BIOTHERM ENAMANDLA AND ENAMANDLA SOLAR PROJECTS

IMPACT ASSESSMENT STUDY: AVIFAUNA

ENAMANDLA PV 5


Compiled by

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EXECUTIVE SUMMARY

BioTherm Energy (Pty) Ltd (BioTherm) is planning to develop five Photovoltaic Solar Power (PV) solar energy facilities (SEFs) on the Farm Hartebeest Vlei 86, approximately 17km from the town of Aggeneys in the Northern Cape Province. The proposed sites are called Enamandla PV1 – PV5.

This report deals specifically with the impacts associated with Enamandla PV5.

The proposed PV5 facility will have several impacts on avifauna at a site level which will, unless mitigated, range from High to Medium.

The impact of displacement of priority species due to habitat transformation associated with the operation of the plant and associated infrastructure is rated as High. The impact of mortality due to collisions with the internal 132kV powerlines is rated as High but can be mitigated to a Medium level. This impact can be partially reversed through mitigation, but it will remain at a Medium level, even after mitigation. The impact of displacement due to disturbance during the construction phase is rated as Medium and will remain at a Medium level despite after mitigation. The remaining envisaged impacts, i.e. mortalities in the operational phase due to collisions with the solar panels and entrapment in perimeter fences are both rated as Medium and should be mitigatable to a Low level with appropriate mitigation.

Alternative 1 and Alternative 2 are situated in similar habitat, therefore the nature of the associated impacts is expected to be similar. There is therefore no preferred alternative from an avifaunal impact perspective.

The relatively small size of the footprint, coupled with the low densities of priority species at the site, particularly Red Lark, leads to the conclusion that the cumulative impact of the facility on priority avifauna should in all likelihood be low, taking into account the current impacts on avifauna within a 65km radius around the development area.

From an avifaunal impact perspective, the proposed development could go ahead, provided the proposed mitigation measures are strictly implemented.

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1. INTRODUCTION

1.1. SCOPE OF WORK

The terms of reference for this impact assessment report are as follows:

- Describe the affected environment from an avifaunal perspective;
- Discuss gaps in baseline data and other limitations;
- List and describe the expected impacts for the PV5 facility and associated infrastructure;
- Assess and evaluate the potential impacts; and
- Recommend mitigation measures to reduce the impact of the expected impacts.

1.2. OBJECTIVES OF THE REPORT

The objectives of the report are to investigate the potential impact of the proposed Enamandla PV5 facility on avifauna in order to assess whether the project is fatally flawed from an avifaunal impact perspective and, if not, what mitigation measures should be implemented to reduce the potential impacts.

1.3. LEGISLATIVE FRAMEWORK

There is no specific legislation pertaining specifically to the impact of solar facilities on avifauna. There are best practice guidelines available which were compiled by Birdlife South Africa (BLSA) in 2012 (Smit 2012). Efforts are currently underway to comprehensively revise these guidelines, however these new guidelines are still in draft form and have not yet been officially adopted by BLSA.

1.3.1 AGREEMENTS AND CONVENTIONS

Table 1 below lists agreements and conventions which South Africa is party to and which is relevant to the conservation of avifauna[1].

Table 1: Agreements and conventions which South Africa is party to and which is relevant to the conservation of avifauna.

Convention name	Description	Geographic scope
African-Eurasian Waterbird Agreement (AEWA)	The Agreement on the Conservation of African-Eurasian Migratory Waterbirds (AEWA) is an intergovernmental treaty dedicated to the conservation of migratory waterbirds and their habitats across Africa, Europe, the Middle East, Central Asia, Greenland and the Canadian Archipelago. Developed under the framework of the Convention on Migratory Species (CMS) and administered by the United Nations Environment Programme (UNEP), AEWA brings together countries and the wider international conservation community in an effort to establish coordinated conservation and management of migratory waterbirds throughout their entire migratory range.	Regional
Convention on Biological Diversity (CBD), Nairobi, 1992	The Convention on Biological Diversity (CBD) entered into force on 29 December 1993. It has 3 main objectives: • The conservation of biological diversity • The sustainable use of the components of biological diversity	Global

[1] (BirdLife International (2016) Country profile: South Africa. Available from: http://www.birdlife.org/datazone/country/south_africa. Checked: 2016-04-02).

	• The fair and equitable sharing of the benefits arising out of the utilization of genetic resources.	
Convention on the Conservation of Migratory Species of Wild Animals, (CMS), Bonn, 1979	As an environmental treaty under the aegis of the United Nations Environment Programme, CMS provides a global platform for the conservation and sustainable use of migratory animals and their habitats. CMS brings together the States through which migratory animals pass, the Range States, and lays the legal foundation for internationally coordinated conservation measures throughout a migratory range.	Global
Convention on the International Trade in Endangered Species of Wild Flora and Fauna, (CITES), Washington DC, 1973	CITES (the Convention on International Trade in Endangered Species of Wild Fauna and Flora) is an international agreement between governments. Its aim is to ensure that international trade in specimens of wild animals and plants does not threaten their survival.	Global
Ramsar Convention on Wetlands of International Importance, Ramsar, 1971	The Convention on Wetlands, called the Ramsar Convention, is an intergovernmental treaty that provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources.	Global
Memorandum of Understanding on the Conservation of Migratory Birds of Prey in Africa and Eurasia	The Signatories will aim to take co-ordinated measures to achieve and maintain the favourable conservation status of birds of prey throughout their range and to reverse their decline when and where appropriate.	Regional

1.3.2 NATIONAL LEGISLATION

1.3.2.1 Constitution of the Republic of South Africa, 1996

The Constitution of the Republic of South Africa provides in the Bill of Rights that: Everyone has the right –

(a) to an environment that is not harmful to their health or well-being; and

(b) to have the environment protected, for the benefit of present and future generations, through reasonable legislative and other measures that –

- (i) prevent pollution and ecological degradation;
- (ii) promote conservation; and
- (iii) secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development.

1.3.2.2 The National Environmental Management Act 107 of 1998 (NEMA)

The National Environmental Management Act 107 of 1998 (NEMA) creates the legislative framework for environmental protection in South Africa, and is aimed at giving effect to the environmental right in the Constitution. It sets out a number of guiding principles that apply to the actions of all organs of state that may significantly affect the environment. Sustainable development (socially, environmentally and economically) is one of the key principles, and internationally accepted principles of environmental management, such as the precautionary principle and the polluter pays principle, are also incorporated.

NEMA also provides that a wide variety of listed developmental activities, which may significantly affect the environment, may be performed only after an environmental impact assessment has been done and authorization has been obtained from the relevant authority. Many of these listed activities can potentially have negative impacts on bird populations in a variety of ways. The clearance of natural vegetation, for instance, can lead to a loss of habitat and may depress prey populations, while erecting structures needed for generating and distributing energy, communication, and so forth can cause mortalities by collision or electrocution.

1.3.2.3 The National Environmental Management: Biodiversity Act 10 of 2004 (NEMBA) and the Threatened or Protected Species Regulations, February 2007 (TOPS Regulations)

The most prominent statute containing provisions directly aimed at the conservation of birds is the National Environmental Management: Biodiversity Act 10 of 2004 read with the Threatened or Protected Species Regulations, February 2007 (TOPS Regulations). Chapter 1 sets out the objectives of the Act, and they are aligned with the objectives of the Convention on Biological Diversity, which are the conservation of biodiversity, the sustainable use of its components, and the fair and equitable sharing of the benefits of the use of genetic resources. The Act also gives effect to CITES, the Ramsar Convention, and the Bonn Convention on Migratory Species of Wild Animals. The State is endowed with the trusteeship of biodiversity and has the responsibility to manage, conserve and sustain the biodiversity of South Africa.

1.4. STUDY APPROACH AND METHODOLOGY

The following approach was followed in compiling the report:

- Bird distribution data of the Southern African Bird Atlas Project2 (SABAP 2) was obtained (http://sabap2.adu.org.za/), in order to ascertain which species occur in the pentads where the proposed CSP facilities are located. A pentad grid cell covers 5 minutes of latitude by 5 minutes of longitude (5'× 5'). Each pentad is approximately 8 × 7.6 km. In order to get a more representative impression of the birdlife, a consolidated data set was obtained for the 9 pentads which overlap substantially with the proposed development. The nine pentad grid cells are 2915_1845, 2915_1850, 2915_1855, 2920_1845, 2920_1850, 2920_1855, 2925_1845, 2925_1850, 2925_1855 (see **Figure 5**). A total of 27 full protocol lists have been completed to date for the 9 pentads where the study area is located (i.e. lists surveys lasting a minimum of two hours each). The SABAP2 data was therefore regarded as a reasonably reliable snapshot of the avifauna, especially when supplemented by actual data collected during surveys and through general knowledge of the area.

- A classification of the vegetation types in the study area was obtained from the Atlas of Southern African Birds 1 (SABAP1) and the National Vegetation Map compiled by the South African National Biodiversity Institute (Mucina & Rutherford 2006).

- Data on the location of large raptor nests in the Northern Cape for the period 1994 – 2009 was obtained from the Kalahari Raptor Project (Maritz 2009).

- The national threatened status of all priority species was determined with the use of the most recent edition of the Red Data Book of Birds of South Africa, Lesotho and Swaziland (Taylor *et al.* 2015), and the latest authoritative summary of southern African bird biology (Hockey *et al.* 2005).

- The global threatened status of all priority species was determined by consulting the latest (2016.2) IUCN Red List of Threatened Species (http://www.iucnredlist.org/).

- The BirdLife South Africa (BLSA) was consulted on Important Bird Areas of Southern Africa for information on relevant Important Bird Areas (IBAs) (http://www.birdlife.org.za/conservation/important-bird-areas) (Marnewick *et al*. 2015).

- Satellite imagery from Google Earth was used in order to view the broader area on a landscape level and to help identify bird habitat on the ground.

- An intensive literature search was conducted to source information on the impacts of solar facilities on avifauna.

- A site visits was conducted on 16-19 November 2015, to get an overview of the habitat at the development area. Subsequent to that, additional information on bird diversity and abundance at the site was obtained through a monitoring programme which lasted from December 2015 to September 2016 (four seasons). Data was collected through transect counts, incidental sightings and the recording of flight behaviour from vantage points (VPs) (see APPENDIX 1).

1.5. ASSUMPTIONS

It is assumed that the sources of information used in this report are reliable.

1.6. LIMITATIONS OF THIS STUDY

- The impact of solar installations on avifauna is a new field of study, with only one scientific study published to date (McCrary et al. 1986) and one unpublished scientific study on the impact of solar facilities on avifauna in South Africa (Visser 2016). Strong reliance was therefore placed on expert opinion and data from existing monitoring programmes at solar facilities in the USA which have recently (2013 - 2015) commenced with avifaunal monitoring. The pre-cautionary principle was applied throughout as the full extent of impacts on avifauna at solar facilities is not presently known.

- The assessment of impacts is based on the baseline environment as it currently exists in the study area. Future changes in the baseline environment were not taken into account.

- The focus of the study is primarily on the potential impacts on priority species which were defined as follows:

    - South African Red Data species;
    - South African endemics and near-endemics;
    - Waterbirds;
    - Raptors; and
    - IBA trigger species

1.7. DECLARATION OF INDEPENDENCE

Chris van Rooyen
Chris has 20 years' experience in the management of wildlife interactions with electricity infrastructure. He was head of the Eskom-Endangered Wildlife Trust (EWT) Strategic Partnership from 1996 to 2007, which has received international acclaim as a model of co-operative management between industry and natural resource conservation. He is an acknowledged global expert in this field and has worked in South Africa, Namibia, Botswana, Lesotho, New Zealand, Texas, New Mexico and Florida. Chris also has extensive project management experience and has received several management awards from Eskom for his work in the Eskom-EWT Strategic Partnership. He is the author of 15 academic papers (some with co-authors), co-author of two book chapters and several research reports. He has been involved as ornithological consultant in numerous power line and several renewable energy projects. Chris is also co-author of the Best Practice for Avian Monitoring and Impact Mitigation at Wind Development Sites in Southern Africa, which is currently (2016) accepted as the industry standard. Chris also works outside the electricity industry and had done a wide range of bird impact assessment studies associated with various residential and industrial developments.

Albert Froneman
Albert has an M. Sc. in Conservation Biology from the University of Cape Town, and started his career in the natural sciences as a Geographic Information Systems (GIS) specialist at Council for Scientific and Industrial Research (CSIR). In 1998, he joined the Endangered Wildlife Trust where he headed up the Airports Company South Africa – EWT Strategic Partnership, a position he held until he resigned in 2008 to work as a private ornithological consultant. Albert's specialist field is the management of wildlife, especially bird related hazards at airports. His expertise is recognized internationally; in 2005 he was elected as Vice Chairman of the International Bird Strike Committee. Since 2010, Albert has worked closely with Chris van Rooyen in developing a protocol for pre-construction monitoring at wind energy facilities, and he is currently jointly coordinating pre-construction monitoring programmes at several wind

farm facilities. Albert also works outside the electricity industry and had done a wide range of bird impact assessment studies associated with various residential and industrial developments.

Nico Laubscher

Nico holds a D.Sc. from the University of Potchefstroom and was head of the Statistics Division, National Research Institute for Mathematical Sciences of the CSIR from 1959 – 1975. He retired in 1989 as head of the Centre for Statistical Consultation at the University of Stellenbosch. Nico held several offices, including President of the South African Statistical Association, and editor of the South African Statistical Journal. Nico has five decades' experience in statistical analysis and data science applications, including specialisation in model building with massive data sets, designing of experiments for process improvement and analysis of data so obtained, and statistical process control. He also has published peer reviewed papers in several leading statistical journals, including Annals of Mathematical Statistics, American Statistical Journal, Technometrics and The American Statistician. He currently operates as a private statistical consultant to industry and academia.

SPECIALIST DECLARATION

I, Chris van Rooyen as duly authorised representative of Chris van Rooyen Consulting, and working under the supervision of and in association with Albert Froneman (SACNASP Zoological Science Registration number 400177/09) as stipulated by the Natural Scientific Professions Act 27 of 2003, hereby confirm my independence (as well as that of Chris van Rooyen Consulting) as a specialist and declare that neither I nor Chris van Rooyen Consulting have any interest, be it business, financial, personal or other, in any proposed activity, application or appeal in respect of which WSP was appointed as environmental assessment practitioner in terms of the National Environmental Management Act, 1998 (Act No. 107 of 1998), other than fair remuneration for worked performed, specifically in connection with the Environmental Impact Assessment for the proposed Enamandla CSP facilities.

Signed: Chris van Rooyen
Tel: 0824549570
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See APPENDIX 2 for Chris van Rooyen's CV.

2. DESCRIPTION OF THE PROJECT

BioTherm Energy (Pty) Ltd (BioTherm) is planning to develop five photo-voltaic solar energy facilities (SEFs) on the Farm Hartebeest Vlei 86, comprising 13 191.35 ha, approximately 17km from the town of Aggeneys in the Northern Cape Province. The proposed sites are called Enamandla PV1 – PV5. This report deals specifically with PV5.

<u>Enamandla PV site 5</u>

The proposed project will comprise of the following:

- Solar PV panels
- Panels will be either fixed axis mounting or single axis tracking solutions, and will be either crystalline silicon or thin film technology
- DC power from the panels will be converted into AC power in the inverters and the voltage will be stepped up to 22-33kV (medium voltage) in the transformers

- The medium voltage collector system will comprise of cables (11kV up to and including 33kV) that will be run underground, expect where a technical assessment suggest that overhead lines are applicable
- Onsite 132/400kV Substation, with the transformers for voltage step up from medium voltage to high voltage. Substation will occupy an area of 150m x 150m
- On site 132kV powerline connecting the facility from the onsite substation to a common substation
- A laydown area for the temporary storage of materials during the construction activities
- Access roads and internal roads
- Sewage disposal facility and septic tanks
- Construction of a car park and fencing
- Administration, control and warehouse buildings

See **Figure 1** for the original proposed lay-out (Alternative 1) and **Figure 2** for the subsequent updated lay-out (Alternative 2) for the five PV facilities.

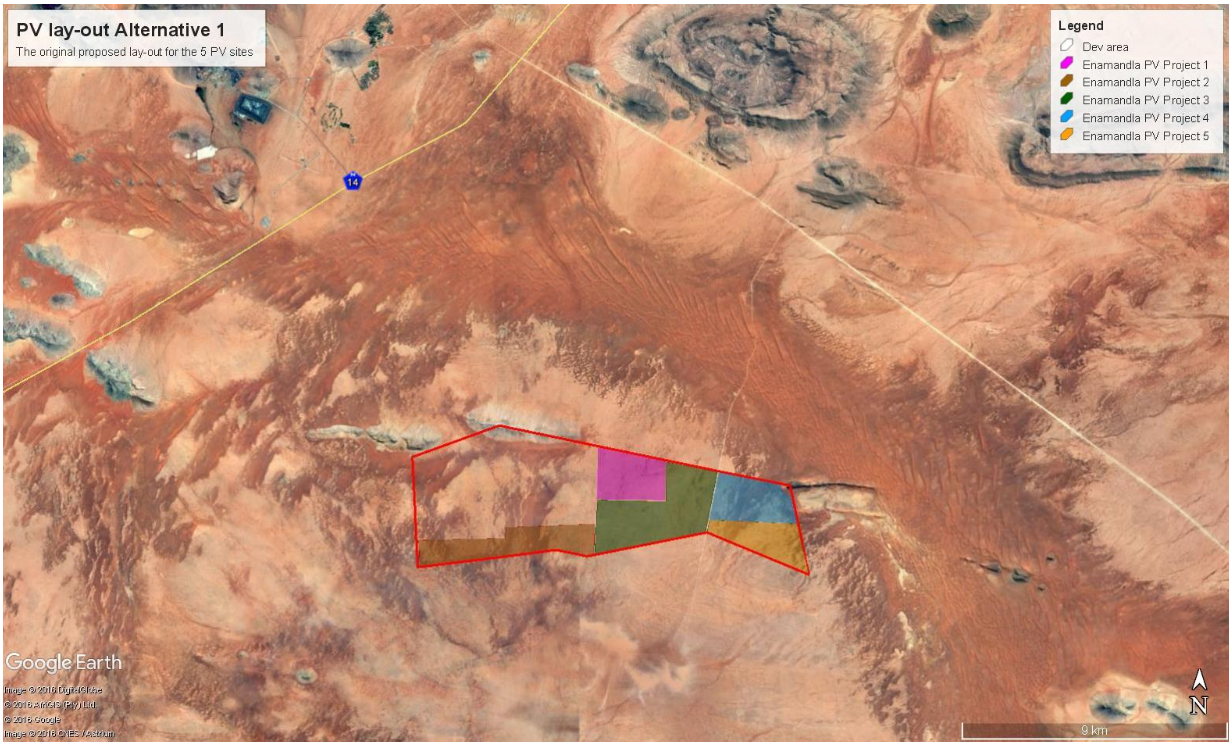

Figure 1: Original lay-out proposed for the PV facilities (Alternative 1)

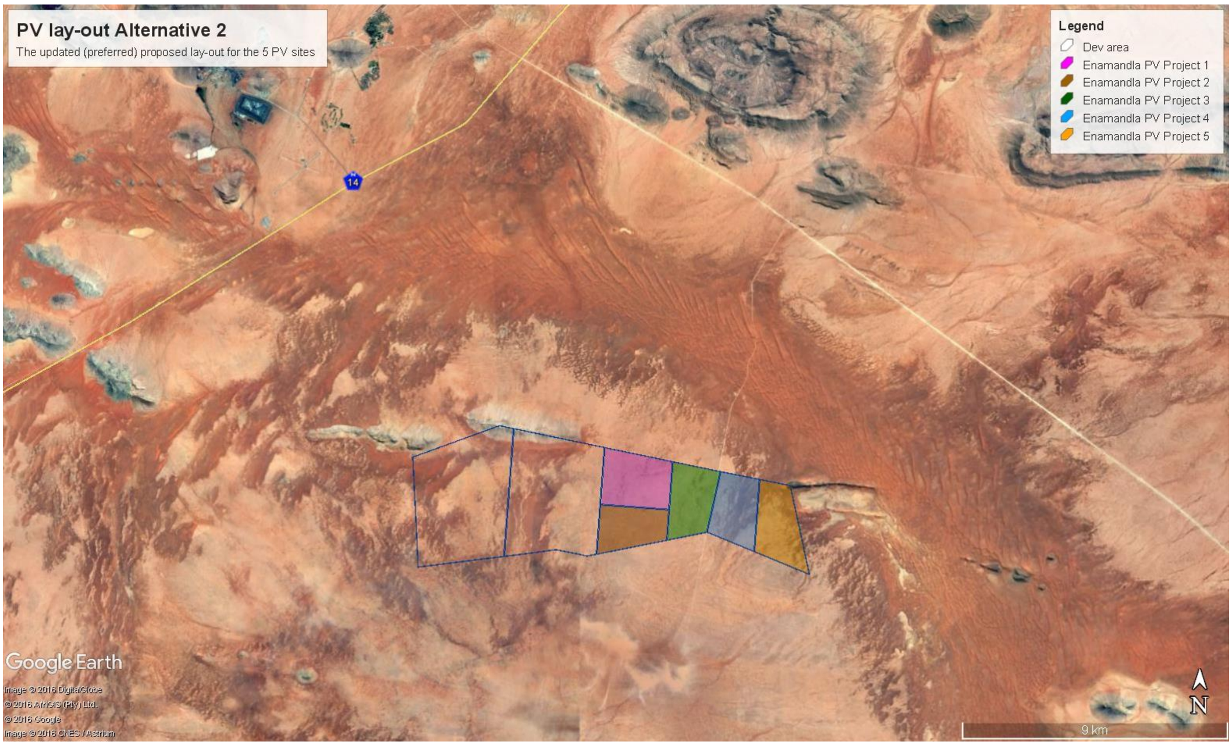

Figure 2: Updated (preferred) lay-out proposed for the PV facilities (Alternative 2)

3. DESCRIPTION OF THE AFFECTED ENVIRONMENT

3.1. STUDY AREA IN GENERAL

3.1.1. BIRD HABITATS

The proposed development area is situated approximately 17km south-east of the town of Aggeneys, in the Khai-Ma Local Municipality of the Northern Cape Province. The habitat in the study area is highly homogenous and consists of extensive sandy and gravel plains, and it lies just south of the Koa River Valley, a fossil river of red dunes which is considered to be the core habitat for the globally threatened Red Lark *Calendulauda burra*. To the north of the site, isolated mountains (Namiesberge, Achab se Berge, Ghaamsberg) are present. The vegetation on the sites themselves consists mostly of grasses and shrubs scattered between bare patches of red sand and gravel. The main vegetation type is Bushmanland Arid Grassland, which is dominated by white grasses (*Stipagrostis* species) giving this vegetation the character of semi-desert "steppe".

SABAP1 recognises six primary vegetation divisions within South Africa, namely (1) Fynbos (2) Succulent Karoo (3) Nama Karoo (4) Grassland (5) Savanna and (6) Forest (Harrison et al 1997). The criteria used by the authors to amalgamate botanically defined vegetation units, or to keep them separate were (1) the existence of clear differences in vegetation structure, likely to be relevant to birds, and (2) the results of published community studies on bird/vegetation associations. It is important to note that no new vegetation unit boundaries were created, with use being made only of previously published data. Using this classification system, the natural vegetation in the study area can be classified as Nama Karoo.

Peak rainfall in the proposed development area occurs mainly in summer and averages around 71mm per year (see **Figure 3**), which makes it an extremely arid area. Because rainfall in the Nama Karoo falls mainly in summer, while peak rainfall in the Succulent Karoo occurs mainly in winter, it provides opportunities for birds to migrate between the Succulent and Nama Karoo, to exploit the enhanced conditions associated with rainfall. Many typical karroid species are nomads, able to use resources that are patchy in time and space, e.g. Sclater's Lark (Barnes 1998).

