1	Unlikely		
188	Swallow South African Cliff	Petrochelidon spilodera	1	1		1				1		1	1	1	Unlikely		*
189	Swallow White-throated	Hirundo albigularis	1	1		1				1		1	1	1	Unlikely		
190	Swamphen African	Porphyrio madagascariensis	1	1	1				1	1		1			Unlikely		

191	Swift African Palm	Cypsiurus parvus	1	1	1	1		1	1	1		1	1	1	Unlikely		
192	Swift Little	Apus affinis	1	1		1				1		1	1	1	Likely		
193	Swift White-rumped	Apus caffer	1	1	1	1						1	1	1	Likely		
194	Tchagra Black-crowned	Tchagra senegalus				1				1				1	Unlikely		
195	Tchagra Brown-crowned	Tchagra australis	1		1	1		1	1	1		1	1		Unlikely		
196	Teal Blue-billed	Spatula hottentota					1	1				1	1		Unlikely		
197	Teal Red-billed	Anas erythrorhyncha	1	1	1	1	1	1		1		1		1	Unlikely		
198	Tern Whiskered	Chlidonias hybrida	1		1										Unlikely		
199	Thick-knee Spotted	Burhinus capensis	1					1	1			1	1		Unlikely		
200	Thrush Groundscraper	Turdus litsitsirupa	1	1		1		1					1		Unlikely		
201	Thrush Karoo	Turdus smithi	1	1	1	1		1	1	1		1	1	1	Likely		*
202	Thrush Kurrichane	Turdus libonyana												1	Unlikely		
203	Tinkerbird Yellow-fronted	Pogoniulus chrysoconus				1								1	Unlikely		
204	Tit Ashy	Melaniparus cinerascens			1					1			1		Unlikely		*
205	Tit Cape Penduline	Anthoscopus minutus				1						1			Unlikely		*
206	Vulture Cape	Gyps coprotheres	1		1	1		1	1			1		1	Very Likely	VU	
207	Vulture Lappet-faced	Torgos tracheliotos				1		1	1						Very Likely	EN	
208	Vulture White-backed	Gyps africanus	1	1	1	1		1	1	1				1	Very Likely	CR	

209	Wagtail Cape	Motacilla capensis	1	1		1	1	1	1	1		1	1	1	Unlikely	
210	Warbler African Reed	Acrocephalus baeticatus	1	1								1	1		Unlikely	
211	Warbler Chestnut-vented	Curruca subcoerulea	1	1	1	1		1	1	1		1	1	1	Likely	
212	Warbler Great Reed	Acrocephalus arundinaceus	1	1											Unlikely	
213	Warbler Lesser Swamp	Acrocephalus gracilirostris	1	1	1	1			1	1		1	1		Unlikely	
214	Warbler Little Rush	Bradypterus baboecala	1							1		1	1		Unlikely	
215	Warbler Marsh	Acrocephalus palustris		1	1							1			Unlikely	
216	Warbler Willow	Phylloscopus trochilus	1		1	1						1	1	1	Unlikely	
217	Waxbill Blue	Uraeginthus angolensis		1	1	1		1	1	1		1	1	1	Likely	
218	Waxbill Common	Estrilda astrild	1			1				1		1	1	1	Unlikely	
219	Waxbill Orange-breasted	Amandava subflava										1	1		Unlikely	
220	Waxbill Violet-eared	Granatina granatina						1		1		1			Unlikely	*
221	Weaver Cape	Ploceus capensis	1									1	1		Unlikely	*
222	Weaver Scaly-feathered	Sporopipes squamifrons	1	1	1	1		1	1	1		1	1		Very Likely	*
223	Weaver Southern Masked	Ploceus velatus	1	1	1	1		1	1	1		1	1	1	Very Likely	
224	Wheatear Capped	Oenanthe pileata		1		1			1			1			Unlikely	

225	Wheatear Mountain	Myrmecocichla monticola								1			1				Unlikely		*
226	White-eye Cape	Zosterops virens	1	1			1	1	1	1		1	1	1			Likely		*
227	White-eye Orange River	Zosterops pallidus	1	1	1	1		1		1		1	1	1			Unlikely		
228	Whitethroat Common	Curruca communis			1												Unlikely		
229	Whydah Long-tailed Paradise	Vidua paradisaea			1	1						1					Unlikely		
230	Whydah Pin-tailed	Vidua macroura	1	1		1			1			1	1	1			Likely		
231	Whydah Shaft-tailed	Vidua regia			1												Unlikely		*
232	Widowbird Long-tailed	Euplectes progne	1	1		1		1	1	1		1	1	1			Likely		
233	Widowbird Red-collared	Euplectes ardens		1								1					Unlikely		
234	Widowbird White-winged	Euplectes albonotatus	1	1	1					1		1	1				Unlikely		
235	Wood Hoopoe Green	Phoeniculus purpureus	1	1				1				1	1	1			Unlikely		
236	Woodpecker Golden-tailed	Campethera abingoni				1											Unlikely		

3.2. BASELINE DATA: BIRDS OCCURRING ON THE PROPOSED SITE

3.2.1. BREEDING, FEEDING AND ROOSTING SITES

The desktop analysis recorded a total of 236 species that have been recorded during SABAP2 in the 9 pentads surrounding the proposed Lichtenburg Solar Park (Figure 10). Of these, 32 were confirmed during the point survey count or are very likely to occur within the study area, and a further 40 are likely to occur (Table 1). Furthermore, the species richness analysis in Estimate S confirmed that the proposed Solar Park would hold ~35 ± 7 species based on the species accumulation curve. Furthermore, the species accumulation curve suggested that adequate sampling for the proposed area was reached and therefore did not require further sampling. In addition, the sampling was conducted at the end of the summer when the majority of migrator species were still around and would therefore not make sense to repeat the survey during the winter months as suggested in the Best Practice Guidelines Birds & Solar Energy (Jenkins et al. 2017). Species whose presence was confirmed include grassland species (e.g., Ant-eating Chat, Zitting Cisticola, Cape Longclaw and Orange River Francolin). Avian diversity on the site is low, a characteristic of natural grasslands (Freeman et al. 2018). Furthermore, endemic or near-endemic species to South Africa, such as Cape Sparrow, Cape Longclaw and Eastern Clapper Lark, were also observed during the field survey (Table 1).

3.2.2. FLIGHT PATHS AND MIGRATION ROUTES

During the field investigation, various flight paths were observed from non-priority species. Priority species such as White-backed and Cape Vultures were seen soaring over the proposed solar park and power lines (Figure 13) as stipulated in the Best Practice Guidelines Birds & Solar Energy (Jenkins et al. 2017). Furthermore, vultures continuously visited the supplementary feeding site and roosted on nearby power lines. However, there are no distinct flight paths across the site, making it difficult to mitigate.

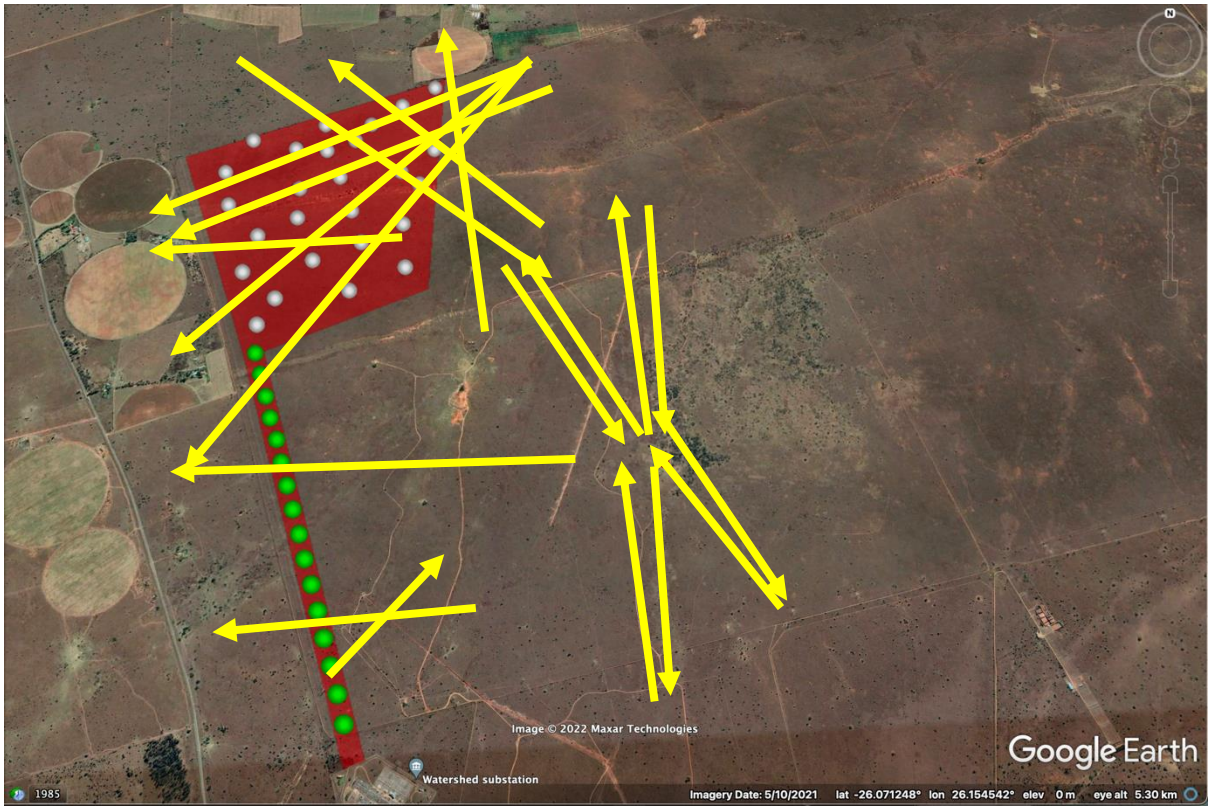

Figure 13. Flight paths were observed during the site visit. This includes the Northern Black Korhaan, African White-backed Vultures, Cape Vultures, African Hawk Eagle, Pied Crows, doves, and swallows, and.

3.2.3. CUMULATIVE EFFECT OF PROPOSED AND APPROVED SOLAR PROJECTS IN THE AREA

Table 2. Renewable energy developments proposed within a 30 km radius of the Lichtenburg Solar Park.

Proposed Development	DEA Reference Number Current Status of EIA	Proposed Capacity	Status
Proposed Establishment Of A Photovoltaic (Pv) Installation At The Bloemfontein Airport, Free State Province	12/12/20/2149/A3	Unkown	Approved
Proposed development of Lichtenburg 1 solar PV energy and associated infrastructure within the Ditsobotla local Municipality in the North West Province	14/12/16/3/3/2/1091	100MW	Approved

Proposed development of the Lichtenburg 2 solar energy facility and its associated infrastructure within Ditsobotla Local Municipality, North West Province	4/12/16/3/3/2/1092	100MW	Approved
The 75MW Tlisitseng PV2 SEF and its associated infrastructure near Lichtenburg, Ditsobotla LM, North West Province	14/12/16/3/3/2/975/AM1	Unkown	Approved
Proposed Watershed Solar Energy Facility North West Province	14/12/16/3/3/2/557	75MW	Approved
Proposed development of Lichtenburg 3 PV solar energy facility and associated infrastructure within Ditsobotla Local Municipality, North West Province	14/12/16/3/3/2/1093	100MW	Approved
Proposed Hibernia solar Energy Facility, North West Province	14/12/16/3/3/2/1062	Unkown	Approved
Proposed Hibernia solar energy facility, North West Province	14/12/16/3/3/1/1062/AM1	Unkown	Approved