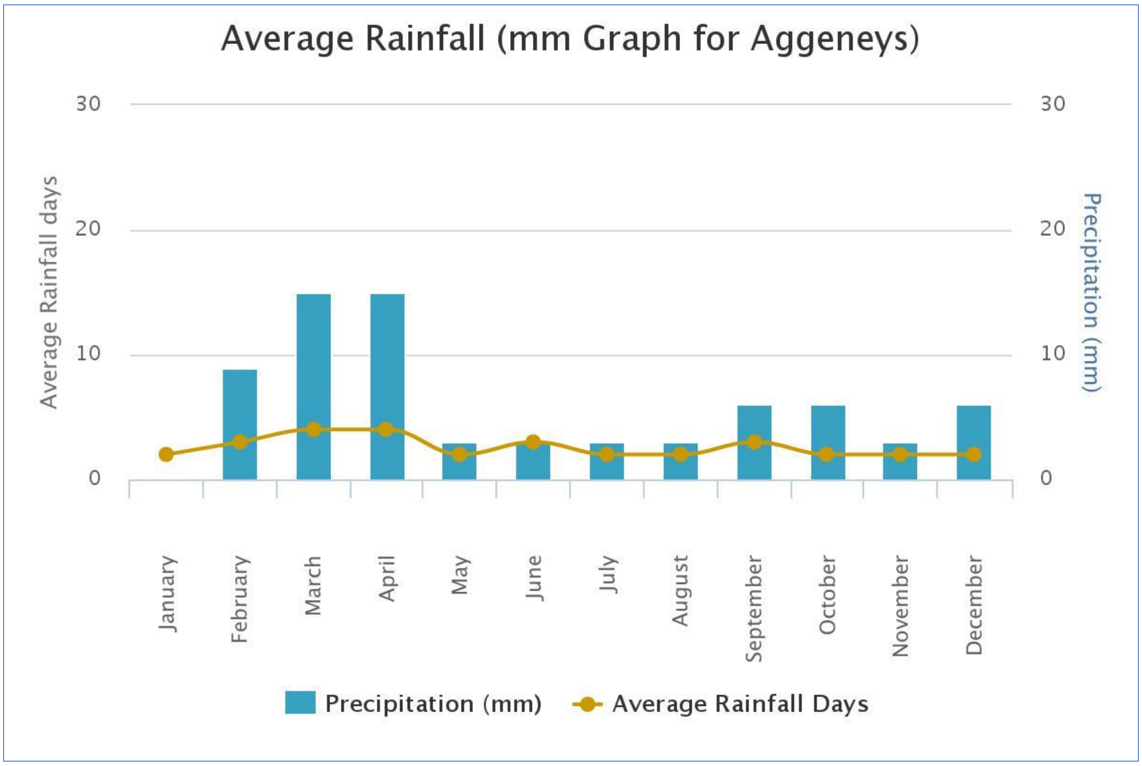

Figure 3: Average rainfall in the study area (http://www.worldweatheronline.com/aggeneys-weather-averages/north-western-province/za.aspx)

Average daily temperatures range between 29 C° in January and 14C° in July[2]

The development area borders directly on the Haramoep and Black Mountain (SA035) Important Bird Area (IBA) see **Figure 4**. Situated near Aggeneys, this IBA is characterised by an arid landscape of extensive sandy and gravel plains with sparse vegetation scattered between bare sand patches. Inselbergs form islands of rocky habitat in a sea of red sand. Large sand dunes fill the fossil course of the Koa River. The gravel plains are covered by sparse dwarf shrubs and short bushman grasses and they hide dwarf succulents. The dry riverbeds support taller woody vegetation, including *Boscia* species. Although much of the land area remains natural, large areas are overgrazed and degraded. Approximately 90% of the land is natural and utilised for ranching. The rest has been transformed by agriculture, mining activities, homesteads, settlements, erosion, roads and power-line servitudes (Marnewick *et al*. 2015).

This IBA is one of only a few sites protecting the globally threatened Red Lark, which inhabits the red sand dunes and sandy plains with a mixed grassy dwarf shrub cover; and the near-threatened Sclater's Lark, on the barren stony plains. It also holds 16 of the 23 Namib-Karoo biome-restricted assemblage species as well as a host of other arid-zone birds. Ludwig's Bustard and Kori Bustard *Ardeotis kori* are regularly seen. Martial Eagle, Secretarybird, Verreauxs' Eagle, Booted Eagle, Cape Eagle-Owl *Bubo capensis* and Spotted Eagle-Owl *Bubo africanus* are present (Marnewick *et al*. 2015).

The following species are classified as trigger species for the IBA:

<u>Globally threatened birds</u>

- Red Lark;
- Sclater's Lark;
- Martial Eagle;
- Kori Bustard

[2] http://www.worldweatheronline.com/aggeneys-weather-averages/north-western-province/za.aspx.

- Ludwig's Bustard and
- Secretarybird.

Regionally threatened birds
- Karoo Korhaan and
- Verreauxs' Eagle.

Restricted-range and biome-restricted birds
- Stark's Lark;
- Karoo Long-billed Lark;
- Black-eared Sparrow-lark
- Tractrac Chat;
- Sickle-winged Chat;
- Karoo Chat;
- Sociable Weaver;
- Pale-winged Starling;
- Black-headed Canary
- Karoo Eremomela;
- Layard's Tit-Babbler *Sylvia layardi;*
- Cinnamon-breasted Warbler *Euryptila subcinnamomea;* and
- Namaqua Warbler *Phragmacia substriata;*

Several of the IBA trigger species could potentially occur at the proposed development area (see 3.1.3. Avifauna below).

See **Figure 4** for a map of the development area relative to the Haramoep and Black Mountain (SA035) Important Bird Area.

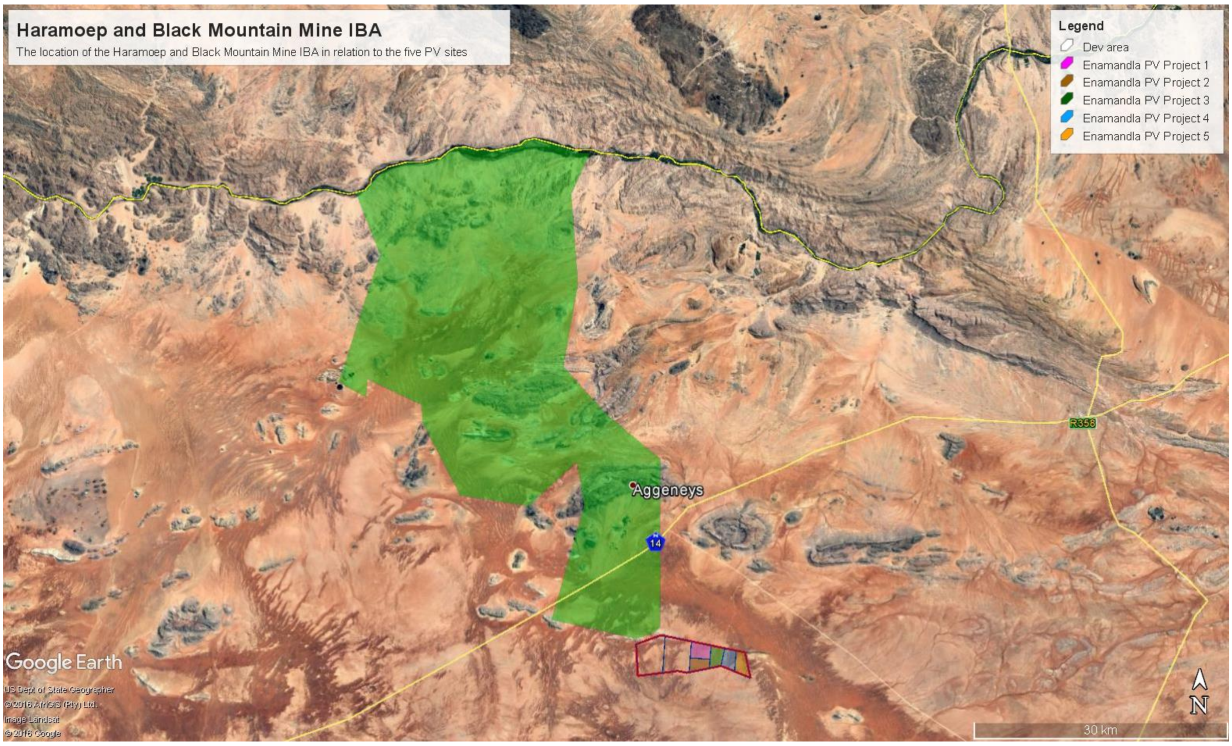

Figure 4: Haramoep and Black Mountain (SA035) Important Bird Area relative to the development area.

Whilst the distribution and abundance of the bird species in the study area are mostly associated with natural vegetation, as this comprises virtually all the habitat, it is also necessary to examine a few external modifications to the environment that have relevance for priority species.

The following anthropogenic avifaunal-relevant habitat modifications were recorded within the greater study area:

- Water points: The land use in the greater study area is mostly sheep farming, with some game and cattle also present. The land is divided into fenced off grazing camps, with a few boreholes with associated water reservoirs and drinking troughs. These troughs and reservoirs are a big draw card for several bird species. Priority species that could regularly visit waterholes are Southern Pale Chanting Goshawk, Red Lark, Sclater's Lark, Martial Eagle, Booted Eagle, Secretarybird, Black-eared Sparrowlark, Lanner Falcon and Black-chested Snake-Eagle. Large flocks of Namaqua Sandgrouse *Pterocles namaqua* descend to water troughs to drink, which in turn draw in raptors.

- Transmission lines, reticulation lines, telephone lines and fence lines: The Aggeneys – Aries 400kV transmission line runs to the north of the proposed development area. There are also several high voltage lines west of the N14 which converges into the Aggeneys MTS. The transmission towers are used by raptors for perching and roosting, and potentially also for breeding. An active Martial Eagle nest was recorded on a tower at 29°18'52.00"S 19°10'9.71"E, which is approximately 20km away from the proposed development area. The transmission lines, reticulation lines and telephones lines are all used as perches by a number of priority raptors, e.g. Greater Kestrel, Black-chested Snake-eagle, Martial Eagle and Rock Kestrel. Smaller species such as Red Lark and Sclater's Lark also often perch on the fence lines, as do Greater Kestrel and Rock Kestrel. The transmission lines in the study area pose a major risk of collisions to Ludwig's Bustard, Karoo Korhaan and Secretarybird.

See APPENDIX 3 for a photographic record of the habitat at the development area.

3.1.2 AVIFAUNA

3.1.2.1 Species potentially occurring at the site

A total of 113 species could potentially occur in the proposed development area. This figure is based on SABAP1 and SABAP2 records, supplemented by actual monitoring at the sites. Of these, 42 are classified as priority species. **Table 2** below lists the priority species that could potentially occur in the proposed development area, as well as the potential impact on the species in the study area.

3.1.2.2 Results of the pre-construction monitoring

In order to get an accurate assessment of the abundance and variety of avifauna at the proposed development area, a pre-construction monitoring programme was instituted which ran over four seasons[3]. Data was collected through drive and walk transect counts, incidental sightings and the recording of flight behaviour from vantage points (see APPENDIX 1 for a comprehensive exposition of the methodology followed).

The objective of the transect monitoring is to gather baseline data on the use of the site by avifauna in order to measure post-construction displacement by the solar farm activities, should the facilities be constructed. Two types of transect counts were conducted, namely drive transects which are aimed mainly at recording large terrestrial species, and walk transects, which are aimed mainly at recording small species which are likely to be overlooked during drive transects. The objective of vantage point counts is to record flight activity of priority species to measure the potential collision risk with the solar panels, to see if post-construction flight behaviour is influenced by the solar panels, and to assess potential mortality of priority species due to solar flux, based on recorded pre-construction flight patterns.

Table 3 lists all 43 species which were recorded during the course of the pre-construction monitoring at the development area.

[3] The pre-construction monitoring covered five PV sites, as well as the two neighbouring CSP sites, all of which are located in similar habitat and makes up the development area.

Table 2: Priority species that could potentially occur at the development sites. **EN = Endangered VU = Vulnerable NT = Near threatened LC = Least concern**

Family name	Taxonomic name	SABAP2 Reporting rate %	Global status	Regional status	Endemic - South Africa	Endemic - Southern Africa	Recorded during pre-construction monitoring	Displacement due to disturbance	Displacement due to habitat transformation	Collisions with solar panels	Collisions with internal powerlines	Entrapment in fences
Bustard, Ludwig's	*Neotis ludwigii*	7.41	EN	EN		Near-endemic	x	x	x		x	x
Chat, Tractrac	*Cercomela tractrac*	14.81				Near-endemic	x	x	x	x		
Harrier, Montagu's	*Circus pygargus*	0					x		x			
Kestrel, Greater	*Falco rupicoloides*	37.04					x	x	x			
Korhaan, Karoo	*Eupodotis vigorsii*	14.81	LC	NT		Endemic	x	x	x		x	x
Lark, Red	*Calendulauda burra*	66.67	VU	VU	Endemic	Endemic	x	x	x	x		
Secretarybird	*Sagittarius serpentarius*	0	VU	VU			x	*x*	x		x	x
Snake-eagle, Black-chested	*Circaetus pectoralis*	7.41					x	x	x			
Sparrowlark, Black-eared	*Eremopterix australis*	11.11			Near endemic	Endemic	x	x	x	x		
Buzzard, Jackal	*Buteo rufofuscus*	3.7			Near endemic	Endemic		x	x			
Canary, Black-headed	*Serinus alario*	11.11			Near endemic	Endemic		x	x	x		
Chat, Karoo	*Cercomela schlegelii*	44.44				Near-endemic	x	x	x	x		
Chat, Sickle-winged	*Cercomela sinuata*	7.41			Near endemic	Endemic		x	x	x		

Family name	Taxonomic name	SABAP2 Reporting rate %	Global status	Regional status	Endemic - South Africa	Endemic - Southern Africa	Recorded during pre-construction monitoring	Displacement due to disturbance	Displacement due to habitat transformation	Collisions with solar panels	Drowning in water ponds	Entrapment in fences
Coot, Red-knobbed	*Fulica cristata*	11.11								x		
Duck, Maccoa	*Oxyura maccoa*	7.41	NT	NT						x		
Duck, Yellow-billed	*Anas undulata*	3.7								x		
Eagle, Booted	*Hieraaetus pennatus*	3.7						x	x	x	x	
Eagle, Martial	*Polemaetus bellicosus*	3.7	VU	EN				x	x		x	
Eagle, Verreaux's	*Aquila verreauxii*	7.41	LC	VU			x	x	x		x	
Eremomela, Karoo	*Eremomela gregalis*	7.41			Near endemic	Endemic		x	x	x	x	
Falcon, Lanner	*Falco biarmicus*	3.7	LC	VU				x	x	x	x	
Falcon, Pygmy	*Polihierax semitorquatus*	7.41							x	x	x	
Flamingo, Greater	*Phoenicopterus roseus*		LC	NT						x		
Flamingo, Lesser	*Phoenicopterus minor*		LC	NT						x		
Flycatcher, Fairy	*Stenostira scita*	3.7			Near endemic	Endemic		x	x	x	x	
Goose, Egyptian	*Alopochen aegyptiaca*	11.11								x		
Grebe, Little	*Tachybaptus ruficollis*	11.11								x		
Kestrel, Rock	*Falco rupicolus*	40.74					x	x	x	x	x	
Kite, Black-shouldered	*Elanus caeruleus*	3.7						x	x	x	x	

Family name	Taxonomic name	SABAP2 Reporting rate %	Global status	Regional status	Endemic - South Africa	Endemic - Southern Africa	Recorded during pre-construction monitoring	Displacement due to disturbance	Displacement due to habitat transformation	Collisions with solar panels	Drowning in water ponds	Entrapment in fences
Lark, Cape Clapper	*Mirafra apiata*	11.11			Near endemic	Endemic		x	x	x	x	
Lark, Karoo Long-billed	*Certhilauda subcoronata*	48.15				Endemic		x	x	x	x	
Lark, Stark's	*Spizocorys starki*	14.81				Near-endemic		x	x	x	x	
Ruff	*Philomachus pugnax*	3.7								x		
Sandpiper, Common	*Actitis hypoleucos*	3.7								x		
Sandpiper, Wood	*Tringa glareola*	3.7								x		
Shelduck, South African	*Tadorna cana*	14.81				Endemic				x		
Shoveler, Cape	*Anas smithii*	7.41				Near-endemic				x		
Starling, Pale-winged	*Onychognathus nabouroup*	77.78				Near-endemic		x		x	x	
Stilt, Black-winged	*Himantopus himantopus*	7.41								x		
Stint, Little	*Calidris minuta*	3.7								x		
Teal, Cape	*Anas capensis*	11.11								x		
Weaver, Sociable	*Philetairus socius*	77.78				Endemic		x	x	x	x	
Courser, Burchell’s	*Cursorius rufus*	0	LC	VU			x	x	x	x		
Chanting Goshawk, Southern Pale	*Melierax canorus*	55.56				Near-endemic	x	x			x	

Table 3: Species recorded during the pre-construction monitoring at the proposed development area.

Priority species	Scientific name	Status	Drive	Walk	VP	Incidental
Black-chested Snake-Eagle	*Circaetus pectoralis*	Raptor				*
Black-eared Sparrowlark	*Eremopterix australis*	Near endemic	*	*	*	*
Burchell's Courser	*Cursorius rufus*	VU	*	*		*
Greater Kestrel	*Falco rupicoloides*	Raptor	*	*	*	*
Karoo Chat	*Cercomela schlegelii*	IBA trigger spp		*		
Karoo Korhaan	*Eupodotis vigorsii*	NT	*	*		*
Ludwig's Bustard	*Neotis ludwigii*	EN				*
Montagu's Harrier	*Circus pygargus*	Raptor		*		
Red Lark	*Calendulauda burra*	VU	*	*	*	*
Secretarybird	*Sagittarius serpentarius*	VU	*	*		*
Southern Pale Chanting Goshawk	*Melierax canorus*	Raptor				*
Tractrac Chat	*Cercomela tractrac*	IBA trigger spp	*	*	*	*
Verreaux's Eagle	*Aquila verreauxii*	VU			*	*
	Priority species subtotal:		7	9	5	11
Non-priority species	**Scientific name**	**Status**	**Drive**	**Walk**	**n/a**	**n/a**
Alpine Swift	*Tachymarptis melba*	-		*		
Anteating Chat	*Myrmecocichla formicivora*	-	*	*		
Barn Swallow	*Hirundo rustica*	-	*	*		
Bokmakierie	*Telophorus zeylonus*	-	*	*		
Cape Crow	*Corvus capensis*	-	*	*		
Cape Sparrow	*Passer melanurus*	-	*	*		
Capped Wheatear	*Oenanthe pileata*	-	*	*		
Chat Flycatcher	*Bradornis infuscatus*	-		*		
Common Fiscal	*Lanius collaris*	-	*	*		
Common Swift	*Apus apus*	-	*	*		
Double-banded Courser	*Rhinoptilus africanus*	-	*	*		
Eastern Clapper Lark	*Mirafra [apiata] fasciolata*	-	*	*		
Familiar Chat	*Cercomela familiaris*	-	*			
Fawn-coloured Lark	*Calendulauda africanoides*	-		*		
Greater Striped Swallow	*Hirundo cucullata*	-	*	*		
Grey-backed Sparrowlark	*Eremopterix verticalis*	-	*	*		
House Sparrow	*Passer domesticus*	-	*			
Lark-like Bunting	*Emberiza impetuani*	-	*	*		
Mountain Wheatear	*Oenanthe monticola*	-	*			
Namaqua Dove	*Oena capensis*	-		*		
Namaqua Sandgrouse	*Pterocles namaqua*	-	*	*		
Northern Black Korhaan	*Afrotis afraoides*	-	*	*		
Pied Crow	*Corvus albus*	-	*	*		
Pink-billed Lark	*Spizocorys conirostris*	-	*	*		
Red-capped Lark	*Calandrella cinerea*	-	*	*		
Red-headed Finch	*Amadina erythrocephala*	-	*			
Rock Martin	*Hirundo fuligula*	-	*	*		
Rufous-eared Warbler	*Malcorus pectoralis*	-	*	*		
Scaly-feathered Finch	*Sporopipes squamifrons*	-	*	*		
Speckled Pigeon	*Columba guinea*	-	*			
Spike-heeled Lark	*Chersomanes albofasciata*	-	*	*		
White-throated Canary	*Crithagra albogularis*	-	*			
Yellow-bellied Eremomela	*Eremomela icteropygialis*	-		*		
	Non-Priority species subtotal:		28	27		
	Grand Total:		35	36	5	11

Figures 5 and 6 below gives an indication of the relative abundance of priority species, as recorded through transect counts during the pre-construction monitoring at the proposed development area. Abundance is expressed in terms of birds/km.

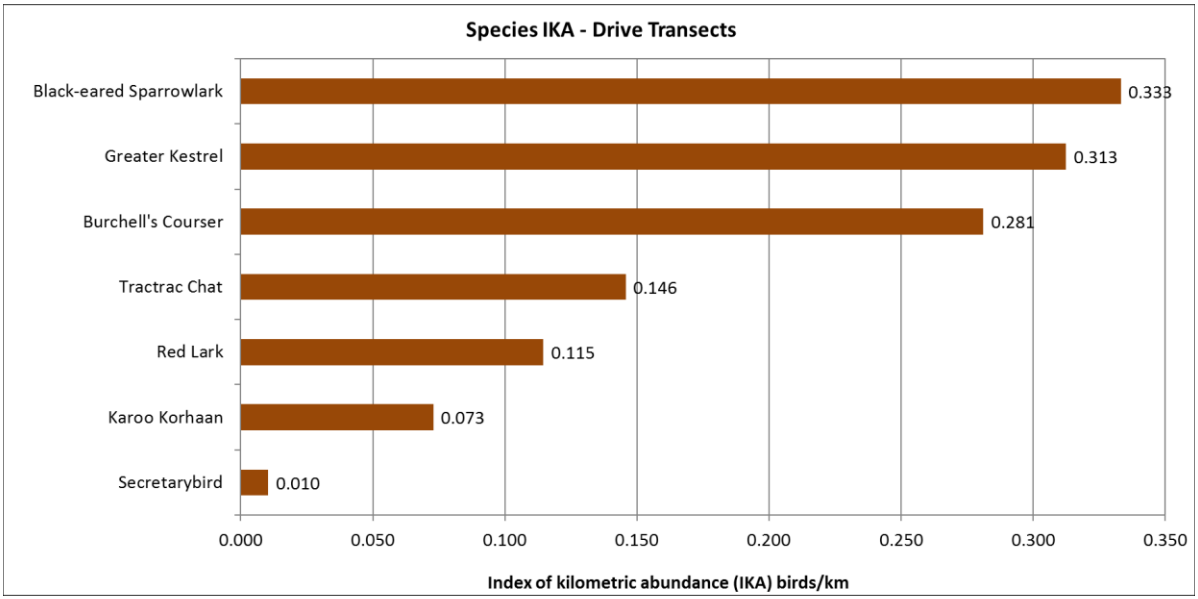

Figure 5: IKA for priority species recorded via drive transect counts at the proposed development area.

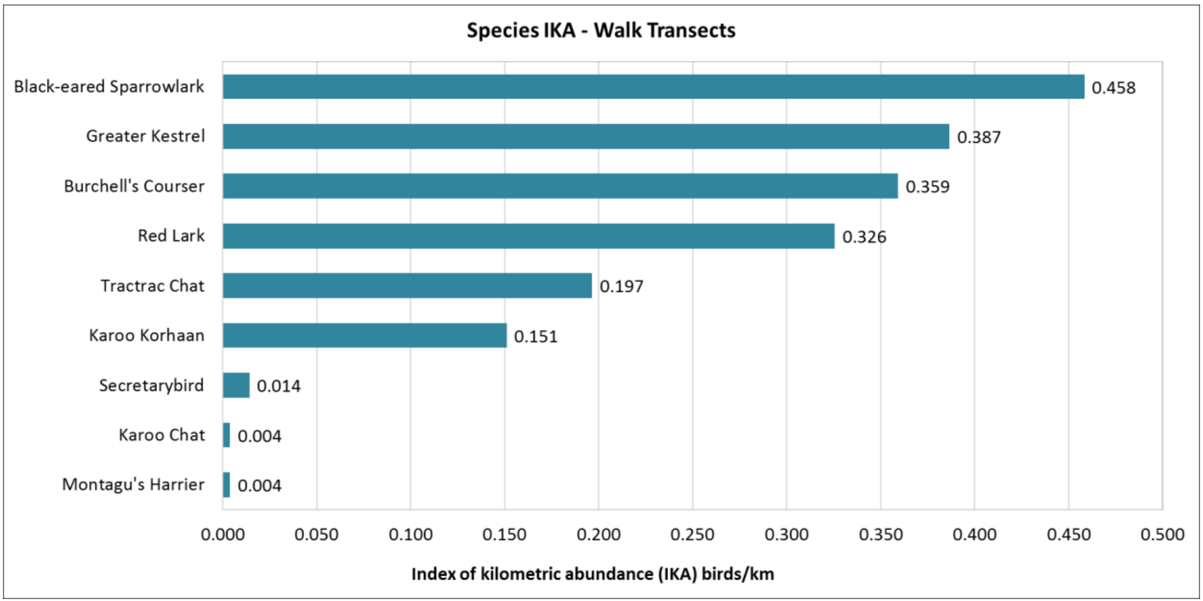

Figure 6: IKA for priority species recorded via walk transect counts at the proposed development area.

Figure 7 shows the spatial distribution of transect recorded priority species at the development area.

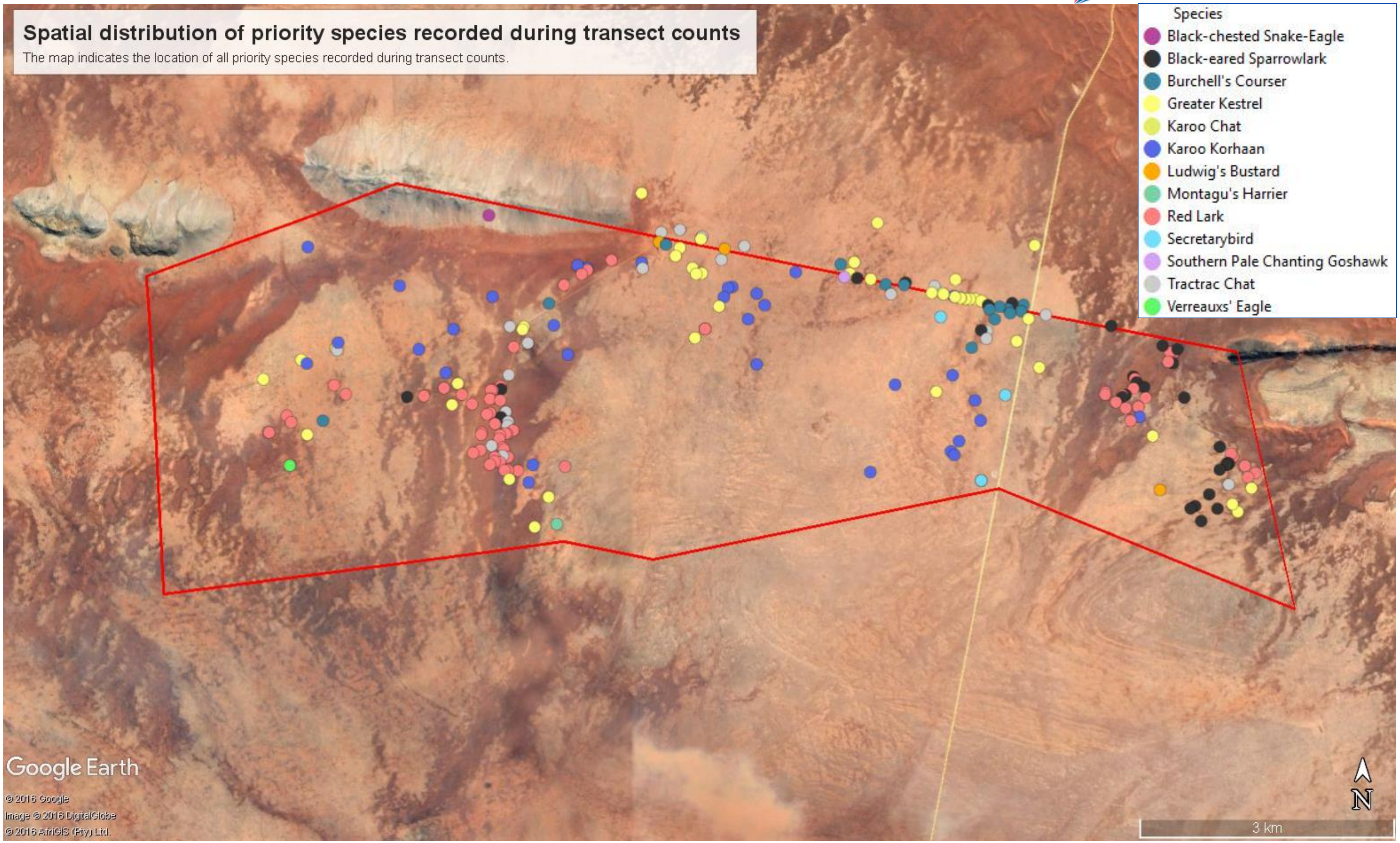

Figure 7: The spatial distribution of transect recorded individuals of priority species at the development area.

A total of 144 hours of vantage point watches were completed at three vantage points at the development area in order to record flight patterns of priority species. In the four sampling periods, priority species were recorded flying for a total of 34 minutes and 15 seconds. A total of 20 individual flights were recorded. Of these, 2 (10%) flights were at high altitude (>250m), 7 (35%) were at medium altitude (i.e. between 20 and 250m) and 11 (55%) were at high altitude (above rotor height).

The passage rate for priority species recorded at the development area (all flight heights) was 0.12 birds/hour[4]. See **Figure 7** below for the duration of flights for each species, at each height class[5].

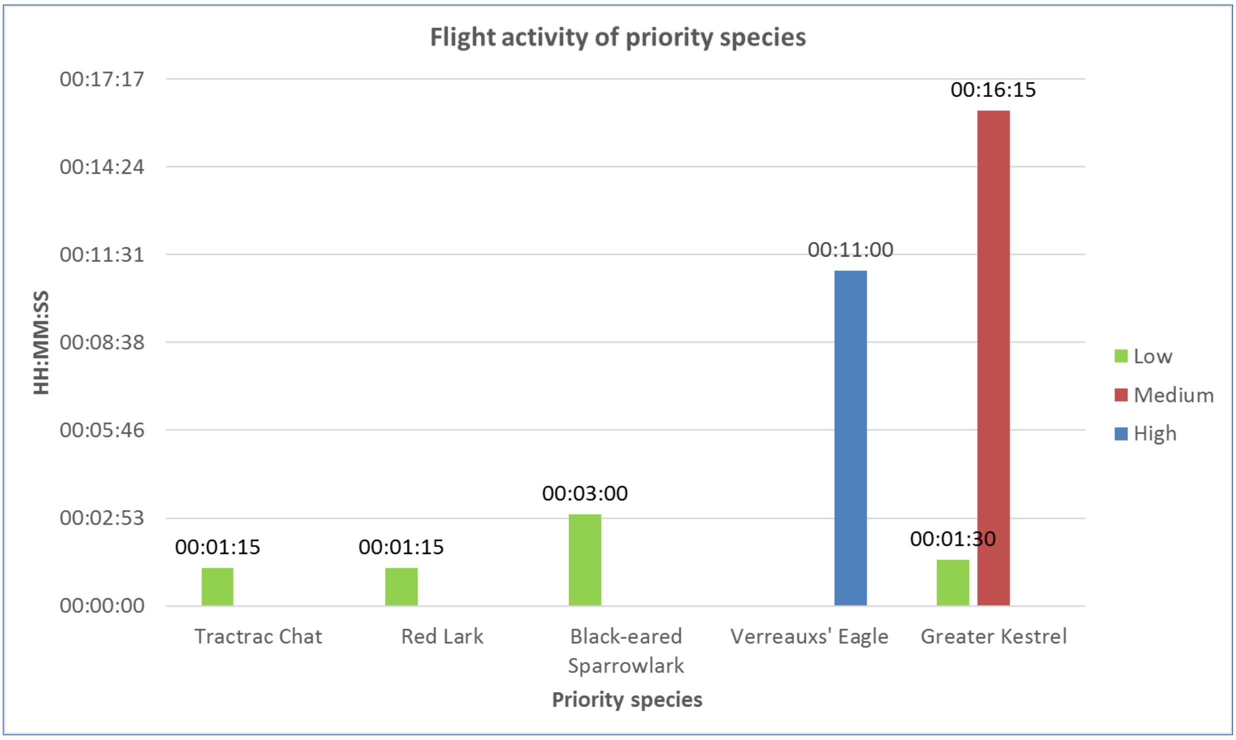

Figure 7: Flight times and heights recorded for priority species at the development area.

The spatial distribution of the flight activity of the various priority species which were recorded during VP watches are presented in **Figures 8 - 10** below.

One of the most important aspects that need to be investigated is whether the flight data that was gathered during sampling surveys can be regarded as representative of the typical flight behaviour of priority species at the site. The statistical analyses which test this aspect of the data is contained in APPENDIX 4. The computations and the outcome of the data exhibited in the tables and graphs in APPENDIX 4 show that the data gathered during VP watches may be taken to be statistically representative of the flight activity of priority species of birds during the survey sampling periods and that more data will not necessarily succeed in improving the estimates in a substantial way.

[4] A distinction was drawn between passages and flights. A passage may consist of several flights e.g. every time an individual bird changes height or mode of flight, this was recorded as an individual flight, although it still forms part of the same passage.

[5] Flight duration was calculated by multiplying the flight time with the number of individuals in the flight e.g. if the flight time was 30 seconds and it contained two individuals, the flight duration was 30 seconds x 2 = 60 seconds.

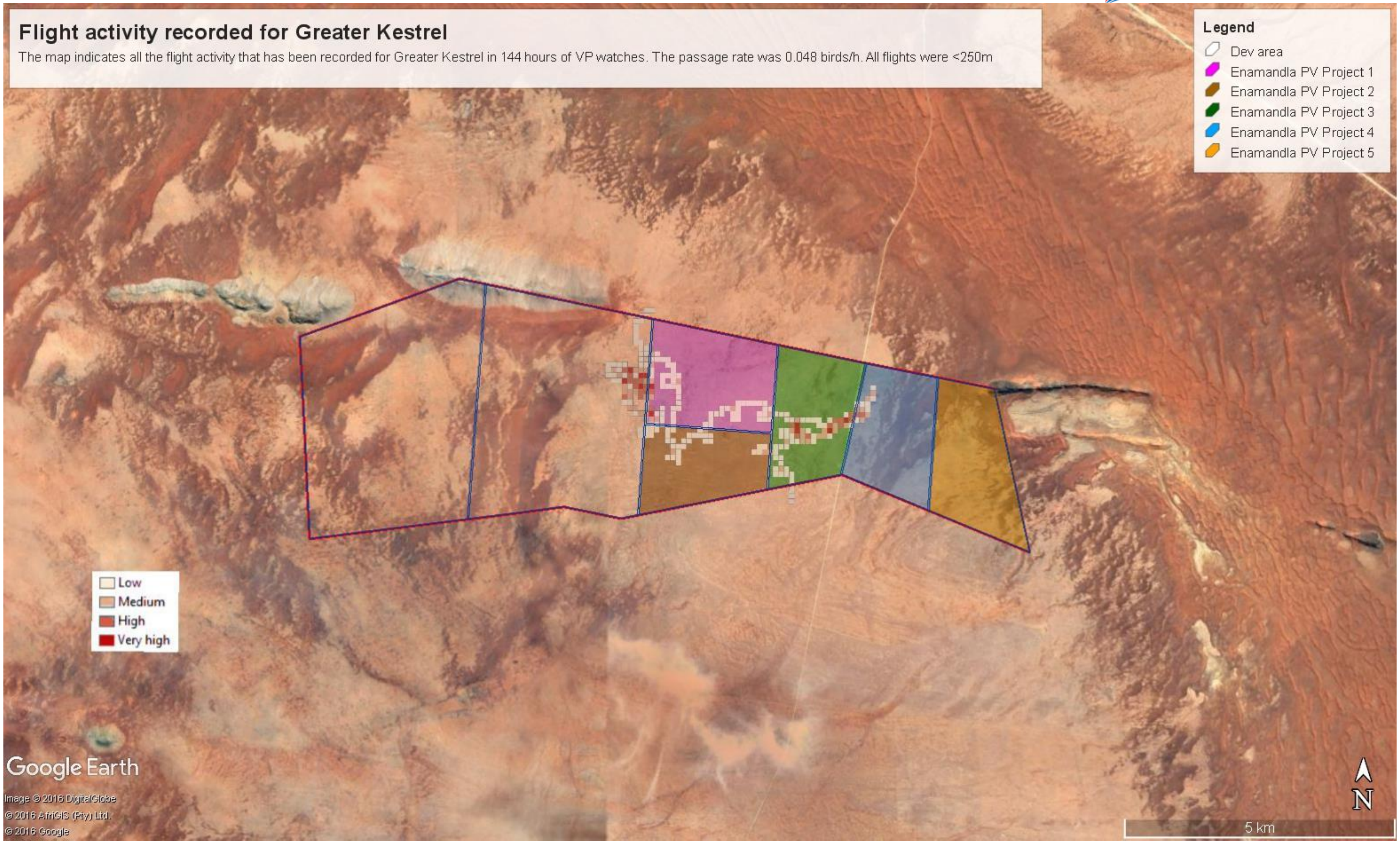

Figure 8: Distribution of flight activity of Greater Kestrel.

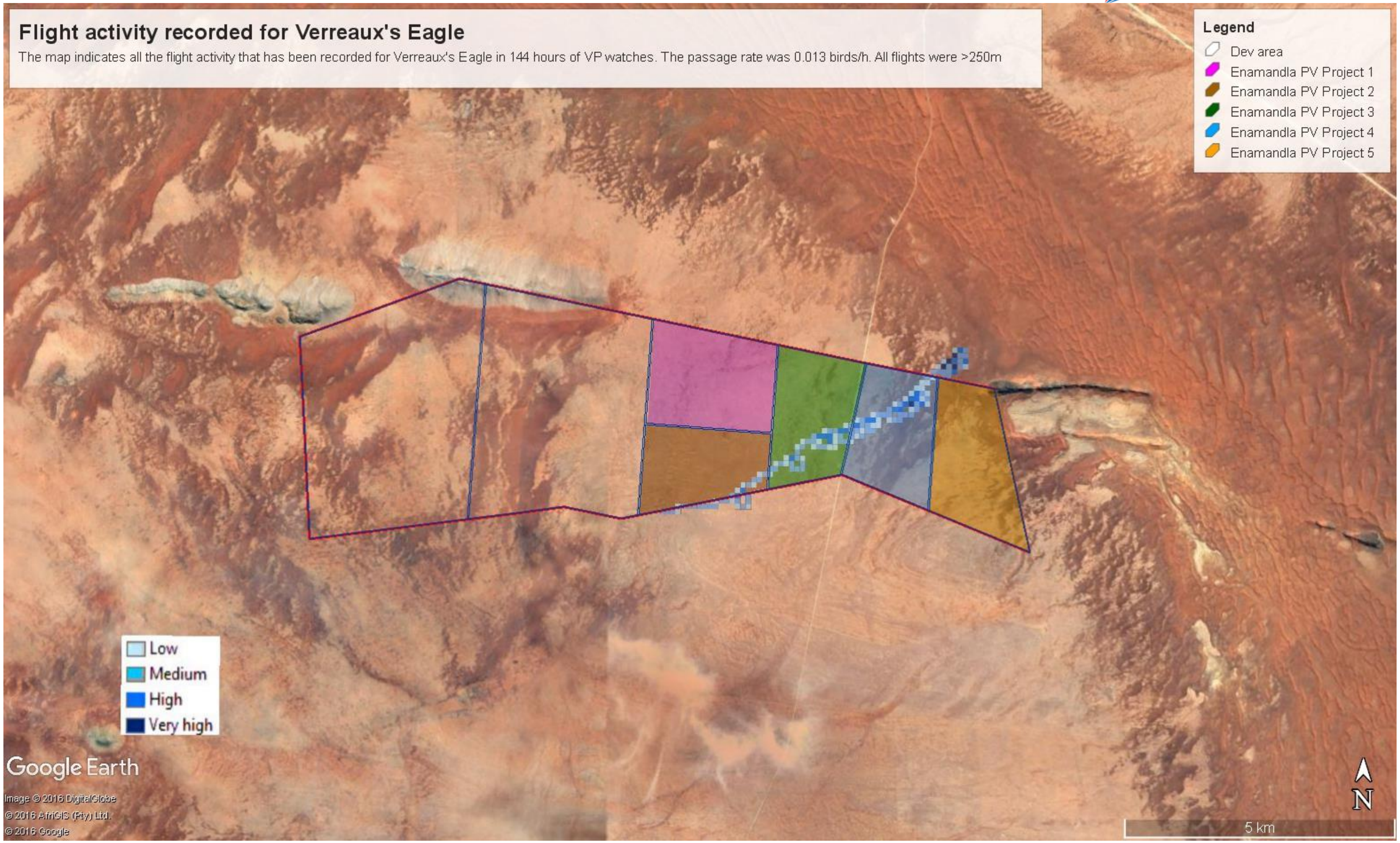

Figure 9: Distribution of flight activity of Verreaux's Eagle.

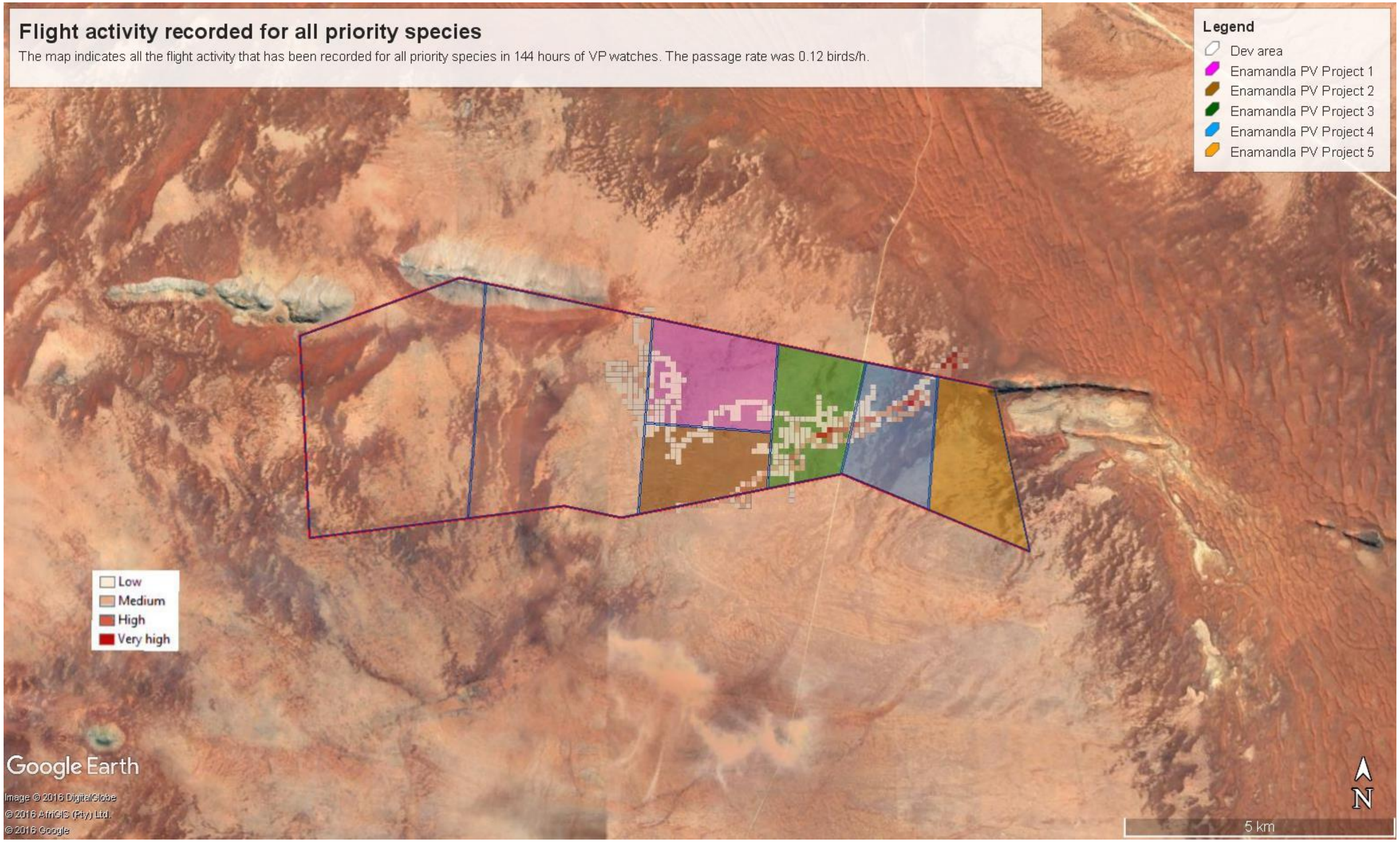

Figure 10: Distribution of flight activity of all priority species.

3.1.2.3 Discussion of the results of the pre-construction monitoring

The transect counts indicate a low density of priority species at the development area. The IKA for drive transects for all priority species were 1.27 birds/km, and for walk transects it was 1.9 birds. This is to be expected from a very arid area.

As far as the spatial distribution of priority species are concerned, the most obvious pattern that emerges is the clustering of Red Lark records in sandy areas. This correlates with the habitat description for the species in Hockey *et al.* 2005 i.e. red sand dunes and sandy plains with scattered large seeded grasses.

The VP watches indicate very low flight activity of priority species, with a passage rate of 0.12 birds/h. Greater Kestrel emerged with the highest level of flight activity, but even that is still very low with a passage rate of 0.048 birds/h. The spatial distribution of priority species flights does not provide evidence of any clear flight paths. All the flight activity was concentrated in the eastern half of the development area, but no apparent reason can be detected for this spatial distribution, as the habitat is very uniform.

3.2. ENAMANDLA PV SITE 5

The habitat descriptions and avifaunal composition described for the greater study area in the preceding sections are perfectly applicable to the PV5 site, which consists of a mixture of gravelly and sandy areas. There are no specific habitat features relevant to avifauna to distinguish it from the surrounding greater study area. The only notable points are that the PV5 site is not bisected by any HV lines, but it does contain a borehole. There are several fence lines which divides the area into grazing camps. The only avifaunal relevant difference between PV5 and the other PV sites is the presence of a water point. This means that the impact of displacement due to habitat transformation could potentially be more severe, because it will affect a larger range of priority species which are attracted to the surface water. Surface water in this arid environment is a huge draw-card for many species, therefore the loss of a borehole could be a significant loss. However, the creation of new sources of surface water in the form of evaporation ponds and water treatment plants at the neighbouring CSP sites should off-set this loss, provide the ponds are properly mitigated to prevent birds from drowning.

4. FINDINGS

4.1 IMPACTS OF SOLAR FACILITIES AND ASSOCIATED INFRASTRUCTURE ON AVIFAUNA

A literature review reveals a scarcity of published, scientifically examined information regarding large-scale PV plants and birds. The reason for this is mainly that large-scale PV plants is a relatively recent phenomenon. The main source of information for these types of impacts are from compliance reports and a few government sponsored studies relating to recently constructed solar plants in the south-west United States. In South Africa, one unpublished scientific study has been completed on the impacts of PV plants in a South African context (Visser 2016).

In summary, the potential impacts of PV plants on avifauna which have emerged so far include the following:

- Displacement due to disturbance and habitat transformation associated with the construction of the solar PV plant and associated infrastructure;
- Collisions with the solar panels;
- Entrapment in perimeter fences;
- Collisions with the associated power lines resulting in mortality.

4.1.1 DIRECT IMPACTS OF THE SOLAR INFRASTRUCTURE ON BIRDS

4.1.1.1 Impact trauma

This impact refers to collision-related fatality i.e. fatality resulting from the direct contact of the bird with a project structure(s), usually a solar panel. This type of fatality has been documented at solar projects of all technology types (McCrary *et al*. 1986; Hernandez *et al*. 2014; Kagan *et al*. 2014). In some instances, the bird is not killed outright by the collision impact, but succumbs to predation later, as it cannot avoid predators due to its injured state.

Sheet glass used in commercial and residential buildings has been well established as a hazard for birds. When the sky is reflected in the sheet glass, birds fail to see the building as an obstacle and attempt to fly through the glass, mistaking it for empty space. A recent comprehensive review estimated between 365 – 988 million birds are killed annually in the USA due to collisions with glass panels (Loss *et al*. 2014). It is therefore to be expected that the reflective surfaces of solar panels will constitute a similar risk to avifauna.

A related problem is the so-called “lake effect” i.e. it seems very likely that reflections from solar facilities' infrastructure, particularly large sheets of dark blue photovoltaic panels, may well be attracting birds in flight across the open desert, who mistake the broad reflective surfaces for water (Kagan *et al*. 2014)[6].

Weekly mortality searches at 20% coverage were conducted at the 250MW, 1 300ha California Valley Solar Ranch PV site (Harvey & Associates 2014a and 2014b). According to the information that could be sourced from the internet (two quarterly reports), 152 avian mortalities were reported for the period 16 November 2013 – 15 February 2014, and 54 for the period 16 February 2014 – 15 May 2014, of which approximately 90% were based on feathers spots which precluded a finding on the cause of death. These figures give an estimated unadjusted 1 030 mortalities per year, which is obviously an underestimate as it does not include adjustments for carcasses removed by scavengers and missed by searchers. The authors stated clearly that these quarterly reports do not include the results of searcher efficiency trials, carcass removal trials, or data analyses, nor does it include detailed discussions.

In a report by the National Fish and Wildlife Forensic Laboratory (Kagan *et al*. 2014), the cause of avian mortalities was estimated based on opportunistic avian carcass collections at the 1 600ha Ivanpah CSP central receiver plant, 1 600ha Desert Sunlight PV plant and 1 880ha Genesis parabolic trough solar plants. The results of the investigation are tabled below in **Table 4:**

Table 4: Comparison of avian mortality causes at three solar plants in California, USA (Kagan *et al.* 2014).

Cause of death	Ivanpah central receiver CSP	Genesis parabolic trough CSP	Desert Sunlight PV	Total
Solar flux	47	0	0	47
Impact trauma	24	6	19	49
Predation trauma	5	2	15	22
Trauma of undetermined causes	14	0	0	14
Electrocution	1	0	0	1
Emaciation	1	0	0	1
Undetermined (remains in poor condition)	46	17	22	85
No evident cause of death	3	6	5	14
Total	141	31	61	233

Impact trauma emerge as the highest identifiable cause of avian mortality for all technology types, including PV, but most mortality could not be traced to an identifiable cause.

[6] This could either result in birds colliding directly with the solar panels, or getting stranded and unable to take off again because many aquatic bird species find it very difficult and sometimes impossible to take off from dry land e.g. grebes and cormorants. This exposes them to predation, even if they do not get injured through direct collisions with the panels.

Walston *et al.* 2015 conducted a comprehensive review of avian fatality data from large scale solar facilities (all technology types) in the USA. They found that the causes of death documented at solar facilities include solar flux, impact trauma, predation trauma, electrocution, and emaciation; however, the cause of death is often unknown. Except for California Solar One (a CSP plant), the cause of death could not be determined for most bird deaths at all solar facilities. **Collision as cause of death ranked second at Desert Sunlight PV plant and California Valley Solar Ranch (CVSR) PV plant, after unknown causes.** Cause of death could not be determined for over 50% of the fatality observations and many carcasses included in these analyses consisted only of feather spots (feathers concentrated together in a small area) or partial carcasses, thus making determination of cause of death difficult. It is anticipated that some unknown fatalities were caused by predation or some other factor unrelated to the solar project. However, they found that the lack of systematic data collection and standardization was a major impediment in establishing the actual extent and causes of fatalities across projects.