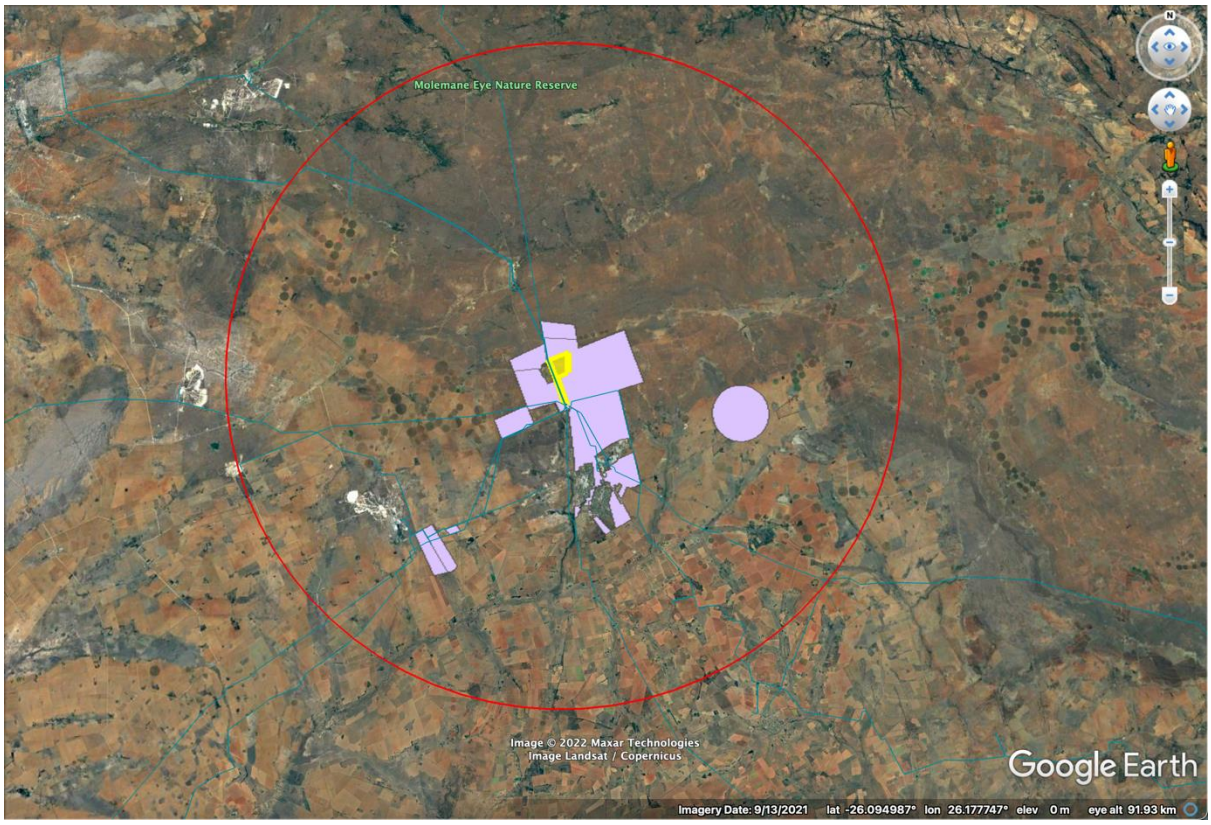

Figure 14. The proposed Lichtenburg Solar Park area (yellow) falls within the footprint of existing PV projects (purple) north of Lichtenburg within a 30 km radius.

The total footprint in a 30 km radius around the proposed development amounts to approximately 14 000 ha. The proposed Lichtenburg Solar Park footprint covers ~240 ha, less than 0.01% of the total approved solar parks in the 30 km radius around the proposed solar park. However, the cumulative impact would be considered low, but the overall impact would be regarded as medium to high in terms of the active supplementary feeding site that would be surrounded by Solar Parks. However, solar farms are not known to negatively impact the priority species identified here but the power line infrasture associated with it.

3.3. BASELINE DATA: THREATENED SPECIES OCCURRING AT THE DEVELOPMENT SITE

As for the Lichtenburg Solar Park development Avifaunal Specialist Assessment, 12 threatened or near-threatened species have been recorded in the greater region during the desktop survey, and only two were confirmed during the field survey. However, the proposed solar park is unlikely to pose a significant threat to any of the following species, but the proposed powerline connecting the solar park and substation poses a significant threat regarding collisions and electrocution with the infrastructure. The threats to each species are discussed in more detail in Table 3.

Table 3. Red-listed species (according to Taylor et al. 2015) whose possible presence at the proposed Lichtenburg Solar Park development site was evaluated during the assessment process. NT = *Near Threatened*; VU = *Vulnerable*; EN = *Endangered*; CR = *Critically Endangered*[2]Indicates species listed as Protected ("PR"), Vulnerable ("VU"), Endangered ('EN") or Critically Endangered ("CR") in the National Environmental Management: Biodiversity Act, 2004 list of Threatened or Protected Species (2007 version)

Common Name	Species	Red Data Status[1]	NEMBA[2]	Likelihood
Eagle Martial	Polemaetus bellicosus	EN	VU	Unlikely to occur at the site due to low reporting rates. However, they might use the power lines as roosting sites and therefore can not exclude the threat of the proposed power line for this threatened species (Figure 15).
Falcon Lanner	Falco biarmicus	VU		Likely, to occur at the site as it was observed outside the surveying efforts on the breeding centre. They will use the proposed infrastructure as roosting sites and therefore can not exclude this threatened species (Figure 15).
Falcon Red-footed	Falco vespertinus	NT		Unlikely to occur at the site due to low reporting rates. However, they might use the power lines as roosting sites and therefore can not exclude the threat of the proposed power line for this threatened species (Figure 15).
Flamingo Greater	Phoenicopterus roseus	NT		Unlikely to occur at the site as the habitat is not suitable (Figure 15).
Flamingo Lesser	Phoeniconaias minor	NT		Unlikely to occur at the site as the habitat is not suitable (Figure 15).
Painted-snipe Greater	Rostratula benghalensis	NT		Unlikely to occur at the site as the habitat is not suitable (Figure 15).
Roller European	Coracias garrulus	NT		Unlikely to occur at the site as the habitat is not suitable (Figure 15).
Secretarybird	Sagittarius serpentarius	VU		Unlikely to occur at the site due to low reporting rates (Figure 15).
Stork Marabou	Leptoptilos crumenifer	NT		Unlikely to occur at the site as the habitat is not suitable (Figure 15).
Vulture Cape	Gyps coprotheres	VU	EN	Confirmed, and are at high risk of negative interaction with power lines structures (collision or electrocution). The supplementary feeding site increases the vulture presence in the area as it is such an important feeding site that supply food to birds across the North West province. All the proposed mitigations need to consider to remove the impact of the proposed development on this species (Figure 15).
Vulture Lappet-faced	Torgos tracheliotos	EN	EN	Very Likely, and are at high risk of negative interaction with power lines structures (collision or electrocution). The supplementary feeding site increases the vulture presence in the area as it is such an important feeding site that supply food to birds across the North West province. All the proposed mitigations need to consider to remove the impact of the proposed development on this species (Figure 15).
Vulture White-backed	Gyps africanus	CR	EN	Confirmed, and are at high risk of negative interaction with power lines structures (collision or electrocution). The supplementary feeding site increases the vulture presence in the area as it is such an important feeding site that supply food to birds across the North West province. All the proposed mitigations neeconsidercider to remove the impact of the proposed development on this species (Figure 15).