Walston *et al.* 2015 conducted a comprehensive review of avian fatality data from large scale solar facilities in the USA. They found that the causes of death documented at solar facilities include solar flux, impact trauma, predation trauma, electrocution, and emaciation; however, the cause of death is often unknown. With the exception of California Solar One, the cause of death could not be determined for the majority of bird deaths at all solar facilities. Solar flux was the second-ranked cause of death, after unknown causes, at the Ivanpah power tower solar facility. It is important to note that fatality observations made within these large solar facilities may not be caused by the project facilities. Cause of death could not be determined for over 50% of the fatality observations and many carcasses included in these analyses consisted only of feather spots (feathers concentrated together in a small area) or partial carcasses, thus making determination of cause of death difficult. It is anticipated that some unknown fatalities were caused by predation or some other factor unrelated to the solar project. Passerines were the taxonomic group most frequently found killed or injured at six California solar energy facilities, ranging from 39.6% to 62.5% of the avian mortalities. However, they found that the lack of systematic data collection and standardization was a major impediment in establishing the actual extent and causes of fatalities across projects.

The unusually high number of waterbird mortalities at the Desert Sunlight PV facility (44%) seems to support the “lake effect” hypothesis (West 2014). In the case of Desert Sunlight, the proximity of evaporation ponds may act as an additional risk increasing factor, in that birds are both attracted to the water feature and habituated to the presence of an accessible aquatic environment in the area. This may translate into the misinterpretation of diffusely reflected sky or horizontal polarised light source as a body of water. However, due to limited data it would be premature to make any general conclusions about the influence of the lake effect or other factors that contribute to fatality of water-dependent birds. The activity and abundance of water-dependent species near solar facilities may depend on other site-specific or regional factors, such as the surrounding landscape (Walston *et al*. 2015).

The only scientific investigation of potential avifaunal impacts that has been performed at a South African PV facility was completed in 2016 at the 96 MW Jasper PV solar facility (28°17′53″S, 23°21′56″E) which is located on the Humansrus Farm, approximately 4 km south-east of Groenwater and 30 km east of Postmasburg in the Northern Cape Province (Visser 2016). The Jasper PV facility contains 325 360 solar panels over a footprint of 180 hectares with the capacity to deliver 180 000 MWh of renewable electricity annually. The solar panels face north at a fixed 20° angle, reaching a height of approximately 1.86 m relative to ground level with a distance of 3.11 m between successive rows of panels. Mortality surveys were conducted from the 14th of September 2015 until the 6th of December 2015, with a total of seven mortalities recorded among the solar panels which gives an average rate of 0.003 birds per hectare surveyed per month. All fatalities were inferred from feather spots. The study concluded *inter alia* that the short study period, and lack of comparable results from other sources made it difficult to provide a meaningful assessment of avian mortality at PV facilities. It further stated that despite these limitations, the few bird fatalities that were recorded might suggest that there is no significant collision-related mortality at the study site. The conclusion was that to fully understand the risk of solar energy development on birds, further collation and analysis of data from solar energy facilities across spatial and temporal scales, based on scientifically rigorous research designs, is required (Visser 2016).

Variables that may affect the illusory characteristics of solar panels are structural elements or markings that may break up the reflection. Visual markers spaced at distances of 28cm apart or less have been shown to reduce the number of window strike events on large commercial buildings (Kagan *et al.* 2014). A paper by Horvath *et al.* (2010) provides experimental evidence that placing a white outline and/or white grid lines on solar panels significantly reduce the attractiveness of those panels to aquatic insects, with a loss of only 1.8% in energy producing surface area. While similar detailed studies have yet to be carried out with birds, this work, combined with the window strike results, suggest that significant reductions in avian mortality at solar facilities could be achieved by relatively minor modifications of panel and mirror design (Kagan *et al.* 2014).

It is clear from this limited literature survey that the lack of systematic and standardised data collection is a major problem in the assessment of the causes and extent of avian mortality at all types of solar facilities, regardless of the technology employed. Until statistically tested results emerge from existing compliance programmes and more dedicated scientific research, conclusions will inevitably be largely speculative and based on professional opinion.

4.1.1.2 Entrapment in perimeter fences

Visser (2016) recorded a fence-line fatality (Orange River Francolin *Scleroptila gutturalis*) resulting from the bird being trapped between the inner and outer perimeter fence of the facility. This was further supported by observations of large-bodied birds unable to escape from between the two fences (e.g. red-crested korhaan *Lophotis ruficrista*)(Visser 2016).

4.1.1.3 Collisions with the internal powerlines

Collisions are probably the bigger threat posed by transmission lines to birds in southern Africa (Van Rooyen 2004). Most heavily impacted upon are bustards, storks, cranes and various species of waterbirds. These species are mostly heavy-bodied birds with limited manoeuvrability, which makes it difficult for them to take the necessary evasive action to avoid colliding with transmission lines (Van Rooyen 2004, Anderson 2001). In a recent PhD study, Shaw (2013) provides a concise summary of the phenomenon of avian collisions with transmission lines:

"The collision risk posed by power lines is complex and problems are often localised. While any bird flying near a power line is at risk of collision, this risk varies greatly between different groups of birds, and depends on the interplay of a wide range of factors (APLIC 1994). Bevanger (1994) described these factors in four main groups – biological, topographical, meteorological and technical. Birds at highest risk are those that are both susceptible to collisions and frequently exposed to power lines, with waterbirds, gamebirds, rails, cranes and bustards usually the most numerous reported victims (Bevanger 1998, Rubolini et al. 2005, Jenkins et al. 2010).

The proliferation of man-made structures in the landscape is relatively recent, and birds are not evolved to avoid them. Body size and morphology are key predictive factors of collision risk, with large-bodied birds with high wing loadings (the ratio of body weight to wing area) most at risk (Bevanger 1998, Janss 2000). These birds must fly fast to remain airborne, and do not have sufficient manoeuvrability to avoid unexpected obstacles. Vision is another key biological factor, with many collision-prone birds principally using lateral vision to navigate in flight, when it is the lower-resolution, and often restricted, forward vision that is useful to detect obstacles (Martin & Shaw 2010, Martin 2011, Martin et al. 2012). Behaviour is important, with birds flying in flocks, at low levels and in crepuscular or nocturnal conditions at higher risk of collision (Bevanger 1994). Experience affects risk, with migratory and nomadic species that spend much of their time in unfamiliar locations also expected to collide more often (Anderson 1978, Anderson 2002). Juvenile birds have often been reported as being more collision-prone than adults (e.g. Brown et al. 1987, Henderson et al. 1996).
Topography and weather conditions affect how birds use the landscape. Power lines in sensitive bird areas (e.g. those that separate feeding and roosting areas, or cross flyways) can be very dangerous (APLIC 1994, Bevanger 1994). Lines crossing the prevailing wind conditions can pose a problem for large birds that use the wind to aid take-off and landing (Bevanger 1994). Inclement weather can disorient birds and reduce their flight altitude, and strong winds can result in birds colliding with power lines that they can see but do not have enough flight control to avoid (Brown et al. 1987, APLIC 2012).

The technical aspects of power line design and siting also play a big part in collision risk. Grouping similar power lines on a common servitude, or locating them along other features such as tree lines, *are both approaches thought to reduce risk (Bevanger 1994). In general, low lines with short span lengths (i.e. the distance between two adjacent pylons) and flat conductor configurations are thought to be the least dangerous (Bevanger 1994, Jenkins et al. 2010). On many higher voltage lines, there is a thin earth (or ground) wire above the conductors, protecting the system from lightning strikes. Earth wires are widely accepted to cause the majority of collisions on power lines with this configuration because they are difficult to see, and birds flaring to avoid hitting the conductors often put themselves directly in the path of these wires (Brown et al. 1987, Faanes 1987, Alonso et al. 1994a, Bevanger 1994)."*

Power line collisions are generally accepted as a key threat to bustards (Raab *et al.* 2009; Raab *et al.* 2010; Jenkins & Smallie 2009; Barrientos *et al.* 2012, Shaw 2013). In a recent study, carcass surveys were performed under high voltage transmission lines in the Karoo for two years, and low voltage distribution lines for one year (Shaw 2013). Ludwig's Bustard was the most common collision victim (69% of carcasses), with bustards generally comprising 87% of mortalities recovered. Total annual mortality was estimated at 41% of the Ludwig's Bustard population, with Kori Bustards also dying in large numbers (at least 14% of the South African population killed in the Karoo alone). Karoo Korhaan was also recorded, but to a much lesser extent than Ludwig's Bustard. The reasons for the relatively low collision risk of this species probably include their smaller size (and hence greater agility in flight) as well as their more sedentary lifestyles, as local birds are familiar with their territory and are less likely to collide with power lines (Shaw 2013).

Several factors are thought to influence avian collisions, including the manoeuvrability of the bird, topography, weather conditions and power line configuration. An important additional factor that previously has received little attention is the visual capacity of birds; i.e. whether they are able to see obstacles such as power lines, and whether they are looking ahead to see obstacles with enough time to avoid a collision. In addition to helping explain the susceptibility of some species to collision, this factor is key to planning effective mitigation measures. Recent research provides the first evidence that birds can render themselves blind in the direction of travel during flight through voluntary head movements (Martin & Shaw 2010). Visual fields were determined in three bird species representative of families known to be subject to high levels of mortality associated with power lines i.e. Kori Bustards, Blue Cranes *Anthropoides paradiseus* and White Storks *Ciconia ciconia*. In all species the frontal visual fields showed narrow and vertically long binocular fields typical of birds that take food items directly in the bill under visual guidance. However, these species differed markedly in the vertical extent of their binocular fields and in the extent of the blind areas which project above and below the binocular fields in the forward facing hemisphere. The importance of these blind areas is that when in flight, head movements in the vertical plane (pitching the head to look downwards) will render the bird blind in the direction of travel. Such movements may frequently occur when birds are scanning below them (for foraging or roost sites, or for conspecifics). In bustards and cranes pitch movements of only 25° and 35°, respectively, are sufficient to render the birds blind in the direction of travel; in storks, head movements of 55° are necessary. That flying birds can render themselves blind in the direction of travel has not been previously recognised and has important implications for the effective mitigation of collisions with human artefacts including wind turbines and power lines. These findings have applicability to species outside of these families especially raptors (*Accipitridae*) which are known to have small binocular fields and large blind areas similar to those of bustards and cranes, and are also known to be vulnerable to power line collisions.

Despite doubts about the efficacy of line marking to reduce the collision risk for bustards (Jenkins *et al.* 2010; Martin *et al.* 2010), there are numerous studies which prove that marking a line with PVC spiral type Bird Flight Diverters (BFDs) generally reduce mortality rates (e.g. Barrientos *et al.* 2011; Jenkins *et al.* 2010; Alonso & Alonso 1999; Koops & De Jong 1982), including to some extent for bustards (Barrientos *et al.* 2012; Hoogstad 2015 pers.comm). Beaulaurier (1981) summarised the results of 17 studies that involved the marking of earth wires and found an average reduction in mortality of 45%. Barrientos *et al.* (2011) reviewed the results of 15 wire marking experiments in which transmission or distribution wires were marked to examine the effectiveness of flight diverters in reducing bird mortality. The presence of flight diverters was associated with a decrease of 55–94% in bird mortalities. Koops and De Jong (1982) found that the spacing of the BFDs was critical in reducing the mortality rates - mortality rates are reduced up to 86% with a spacing of 5m, whereas using the same devices at 10m intervals only reduces the mortality by 57%. Barrientos *et al.* (2012) found that larger BFDs were more effective in reducing Great Bustard collisions than smaller ones. Line markers should be as large as possible, and highly contrasting with the background. Colour is probably less important as during the day the background will be brighter than the obstacle with the reverse true at lower light levels (e.g. at twilight, or during overcast conditions). Black and white interspersed patterns are likely to maximise the probability of detection (Martin *et al.* 2010).

4.1.2 INDIRECT IMPACTS OF THE SOLAR INFRASTRUCTURE ON BIRDS

4.1.2.1 Displacement due to habitat transformation and disturbance associated with the construction and operation of the plant

Ground-disturbing activities affect a variety of processes in arid areas, including soil density, water infiltration rate, vulnerability to erosion, secondary plant succession, invasion by exotic plant species, and stability of cryptobiotic soil crusts. All of these processes have the ability—individually and together—to alter habitat quality, often to the detriment of wildlife, including avifauna. Any disturbance and alteration to the desert landscape, including the construction and decommissioning of utility-scale solar energy facilities, has the potential to increase soil erosion. Erosion can physically and physiologically affect plant species and can thus adversely influence primary production and food availability for wildlife (Lovich & Ennen 2011).

Solar energy facilities require substantial site preparation (including the removal of vegetation) that alters topography and, thus, drainage patterns to divert the surface flow associated with rainfall away from facility infrastructure. Channelling runoff away from plant communities can have dramatic negative effects on water availability and habitat quality in arid areas. Areas deprived of runoff from sheet flow support less biomass of perennial and annual plants relative to adjacent areas with uninterrupted water-flow patterns (Lovich & Ennen 2011).

The activities listed below are typically associated with the construction and operation of solar facilities and could have direct impacts on avifauna (County of Merced 2014):

- Preparation of solar panel areas for installation, including vegetation clearing, grading, cut and fill;
- Excavation/trenching for water pipelines, cables, fibre-optic lines, and the septic system;
- Construction of piers and building foundations;
- Construction of new dirt or gravel roads and improvement of existing roads;
- Temporary stockpiling and side-casting of soil, construction materials, or other construction wastes;
- Soil compaction, dust, and water runoff from construction sites;
- Increased vehicle traffic;
- Short-term construction-related noise (from equipment) and visual disturbance;
- Degradation of water quality in drainages and other water bodies resulting from project runoff;
- Maintenance of fire breaks and roads; and
- Weed removal, brush clearing, and similar land management activities related to the ongoing operation of the project.

These activities could have an impact on birds breeding, foraging and roosting in or in close proximity through disturbance and transformation of habitat, which could result in temporary or permanent displacement.

In a study comparing the avifaunal habitat use in PV arrays with adjoining managed grassland at airports in the USA, DeVault *et al.* (2014) found that species diversity in PV arrays was reduced compared to the grasslands (37 *vs.* 46), supporting the view that solar development (both PV and CSP) is generally detrimental to wildlife on a local scale.

In order to identify functional and structural changes in bird communities in and around the development footprint, Visser (2016) gathered bird transect data at the 180 hectares, 96 MW Jasper PV solar facility in the Northern Cape, representing the solar development, boundary, and untransformed landscape. She found both bird density and diversity per unit area was higher in the boundary and untransformed landscape, however, the extent therefore was not considered to be statistically significant. This indicates that the PV facility matrix is permeable to most species. However, key environmental features, including available habitat and vegetation quality are most likely the overriding factors influencing species' occurrence and their relative density within the development footprint. Her most significant finding was that the distribution of birds in the landscape changed, from a shrubland to open country and grassland bird community, in response to changes in the distribution and abundance of habitat resources such as food, water and nesting sites. These changes in resource availability patterns were detrimental to some bird species and beneficial to others. Shrubland specialists appeared to be negatively affected by the presence of the PV facility. In contrast, open country/grassland and generalist species, were favoured by its development (Visser 2016).

It is highly likely that the same pattern of reduced avifaunal densities and possible changes in densities and composition favouring some species will manifest itself at the proposed Enamandla PV facilities.

4.2. ENAMANDLA PV SITE 5

4.2.1 CONSTRUCTION PHASE

4.2.1.1 Displacement due to disturbance associated with the construction of the solar plant and associated infrastructure

The construction of the PV plant and associated infrastructure (roads, cables and buildings) will result in a significant amount of movement and noise, which will lead to displacement of avifauna from the site. It is highly likely that most priority species listed in **Table 2** will vacate the area for the duration of these activities.

4.2.2 OPERATIONAL PHASE

4.2.2.1 Displacement due to habitat transformation associated with the PV plant and associated infrastructure

The construction of the PV plant and associated infrastructure will result in the radical transformation of the existing natural habitat. The vegetation will be cleared prior to construction commencing. Once operational, the construction of the solar panels will prevent sunlight from reaching the vegetation below, which is likely to result in stunted vegetation growth and possibly complete eradication of some plant species. The natural vegetation is likely to persist in the rows between the solar panels, but it will be a fraction of what was available before the construction of the plant. **Table 2** lists the priority species that could potentially be affected by this impact. Small birds are often capable of surviving in small pockets of suitable habitat, and are therefore generally less affected by habitat fragmentation than larger species. It is, therefore, likely that many of the smaller priority species will continue to use the habitat available within the solar facility albeit at lower densities e.g. larks, chats, sparrow-larks and many non-priority small species. This will however differ from species to species and it may not be true for all the smaller species. Larger species which require contiguous, un-fragmented tracts of suitable habitat (e.g. large raptors, korhaans and bustards) are more likely to be displaced entirely from the area of the proposed plant although in the case of some raptors (e.g. Southern Pale Chanting Goshawk and Lanner Falcon) the potential availability of carcasses or injured birds due to collisions with the solar panels may attract them to the area. Rock Kestrels, Southern Pale Chanting Goshawks and Greater Kestrel might be attracted to the solar panels as convenient perches from where they can hunt rodents.

4.2.2.2 Collisions with the solar panels

The priority species that could potentially be exposed to collision risk are listed in **Table 2**. The so-called "lake effect" could act as a potential attraction to some species and it is expected that non-priority flocking species i.e. Grey-backed Sparrow-lark *Eremopterix verticalis*, Namaqua Sandgrouse, and several species of doves as well as other passerines would be most susceptible to this impact as they habitually arrive in flocks at surface water to drink. Multiple mortalities could potentially result from this, which in turn could attract raptors e.g. Booted Eagle, Southern Pale Chanting Goshawk and Lanner Falcon which will feed on dead and injured birds which could in turn expose them to collision risk, especially when pursuing injured birds. The "lake effect" may also potentially draw various water birds to the area, including Greater and Lesser Flamingo, which may result in collision with the solar panels, or resulting in them getting stranded and unable to take off again. The presence of evaporation ponds and water treatment plants at the adjoining CSP plants may be additional aggravating factors in this respect.

4.2.2.3 Entrapment in perimeter fences

Large-bodied priority species such as Ludwig's Bustard, Karoo Korhaan and Secretarybird may be vulnerable to entrapment between double perimeter fences. The priority species that could potentially be exposed to fence entrapment are listed in **Table 2**. Apart from these priority species, non-priority species such as and Northern Black Korhaan *Afrotis afraoides* may also be vulnerable to this impact. The possibility of using a single perimeter fence should therefore be investigated.

4.2.2.4 Collisions with the internal powerlines

The most likely candidates for collision mortality on the proposed powerlines are Ludwig's Bustards, Karoo Korhaan and Secretarybird. Waterbirds might also be at risk if the birds mistake the solar panels for water and descend to the perceived surface water (see **Table 2** for a list of species that could be at risk).

4.2.3 DE-COMMISSIONING PHASE

4.2.3.1 Displacement due to disturbance associated with the de-commissioning of the solar plant and associated infrastructure

The de-commissioning of the PV plant and associated infrastructure (roads, cables and buildings) will result in a significant amount of movement and noise, which will lead to temporary displacement of avifauna from the site. It is highly likely that most priority species listed in **Table 2** will vacate the area for the duration of these activities. However, once the activities have ceased, the site should be re-colonised in due course.

4.2.4 NO-GO AREAS

No no-go areas were identified at the site.

4.2.5 PREFERRED ALTERNATIVE

Alternative 1 and Alternative 2 are situated in similar habitat, therefore the nature of the associated impacts is expected to be similar. There is therefore no preferred alternative from an avifaunal impact perspective.

4.2.6 CUMULATIVE IMPACTS

The renewable energy project applications currently registered with DEA within a 65km radius around the proposed developments are listed in APPENDIX 5[7]. Possible impacts by renewable energy projects on birds within this area are temporary displacement due to disturbance associated with the construction of the solar plant and associated infrastructure, collisions with the solar panels and solar panels, burning due to solar flux (only relevant to power tower CSP plants), permanent displacement due to habitat transformation, drowning in evaporation ponds, entrapment in perimeter fences and collisions with the associated power lines resulting in mortality. The total estimated area that could potentially be affected by renewable projects are approximately 50 366 ha, or 3.7% of the land surface within the 65km radius[8]. The actual footprint is likely to be smaller, as this figure is based largely on land parcel size, and not the actual infrastructure footprint.

[7] This information was provided by WSP Parsons Brinckerhoff and is assumed to be accurate.

[8] Ibid

Apart from renewable energy developments, several other threats are currently facing avifauna within this area (Marnewick *et al.* 2015):

- There is a history of overstocking in this region, which has led to degradation of habitat. Many ranchers trying to make a living on properties that are economically unviable overexploited the vegetation. Trampling by cattle added to the reduction in vegetation cover and caused erosion and the shifting of dunes. Approximately 75% of optimal habitat for the Red Lark has been lost over the past century. The disappearance of the Red Lark from ranches where dune grassland has been replaced by ephemerals is probably linked to the reduction in grass awns for nesting, shelter and invertebrate and plant foods. In recent years, there has been a shift from cattle ranching to raising sheep and goats on many farms in the region. However, overstocking and overgrazing continue to pose a threat.
- There is a serious threat from climate change. It is predicted that temperatures will increase and rainfall decrease sharply in arid areas such as Bushmanland. Locally resident endemic larks are at risk. Vegetation change will have marked effects on species such as the restricted-range, habitat-specific Red Lark. Increased CO_2 can lead to the increase of shrubs at the expense of grasses, causing a shift in vegetation diversity and structure and making habitat unsuitable for some species. It is expected that the Red Lark will not meet the challenge of global warming.
- Droughts are expected to become more severe because of climate change, and birds will have to cope with greater food variability, unsuitable habitats, different predators, parasites and diseases, and competition. Nomadic species, such as Stark's Lark, may find it easier to cope, only having to decide where to go. But resident species, like Sclater's Lark and Red Lark, are more likely to remain in their patch and use available resources as best they can. Large, mainly resident species that depend on rainfall are also at risk. They would include territorial eagles, such as Verreauxs' Eagle and Martial Eagle. Certain behavioural traits of these birds, such as extended parental care and slow reproductive rates, are likely to increase their vulnerability to climate change.
- Other significant threats are the development of new mines, the expansion of irrigation along the Orange River, the extensive invasion of mesquite (*Prosopis* sp.) along the Orange River banks and drainage lines, and new power lines and transmission lines from substations to renewable energy facilities.

The five PV sites are approximately 1 800 ha in extent, which is approximately 0.13% of the total land surface within a 65km radius around the proposed development. The greatest potential concern is for the Red Lark, due to its highly restricted range. This area also contains the whole of the Koa River Valley. Dean *et al.* 1991 estimated the total suitable habitat dune habitat for Red Larks at about 140 000 ha, centred around the Koa Valley. This figure is probably too conservative for the following reasons:

- Dean makes the following statement in the Red Lark SABAP 1 species account (Harrison *et al*. 1997)" …. atlas records, particularly in the eastern parts of its range, suggest it may be more common and widespread than previously thought"

- Red Larks are regularly recorded in what would be considered sub-optimal habitat e.g. at wind farm sites 80km south of the Koa Valley near Loeriesfontein. The implication of this is that the species is in all likelihood more common outside of typical dune habitat than was previously thought. It seems therefore that Bushmanland Basin Shrubland, of which a total of more than 3 million hectares is contained within the distribution range of the Red Lark, could potentially contain much larger numbers of the species than has been assumed up to now, especially in areas with an abundance of "white grasses".

Red Larks were not encountered in high densities at the site during the pre-construction monitoring, indicating that the habitat may not be optimal for the species. It may be that the almost total lack of any shrubs at the development area is an inhibiting factor, as the species likes to perch on a shrub when calling (pers. obs). The relatively small size of the proposed development footprint, coupled with the low densities of priority species, particularly Red Lark, leads to the conclusion that the cumulative impact of the PV5 facility on priority avifauna should, with appropriate mitigation, in all likelihood be low.

5. ASSESSMENT OF IMPACTS

The EIA uses a methodological framework developed by WSP | Parsons Brinckerhoff to meet the combined requirements of international best practice and NEMA, Environmental Impact Assessment Regulations, 2014 (GN No. 982) (the "EIA Regulations").

As required by the EIA Regulations (2014), the determination and assessment of impacts were based on the following criteria:

- Nature of the Impact
- Significance of the Impact
- Consequence of the Impact
- Extent of the impact
- Duration of the Impact
- Probability if the impact
- Degree to which the impact:
  - can be reversed;
  - may cause irreplaceable loss of resources; and
  - can be avoided, managed or mitigated.

Following international best practice, additional criteria have been included to determine the significant effects. These include the consideration of the following:

- Magnitude: to what extent environmental resources are going to be affected;
- Sensitivity of the resource or receptor (rated as high, medium and low) by considering the importance of the receiving environment (international, national, regional, district and local), rarity of the receiving environment, benefits or services provided by the environmental resources and perception of the resource or receptor); and
- Severity of the impact, measured by the importance of the consequences of change (high, medium, low, negligible) by considering inter alia magnitude, duration, intensity, likelihood, frequency and reversibility of the change.

It should be noted that the definitions given are for guidance only, and not all the definitions will apply to all the environmental receptors and resources being assessed. Impact significance was assessed with and without mitigation measures in place.

5.1 METHODOLOGY

Impacts were assessed in terms of the following criteria:

- The **nature**, a description of what causes the effect, what will be affected and how it will be affected

NATURE OR TYPE OF IMPACT	DEFINITION
Beneficial / Positive	An impact that is considered to represent an improvement on the baseline or introduces a positive change.
Adverse / Negative	An impact that is considered to represent an adverse change from the baseline, or introduces a new undesirable factor.
Direct	Impacts that arise directly from activities that form an integral part of the Project (e.g. new infrastructure).

Nature or Type of Impact	Definition
Indirect	Impacts that arise indirectly from activities not explicitly forming part of the Project (e.g. noise changes due to changes in road or rail traffic resulting from the operation of Project).
Secondary	Secondary or induced impacts caused by a change in the Project environment (e.g. employment opportunities created by the supply chain requirements).
Cumulative	Impacts are those impacts arising from the combination of multiple impacts from existing projects, the Project and/or future projects.

→ The physical **extent**, wherein it is indicated whether:

Score	Description
1	the impact will be limited to the site;
2	the impact will be limited to the local area;
3	the impact will be limited to the region;
4	the impact will be national; or
5	the impact will be international;

→ The **duration**, wherein it is indicated whether the lifetime of the impact will be:

Score	Description
1	of a very short duration (0 to 1 years)
2	of a short duration (2 to 5 years)
3	medium term (5–15 years)
4	long term (> 15 years)
5	permanent

- The **magnitude of impact on ecological processes**, quantified on a scale from 0-10, where a score is assigned:

SCORE	DESCRIPTION
0	small and will have no effect on the environment.
2	minor and will not result in an impact on processes.
4	low and will cause a slight impact on processes.
6	moderate and will result in processes continuing but in a modified way.
8	high (processes are altered to the extent that they temporarily cease).
10	very high and results in complete destruction of patterns and permanent cessation of processes.

- The **probability of occurrence**, which describes the likelihood of the impact actually occurring. Probability is estimated on a scale where:

SCORE	DESCRIPTION
1	very improbable (probably will not happen.
2	improbable (some possibility, but low likelihood).
3	probable (distinct possibility).
4	highly probable (most likely).
5	definite (impact will occur regardless of any prevention measures).

- the **significance**, which is determined through a synthesis of the characteristics described above (refer formula below) and can be assessed as low, medium or high;
- the **status**, which is described as either positive, negative or neutral;
- the degree to which the impact can be reversed;
- the degree to which the impact may cause irreplaceable loss of resources; and
- the *degree* to which the impact can be mitigated.

The **significance** is determined by combining the criteria in the following formula:

$$S = (E+D+M)*P$$

S = Significance weighting
E = Extent
D = Duration
M = Magnitude
P = Probability

The **significance weightings** for each potential impact are as follows:

OVERALL SCORE	SIGNIFICANCE RATING	DESCRIPTION
< 30 points	**Low**	where this impact would not have a direct influence on the decision to develop in the area
31-60 points	**Medium**	where the impact could influence the decision to develop in the area unless it is effectively mitigated
> 60 points	**High**	where the impact must have an influence on the decision process to develop in the area

5.1.1. ENAMANDLA PV SITE 5 (ALTERNATIVES 1 AND 2

The impact assessment tables are attached as APPENDIX 6.

6. MITIGATION AND MANAGEMENT MEASURES

The proposed mitigation measures are set out below in **Table 5.**

6.1. ENAMANDLA PV SITE 5 (ALTERNATIVES 1 AND 2)

Table 5: Mitigation and management

Activity	Mitigation and Management Measure	Responsible Person	Applicable Development Phase	Include as Condition of Authorisation	Monitoring requirements
The construction of the PV plant and associated infrastructure will result in a significant amount of movement and noise, which will lead to displacement of avifauna from the site due to disturbance. It is highly likely that most priority species will vacate the area for the duration of these activities.	• Construction activity should be restricted to the immediate footprint of the infrastructure. • Access to the remainder of the site should be strictly controlled to prevent unnecessary disturbance of priority species. • Measures to control noise and dust should be applied according to current best practice in the industry. • Maximum use should be made of existing access roads and the construction of new roads should be kept to a minimum as far as practical. • The recommendations of the ecological and botanical specialist studies must be strictly implemented, especially as far as limitation of the construction footprint and rehabilitation of disturbed areas is concerned.	Construction manager Environmental Control Officer	Construction	Yes	None

ACTIVITY	MITIGATION AND MANAGEMENT MEASURE	RESPONSIBLE PERSON	APPLICABLE DEVELOPMENT PHASE	INCLUDE AS CONDITION OF AUTHORISATION	MONITORING REQUIREMENTS
Displacement due to habitat transformation associated with the PV plant and associated infrastructure	• The recommendations of the ecological and botanical specialist studies must be strictly implemented, especially as far as limitation of the construction footprint and rehabilitation of transformed areas is concerned.	Site management	Operation	Yes	None
Collisions with the solar panels	• Depending on the results of the carcass searches, a range of mitigation measures will have to be considered if mortality levels turn out to be significant, including minor modifications of panel and mirror design to reduce the illusory characteristics of solar panels. What is considered to be significant will have to be established on a species specific basis by the avifaunal specialist, in consultation with BirdLife South Africa.	Site management Avifaunal specialist	Operation	Yes	• Formal operational phase monitoring should be implemented once the solar panels have been constructed. • Two - weekly carcass searches should be implemented to search the ground between solar panels. • Depending on the results of the carcass searches, a range of mitigation measures will have to be considered if mortality levels turn out to be significant, including minor modifications of panel and mirror design to reduce the illusory characteristics of solar panels. What is considered to be significant will have to be established on a species specific basis by the avifaunal specialist, in consultation with BirdLife South Africa. • The exact protocol to be followed for the carcass searches and operational phase monitoring must be compiled by the avifaunal specialist in consultation with the

ACTIVITY	MITIGATION AND MANAGEMENT MEASURE	RESPONSIBLE PERSON	APPLICABLE DEVELOPMENT PHASE	INCLUDE AS CONDITION OF AUTHORISATION	MONITORING REQUIREMENTS
					plant operator before the commencement of operations.
Entrapment in perimeter fences	• A single perimeter fence should be considered and if not an option for security reasons, the perimeter fence should be patrolled daily to look for trapped birds.	Site management	Operation	Yes	None
Collisions with the earthwire of the 132kV lines	• The powerlines should be marked with BFDs for their entire length on the earth wire of the line, 5m apart, alternating black and white. See APPENDIX 7 for the type of BFD which is recommended.	Construction manager Environmental Control Officer Site management Avifaunal specialist	Construction and Operation	Yes	• The powerlines should be inspected at least once a quarter for a minimum of one year by the avifaunal specialist to establish if there is any significant collision mortality. Thereafter the frequency of inspections will be informed by the results of the first year. • The detailed protocol to be followed for the inspections will be compiled by the avifaunal specialist prior to the first inspection.
The de-commisioning of the PV plant and associated infrastructure will result in a significant amount of movement and noise, which will lead to displacement of avifauna from the site due to disturbance. It is highly	• Activity should be restricted to the immediate footprint of the infrastructure. • Access to the remainder of the site should be strictly controlled to prevent unnecessary disturbance of priority species.	Construction manager Environmental Control Officer	De-commissioning	No	None

ACTIVITY	MITIGATION AND MANAGEMENT MEASURE	RESPONSIBLE PERSON	APPLICABLE DEVELOPMENT PHASE	INCLUDE AS CONDITION OF AUTHORISATION	MONITORING REQUIREMENTS
likely that most priority species will vacate the area	• Measures to control noise and dust should be applied according to current best practice in the industry. • Maximum use should be made of existing access roads and the construction of new roads should be kept to a minimum as far as practical. • The recommendations of the ecological and botanical specialist studies must be strictly implemented, especially as far as limitation of the footprint and rehabilitation of disturbed areas is concerned.				

7. STAKEHOLDER CONSULTATION

7.1. STAKEHOLDER CONSULTATION PROCESS

Public participation is a requirement of the S&EIR process; it consists of a series of inclusive and culturally appropriate interactions aimed at providing stakeholders with opportunities to express their views, so that these can be considered and incorporated into the S&EIR decision-making process. Effective public participation requires the prior disclosure of relevant and adequate project information to enable stakeholders to understand the risks, impacts, and opportunities of the Proposed Project.

A comprehensive stakeholder consultation process was undertaken during the scoping phase. Stakeholders were identified through existing databases, site notices, newspaper adverts and meetings. All stakeholders identified to date have been registered on the project database. All concerns, comments, viewpoints and questions (collectively referred to as 'issues') received to date have been documented and responded to in a Comment and Response Report.

There will be ongoing communication between WSP | Parsons Brinckerhoff and stakeholders throughout the S&EIR process.

7.2. STAKEHOLDER COMMENTS AND RESPONSE

STAKEHOLDER DETAILS	COMMENT	SPECIALIST RESPONSE
No comments were received on the PV developments		

8. CONCLUSIONS

8.1. ENAMANDLA PV SITE 5 (ALTERNATIVES 1 AND 2)

The proposed PV5 facility will have several impacts on avifauna at a site level which will, unless mitigated, range from High to Medium.

The impact of displacement of priority species due to habitat transformation associated with the operation of the plant and associated infrastructure is rated as High. This impact can be partially reversed through mitigation, but it will remain at a Medium level, even after mitigation. The impact of mortality due to collisions with the internal 132kV powerlines is rated as High but can be mitigated to a Medium level. The impact of displacement due to disturbance during the construction phase is rated as Medium and will remain at a Medium level despite after mitigation. The remaining envisaged impacts, i.e. mortalities in the operational phase due to collisions with the solar panels and entrapment in perimeter fences are both rated as Medium and should be mitigatable to a Low level with appropriate mitigation.

Alternative 1 and Alternative 2 are situated in similar habitat, therefore the nature of the associated impacts is expected to be similar. There is no preferred alternative from an avifaunal impact perspective.

The relatively small size of the footprint, coupled with the low densities of priority species at the site, particularly Red Lark, leads to the conclusion that the cumulative impact of the facility on priority avifauna should in all likelihood be low, taking into account the current impacts on avifauna within a 65km radius around the development area.

From an avifaunal impact perspective, the proposed development could go ahead, provided the proposed mitigation measures are strictly implemented.

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APPENDIX 1: PRE-CONSTRUCTION MONITORING METHODOLOGY

1. Objectives

The objective of the pre-construction monitoring at the proposed Enamandla Solar Facilities was to gather baseline data over a period of 12 months on the following aspects pertaining to avifauna:

- The abundance and diversity of birds at the development area to measure the potential displacement effect of the solar farms.
- Flight patterns of priority species at the development area to measure the potential impact on flight activity of the solar farms.

2. Methods

The monitoring protocol for the site was designed according to the draft version (November 2015) of *Best Practice Guidelines for assessing and monitoring the impact of solar energy facilities on birds in southern Africa (Jenkins et al.).*

Monitoring was conducted in the following manner:

- One drive transects of 11km was identified at the PV, CSP trough and CSP tower sites and is counted 3 times per sampling season. All birds were recorded.
- In addition, seven walk transects of one kilometre each were identified and each is counted 8 times per survey. All birds are recorded during walk transects. -
- The following variables are recorded:
    - Species;
    - Number of birds;
    - Date;
    - Start time and end time;
    - Distance from transect (0-50 m, 50-100 m, >100 m);
    - Wind direction;
    - Wind strength (calm; moderate; strong);
    - Weather (sunny; cloudy; partly cloudy; rain; mist);
    - Temperature (cold; mild; warm; hot);
    - Behaviour (flushed; flying-display; perched; perched-calling; perched-hunting; flying-foraging; flying-commute; foraging on the ground); and
    - Co-ordinates (priority species only).

- Three vantage points (VP) were identified from which the majority of the proposed solar areas can be observed, to record the flight altitude and patterns of priority species. The following variables are recorded for each flight:
    - Species;
    - Number of birds;
    - Date;
    - Start time and end time;
    - Wind direction;
    - Wind strength (estimated Beaufort scale 1-7);
    - Weather (sunny; cloudy; partly cloudy; rain; mist);
    - Temperature (cold; mild; warm; hot);
    - Flight altitude (high i.e. >250m; medium i.e. 20m – 250m; low i.e. <20m);
    - Flight mode (soar; flap; glide; kite; hover); and
    - Flight time (in 15 second-intervals).

Monitoring was conducted in the following periods:

Summer 1: 28 December 2015 - 4 January 2016 (8 Days)
Summer 2: 28 February 2016 - 6 March 2016 (8 Days)
Autumn: 1 May 2016 - 10 May 2016 (10 Days)
Spring: 1 September 2016 - 7 September 2016 (8 Days)

South African Red Data species, endemic and near-endemic species, raptors, waterbirds and IBA trigger species for the Haramoep and Black Mountain (SA035) Important Bird Area (IBA) were classified as priority species.

Figure 1 below indicates the area where monitoring took place.

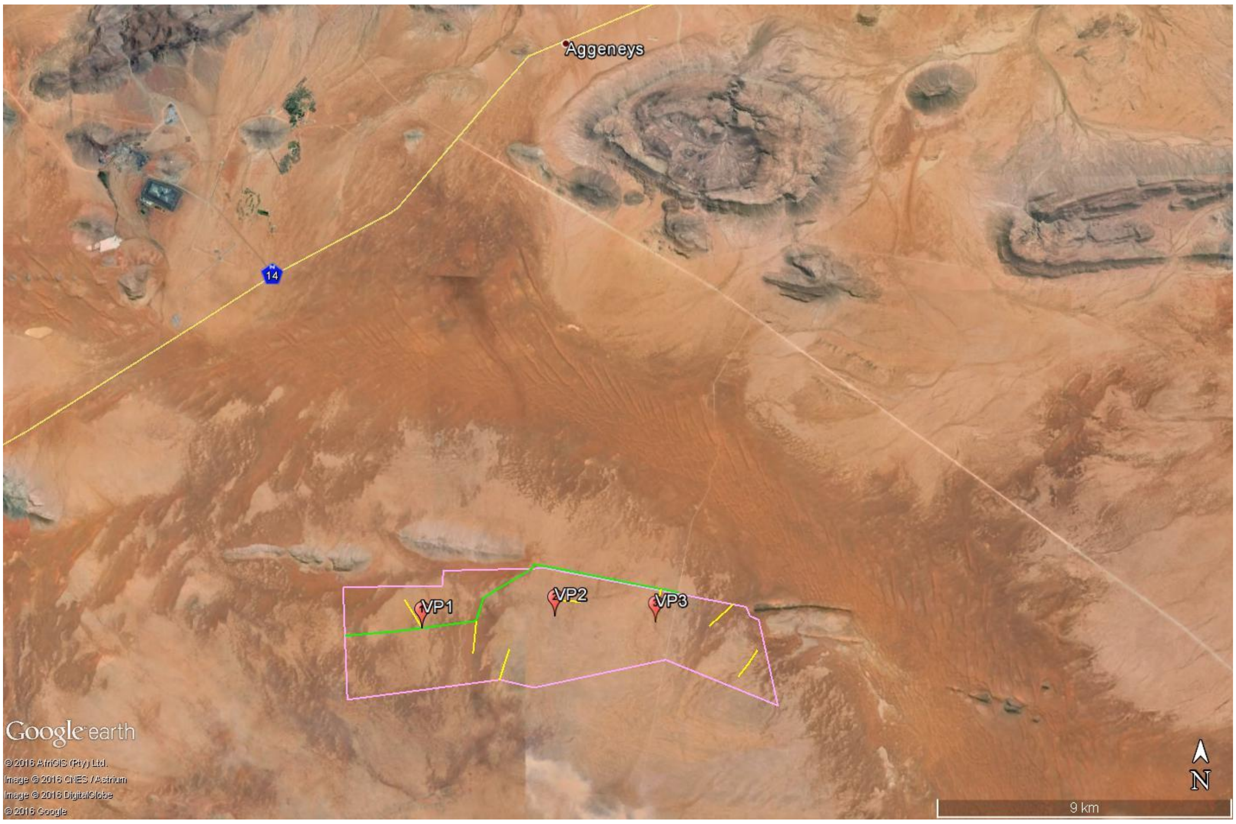


Figure 1: Area where monitoring took place, with position of VPs (red placemark), walk transects (yellow lines), drive transect (green line) and development area (pink polygon).

APPENDIX 2: CHRIS VAN ROOYEN CV

Curriculum vitae: Chris van Rooyen

Name	:	Chris van Rooyen
Profession/Specialisation	:	Avifaunal Specialist
Highest Qualification	:	LLB
Nationality	:	South African
Years of experience	:	20 years

Key Qualifications

Chris van Rooyen has twenty years' experience in the assessment of avifaunal interactions with industrial infrastructure. He was employed by the Endangered Wildlife Trust as head of the Eskom-EWT Strategic Partnership from 1996 to 2007, which has received international acclaim as a model of co-operative management between industry and natural resource conservation. He is an acknowledged global expert in this field and has consulted in South Africa, Namibia, Botswana, Lesotho, New Zealand, Texas, New Mexico and Florida. He also has extensive project management experience and he has received several management awards from Eskom for his work in the Eskom-EWT Strategic Partnership. He is the author and/or co-author of 17 conference papers, co-author of two book chapters, several research reports and the current best practice guidelines for avifaunal monitoring at wind farm sites. He has completed more than 100 power line assessments; and has to date been employed as specialist avifaunal consultant on more than 50 renewable energy generation projects. He has also conducted numerous risk assessments on existing power lines infrastructure. He also works outside the electricity industry and he has done a wide range of bird impact assessment studies associated with various residential and industrial developments (see key project experience below).

Key Project Experience

Bird Impact Assessment Studies and avifaunal monitoring for wind-powered generation facilities:

1. Eskom Klipheuwel Experimental Wind Power Facility, Western Cape
2. Mainstream Wind Facility Jeffreys Bay, Eastern Cape (EIA and monitoring)
3. Biotherm, Swellendam, (Excelsior), Western Cape (EIA and monitoring)
4. Biotherm, Napier, (Matjieskloof), Western Cape (pre-feasibility)
5. Windcurrent SA, Jeffreys Bay, Eastern Cape (2 sites) (EIA and monitoring)
6. Caledon Wind, Caledon, Western Cape (EIA)
7. Innowind (4 sites), Western Cape (EIA)
8. Renewable Energy Systems (RES) Oyster Bay, Eastern Cape (EIA and monitoring)
9. Oelsner Group (Kerriefontein), Western Cape (EIA)
10. Oelsner Group (Langefontein), Western Cape (EIA)
11. InCa Energy, Vredendal Wind Energy Facility Western Cape (EIA)
12. Mainstream Loeriesfontein Wind Energy Facility (EIA and monitoring)
13. Mainstream Noupoort Wind Energy Facility (EIA and monitoring)
14. Biotherm Port Nolloth Wind Energy Facility (Monitoring)
15. Biotherm Laingsburg Wind Energy Facility (EIA and monitoring)
16. Langhoogte Wind Energy Facility (EIA)
17. Vleesbaai Wind Energy Facility (EIA and monitoring)
18. St. Helena Bay Wind Energy Facility (EIA and monitoring)
19. Electrawind, St Helena Bay Wind Energy Facility (EIA and monitoring)
20. Electrawind, Vredendal Wind Energy Facility (EIA)
21. SAGIT, Langhoogte and Wolseley Wind Energy facilities
22. Renosterberg Wind Energy Project – 12 month preconstruction avifaunal monitoring project (2014)
23. De Aar – North (Mulilo) Wind Energy Project – 12 month preconstruction avifaunal monitoring project (2014)
24. De Aar – South (Mulilo) Wind Energy Project – 12 month bird monitoring (2014)

25. Namies – Aggenys Wind Energy Project – 12 month bird monitoring (2014)
26. Pofadder - Wind Energy Project – 12 month bird monitoring (2014)
27. Dwarsrug Loeriesfontein - Wind Energy Project – 12 month bird monitoring (2014)
28. Waaihoek – Utrecht Wind Energy Project – 12 month bird monitoring (2014)
29. Amathole – Butterworth Utrecht Wind Energy Project – 12-month bird monitoring & EIA specialist
30. Phezukomoya and San Kraal Wind Energy Projects 12-month bird monitoring & EIA specialist study (Innowind)
31. Beaufort West Wind Energy Facility 12-month bird monitoring & EIA specialist study (Mainstream)
32. Leeuwdraai Wind Energy Facility 12-month bird monitoring & EIA specialist study (Mainstream)
33. Sutherland Wind Energy Facility 12-month bird monitoring (Mainstream)
34. Maralla Wind Energy Facility 12-month bird monitoring & EIA specialist study (Biotherm)
35. Esizayo Wind Energy Facility 12-month bird monitoring & EIA specialist study (Biotherm)
36. Humansdorp Wind Energy Facility 12-month bird monitoring & EIA specialist study (Cennergi)
37. Aletta Wind Energy Facility 12-month bird monitoring & EIA specialist study (Biotherm)
38. Eureka Wind Energy Facility 12-month bird monitoring & EIA specialist study (Biotherm)
39. Makambako Wind Energy Faclity (Tanzania) 12-month bird monitoring & EIA specialist study (Windlab)
40. R355 Wind Energy Facility 12-month bird monitoring (Mainstream)
41. Groenekloof Wind Energy Facility 12-month bird monitoring & EIA specialist study (Mulilo)
42. Tsitsikamma Wind Energy Facility 24-months post-construction monitoring (Cennergi)
43. Noupoort Wind Energy Facility 24-months post-construction monitoring (Mainstream)
44. Kokerboom Wind Energy Facility 12-month bird monitoring & EIA specialist study (Business Venture Investments)
45. Kuruman Wind Energy Facility 12-month bird monitoring & EIA specialist study (Mulilo)

Bird Impact Assessment Studies for Solar Energy Plants:

1. Concentrated Solar Power Plant, Upington, Northern Cape.
2. Globeleq De Aar and Droogfontein Solar PV Pre- and Post-construction avifaunal monitoring
3. JUWI Kronos PV project, Copperton, Northern Cape
4. Sand Draai CSP project, Groblershoop, Northern Cape
5. Biotherm Helena PV Project, Copperton, Northern Cape
6. Biotherm Letsiao CSP Project, Aggeneys, Northern Cape
7. Biotherm Enamandla PV Project, Aggeneys, Northern Cape
8. Biotherm Sendawo PV Project, Vryburg, North-West
9. Biotherm Tlisitseng PV Project, Lichtenburg, North-West
10. JUWI Hotazel Solar Park Project, Hotazel, Northern Cape
11. Veld Solar One Project, Aggeneys, Northern Cape.