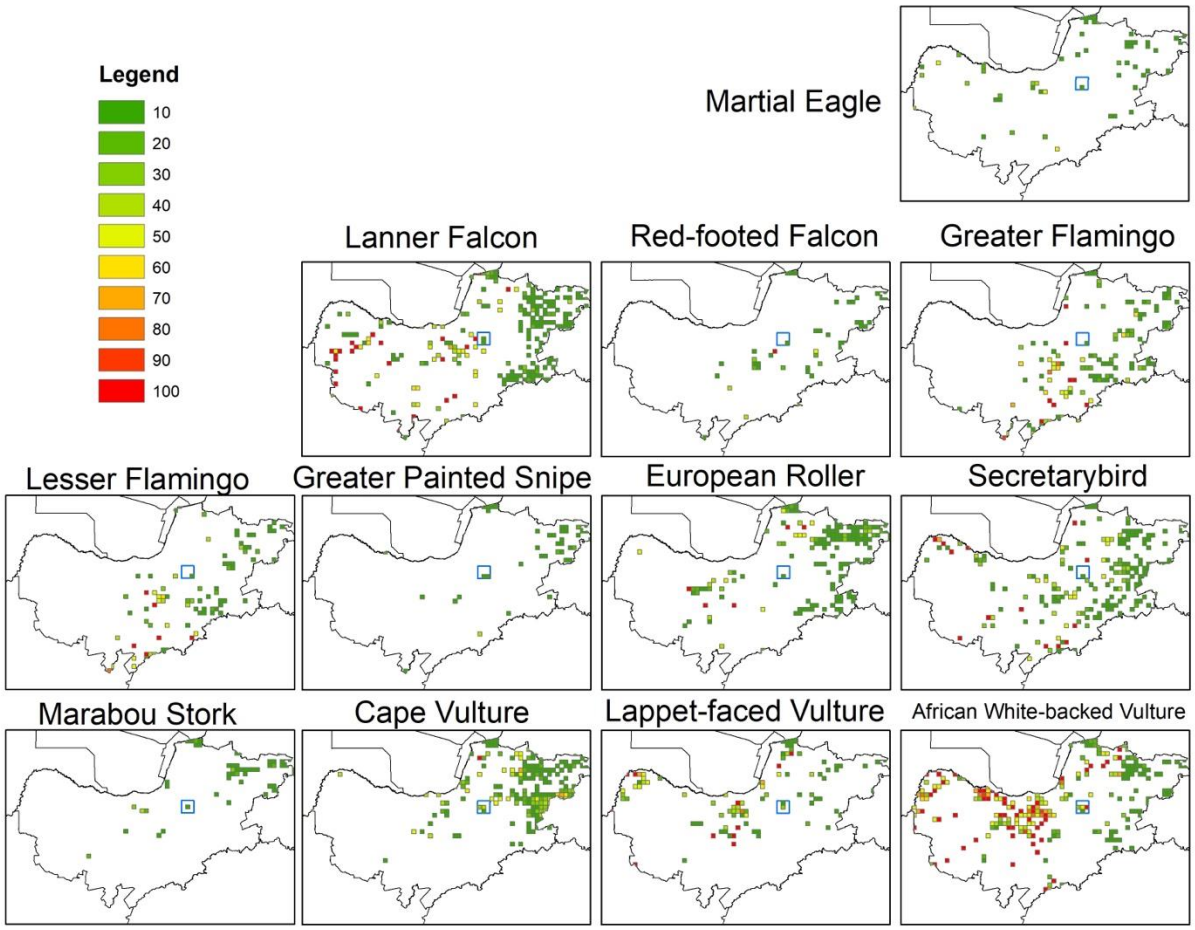

Figure 15. The reporting rate of SABAP pentads for the priority species listed in Table 3, highlights the likeliness of the species occurring within the proposed solar development.

4. DISCUSSION: IMPACT ASSESSMENT AND MITIGATION RECOMMENDATIONS

4.1. METHODOLOGY OF IMPACT ASSESSMENT

The following section assesses the likely impacts on the avifauna due to the proposed Lichtenburg Solar Park Development on the EIA guideline for renewable energy projects (Department of Environmental Affairs 2015) and the Best Practice Guidelines Birds & Solar Energy (Jenkins et al. 2017). The impacts have been quantified and evaluated according to an Impact Assessment Methodology shown in Tables 4, 5 and 6. This qualitative assessment method has been adapted from that of Warner and Preston (1974) and Morris and Therivel (1995) to measure the level of impact on the avifauna before and after mitigation.

Table 4. Criteria are used to measure the level of impact.

Magnitude	
Small and will have no effect on the environment	0
Minor and will not result in an impact on the ecological processes	2

Low and will cause a slight impact on the ecological processes	4
Moderate and will result in the ecological process continuing but in a modified way	6
High (processes are altered to the extent that they temporarily cease)	8
Very high and results in complete (irreversible) destruction of the ecology	10
Scale	
Localised (At localised scale and less than 10 hectares in scale)	1
Localised (At localised scale between 10 and 100 hectares in scale)	2
Entire study area (The proposed site and its environs e.g. neighbouring areas)	3
Beyond Municipal boundaries	4
Provincial-level	5
Duration	
Very short (0 - 1 year)	1
Short (1 - 5 years)	2
Medium term (5 - 15 years)	3
Long term (>15 years)	4
Permanent	5
Probability	
Highly improbable (<20% chance of occurring)	1
Improbable (20 - 40% chance of occurring)	2
Probable (40% - 70% chance of occurring)	3
Highly probable (>70% - 90% chance of occurring)	4
Definite (>90% chance of occurring)	5
Risk= (Scale+Duration+Magnitude) x Probability	

Table 5. The risk matrix indicates the scale of impact calculated using the above equation.