Bird Impact Assessment Studies for the following overhead line projects:

1. Chobe 33kV Distribution line
2. Athene - Umfolozi 400kV
3. Beta-Delphi 400kV
4. Cape Strengthening Scheme 765kV
5. Flurian-Louis-Trichardt 132kV
6. Ghanzi 132kV (Botswana)
7. Ikaros 400kV
8. Matimba-Witkop 400kV
9. Naboomspruit 132kV
10. Tabor-Flurian 132kV
11. Windhoek - Walvisbaai 220 kV (Namibia)
12. Witkop-Overyssel 132kV
13. Breyten 88kV
14. Adis-Phoebus 400kV

15. Dhuva-Janus 400kV
16. Perseus-Mercury 400kV
17. Gravelotte 132kV
18. Ikaros 400 kV
19. Khanye 132kV (Botswana)
20. Moropule – Thamaga 220 kV (Botswana)
21. Parys 132kV
22. Simplon –Everest 132kV
23. Tutuka-Alpha 400kV
24. Simplon-Der Brochen 132kV
25. Big Tree 132kV
26. Mercury-Ferrum-Garona 400kV
27. Zeus-Perseus 765kV
28. Matimba B Integration Project
29. Caprivi 350kV DC (Namibia)
30. Gerus-Mururani Gate 350kV DC (Namibia)
31. Mmamabula 220kV (Botswana)
32. Steenberg-Der Brochen 132kV
33. Venetia-Paradise T 132kV
34. Burgersfort 132kV
35. Majuba-Umfolozi 765kV
36. Delta 765kV Substation
37. Braamhoek 22kV
38. Steelpoort Merensky 400kV
39. Mmamabula Delta 400kV
40. Delta Epsilon 765kV
41. Gerus-Zambezi 350kV DC Interconnector: Review of proposed avian mitigation measures for the Okavango and Kwando River crossings
42. Giyani 22kV Distribution line
43. Liqhobong-Kao 132/11kV distribution power line, Lesotho
44. 132kV Leslie – Wildebeest distribution line
45. A proposed new 50 kV Spoornet feeder line between Sishen and Saldanha
46. Cairns 132kv substation extension and associated power lines
47. Pimlico 132kv substation extension and associated power lines
48. Gyani 22kV
49. Matafin 132kV
50. Nkomazi_Fig Tree 132kV
51. Pebble Rock 132kV
52. Reddersburg 132kV
53. Thaba Combine 132kV
54. Nkomati 132kV
55. Louis Trichardt – Musina 132kV
56. Endicot 44kV
57. Apollo Lepini 400kV
58. Tarlton-Spring Farms 132kV
59. Kuschke 132kV substation
60. Bendstore 66kV Substation and associated lines
61. Kuiseb 400kV (Namibia)
62. Gyani-Malamulele 132kV
63. Watershed 132kV
64. Bakone 132kV substation
65. Eerstegoud 132kV LILO lines
66. Kumba Iron Ore: SWEP - Relocation of Infrastructure
67. Kudu Gas Power Station: Associated power lines
68. Steenberg Booysendal 132kV
69. Toulon Pumps 33kV
70. Thabatshipi 132kV
71. Witkop-Silica 132kV
72. Bakubung 132kV

73. Nelsriver 132kV
74. Rethabiseng 132kV
75. Tilburg 132kV
76. GaKgapane 66kV
77. Knobel Gilead 132kV
78. Bochum Knobel 132kV
79. Madibeng 132kV
80. Witbank Railway Line and associated infrastructure
81. Spencer NDP phase 2 (5 lines)
82. Akanani 132kV
83. Hermes-Dominion Reefs 132kV
84. Cape Pensinsula Strengthening Project 400kV
85. Magalakwena 132kV
86. Benficosa 132kV
87. Dithabaneng 132kV
88. Taunus Diepkloof 132kV
89. Taunus Doornkop 132kV
90. Tweedracht 132kV
91. Jane Furse 132kV
92. Majeje Sub 132kV
93. Tabor Louis Trichardt 132kV
94. Riversong 88kV
95. Mamatsekele 132kV
96. Kabokweni 132kV
97. MDPP 400kV Botswana
98. Marble Hall NDP 132kV
99. Bokmakiere 132kV Substation and LILO lines
100. Styldrift 132kV
101. Taunus – Diepkloof 132kV
102. Bighorn NDP 132kV
103. Waterkloof 88kV
104. Camden – Theta 765kV
105. Dhuva – Minerva 400kV Diversion
106. Lesedi –Grootpan 132kV
107. Waterberg NDP
108. Bulgerivier – Dorset 132kV
109. Bulgerivier – Toulon 132kV
110. Nokeng-Fluorspar 132kV
111. Mantsole 132kV
112. Tshilamba 132kV
113. Thabamoopo - Tshebela – Nhlovuko 132kV
114. Arthurseat 132kV
115. Borutho 132kV MTS
116. Volspruit - Potgietersrus 132kV
117. Neotel Optic Fibre Cable Installation Project: Western Cape
117. Matla-Glockner 400kV
118. Delmas North 44kV
119. Houwhoek 11kV Refurbishment
120. Clau-Clau 132kV
121. Ngwedi-Silwerkrans 134kV
122. Nieuwehoop 400kV walk-through
123. Booysendal 132kV Switching Station
124. Tarlton 132kV
125. Medupi - Witkop 400kV walk-through
126. Germiston Industries Substation
127. Sekgame 132kV
128. Botswana – South Africa 400kV Transfrontier Interconnector
129. Syferkuil – Rampheri 132kV
130. Queens Substation and associated 132kV powerlines

131. Oranjemond 400kV Transmission line

Bird Impact Assessment Studies for the following residential and industrial developments:

1. Lizard Point Golf Estate
2. Lever Creek Estates
3. Leloko Lifestyle Estates
4. Vaaloewers Residential Development
5. Clearwater Estates Grass Owl Impact Study
6. Sommerset Ext. Grass Owl Study
7. Proposed Three Diamonds Trading Mining Project (Portion 9 and 15 of the Farm Blesbokfontein)
8. N17 Section: Springs To Leandra –"Borrow Pit 12 And Access Road On (Section 9, 6 And 28 Of The Farm Winterhoek 314 Ir)
9. South African Police Services Gauteng Radio Communication System: Portion 136 Of The Farm 528 Jq, Lindley.
10. Report for the proposed upgrade and extension of the Zeekoegat Wastewater Treatment Works, Gauteng.
11. Bird Impact Assessment for Portion 265 (a portion of Portion 163) of the farm Rietfontein 189-JR, Gauteng.
12. Bird Impact Assessment Study for Portions 54 and 55 of the Farm Zwartkop 525 JQ, Gauteng.
13. Bird Impact Assessment Study Portions 8 and 36 of the Farm Nooitgedacht 534 JQ, Gauteng.
14. Shumba's Rest Bird Impact Assessment Study
15. Randfontein Golf Estate Bird Impact Assessment Study
16. Zilkaatsnek Wildlife Estate
17. Regenstein Communications Tower (Namibia)
18. Avifaunal Input into Richards Bay Comparative Risk Assessment Study
19. Maquasa West Open Cast Coal Mine
20. Glen Erasmia Residential Development, Kempton Park, Gauteng
21. Bird Impact Assessment Study, Weltevreden Mine, Mpumalanga
22. Bird Impact Assessment Study, Olifantsvlei Cemetery, Johannesburg
23. Camden Ash Disposal Facility, Mpumalanga
24. Lindley Estate, Lanseria, Gauteng

Professional affiliations

I work under the supervision of and in association with Albert Froneman (MSc Conservation Biology) (SACNASP Zoological Science Registration number 400177/09) as stipulated by the Natural Scientific Professions Act 27 of 2003.

APPENDIX 3: BIRD HABITAT

Figure 1: Typical Bushmanland Arid Grassland gravel plain habitat with fence lines.

Figure 2: Typical Bushmanland Arid Grassland with red sand, favoured by Red Larks in the development area.

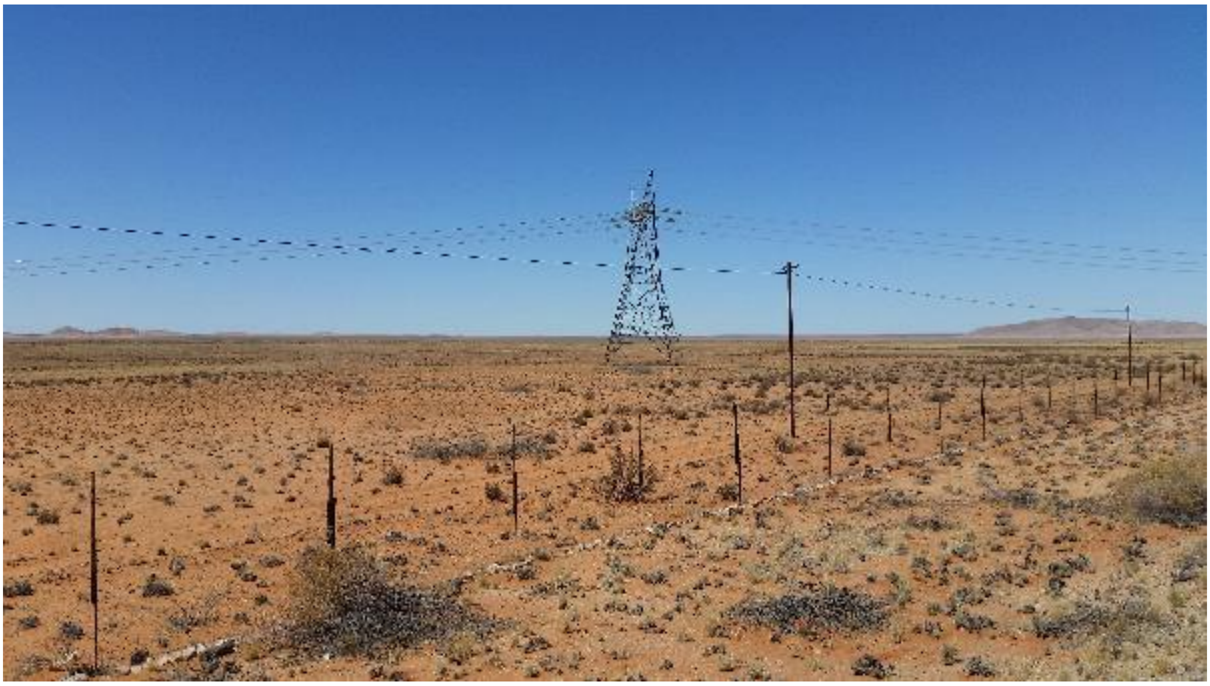


Figure 3: Transmission lines in the greater study area.

Figure 4: The study area is extremely arid with virtually no shrubs.

APPENDIX 4: STATISTICAL ANALYSIS

LETSOAI & ENAMANDLA AGGENEYS DATA STATISTICAL ANALYSIS

1 INTRODUCTION

This report is based on data captured in the MS Excel file "*L&E Aggenys BT VP Su1 Su2 Au Sp AF 20161011.xls*". That file contains records for each individual flight of priority species birds that were recorded at three vantage points set up at the site. Observations were recorded in sampling units of time referred to as "watch periods", each of three hours duration. The word *"flight"* indicates a group of birds flying or associating together. Individual birds in a flight were counted and recorded and these are referred to as "*individual*" counts. When no bird was seen during a watch period, the species was identified by the label "*None*". Every species is categorised into a "*Flight Class".* In this survey two flight classes were recorded viz. "Soaring" and "Terrestrial".

There were *48 watch periods* of three hours each, spread over the *three* vantage points, allocated to each of the four seasons as set out in Table *1*. Environmental and other relevant information were also recorded (e.g. Temperature, Wind Direction, Wind Speed, categories of height at which the birds were observed, etc.).

Table *1*. The survey dates.

Start Date	End Date	Season	Watch Periods	Hours Observed
2015-12-26	2016-01-01	Summer 2015	12	36
2016-02-29	2016-03-06	Summer 2016	12	36
2016-05-02	2016-05-08	Autumn 2016	12	36
2016-09-01	2016-09-06	Spring 2016	12	36

Basic summary statistics concerning the data are presented in this report in tables *A – I* in Section *A* of the Appendix. The matter of whether the data obtained are representative of the true occurrence of those birds identified as priority species is investigated. The sample size (number of watch periods) is also considered to establish the validity of the estimates of the average number of birds observed.

The statistical terminology used is defined and explained in Section *B* of the *Appendix* at the end of this report.

2 DESCRIPTIVE STATISTICS

Several tables of descriptive statistics are presented. The watch periods were all of the same length, viz. three hours and thus counts, averages and variabilities are expressed per *3* hours.

The following basic statistics were computed and presented in Section *A* of the *Appendix*.

- A count of the total number of individual birds (by species and flight class) observed during the survey against the *Height* at which they flew. These data are displayed as Table *A* in Section *A* of the *Appendix*.
- Table *B* shows the times that the soaring and terrestrial birds flew at medium height and at all heights. The times spent at medium height are expressed as a percentage of the total observed flying times. These percentages have to be interpreted with care and should always be seen together with the total flight time.
- Tables *C – G* provide summary statistics to provide insight into the behaviour of the species observed w.r.t. their presence according to season and their occurrence profiles during various weather conditions such as temperature, wind direction and wind strength.
- The counts observed during consecutive watch periods, also identified by season and vantage point, are listed separately in Table *H* (soaring birds) and Table *I* (terrestrial birds) in section *A* of the *Appendix*. These tables also contain updated average counts for consecutive watch periods.

The computations were done using STATISTICA statistical software (see Dell Inc., *2015*) and with routines developed for this purpose in "Statistica Visual Basic", the programming language of STATISTICA.

3 ESTIMATION OF THE POPULATION MEAN

The descriptive statistics of average counts, standard deviations (*Std.Dev.*) and *95%* lower and upper confidence intervals (LCL and UCL) for the mean count per watch period for the data in each of the seasons are computed from Tables *H* and *I*. The seasonal and overall estimates are listed in Tables *2 – 5*.

The computation of confidence intervals assumes that certain assumptions are to be met by the underlying distribution of counts. One possibility is to assume the normal distribution which is the default standard for such computations in statistical software packages.
The viability of such an assumption is investigated by firstly plotting the raw data counts for soaring *flights* for each of the watch periods *1* to *48* in their time sequence (see Figure *1*).

Figure *1*: Sequential time plot (by consecutive watch period number) of *individual* soaring and terrestrial bird counts.

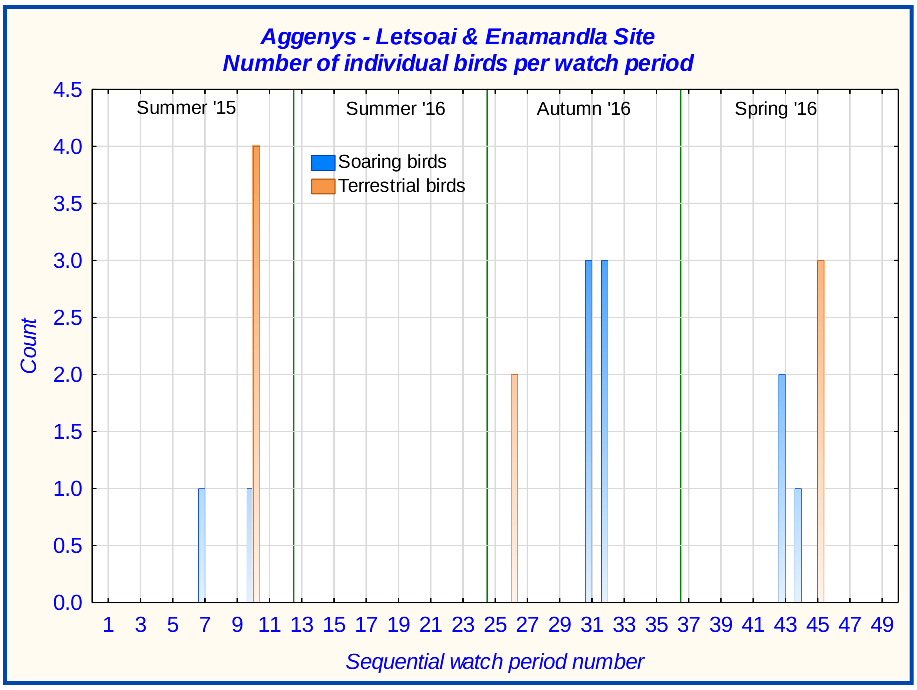
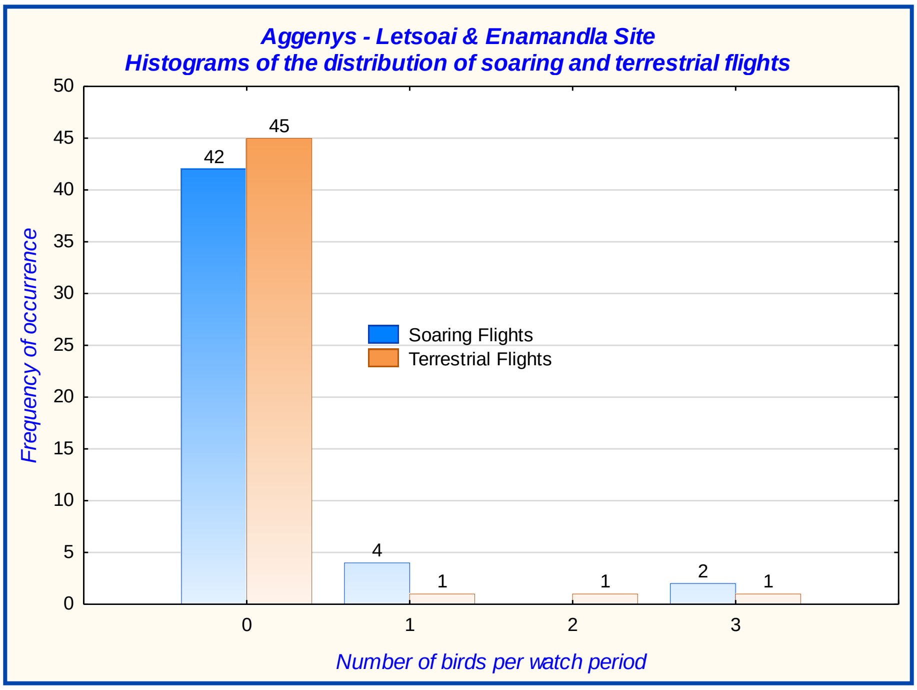


Figure *1* shows (for soarers and terrestrials) that few flights were recorded throughout all seasons of the survey, in particular no birds recorded during the Summer 2016 period. Also, there is not much difference in the counts between flights and individuals.

Figure *2* shows the *distribution* of counts for soaring as well as terrestrial bird flights over all seasons. The distribution of counts are considered for flights only as they are thought to be the random events that are materialising in each sampling unit. In addition, for the data at hand, as indicated, there is not much difference between flights and individual counts.

Figure *2*. Histogram of the distributions for Soaring and terrestrial bird flight counts over all four seasons.



In Figure *1*, for example, it is seen that in *42* of the *48* watch periods no soaring birds were recorded. The equivalent number for terrestrials was *45*.

In general, for situations where *counts* are made per fixed sampling unit (in this case a watch period of 3*h*) the Poisson distribution is particularly relevant. The Poisson process is a probability model in which events (e.g. the sighting of a flight of birds) occur randomly and uniformly in time or space. The assumptions supporting such a model are independence of the events, individuality of each event and the uniform arrival of events over the time period of the sampling unit. Details of this is discussed by Kalbfleisch, 1985, pp. *128 – 133*. There may be arguments against the validity of these assumptions in counting birds but they are probably as close to reality as can be hoped for. One way to recognise the Poisson distribution is that its average value and variance are identical (see Kalbfleisch, *1985*, p. *172*). This property is not unique to the Poisson - other distributions may also possess it.

4 SAMPLE SIZE

The basic statistics presented in Tables *2 – 5* show that the seasonal distributions, particularly for the Summer and Autumn data (where most counts and most variability in the counts are found) do not have values for mean and variance that are close together. However, even so, it is believed that the Poisson is a much more appropriate approximation than the normal distribution for these extremely skew distributions. The confidence limits in Tables *2 – 5* are thus based on the assumption of underlying Poisson distributions for the counts.

Table *2* reports the statistics for the number of *flights* recorded over all watch periods for soaring birds. Table *3, 4* and *5* report the same for individual soaring birds, terrestrial flights and terrestrial individuals respectively. The mathematical details of computing the confidence intervals and precisions are presented in section *C* of the Appendix.

Table *2*. Soaring birds, Flights: basic statistics with *95*% confidence interval and precision for the number of flights per *3*h watch period.

Season	Watch periods	Soaring birds: Flights						
		Count	Avge	Variance	Std.Dev.	95% LCL	95% UCL	Precision
Summer '15	12	2	0.17	0.15	0.39	0.02	0.60	0.29
Summer '16	12	0	0.00	0.00	0.00	0.00	0.31	0.15
Autumn '16	12	6	0.50	1.36	1.17	0.18	1.09	0.45
Spring '16	12	2	0.17	0.15	0.39	0.02	0.60	0.29
All Grps	48	10	0.21	0.42	0.65	0.10	0.38	0.14

The interpretation of the data in Table *2* is as follows. Column *2* shows that there were 12 watch periods allocated to each season. For Summer 2015, by way of example, column *3* shows that *2* flights of soaring birds were counted, leading to an estimated overall average of *0.17* flights per *3*h watch period, a variance of *0.15,* standard deviation of *0.39* and a *95%* confidence interval for the true mean of (*0.02 – 0.60*). The precision for the estimate of the mean value for the number of soaring flights for that season is *0.29*. The other rows in the table and those in Tables *3 – 5* are interpreted similarly.

Table 3. Soaring birds, Individuals: basic statistics with 95% confidence interval and precision for the number of individuals per 3h watch period.

Season	Watch periods	Soaring birds: Individuals						
		Count	Avge	Variance	Std.Dev.	95% LCL	95% UCL	Precision
Summer '15	12	2	0.17	0.15	0.39	0.02	0.60	0.29
Summer '16	12	0	0.00	0.00	0.00	0.00	0.31	0.15
Autumn '16	12	6	0.50	1.36	1.17	0.18	1.09	0.45
Spring '16	12	3	0.25	0.39	0.62	0.05	0.73	0.34
All Grps	48	11	0.23	0.48	0.69	0.11	0.41	0.15

It was previously noted that the data for the flights and individuals for the soaring birds are practically identical. Tables *2* and *3* show this clearly.

Table 4. Terrestrial birds, Flights: basic statistics with 95% confidence interval and precision for the number of individuals per *3*h watch period.

Season	Watch periods	Terrestrial birds: Flights						
		Count	Avge	Variance	Std.Dev.	95% LCL	95% UCL	Precision
Summer '15	12	1	0.08	0.08	0.29	0.00	0.46	0.23
Summer '16	12	0	0.00	0.00	0.00	0.00	0.31	0.15
Autumn '16	12	2	0.17	0.33	0.58	0.02	0.60	0.29
Spring '16	12	3	0.25	0.75	0.87	0.05	0.73	0.34
All Grps	48	6	0.13	0.28	0.53	0.05	0.27	0.11

Table 5. Terrestrial birds, Individuals: basic statistics with 95% confidence interval and precision for the number of individuals per *3*h watch period.

Season	Watch periods	Terrestrial birds: Individuals						
		Count	Avge	Variance	Std.Dev.	95% LCL	95% UCL	Precision
Summer '15	12	4	0.33	1.33	1.15	0.09	0.85	0.38
Summer '16	12	0	0.00	0.00	0.00	0.00	0.31	0.15
Autumn '16	12	2	0.17	0.33	0.58	0.02	0.60	0.29
Spring '16	12	3	0.25	0.75	0.87	0.05	0.73	0.34
All Grps	48	9	0.19	0.58	0.76	0.09	0.36	0.14

From Tables *3* and *5* (estimating statistics for individuals) it is seen that the largest precision ($d = 0.45$) is less than ½. This means that the average for any season could be estimated to within ½ a bird per 3h watch period (with 95% certainty). In this sense the sample size of $N = 12$ per season is considered to provide adequate precision.

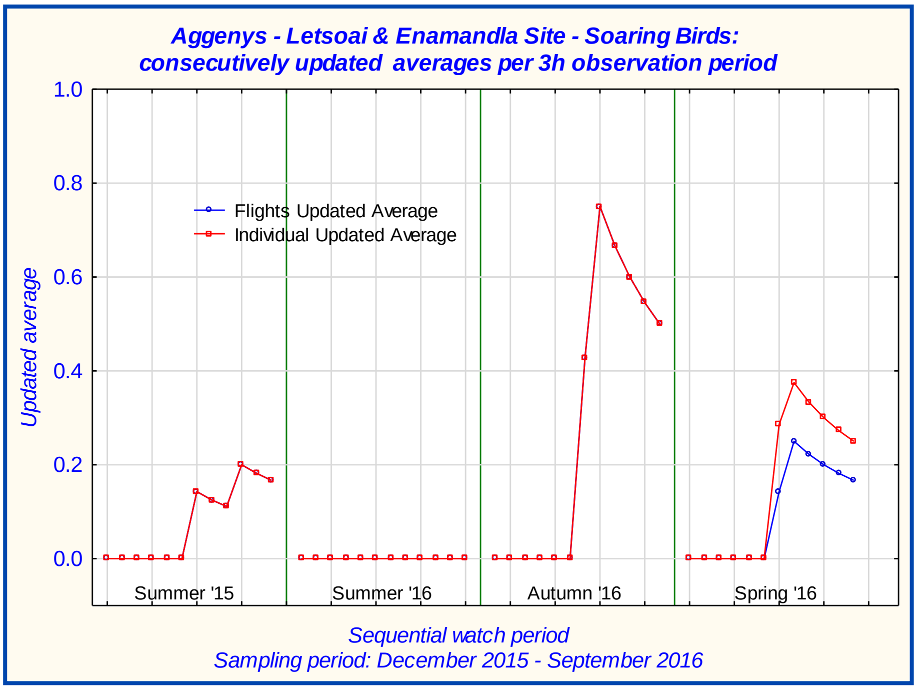
No data were obtained for the Winter of 2016. Recognising that it is not within the ambit of the statistician to make conclusions without data, the available data point to it that the precision (even with data for the Winter season) is unlikely to exceed 0.45 and that the sample size estimate is likely to remain true.

5 STABILITY AND REPRESENTATIVENESS

Insight into the accuracy (i.e. closeness to the true value), representativeness and stability of the counting process may be obtained by noting that as the data are gathered watch period by watch period an improved estimate of the average number of birds occurring in the area will be achieved for each added count. As more data are gathered the more accurate the estimate will become. The issue is to determine if the updated average count begins to stabilise towards the end of the survey (and thus the conclusion that an accurate, representative sample has been achieved).

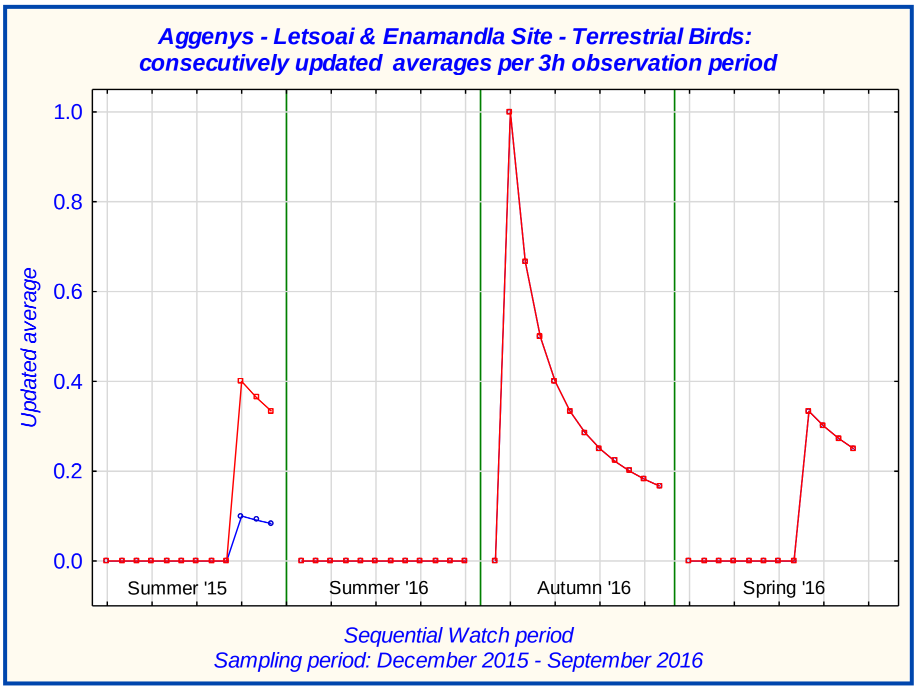
To investigate the behaviour of this process the average number of *flights* (and *individual*s) per *3*h watch period is computed from all preceding data as the data become available in consecutive watch periods. These updated averages are expected to vary to some extent in the initial stages of sampling but to stabilise as more data come in. Since the counts may vary (in principle) substantially over the seasons (especially for individual counts) the updated averages are determined separately for each season and are listed in Tables *H* and *I* in the Appendix. These data are plotted (by season) in Figure 4 for soaring birds and Figure 4 for terrestrial birds.

Figure 3. Soaring birds: updated average for *Flight* and *Individual* counts, separately by season.



When a single red line appears in the chart, each recorded flight consisted of only a single bird. The graphs tend to flatten out towards the end of each separate season and that implies stability of the series of counts. However, the graphs in each of the panels will be sensitive to even a single record being added. This is due to the small number of observed birds.

Figure 4. Terrestrial birds: updated average for *Flight* and *Individual* counts, separately by season.



The information depicted in Figures *3* and *4* show the extent to which stability in estimating the overall mean is achieved over time. In agreement with the computation of sample size reported in section *4*, it is not expected that further sampling will succeed in changing the estimated average number of flight or individual counts in any substantial way.

6 CONCLUSION

The computations and the outcome of the data exhibited in the tables and graphs in this report show that the survey may be taken to be statistically representative of the soaring and terrestrial priority species of birds that occur in the area. It has also been demonstrated that more samples would not yield a meaningful improvement in the accuracy and precision of estimating the terrestrial mean number of birds per watch period.

7 REFERENCES

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APPENDIX

ADDITIONAL STATISTICS

Table A. Number of individual priority species birds recorded during the survey by Species, Flight Class and Flying Height distribution.

Species	Flight Class	Flying Height			Row Totals
		Low	Medium	High	
Greater Kestrel	Soaring	2	7	0	9
Verreauxs' Eagle	Soaring	0	0	2	2
Count (Soaring)		2	7	2	11
Black-eared Sparrowlark	Terrestrial	4	0	0	4
Tractrac Chat	Terrestrial	2	0	0	2
Red Lark	Terrestrial	3	0	0	3
Count (Terrestrial)		9	0	0	9
Total count (Overall)		11	7	2	20

Table B. Number of individual priority species birds recorded during the survey by Species, Flight Class, the number (N) that flew at medium / all heights and Flight Duration (minutes) at medium / all heights. The time at medium height is expressed as a percentage of the time at all heights.

Species	Flight Class	Valid N and Flight Duration (minutes)				
		At Medium Height		At All Heights		% Time at Medium Ht
		N	Time (min)	N	Time (min)	
Greater Kestrel	Soaring	7	16.25	10	19.75	82.3%
Verreauxs' Eagle	Soaring	0	0	2	11.00	0%
Count (Soaring)		7	16.25	12	30.75	52.8%
Black-eared Sparrowlark	Terrestrial	0	0	4	3.0	0%
Tractrac Chat	Terrestrial	0	0	2	1.25	0%
Red Lark	Terrestrial	0	0	3	1.25	0%
Count (Terrestrial)		0	0	9	5.50	0%
Total count (Overall)		7	16.25	21	36.25	44.8%

Table C: Number of individual priority species birds recorded by Species, Flight Class and Season.						
Species	**Flight Class**	**Season**				**Row Totals**
		Summer '15	**Summer '16**	**Autumn16**	**Winter16**	
Greater Kestrel	Soaring	2	0	6	1	9
Verreauxs' Eagle	Soaring	0	0	0	2	2
Count (Soaring)		2	0	6	3	11
Black-eared Sparrowlark	Terrestrial	4	0	0	0	4
Tractrac Chat	Terrestrial	0	0	2	0	2
Red Lark	Terrestrial	0	0	0	3	3
Count (Terrestrial)		4	0	2	3	9
Total count (Overall)		6	0	8	6	20

Table D: Number of individual priority species birds recorded by Species, Flight Class and Temperature.						
Species	**Flight Class**	**Temperature**				**Row Totals**
		Cold	**Mild**	**Warm**	**Hot**	
Greater Kestrel	Soaring	0	0	0	9	9
Verreauxs' Eagle	Soaring	0	0	0	2	2
Count (Soaring)		0	0	0	11	11
Black-eared Sparrowlark	Terrestrial	0	0	0	4	4
Tractrac Chat	Terrestrial	0	2	0	0	2
Red Lark	Terrestrial	3	0	0	0	3
Count (Terrestrial)		3	2	0	4	9
Total count (Overall)		3	2	0	15	20

Table E: Number of individual priority species birds, by Species, Flight Class and Weather Condition.					
Species	**Flight Class**	**Cloudy**	**Partly Cloudy**	**Sunny**	**Row Totals**
Greater Kestrel	Soaring	1	0	8	9
Verreauxs' Eagle	Soaring	0	0	2	2
Count (Soaring)		1	0	10	11
Black-eared Sparrowlark	Terrestrial	0	0	4	4
Tractrac Chat	Terrestrial	0	0	2	2
Red Lark	Terrestrial	0	3	0	3
Count (Terrestrial)		0	3	6	9
Total count (Overall)		1	3	16	20

Table F: Number of individual priority species birds recorded by Species and Wind Direction.

Species	Flight Class	Wind Direction								Row Totals
		N	NE	E	SE	S	SW	W	NW	
Greater Kestrel	Soaring	1	0	0	1	1	0	0	6	9
Verreauxs' Eagle	Soaring	0	0	2	0	0	0	0	0	2
Count (Soaring)		1	0	2	1	1	0	0	6	11
Black-eared Sparrowlark	Terrestrial	0	0	0	0	4	0	0	0	4
Tractrac Chat	Terrestrial	0	0	0	2	0	0	0	0	2
Red Lark	Terrestrial	0	0	0	3	0	0	0	0	3
Count (Terrestrial)		0	0	0	5	4	0	0	0	9
Total count (Overall)		1	0	2	6	5	0	0	6	20

Table G: Number of individual priority species birds recorded by Species, Flight Class and Wind Strength (Beaufort scale).

Species	Flight Class	Light Air	Light Breeze	Gentle Breeze	Moder ate Breeze	Fresh Breeze	Strong Breeze	Total
Greater Kestrel	Soaring	0	2	7	0	0	0	9
Verreauxs' Eagle	Soaring	0	2	0	0	0	0	2
Count (Soaring)		0	4	7	0	0	0	11
Black-eared Sparrowlark	Terrestrial	0	4	0	0	0	0	4
Tractrac Chat	Terrestrial	0	2	0	0	0	0	2
Red Lark	Terrestrial	0	0	0	3	0	0	3
Count (Terrestrial)		0	6	0	3	0	0	9
Total count (Overall)		0	10	7	3	0	0	20

Table H: ***Soaring Birds*: Flights and Individuals for priority species per watch period and by vantage point over time with updated averages per consecutive watch period.**

Watch Number	Date	Season	VP	Flights count	Flights Updated Avge *	Individuals count	Individuals Updated Avge*
1	2015-12-26	Summer '15	VP1	0.0	0.00	0.0	0.00
2	2015-12-26	Summer '15	VP1	0.0	0.00	0.0	0.00
3	2015-12-26	Summer '15	VP1	0.0	0.00	0.0	0.00
4	2015-12-26	Summer '15	VP1	0.0	0.00	0.0	0.00
5	2015-12-28	Summer '15	VP2	0.0	0.00	0.0	0.00
6	2015-12-28	Summer '15	VP2	0.0	0.00	0.0	0.00
7	2015-12-28	Summer '15	VP2	1.0	0.14	1.0	0.14
8	2015-12-28	Summer '15	VP2	0.0	0.13	0.0	0.13
9	2016-01-01	Summer '15	VP3	0.0	0.11	0.0	0.11
10	2016-01-01	Summer '15	VP3	1.0	0.20	1.0	0.20
11	2016-01-01	Summer '15	VP3	0.0	0.18	0.0	0.18
12	2016-01-01	Summer '15	VP3	0.0	0.17	0.0	0.17
13	2016-02-29	Summer '16	VP1	0.0	0.00	0.0	0.00
14	2016-02-29	Summer '16	VP1	0.0	0.00	0.0	0.00
15	2016-02-29	Summer '16	VP1	0.0	0.00	0.0	0.00
16	2016-02-29	Summer '16	VP1	0.0	0.00	0.0	0.00
17	2016-03-04	Summer '16	VP2	0.0	0.00	0.0	0.00
18	2016-03-04	Summer '16	VP2	0.0	0.00	0.0	0.00
19	2016-03-04	Summer '16	VP2	0.0	0.00	0.0	0.00
20	2016-03-04	Summer '16	VP2	0.0	0.00	0.0	0.00
21	2016-03-06	Summer '16	VP3	0.0	0.00	0.0	0.00
22	2016-03-06	Summer '16	VP3	0.0	0.00	0.0	0.00
23	2016-03-06	Summer '16	VP3	0.0	0.00	0.0	0.00
24	2016-03-06	Summer '16	VP3	0.0	0.00	0.0	0.00
25	2016-05-02	Autumn '16	VP3	0.0	0.00	0.0	0.00
26	2016-05-02	Autumn '16	VP3	0.0	0.00	0.0	0.00
27	2016-05-02	Autumn '16	VP3	0.0	0.00	0.0	0.00
28	2016-05-02	Autumn '16	VP3	0.0	0.00	0.0	0.00
29	2016-05-06	Autumn '16	VP2	0.0	0.00	0.0	0.00
30	2016-05-06	Autumn '16	VP2	0.0	0.00	0.0	0.00
31	2016-05-06	Autumn '16	VP2	3.0	0.43	3.0	0.43
32	2016-05-06	Autumn '16	VP2	3.0	0.75	3.0	0.75
33	2016-05-08	Autumn '16	VP1	0.0	0.67	0.0	0.67
34	2016-05-08	Autumn '16	VP1	0.0	0.60	0.0	0.60
35	2016-05-08	Autumn '16	VP1	0.0	0.55	0.0	0.55

36	2016-05-08	Autumn '16	VP1	0.0	0.50	0.0	0.50
37	2016-09-01	Spring '16	VP1	0.0	0.00	0.0	0.00
38	2016-09-01	Spring '16	VP1	0.0	0.00	0.0	0.00
39	2016-09-01	Spring '16	VP1	0.0	0.00	0.0	0.00
40	2016-09-01	Spring '16	VP1	0.0	0.00	0.0	0.00
41	2016-09-03	Spring '16	VP3	0.0	0.00	0.0	0.00
42	2016-09-03	Spring '16	VP3	0.0	0.00	0.0	0.00
43	2016-09-03	Spring '16	VP3	1.0	0.14	2.0	0.29
44	2016-09-03	Spring '16	VP3	1.0	0.25	1.0	0.38
45	2016-09-06	Spring '16	VP2	0.0	0.22	0.0	0.33
46	2016-09-06	Spring '16	VP2	0.0	0.20	0.0	0.30
47	2016-09-06	Spring '16	VP2	0.0	0.18	0.0	0.27
48	2016-09-06	Spring '16	VP2	0.0	0.17	0.0	0.25

* The updated averages (for each season) are computed over the number consecutive watch periods in the season.

Table I: ***Terrestrial Birds*: Flights and Individuals for priority species per watch period and by vantage point over time with updated averages per consecutive watch period.**

Watch Number	Date	Season	VP	Flights count	Flights Updated Avge *	Individuals count	Individuals Updated Avge*
1	2015-12-26	Summer '15	VP1	0.0	0.00	0.0	0.00
2	2015-12-26	Summer '15	VP1	0.0	0.00	0.0	0.00
3	2015-12-26	Summer '15	VP1	0.0	0.00	0.0	0.00
4	2015-12-26	Summer '15	VP1	0.0	0.00	0.0	0.00
5	2015-12-28	Summer '15	VP2	0.0	0.00	0.0	0.00
6	2015-12-28	Summer '15	VP2	0.0	0.00	0.0	0.00
7	2015-12-28	Summer '15	VP2	0.0	0.00	0.0	0.00
8	2015-12-28	Summer '15	VP2	0.0	0.00	0.0	0.00
9	2016-01-01	Summer '15	VP3	0.0	0.00	0.0	0.00
10	2016-01-01	Summer '15	VP3	1.0	0.10	4.0	0.40
11	2016-01-01	Summer '15	VP3	0.0	0.09	0.0	0.36
12	2016-01-01	Summer '15	VP3	0.0	0.08	0.0	0.33
13	2016-02-29	Summer '16	VP1	0.0	0.00	0.0	0.00
14	2016-02-29	Summer '16	VP1	0.0	0.00	0.0	0.00
15	2016-02-29	Summer '16	VP1	0.0	0.00	0.0	0.00
16	2016-02-29	Summer '16	VP1	0.0	0.00	0.0	0.00
17	2016-03-04	Summer '16	VP2	0.0	0.00	0.0	0.00
18	2016-03-04	Summer '16	VP2	0.0	0.00	0.0	0.00

19	2016-03-04	Summer '16	VP2	0.0	0.00	0.0	0.00
20	2016-03-04	Summer '16	VP2	0.0	0.00	0.0	0.00
21	2016-03-06	Summer '16	VP3	0.0	0.00	0.0	0.00
22	2016-03-06	Summer '16	VP3	0.0	0.00	0.0	0.00
23	2016-03-06	Summer '16	VP3	0.0	0.00	0.0	0.00
24	2016-03-06	Summer '16	VP3	0.0	0.00	0.0	0.00
25	2016-05-02	Autumn '16	VP3	0.0	0.00	0.0	0.00
26	2016-05-02	Autumn '16	VP3	2.0	1.00	2.0	1.00
27	2016-05-02	Autumn '16	VP3	0.0	0.67	0.0	0.67
28	2016-05-02	Autumn '16	VP3	0.0	0.50	0.0	0.50
29	2016-05-06	Autumn '16	VP2	0.0	0.40	0.0	0.40
30	2016-05-06	Autumn '16	VP2	0.0	0.33	0.0	0.33
31	2016-05-06	Autumn '16	VP2	0.0	0.29	0.0	0.29
32	2016-05-06	Autumn '16	VP2	0.0	0.25	0.0	0.25
33	2016-05-08	Autumn '16	VP1	0.0	0.22	0.0	0.22
34	2016-05-08	Autumn '16	VP1	0.0	0.20	0.0	0.20
35	2016-05-08	Autumn '16	VP1	0.0	0.18	0.0	0.18
36	2016-05-08	Autumn '16	VP1	0.0	0.17	0.0	0.17
37	2016-09-01	Spring '16	VP1	0.0	0.00	0.0	0.00
38	2016-09-01	Spring '16	VP1	0.0	0.00	0.0	0.00
39	2016-09-01	Spring '16	VP1	0.0	0.00	0.0	0.00
40	2016-09-01	Spring '16	VP1	0.0	0.00	0.0	0.00
41	2016-09-03	Spring '16	VP3	0.0	0.00	0.0	0.00
42	2016-09-03	Spring '16	VP3	0.0	0.00	0.0	0.00
43	2016-09-03	Spring '16	VP3	0.0	0.00	0.0	0.00
44	2016-09-03	Spring '16	VP3	0.0	0.00	0.0	0.00
45	2016-09-06	Spring '16	VP2	3.0	0.33	3.0	0.33
46	2016-09-06	Spring '16	VP2	0.0	0.30	0.0	0.30
47	2016-09-06	Spring '16	VP2	0.0	0.27	0.0	0.27
48	2016-09-06	Spring '16	VP2	0.0	0.25	0.0	0.25

* The updated averages (for each season) are computed over the number consecutive watch periods in the season.

DEFINITION OF TERMS

These notes explain some of the terminology used in the report.

Average: The *average value* (also referred to as the *mean value*) is a measure of the location of the centre of gravity of a data distribution.

Variability: The *variance* is a measure of the variability of the observed data (e.g. counts per *3*h) around the mean value of the data. Its square root, the *standard deviation*, does the same but is scaled to the same units as those of the observed data.

Confidence Interval: A *confidence interval* for the true mean of a population (e.g. the true mean of the number of terrestrial birds occurring in an area) is an interval, computed from a random sample, that reflects the uncertainty of the estimate based on a single sample. If it were possible to take the infinite number of all possible samples of size *N* per season (in the present case of sampling) and a *95%* confidence interval for the mean is computed in each case, then *0.95*N* of those intervals will contain the true mean value. The larger the sample size, the narrower the confidence interval. On the other hand, the larger the standard deviation of a distribution, the wider the confidence interval for the mean.

Precision: A sample *estimate* of a parameter that describes a population (e.g. its true mean) depends on the sample size and is desired to be close to the true value of the parameter. The closeness of such an estimate to the true value is known as its *accuracy*. The precision of an estimate relates to the variability of the measurements. The closer together the data, the more precise the estimate. Half the width of the confidence interval for the parameter is defined as the *precision* of the estimate of the parameter. The larger the sample size the better (smaller) the precision.

Distribution of counts: It is recognised that counts of events (randomly distributed over space or time) that took place, for example, in a fixed time period (e.g. the count of birds in a watch period of fixed length) may have a *Poisson distribution* when the events occur randomly over time. The mean value and variance (the squared standard deviation) of a Poisson distribution are identical. This means that large mean values (of counts per SU) imply poorer precision.

POISSON DISTRIBUTION – CONFIDENCE INTERVAL

If the count of birds per sampling unit (SU) [i.e. a watch period] is assumed to have a Poisson distribution with an (unknown) average value of λ and if *N* SUs were sampled (for example 2h watch periods are sampled $N = 30$ times) the sum of the *N* counts also has a Poisson distribution (with true average λN), see Brownlee, *1960*, p. *141*.

The Poisson probability (which is characterised uniquely by its average parameter (in this case λN) for finding a count of X = x birds from the *N* SUs is given by: $P(X = x) = e^{-\lambda N}(\lambda N)^x \,/\, x!$, for values of $x = 0, 1, 2, \ldots$.

A ($1 - \beta$) confidence interval for the mean value, λN, of this Poisson is determined by a lower limit $L_1 = \frac{1}{2}\chi^2_{\beta/2}(2X)$ and an upper limit $L_2 = \frac{1}{2}\chi^2_{1-\beta/2}(2X+2)$, see Zar (2010), pp. 587 – 589. Here $\chi^2_\alpha(\nu)$ is the α-point of the chi-squared distribution with ν degrees of freedom, i.e. the χ^2 - value with cumulative probability of α up to that value. *X* denotes the count of the number of birds over *N* SUs.

This means that the coverage probability for λN , based on a count of *X* birds per *N* SUs is $P(L_1 \le \lambda N \le L_2) = 1 - \beta$. Thus a $1 - \beta$ confidence interval for λ (the expected average value per SU) is given by the interval $(L_1 / N; \quad L_2 / N)$.

These formulas were used to determine the confidence intervals in the Tables in Section *3* of the report.

POISSON DISTRIBUTION – SAMPLE SIZE

Consider the question of how many watch periods (i.e. sampling units, N) must be sampled in order to obtain an estimate of the true count per SU with *precision* of "d" units with prescribed probability, e.g. 95%. Thus, what must N be so that the true mean count per SU lies in an interval of half-width d with certainty of $1 - \beta$?

As was indicated in the previous section, this interval is $(L_1 / N;\ \ L_2 / N)$ and thus the precision is $d = \frac{1}{2}(L_2 - L_1) / N$. The true average is estimated from the observed total count, X, and is given by $\hat{\lambda} = X / N$. This estimate is NOT in the centre of the confidence interval, but even so, we shall take half of the width of the confidence interval and call it the *$1 - \beta$ precision*. A sample size that will be sufficiently large to provide an estimate of the true mean count per SU with an acceptable value for its precision (say $d = d_0$) must thus satisfy the inequality: $\frac{1}{2}(L_2 - L_1) / N \leq d_0$ or, solving for N:

(1) $$N \geq \tfrac{1}{2}(L_2 - L_1) / d_0 = \left(\chi^2_{1-\beta/2}(2X+2) - \chi^2_{\beta/2}(2X)\right) / 4d_0.$$

If a count *of* $X = x$ is observed and a specified value for d_0 is desired, the sample size must be at least N as in (*1*). This allows the user to verify, for a given count, if the actual number of SU's is sufficiently large to achieve the desired precision.

APPENDIX 5: RENEWABLE ENERGY APPLICATIONS WITHIN A 65KM RADIUS

PROPOSED DEVELOPMENT NAME	DEA REFERENCE	CURRENT EA STATUS	EXTENT	PROPOSED CAPACITY	IMPACTS			PROPOSED MITIGATION MEASURES
					Construction	Operation	Decommissioning	
					Overall	Overall	Overall	
Construction of the Wind and Photovoltaic (PV) Energy Facilities, including the Construction of the Wind and PV Substations and Gridline Connections, near Springbok, within the Nama-Khoi Local Municipality, Northern Cape Province.	14/12/16/3/3/2/346/AM1	In Process	46 535	75	L	L		Post-construction Monitoring of the local avifauna for a one year (12 month) period in accordance with Birdlife South Africa's guidelines for solar energy facilities.
Construction of the Wind and Photovoltaic (PV) Energy Facilities, including the Construction of the Wind and PV Substations and Gridline Connections, Near Springbok, within the Nama-Khoi Local Municipality, Northern Cape Province.	14/12/16/3/3/2/447	In Process	46535	1000	L	L		Post-construction Monitoring of the local avifauna for a one year (12 month) period in accordance with Birdlife South Africa's guidelines for solar energy facilities.
The Proposed Boesmanland Solar Farm Portion 6 (A Portion Of Portion 2), Farm 62 Zuurwater, Aggeneys, Northern Cape Province.	12/12/20/2602	Approved	200	75	L-M	L		The length of any new power lines that need to be installed should be kept to a minimum. Ensure that all new lines are marked with bird flight diverters along their entire length. If the new lines were to run parallel to existing unmarked lines this would potentially create a net benefit as this could reduce the collision risk posed by the older line. All new power line infrastructure should be bird-friendly in configuration and adequately insulated (Lehman et al. 2007).

Proposed Development Name	DEA Reference	Current EA Status	Extent	Proposed Capacity	Impacts: Construction (Overall)	Impacts: Operation (Overall)	Impacts: Decommissioning (Overall)	Proposed Mitigation Measures
								These activities should be supervised by someone with experience in this field.
75MW PV plant on the Farm Zuurwater No 62 in the Namakwa District, Northern Cape Province, Phase 4.	14/12/16/3 /3/2/473	In Process	222	75		M-H		Limit disturbance at proposed substation and powerline sites Powerline construction should take nesting birds in account Avifaunal walk-through must be conducted to fit powerlines with flappers where necessary. No powerline towers may be placed within 32m of a pan.
Proposed Boesmanland Solar Farm Portion 6 (A portion of portion 2) Farm 62 Zuurwater, Aggeneys, Northern Cape.	14/12/16/3 /3/2/222	Approved	200	75	L-M	L		Same as 12/12/20/2602?
Proposed Wind Energy Facility and Associated Infrastructure on Namies Wind Farm Pty Ltd, near Aggeneys, Northern Cape Province.	14/12/16/3 /3/2/550	In Process	15	220	L	L-H		A 1.2km no-go buffer is proposed around the Martial Eagle nest situated at 29°18'52.00"S 19°10'9.71"E. A 200m no-go buffer is proposed around water points. A 50m no-turbine buffer is proposed around drainage lines (optimal Red Lark habitat). A total exclusion zone will not be feasible, as the internal road network will have to cross drainage lines at some point. However, the construction of infrastructure in drainage lines should be kept to an absolute minimum, and avoided where possible. Monitoring of the breeding pair of Martial Eagles should be implemented during the construction phase, to ascertain if the

Proposed Development Name	DEA Reference	Current EA Status	Extent	Proposed Capacity	Impacts													Proposed Mitigation Measures
					Construction				Operation					Decommissioning				
					Overall				Overall					Overall				
																		1.2km buffer zone is effective to prevent disturbance of the birds. The construction of turbine No 1 should be timed to take place outside the breeding season i.e. between November and April. Formal monitoring should be resumed once the turbines have been constructed, as per best practice guidelines. The purpose of this would be to establish if displacement of priority species has occurred and to what extent. The exact time when post-construction monitoring should commence, will depend on the construction schedule, and will be agreed upon with the site operator once these timelines have been finalised. The duration of the post-construction monitoring would need to be for at least an equivalent period to the pre-construction monitoring (four seasons); and then for at least eight years thereafter. Thereafter the need for additional monitoring will be determined and agreed to with the developer. The exact scope and nature of the post-construction monitoring will be informed on an ongoing basis by the result of the monitoring through a process of adaptive management. Construction activity should be restricted to the immediate footprint of the infrastructure, and in particular to the proposed road network. Access to the remainder of the site should be strictly controlled to prevent

PROPOSED DEVELOPMENT NAME	DEA REFERENCE	CURRENT EA STATUS	EXTENT	PROPOSED CAPACITY	IMPACTS													PROPOSED MITIGATION MEASURES
					Construction				Operation					Decommissioning				
					Overall				Overall					Overall				
																		unnecessary disturbance of priority species. A 1km no-go buffer is proposed around the Martial Eagle nest situated at 29°18'52.00"S 19°10'9.71"E. A 200m no-go buffer is proposed around water points. It is strongly recommended that the option of tagging one or both of the adult Martial Eagles with satellite tracking devices are investigated to establish actual use of the site by the birds, for future adaptive management purposes i.e. to establish which turbines potentially pose the highest risk to the birds, and whether selective curtailment might be necessary. This should ideally take place before the site becomes operational to establish whether the birds have adapted their use of the site to accommodate the turbines. It is also recommended that the flight activity of the juvenile Martial Eagle is monitored by monthly direct observations from October – March i.e. after fledging up until it leaves its natal territory, to assess its flight patterns during this period when it will be most vulnerable to potential collision. This should give an indication of the extent of the potential curtailment (if any) that would be required to minimize the risk of collisions i.e. which turbines and for what period.