CONSEQUENCE (Scale + Duration + Magnitude)

PROBABILIT	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
2	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40
3	3	6	9	12	15	18	21	24	27	30	33	36	39	42	45	48	51	54	57	60
4	4	8	12	16	20	24	28	32	36	40	44	48	52	56	60	64	68	72	76	80
	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100

Table 6. Impact assessment levels and their bearing on the decision-making process

Low	<30	Where this impact would not have a direct influence on the decision to developin the area
Medium	30 - 60	Where the impact could influence the decision to develop in the area unless itis effectively mitigated

High	>60	Where the impact must influence the decision process to develop inthe area
Confidence of assessment		
Low	The degree of confidence in predictions based on available information, judgement andspecialist's knowledge	
Medium		
High		

4.2. GENERAL IMPACTS

AGES Limpopo (Pty) LTD identified portion 25 of the Farm Houthaalboomen 31 IP and Portion 10 of the Farm Lichtenburg Town and Townlands 27 IP as suitable for the proposed PV Solar Park development during a pre-feasibility analysis. However, the potential occurrence of some threatened species at the proposed site is always of deep concern. As part of the risk assessment process, it is essential to identify any possible mitigating actions or circumstances that may soften or eliminate the potential impacts. Alterations to the design of the infrastructure to improve its "bird safety" character can be suggested, or the consideration of environmental mitigation such as the nature of the proposed project in relation to the surrounding landscape. In this particular case, the proposed development is situated in mixed grasslands with low species richness. However, it is important to note that high-priority species occur and utilise the surrounding environment, especially threatened vultures using the supplementary feeding sites.

In broad terms, the impacts of the proposed development are as follows:

- Displacement through habitat loss and human activity (Table 7)
- Disturbance during the construction phase (Table 8)
- Disturbance during the operations phase (Table 9)
- Collision risk with solar panels (Table 10)
- Collision risk with power lines (Table 11)
- Electrocution risk with power lines (Table 12)
- Electromagnetic fields (Table 13)
- Roosting and breeding on panels (Table 13)

4.3. SPECIFIC IMPACTS AND MITIGATION RECOMMENDATIONS

Table 7: Impact assessment – Habitat destruction – Displacement through habitat loss and human activity

Nature: Habitats will be lost in areas cleared for the construction of the development. **Impacts**

During the construction phase of the proposed Lichtenburg Solar Park, we will see permanent habitat destruction and displacement due to the extensive space requirements of the proposed PV solar facility. Clearing for construction across the entire proposed area will impact the threatened, endemic and resident species' breeding and the foraging behaviour and roosting activities at the proposed development site.

It is improbable that any of the priority species will be permanently displaced or affected by the habitat transformation that will take place for the proposed development.

	Without mitigation		**With mitigation**	
Scale	Entire study area	3	Entire study area	3
Duration	Permanent	5	Permanent	5
Magnitude	Very high and results in complete (irreversible) destruction of the ecology	10	Moderate	6
Probability	Highly Probable	4	Probable	3
Significance	**High**	**72**	**Medium**	**42**
Reversibility	Low		Low	
Can impacts be mitigated?	Yes			

Mitigation

- All construction and maintenance activities must be carried out according to the generally accepted environmental best practice guidlines. The temporal and spatial footprint of the development should be kept to a minimum.
- Boundaries need to be marked before the start of the construction.
- Clearing should occur between May – August outside the breeding season
- Any bird nests found during the construction period must be reported to the ECO.
- The above measures must be covered in a site-specific EMP and controlled by an ECO.

Outcome: The proposed development will lead to habitat loss and the displacement of various bird species, However it will not lead to the displacement of any priority species. The species diversity at the proposed PV Solar Park is low and will have a moderate impact if mitigations are taken into consideration during the construction phase.

Table 8: Impact assessment – Disturbance during the construction phase

Nature: Habitats will be lost in areas cleared for the construction of the development.

Impacts

During the construction phase of the proposed Lichtneburg PV Solar Park development, the continued disturbance will occur due to increased human activity and mechanical equipment, negatively impacting birds' breeding activities and community structure in the surrounding areas of the solar park. Avian species with small territories are more susceptible to these disturbances.

	Without mitigation		**With mitigation**	
Scale	Entire study area	3	Entire study area	3
Duration	Short	2	Short	2
Magnitude	Moderate	6	Low and will cause a slight impact on the ecological processes	4
Probability	Highly Probable	4	Probable	3
Significance	**Medium**	**44**	**Low**	**27**
Reversibility	Low		Low	
Can impacts be mitigated?	Yes			

Mitigation

- All construction and maintenance activities must be carried out according to the generally accepted environmental best practice. The temporal and spatial footprint of the development should be kept to a minimum.
- Construction should occur outside the breeding season. It is strongly suggested that this phase be carried out during the winter months (May-August).
- Construction should not be accommodated on-site, and when contractors stay on-site, it should be within the development footprint. Movement outside this development footprint must be restricted.
- Driving must take place on existing roads to the development site, and a speed limit of 30km/h must be implemented.
- An alternative layout has been proposed, which will reduce or remove the threat of the power line. However, it will provide easy access to the entire site from the road along the fence line reducing additional disturbance through natural vegetation.
- Any bird nests found during the construction period must be reported to the ECO.
- The above measures must be covered in a site-specific EMP and controlled by an ECO.

Outcome: The impact of the construction phase is largely unavoidable but can be mitigated with the mitigation mentioned above. The effect during the construction phase is anticipated to be of moderate significance as it is a largely temporary threat. Still, it can be reduced to low significance should the necessary threat preventative steps be implemented.

Table 9: Impact assessment – Disturbance during the operations phase

Nature: Disturbance during the operations phase

Impacts

During the operational phase, lights are required to light the PV Solar Park for security reasons. However, it will result in disorientated birds flying over the site at night or draw birds to insect prey with the risk of collisions with infrastructure. In addition, defecation on the solar panels could lower the panels' efficiency. Furthermore, Birds using PV infrastructure for nesting could cause a variety of maintenance issues and threats to the birds themselves.

	Without mitigation		**With mitigation**	
Scale	Entire study area	3	Entire study area	3
Duration	Permanent	5	Permanent	5
Magnitude	High	8	Moderate	6
Probability	Probable	3	Improbable	2
Significance	**Medium**	**48**	**Low**	**28**
Reversibility	Low		Low	
Can impacts be mitigated?	Yes			

Mitigation

- The use of lighting at night should be kept to a minimum. Furthermore, a red light needs to be used to avoid the attraction of invertebrates and their avian predators to the solar facility. In addition, this will minimise the disturbance to birds flying over the facility at night.
- Low- UV type lights orientated downwards should be used
- Single bird and mammal-friendly fences should be used
- Regular cleaning and maintenance activities should prevent defecation on panels before becoming a problem. Eco-friendly bird deterring devices could prevent large birds from perching on panel structures.
- As the site is considered a high-risk area during construction and post-construction, monitoring by an avifaunal specialist should be conducted for approximately two years. In addition, all incidents should be recorded as meticulously as possible using suitable scientific protocols.
- If any nest construction starts on the panels, the nest should be removed immediately to avoid any electrical shorts and operational risks of fire.
- If there are any persistent problems with avifauna, then an avifaunal specialist should be consulted for advice on further mitigations.
- Driving must take place on existing roads, and a speed limit of 30 km/h must be implemented.
- Any bird nests found during the construction period must be reported to the ECO.
- The above measures must be covered in a site-specific EMP and controlled by an ECO.

Outcome: The impact assessment found threat of disturbance to birds during the operational phase to be moderate significance. Implementing above mitigations, the threat of disturbance will probably be of low significance.

Table 10: Impact assessment – Collision risk with solar panels

Nature: Avifaunal species get disorientated by the reflected light.

Impacts

Large area of the proposed site can increase the risk of reflected light from panels and can be a potential threat to aerial hunters (e.g Lanner Falcon). Waterbirds might mistake PV solar panels for a water source and may attempt to land on panels resulting in injuries or deaths when PV Solar Parks are close to large water bodies and is known as the "lake effect. Lights at PV facility need to be kept to a minimum to minimise disorientation of night-flying birds.

	Without mitigation		**With mitigation**	
Scale	Entire study area	3	Entire study area	3
Duration	Permanent	5	Permanent	5
Magnitude	Low and will cause a slight impact on ecological processes	4	Low and will cause a slight impact on ecological processes	2
Probability	Probable	3	Improbable	2
Significance	**Medium**	**36**	**Low**	**20**
Reversibility	Low		Moderate	
Can impacts be mitigated?	Yes			

Mitigation

- Structural elements or markings can be incorporated into the design that may break up the reflection.
- Increase the spacing between panels to avoid the "lake effect". However, this will increase the surface area of the site.
- Low UV type lights orientated downwards should be used
- Panels should be tilted towards the vertical when not in use.
- ECO's should be trained in collecting collision information.
- As the site is considered a high-risk area during construction and post-construction, monitoring by an avifaunal specialist should be conducted for approximately two years. In addition, all incidents should be recorded as meticulously as possible using suitable scientific protocols.

Outcome: The impact of this threat is largely unknown, and therefore, it is expected that the impact is of medium significance, but with proper mitigation in place, the impact can be considered as low significance.

Table 11: Impact assessment – Collision risk with power lines

Nature: Negative interaction with power lines in terms of collisions

Impacts

Collisions are the most significant single threat posed by transmission power lines to birds in southern Africa (Van Rooyen 2004). Due to limited manoeuvrability, large terrestrial birds and vultures are most susceptible and impacted by transmission lines, making it difficult to avoid colliding with power lines. In this particular case, Cape, White-backed and Lappet-faced Vultures are at extreme risk of increase power line collisions as the site already has nine different power line structures across the landscape. This is problematic as it will be extremely difficult to avoid all the lines if they can't get high enough before passing the power lines to the west and south

of the solar park. During the last year and a half, more than 15 vultures were negatively impacted by these power lines surrounding the Lichtenburg Solar Park (Wolter et al. unpublished).

	Without mitigation		**With mitigation**	
Scale	Entire study period	3	Entire study period	3
Duration	Permanent	5	Permanent	5
Magnitude	High	8	Moderate	6
Probability	Definite	5	Highly Probable	4
Significance	**High**	**80**	**Medium**	**56**
Reversibility	Low		Low	
Can impacts be mitigated?	No, as it will result in complete destruction.			

Mitigation

- The power line route should be the shortest between the Solar Park and the substation.
- Due to the number of power lines already in the area and the presence of the vulture supplementary feeding site, it should be considered to place the power lines underground to remove the threat from the scenario as the priority species are highly vulnerable to negative power line interactions.
- If the power lines can't be placed underground, the design and layout of any proposed power lines within the PV facility must be endorsed by members of the Eskom-EWT Strategic Partnership, considering the mitigation guidelines (Smit 2012; Jenkins et al. 2016).
- Overhead transmission cables should be marked with enough bird diverters and as close as possible to each other to make the lines visible to collision-susceptible species.
- Recommended bird diverters such as brightly coloured "aviation" balls or flapping devices and luminescent light emission reflector devices or solar-powered night deterrents for nocturnal birds should be installed. It is proven that birds collision can be reduced by 50-60%, but it is still not incident proof. Therefore, we would suggest that the powerline be placed underground to remove this threat.
- The site is considered a high-risk area during construction, and post-construction monitoring by an avifaunal specialist should be conducted for approximately two years as described in the Best Practice Guidelines Birds & Solar Energy (Jenkins et al. 2017). In addition, all incidents should be recorded as meticulously as possible using good scientific protocols.
- An alternative layout has been proposed, which will reduce or remove the threat of the power line (Figure 16). This reduce the power line distance between substation and the solar park.
- Given the proposed development, approved projects, and the proximity to town and other human infrastructure. If the lines can't be placed underground or the alternative layout can not be used, all the necessary steps (e.g., financial support and monitoring) and considerations need to be taken to move the supplementary feeding site to an alternative location by consulting the experts at VulPro.