Proposed Development Name	DEA Reference	Current EA Status	Extent	Proposed Capacity	Impacts			Proposed Mitigation Measures
					Construction	Operation	Decommissioning	
					Overall	Overall	Overall	
								Formal monitoring should be resumed once the turbines have been constructed, as per best practice guidelines (see previous section Displacement). The duration of the post-construction monitoring would need to be for at least an equivalent period to the pre-construction monitoring (four seasons); and then for at least eight years thereafter. Thereafter the need for additional monitoring will be determined and agreed to with the site operator. The exact scope and nature of the post-construction monitoring will be informed on an ongoing basis by the result of the monitoring through a process of adaptive management. The purpose of this would be (a) to establish if and to what extent displacement of priority species has occurred through the altering of flight patterns post-construction, and (b) to search for carcasses at turbines. The environmental management plan should provide for the on-going inputs of a suitable experienced ornithological consultant to oversee the post-construction monitoring and assist with the on-going management of bird impacts that may emerge as the post-construction monitoring programme progresses. Depending on the results of the carcass searches, a range of mitigation measures will have to be considered if mortality levels turn out to be significant, including selective curtailment of problem turbines during high risk periods.

PROPOSED DEVELOPMENT NAME	DEA REFERENCE	CURRENT EA STATUS	EXTENT	PROPOSED CAPACITY	IMPACTS			PROPOSED MITIGATION MEASURES
					Construction	Operation	Decommissioning	
					Overall	Overall	Overall	
								If turbines are to be lit at night, lighting should be kept to a minimum and should preferably not be white light. Flashing strobe-like lights should be used where possible (provided this complies with Civil Aviation Authority regulations). Lighting of the wind farm (for example security lights) should be kept to a minimum. Lights should be directed downwards (provided this complies with Civil Aviation Authority regulations). The proposed transmission line for evacuation of the electricity generated by the WEF should be marked with Bird Flight Diverters for its entire length on the earth wire of the line, 5 metres apart, alternating black and white (APPENDIX E indicates the preferred Bird Flight Diverters to be used). If possible, construction activity within a 1.2km distance from the Martial Eagle nest situated at 29°18'52.00"S 19°10'9.71"E should be avoided between November and March to minimize the potential disturbance to the breeding birds.
The Proposed Construction of a Photovoltaic Power Generation Facility within the Black Mountain Mining Area near Aggeneys in the Northern Cape Province.	12/12/20/2151	Approved	19.5	19				Not available
Proposed 75MW Korana Solar Energy Facility, near Pofadder in the Northern Cape.	14/12/16/3/3/2/683	Unknown	3257 (all facilities)	Unknown	L-M	L-M		Monitoring should be implemented to search the ground between arrays of heliostat mirrors on a weekly basis (every two weeks at the longest) for at least one year to determine the magnitude of collision

Proposed Development Name	DEA Reference	Current EA Status	Extent	Proposed Capacity	Impacts												Proposed Mitigation Measures
					Construction				Operation				Decommissioning				
					Overall				Overall				Overall				
																	fatalities. Searches should be done on foot. Searches should be conducted randomly or at systematically selected arrays of heliostat mirrors to the extent that equals 33% or more of the project, including all ground between the power towers and the nearest array of heliostat mirrors. Detection trials should be integrated into the searches. The exact scope and nature of the post-construction monitoring will be informed on an ongoing basis by the result of the monitoring through a process of adaptive management. The environmental management plan should provide for the on-going inputs of a suitable experienced ornithological consultant to oversee the post-construction monitoring and assist with the on-going management of bird impacts that may emerge as the post-construction monitoring programme progresses. Depending on the results of the carcass searches, a range of mitigation measures will have to be considered if mortality levels turn out to be significant, including minor modifications of panel and mirror design to reduce the illusory characteristics of solar panels.
Proposed 140MW Khâi-Mai Wind Energy Facility near Pofadder.	14/12/16/3/3/2/680	Unknown	3257 (all facilities)	Unknown	L-M				L-M								It is recommended that, from a collision perspective, a 1.5km buffer zone is implemented around the Martial Eagle nest situated at 29°19'49.65"S 19°20'34.87"E. This is specifically aimed at reducing the potential collision risk to a newly fledged

PROPOSED DEVELOPMENT NAME	DEA REFERENCE	CURRENT EA STATUS	EXTENT	PROPOSED CAPACITY	IMPACTS												PROPOSED MITIGATION MEASURES
					Construction				Operation				Decommissioning				
					Overall				Overall				Overall				
																	chick which could blunder into a turbine. This would entail the relocation of 5 turbines within a 1.5km radius around the Martial Eagle nest, namely numbers 42, 46, 51, 59 and 63. Should the Martial Eagle nest become occupied before construction commences, it is recommended that the flight activity of the juvenile Martial Eagle be monitored through monthly direct observations from October – March i.e. after fledging until it leaves its natal territory. Such monitoring will be to assess the flight patterns of the juvenile eagle during this period when it will be most vulnerable to potential collision. This should give an indication of the extent of the potential curtailment (if any) that would be required to minimize the risk of collisions i.e. which turbines and for what period. This monitoring should be conducted pro-actively, i.e. before the first turbines are constructed in order to have baseline information available on flight behaviour before the turbines become operational. This will help in the pro-active identification of high risk areas which could form the focus of subsequent monitoring. A 200m no-go buffer is proposed around water points as they serve as focal points for raptor activity. Formal monitoring should be resumed once the turbines have been constructed, as per the most recent edition of the best practice guidelines (Jenkins et al. 2011). The exact scope and nature of the post-construction

Proposed Development Name	DEA Reference	Current EA Status	Extent	Proposed Capacity	Impacts													Proposed Mitigation Measures
					Construction				Operation					Decommissioning				
					Overall				Overall					Overall				
																		monitoring will be informed on an ongoing basis by the result of the monitoring through a process of adaptive management. The purpose of this would be (a) to establish if and to what extent displacement of priority species has occurred through the altering of flight patterns post-construction, and (b) to search for carcasses at turbines. As an absolute minimum, post-construction monitoring should be undertaken for the first two (preferably three) years of operation, and then repeated again in year 5, and again every five years thereafter. The exact scope and nature of the post-construction monitoring will be informed on an ongoing basis by the result of the monitoring through a process of adaptive management. The environmental management plan should provide for the on-going inputs of a suitable experienced ornithological consultant to oversee the post-construction monitoring and assist with the on-going management of bird impacts that may emerge as the post-construction monitoring programme progresses. Depending on the results of the carcass searches, a range of mitigation measures will have to be considered if mortality levels turn out to be significant, including selective curtailment of problem turbines during high risk periods.

Proposed Development Name	DEA Reference	Current EA Status	Extent	Proposed Capacity	Impacts													Proposed Mitigation Measures
					Construction				Operation					Decommissioning				
					Overall				Overall					Overall				
																		If turbines are to be lit at night, lighting should be kept to a minimum and should preferably not be white light. Flashing strobe-like lights should be used where possible (provided this complies with Civil Aviation Authority regulations). Lighting of the wind farm (for example security lights) should be kept to a minimum. Lights should be directed downwards (provided this complies with Civil Aviation Authority regulations). A 50m no-turbine buffer is proposed around drainage lines (optimal Red Lark habitat). A total exclusion zone will not be feasible, as the internal road network will have to cross drainage lines at some point. However, the construction of infrastructure in drainage lines should be kept to an absolute minimum, and avoided where possible. Formal monitoring should be resumed once ırbines have been constructed, as per the recent edition of the best practice ɘlines (Jenkins et al. 2011). The purpose of vould be to establish if displacement of ty species has occurred and to what extent. ɘxact time when post-construction toring should commence, will depend on the truction schedule, and will be agreed upon the site operator once these timelines have finalised. As an absolute minimum, post-construction monitoring should be undertaken for the first two (preferably three) years of operation, and then repeated again in year

Proposed Development Name	DEA Reference	Current EA Status	Extent	Proposed Capacity	Impacts			Proposed Mitigation Measures
					Construction	Operation	Decommissioning	
					Overall	Overall	Overall	
								5, and again every five years thereafter. The exact scope and nature of the post-construction monitoring will be informed on an ongoing basis by the result of the monitoring through a process of adaptive management. The recommendations of the ecological and botanical specialist studies must be strictly implemented, especially as far as limitation of the footprint and rehabilitation of disturbed areas is concerned. The proposed transmission lines for evacuation of the electricity generated by the WEFs should be marked with Bird Flight Diverters (BFDs) for their entire length on the earth wire of the line, 5 metres apart, alternating black and white.
Aggeneys PV	12/12/20/2630	Authorised	116.8	70MW				None
			Total	**Total**				
			50365.3	1608 MW				

APPENDIX 6: IMPACT TABLES

BioTherm Energy - Enamandla PV Site 5 (Alternatives 1, 2 and 3)

Avifauna

Significance Rating Table

Potential Impact		Extent (E)	Duration (D)	Magnitude (M)	Probability (P)	Significance (S=(E+D+M)*P)		Status (+ve or -ve)	Confidence
Enamandla PV Site 5 - Construction Phase									
The construction of the PV plant and associated infrastructure will result in a significant amount of movement and noise, which will lead to displacement of avifauna from the site due to disturbance. It is highly likely that most priority species will vacate the area for the duration of these activities.	Nature of impact:	Negative							
	Without Mitigation	1	1	8	5	50	Medium		High
	degree to which impact can be reversed:	The impact can be partially reversed. Some species will be able to re-colonise the area, although probably at lower densities.							
	degree of impact on irreplaceable resources:	High							
	Mitigation Measures	• Construction activity should be restricted to the immediate footprint of the infrastructure. • Access to the remainder of the site should be strictly controlled to prevent unnecessary disturbance of priority species. • Measures to control noise and dust should be applied according to current best practice in the industry. • Maximum use should be made of existing access roads and the construction of new roads should be kept to a minimum as far as practical. • The recommendations of the ecological and botanical specialist studies must be strictly implemented, especially as far as limitation of the construction footprint and rehabilitation of disturbed areas is concerned.							
	With Mitigation	1	1	8	4	40	Medium		Medium

Potential Impact	Mitigation	Extent (E)	Duration (D)	Magnitude (M)	Probability (P)	Significance (S=(E+D+M)*P)		Status (+ve or -ve)	Confidence
Enamandla PV Site 5 - No-Go									
There will be no additional impacts on avifauna. The ecological integrity of the site as it currently functions will be preserved.	Nature of impact:								
	Without Mitigation								
	degree to which impact can be reversed:								
	degree of impact on irreplaceable resources:								
	Mitigation Measures								
	With Mitigation								

BioTherm Energy - Enamandla PV Site 5 (Alternative 1 and 2)

Avifauna

Significance Rating Table

Enamandla PV Site 5 - Operational Phase									
Potential Impact		Extent (E)	Duration (D)	Magnitude (M)	Probability (P)	Significance (S=(E+D+M)*P)		Status (+ve or -ve)	Confidence
Displacement due to habitat transformation associated with the PV plant and associated infrastructure	Nature of impact:	Negative							
	Without Mitigation	1	4	8	5	65	High	-	Medium
	degree to which impact can be reversed:	Low. The impact will only be reversed if the facility is de-commisioned and the area rehabilitated							
	degree of impact on irreplaceable resources:	High							
	Mitigation Measures	• The recommendations of the ecological and botanical specialist studies must be strictly implemented, especially as far as limitation of the construction footprint and rehabilitation of transformed areas is concerned.							
	With Mitigation	1	4	8	4	52	Medium	-	Medium
Collisions with the solar panels	Nature of impact:	Negative							
	Without Mitigation	1	4	6	3	33	Medium		Low
	degree to which impact can be reversed:	Medium. The impact can be reduced through mitigation measures							
	degree of impact on irreplaceable resources:	Low							
	Mitigation Measures	• Formal operational phase monitoring should be implemented once the solar panels have been constructed. • Two - weekly carcass searches should be implemented to search the ground between solar panels • Depending on the results of the carcass searches, a range of mitigation measures will have to be considered if mortality levels turn out to be significant, including minor modifications of panel and mirror design to reduce the illusory characteristics of panels. What is considered to be significant will have to be established on a species specific basis by the avifaunal specialist, in consultation with BirdLife South Africa. • The exact protocol to be followed for the carcass searches and operational phase monitoring must be compiled by the avifaunal specialist in consultation with the plant operator before the commencement of operations.							
	With Mitigation	1	4	4	3	27	Low		Low
Entrapment in perimeter fences	Nature of impact:	Negative							
	Without Mitigation	1	4	8	3	39	Medium		Medium
	degree to which impact can be reversed:	High. Effective mitigation is available							
	degree of impact on irreplaceable resources:	Medium. The impact can be reduced through mitigation measures							
	Mitigation Measures	A single perimeter fence should be considered and if not an option for security reasons, the perimeter fence should be patrolled daily to look for trapped birds.							
	With Mitigation	1	4	2	2	14	Low		High
Collisions of priority species with the earthwire	Nature of impact:	Negative							
	Without Mitigation	3	4	10	4	68	High	-	High
	degree to which impact can be reversed:	Medium. The impact can be mitigated to some extent							
	degree of impact on irreplaceable resources:	High							
	Mitigation Measures	• The powerlines should be inspected at least once a quarter for a minimum of one year by the avifaunal specialist to establish if there is any significant collision mortality. Thereafter the frequency of inspections will be informed by the							
	With Mitigation	3	4	10	3	51	Medium		Medium

Enamandla PV Site 5 - No-Go									
Potential Impact	Mitigation	Extent (E)	Duration (D)	Magnitude (M)	Probability (P)	Significance (S=(E+D+M)*P)		Status (+ve or -ve)	Confidence
There will be no additional impacts on avifauna. The ecological integrity of the	Nature of impact:								
	Without Mitigation								
	degree to which impact can be reversed:								

ecological integrity of the site as it currently functions will be preserved.	**degree of impact on irreplaceable resources:**								
	Mitigation Measures								
	With Mitigation								

BioTherm Energy - Enamandla PV Site 5 (Alternative 1 and 2)

Avifauna

Significance Rating Table

Enamandla PV Site 5 - Decommissioning Phase									
Potential Impact		**Extent (E)**	**Duration (D)**	**Magnitude (M)**	**Probability (P)**	**Significance (S=(E+D+M)*P)**		**Status (+ve or -ve)**	**Confidence**
The de-commisioning of the PV plant and associated infrastructure will result in a significant amount of movement and noise, which will lead to displacement of avifauna from the site due to disturbance. It is highly likely that most priority species will vacate the area	**Nature of impact:**	Negative							
	Without Mitigation	1	2	8	5	55	**Medium**		High
	degree to which impact can be reversed:	High. Once the activities cease natural re-coloniosation will happen							
	degree of impact on irreplaceable resources:	Low							
	Mitigation Measures	• Activity should be restricted to the immediate footprint of the infrastructure. • Access to the remainder of the site should be strictly controlled to prevent unnecessary disturbance of priority species. • Measures to control noise and dust should be applied according to current best practice in the industry. • Maximum use should be made of existing access roads and the construction of new roads should be kept to a minimum as far as practical. • The recommendations of the ecological and botanical specialist studies must be strictly implemented, especially as far as limitation of the footprint and rehabilitation of disturbed areas is concerned.							
	With Mitigation	1	2	8	4	44	**Medium**		High

Enamandla PV Site 5 - No-Go									
Potential Impact	**Mitigation**	**Extent (E)**	**Duration (D)**	**Magnitude (M)**	**Probability (P)**	**Significance (S=(E+D+M)*P)**		**Status (+ve or -ve)**	**Confidence**
There will be no additional impacts on avifauna. The ecological integrity of the site as it currently functions will be preserved.	**Nature of impact:**								
	Without Mitigation								
	degree to which impact can be reversed:								
	degree of impact on irreplaceable resources:								
	Mitigation Measures								
	With Mitigation								

BioTherm Energy - Enamandla PV Site 5 (Alternative 1 and 2)

Avifauna

Significance Rating Table

Enamandla PV Site 5 - Cumulative Impacts									
Potential Impact		**Extent (E)**	**Duration (D)**	**Magnitude (M)**	**Probability (P)**	**Significance (S=(E+D+M)*P)**		**Status (+ve or -ve)**	**Confidence**
Cumulative impacts on priority avifauna: disturbance, habitat transformation, collisions, entrapment in fences	**Nature of impact:**	Negative							
	Without Mitigation	2	4	4	3	30	Low		Medium
	degree to which impact can be reversed:	Low. The impact of habitat transformation cannot be effectively mitigated							
	degree of impact on irreplaceable resources:	Low. The total available habitat taken up by renewable energy projects are still relatively small							
	Mitigation Measures	Strict monitoring of the number of approved renewable energy projects to ensure that the populations of priority species will be able to absorb the associated impacts							
	With Mitigation	2	4	4	2	20	Low		Low

Enamandla PV Site 5 - No-Go									
Potential Impact	**Mitigation**	**Extent (E)**	**Duration (D)**	**Magnitude (M)**	**Probability (P)**	**Significance (S=(E+D+M)*P)**		**Status (+ve or -ve)**	**Confidence**
There will be no additional impacts on avifauna. The ecological integrity of the site as it currently functions will be preserved.	**Nature of impact:**								
	Without Mitigation								
	degree to which impact can be reversed:								
	degree of impact on irreplaceable resources:								
	Mitigation Measures								
	With Mitigation								

APPENDIX 7: BIRD FLIGHT DIVERTERS

DISTRIBUTION
TECHNICAL BULLETIN

3 April 2009

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PART: 4 - MV

APPROVED BIRD FLIGHT DIVERTERS TO BE USED ON ESKOMS LINES (MITIGATING DEVICES)

This Technical Bulletin replaces all other Technical Bulletins that were published previously.

The following two flight diverters (mitigating devices) have been successfully installed and successfully tested on an active line in the Colesberg area.

1) EBM Flapper

Buyers guide number DDT 3053

The EBM bird flapper tested for the following:

- Pull down test (spirally moving along the conductor) for squirrel and hare conductor
- Testing for radio interference at 27kv on fox conductor
- Testing for corona at 27kv on fox conductor
- Salt fog test for 1000 hours.

The flapper was installed live line on a line in the NW region in conjunction with EWT and proved very successful as a mitigating device.

From field experience and the testing of the flapper it was decided at the Envirotech work group meeting that this EBM flapper can be used on conductors ranging from 6mm to 24mm on ACSR, AAAC conductors and shield wires.

The EBM Flapper can be attached with a link stick and a standard attachment or by hand from a bucket live line or under dead conditions.

Contact Roger Martin: EBM Tel 011 288 0000

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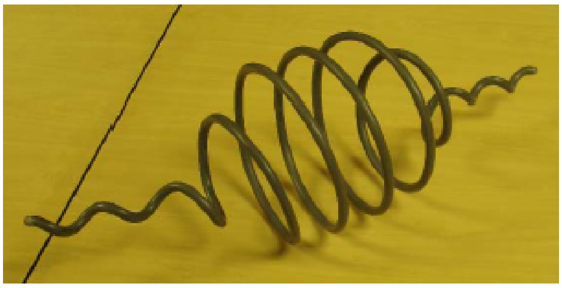
2) Tyco Flight Diverter.



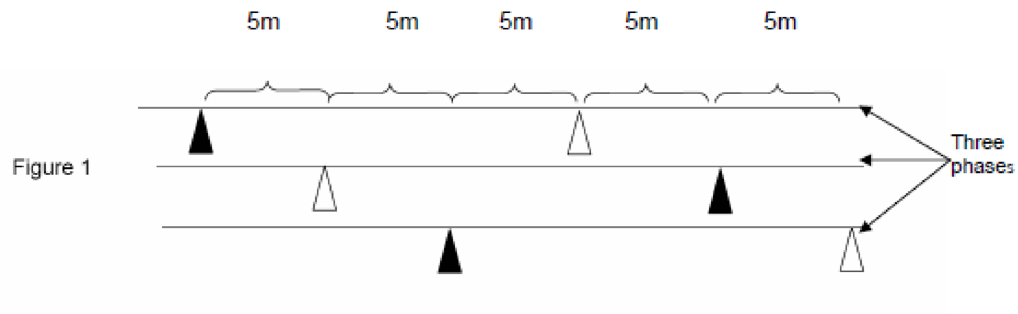
Buyers guide number DDT 3107

The TYCo flight diverter has been used successfully in many places around the world and has been installed on a line in the NW region in conjunction with EWT and proved very successful as a mitigating device. The device is supplied in colours white and grey.

Contact person: Mr Silas Moloko: TIS Tel 011 635 8000

3) Installing Flight Diverters

- Spacing of the bird diverters are to be 5m apart alternating on each phase, for single phase lines the colours would alternate 5m apart on the two lines.
- The flight diverters are to be installed with alternating colours,



Signed

COMPILED BY:

DATE: April 2009
B P Hill
Chief Engineer
IARC

Signed

APPROVED BY:

DATE: April 2009
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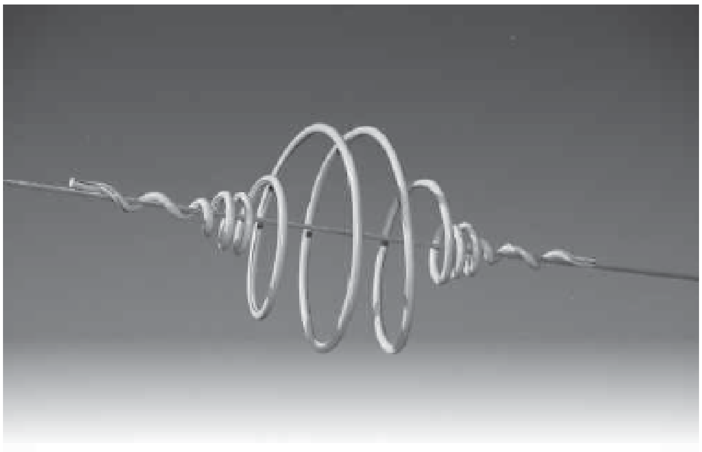
Double Loop Bird Flight Diverter



General Recommendation

The Bird Flight Diverter is designed to make overhead lines visible to birds and provides and economic means of reducing the hazard to both lines and birds. For low and medium voltage construction (up to 40kV) it is applied to the phase conductors (bare or jacketed). For high voltage it is used on the earth wire.

The fitting is light in weight, offers little wind resistance and is easily and quickly applied. The positive grip of the fitting on the conductor ensures that it remains in the applied position and cannot move along the span under vibration.

Visibility: The diverter section increases the visibility profile of the cable or conductor to a degree necessary to ensure safety, but avoids undesirably bulky outline.

Spacing: Spacing distances are not critical and will depend upon local conditions. Since wind resistance is very limited, sufficient fittings can be used to ensure adequate visibility without creating stresses on the line. When marking adjacent spans, overall visibility is improved by staggering the application.

We recommend generally a spacing of 10 or 15 metres.

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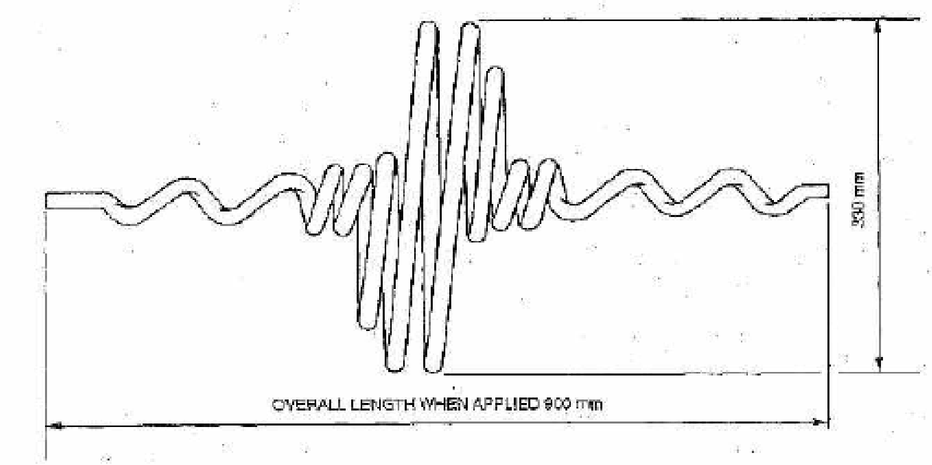
Double Loop Bird Flight Diverter



Material Used: Manufactured from rigid solid high impact polyvinyl chloride, possessing excellent chemical and strength properties and which will retain good physical characteristics within the range of extreme temperatures. Outdoor aging tests indicate that the material does not deteriorate in function or appearance from the effects of severe weather conditions. Industrial fumes and salt water cannot seriously degrade the properties of rigid PVC.

Colour: White or Black

Lay Direction: Bird Flight Diverters are supplied right hand lay for both right hand and left hand lay bare conductors and insulated cables.

CATALOGUE NO.	CONDUCTOR/ E/WIRE DIA. RANGE
BFD 0914/LD2*	9 mm – 14 mm

*Add B or W to denote colour

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