Outcome: The impact assessment found the threat of collision with power line infrastructure to be of high significance, but implementing the above mitigations will still be of moderate to high significance. However, if the

power line is placed underground or the alternative layout is considered, the threat will be eliminated for the proposed site, but the overall threat will still exist.

Table 12: Impact assessment – Electrocution risk with power lines

Nature: Negative interaction with power lines in terms of electrocution

Impacts

As for collisions, it is known that electrocution is a significant cause of mortality for a variety of large bird species such as vultures in South Africa (Van Rooyen and Ledger 1999, Howard et al. 2021). Electrocution is usually associated with distribution lines but still occurs on transmission lines. Large birds of prey, storks and vultures are particularly susceptible as they have long wingspans and prefer roosting on the tallest structures within a landscape, e.g. power lines at the proposed Solar Park to protect them from terrestrial predators. During the last year and a half, more than 15 vultures were negatively impacted by these power lines surrounding the Lichtenburg Solar Park (Wolter et al. unpublished).

	Without mitigation		**With mitigation**	
Scale	Entire study period	3	Entire study period	3
Duration	Permanent	5	Permanent	5
Magnitude	Moderate	6	Low and will cause a slight impact on the ecological processes	4
Probability	Highly Probable	4	Probable	3
Significance	**Medium**	**56**	**Medium**	**36**
Reversibility	Low		Low	
Can impacts be mitigated?	Yes			

Mitigation

- The power line route should be the shortest between the Solar Park and the Substation.
- Due to the number of power lines already in the area and the presence of the vulture supplementary feeding site, it should be considered to place the power lines underground to remove the threat from the scenario as the priority species are highly vulnerable to negative interactions with power lines.
- High-risk perching surfaces should be fitted with bird and perch guards as deterrents (Hunting 2002). Only power line structures considered safe for birds may be erected to avoid the electrocution of birds perching or attempting to perch. It is recommended that the powerline be placed underground to remove this threat.
- The site is considered a high-risk area during construction, and post-construction monitoring by an avifaunal specialist should be conducted for approximately two years as described in the Best Practice Guidelines Birds & Solar Energy (Jenkins et al. 2017). In addition, all incidents should be recorded as meticulously as possible using good scientific protocols.
- An alternative layout has been proposed, which will reduce or remove the threat of the power line (Figure 16). This reduce the power line distance between substation and the solar park.

- Given the proposed development, approved projects, and the proximity to town and other human infrastructure. If the lines can't be placed underground or the alternative layout can not be used, all the necessary steps (e.g., financial support and monitoring) and considerations need to be taken to move the supplementary feeding site to an alternative location by consulting the experts at VulPro.

Outcome: The impact assessment found the threat of collision with power line infrastructure to be of high significance, but implementing the above mitigations will still be of moderate to high significance. However, if the power line is placed underground or the alternative layout is considered, the threat will be eliminated for the proposed site, but the overall threat will still exist.

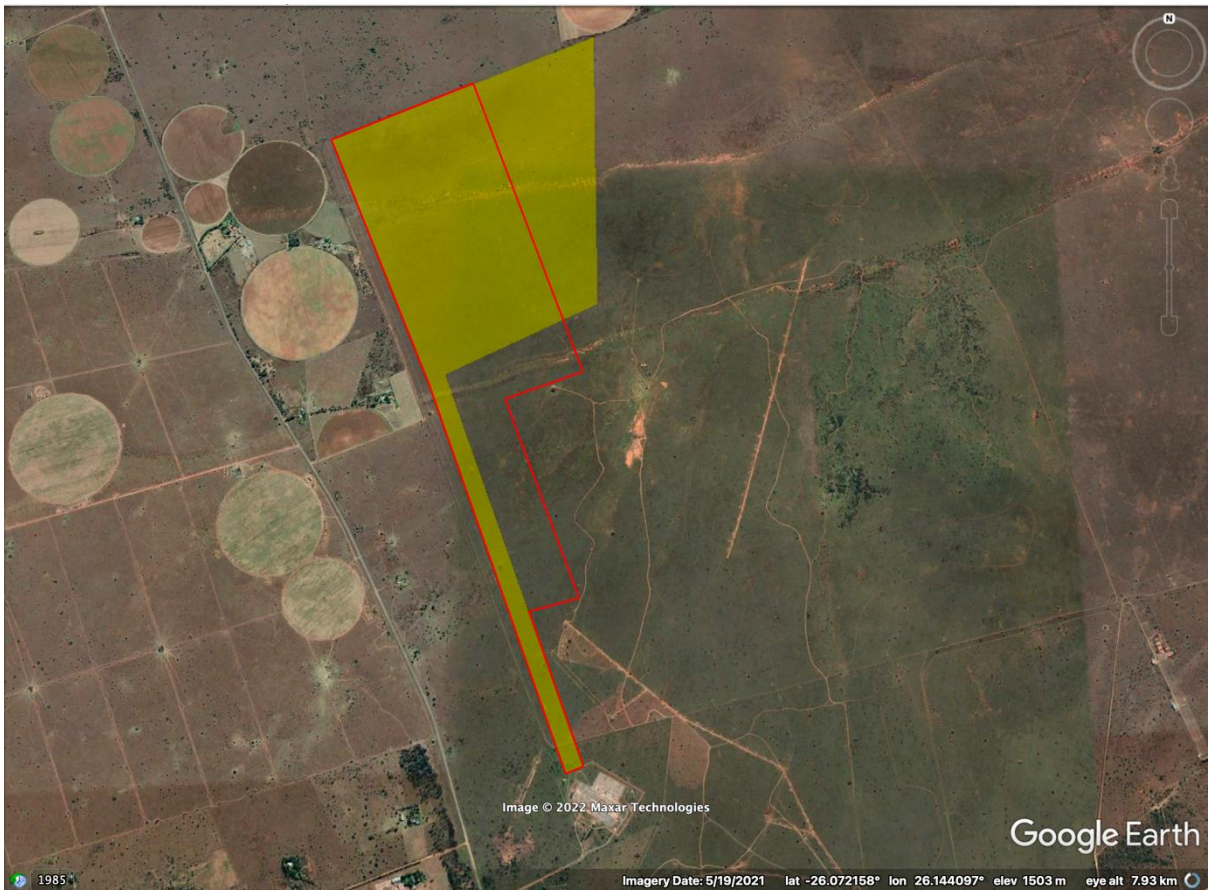

Figure 16. An alternative proposed layout (red outer line) reduces the power line distance to less than 1 km or potentially eliminates the construction of any power lines within the area.

Table 13: Impact assessment – Electromagnetic fields

Nature: There is some evidence that the electromagnetic fields generated by power lines have adverse effects on avian breeding, as well as the ability of migrants to navigate				
	Without mitigation		**With mitigation**	
Scale	Entire study period	3	Entire study period	3
Duration	Permanent	5	Permanent	5
Magnitude	Low and will cause a slight impact on the ecological processes	4	Low and will cause a slight impact on the ecological processes	4
Probability	Improbable	2	Improbable	2
Significance	**Low**	**24**	**Low**	**24**
Reversibility	Low		Low	
Can impacts be mitigated?	No			
Mitigation - None is necessary beyond installing insulators and shielding following Eskom's standard guidelines for best practice (Fernie *et al*. 2000).				
Outcome: The impact can be considered low. However, it will contribute to widespread EMFs generated by electrical infrastructure. Evidence of negative impact is limited, and therefore, mitigations are limited.				

Table 14: Impact assessment – Roosting and breeding on panels

Nature: Photovoltaic panels fixed towards one angle could create a problem. The fixed panels will create nest/perching/roosting areas for various birds from small to big. For example, sparrows and crows can potentially use it as a suitable breeding site.				
	Without mitigation		**With mitigation**	
Scale	Entire study period	3	Entire study period	3
Duration	Long term	4	Long term	4
Magnitude	Minor and will not result in an impact on the ecological processes	2	Small and will not affect the environment	0
Probability	Improbable	2	Improbable	2
Significance	**Low**	**18**	**Low**	**14**
Reversibility	Moderate		Moderate	
Can impacts be mitigated?	Yes			

Mitigation:

- Nest building will not likely be a concern during the construction phase.
- Place rotary solar panels instead of fixed panels should be implemented to avoid any nest construction. Alternatively, panels should be checked weekly to remove any early nest construction.
- Any bird nests found on the panels must be reported to the ECO.
- The above measures must be covered in a site-specific EMP and controlled by an ECO.

Outcome: Continue to remove any nest from fixed solar panels. However, it needs to be reported to the ECO.

4.4. CONCLUSIONS AND RECOMMENDATIONS

While renewable energy sources such as solar energy are important to the future development of power generation and hold great potential to alleviate the dependence on fossil fuels, they are not without their environmental risks and negative impacts. Poorly sited or designed solar power generating facilities can negatively impact birds and their habitats and the functioning of the entire ecosystem.

The assessment of impacts identified by Birdlife SA as significant for PV developments has revealed that the majority of these impacts fall within the "high" risk category (Figure 17) due to the proximity to the supplementary feeding site. However, the risk should reduce to "moderate" risk levels after mitigation and provided the recommended bird conservation protocols are employed. As the majority of threats to birds and other wildlife posed by PV facilities are poorly understood, the Lichtenburg Solar Parks, if endorsed, have the potential to provide an ideal platform for monitoring the impact of Solar Parks on the avifaunal communities in mixed grasslands. Institutions could possibly conduct valuable and relevant research into threats posed to avifauna by PV facilities and how to avoid these threats, especially to high-priority species as described in the Best Practice Guidelines Birds & Solar Energy (Jenkins et al. 2017).

The findings of this report and the relevant impact assessment concluded that the development of the proposed Lichtenburg Solar Park would have a medium impact on the bird communities and will cause a slight impact on the ecological process of the overall bird community. The biggest concern is the threat the power lines within this area hold to threatened species such as the three vulture species present at the site. However, if the distances of the power lines can be reduced or completely eliminated by using the alternative proposed layout, the overall impact of the produced solar park will be reduced. Therefore, careful considerations need to be taken in terms of the proposed power line as the impact can be catastrophic. Still, the issuing authority must consider all prescribed mitigation measures and recommendations.

Figure 17. Area sensitivity analysis for the proposed Lichtenburg Solar Park, mainly due to the active supplementary feeding sites for vultures.

5. POST-CONSTRUCTION MONITORING METHODOLOGY AT EACH SITE

According to the Best Practice Guidelines Birds & Solar Energy (Jenkins et al. 2017), under the high sensitivity of the proposed development, a post-construction survey will be conducted with two survey periods approximately 6 months apart during the austral summer and winter each year for a minimum of 2-3 years. This allows us to make more comprehensive assessments on the impact of solar farms on avifaunal. Each survey will consist of multiple site visits (3-4 days), conducting various point transects during each visit. Transects will be conducted on the proposed solar area and potentially surrounding areas. This is required based on the Birds and Solar Energy Best Practice Guidelines by Jenkins *et al*. (2017). Points were spatially placed to cover all habitat features at each site as described by Leddy *et al*. (1999) and Bibby *et al*. (2000). This analysis will consider possible observer biases, detectability, time of day, weather condition and activity. Furthermore, these points will be walked during cooler periods of the day (*e.g*., early mornings and late afternoons). As described in the Birds and Solar Energy Best Practice Guidelines the species, number, and distance will be recorded with a range finder (e.g., 0-10m,11-50m,51-200m, >200m).

In addition, I will conduct dedicated road counts to observe large terrestrial birds as described in the Birds and Solar Energy Best Practice Guidelines. From these road surveys, I will record any breeding pairs, nest/breeding areas that will undergo further monitoring and any information on the flight patterns of large Raptors. Furthermore, powerlines and solar parks will be walked and surveyed to record any fatalities during each survey. The study design is subject to change if the contract is provided to Kemp Operations.

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