BIOTHERM ENAMANDLA SOLAR PROJECTS (PV SITE 5)

SPECIALIST INPUT INTO THE SCOPING REPORT: AVIFAUNA

Compiled by

Chris van Rooyen Consulting

for

WSP | PARSONS BRINCKERHOFF

APRIL 2016

EXECUTIVE SUMMARY

ENAMANDLA PV SITE 5

DISPLACEMENT DUE TO DISTURBANCE ASSOCIATED WITH THE CONSTRUCTION AND DE-COMMISSIONING OF THE PV PLANT AND ASSOCIATED ROADS, POWERLINE AND CABLES (CONSTRUCTION AND DE-COMMISSIONING)

The construction (and de-commissioning) of the PV plant and associated infrastructure (roads, powerline and cables) will result in a significant amount of movement and noise, which will lead to displacement of priority avifauna from the site. It is highly likely that most priority species will vacate the area for the duration of these activities. **The impact on priority species is expected to be medium.**

Potential mitigation measures are:

- 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 possible.
- 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.

DISPLACEMENT DUE TO HABITAT TRANSFORMATION ASSOCIATED WITH THE PV PLANT AND ASSOCIATED ROAD, POWERLINE AND CABLES (OPERATION)

The construction of the PV plant and associated infrastructure will result in the radical transformation of the existing natural habitat. 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 passerine species will continue to use the habitat available within the solar facility albeit at lower densities. This will however differ from species to species and it may not be true for all of 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 the potential availability of carcasses or injured birds due to collisions with the solar panels may actually attract them to the area. **The significance of the potential displacement impact is likely to be high**.

Potential mitigation is limited, and includes the following:

- Maximum use should be made of existing access roads and the construction of new roads should be kept to a minimum, as far as possible.

- 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.

COLLISIONS WITH THE SOLAR PANELS (OPERATION)

The so-called "lake effect" could act as a potential attraction to some priority species and it is expected that flocking species 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 which will feed on dead and injured birds which could in turn expose them to collision risk, especially when pursuing injured birds. In addition, the "lake effect" produced by the panels may potentially draw various water birds to the area. The presence of evaporation ponds may be an aggravating factor. The evaporation ponds, in combination with the "lake effect" might attract waterbirds. **Expected impact on priority species is medium.**

Potential mitigation measures are:

- Formal operational phase monitoring should be implemented once the solar arrays have been constructed. The purpose of this would be to establish to what extent displacement of priority species have taken place.
- Carcass searches should be implemented to search the ground between solar arrays.
- 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 troughs. 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.

EXCLUSION ZONES

There are currently no exclusion zones from an avifaunal impact perspective.

CONTENTS

1. INTRODUCTION

Biotherm Energy is looking at developing a number of Concentrated Solar Power (CSP) and Photovoltaic (PV) 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 Letsoai CSP (2 x sites) and Enamandla PV (5 x sites).

Enamandla PV site 5

- 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 (1kV up to and including 33kV) that will be run underground, expect where a technical assessment suggest that overhead lines are applicable
- On site 132kV powerline connecting the facility to the onsite substation
- 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
- 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 below for a map of the study area. The Enamandla PV site 5 is indicated as PV 5.

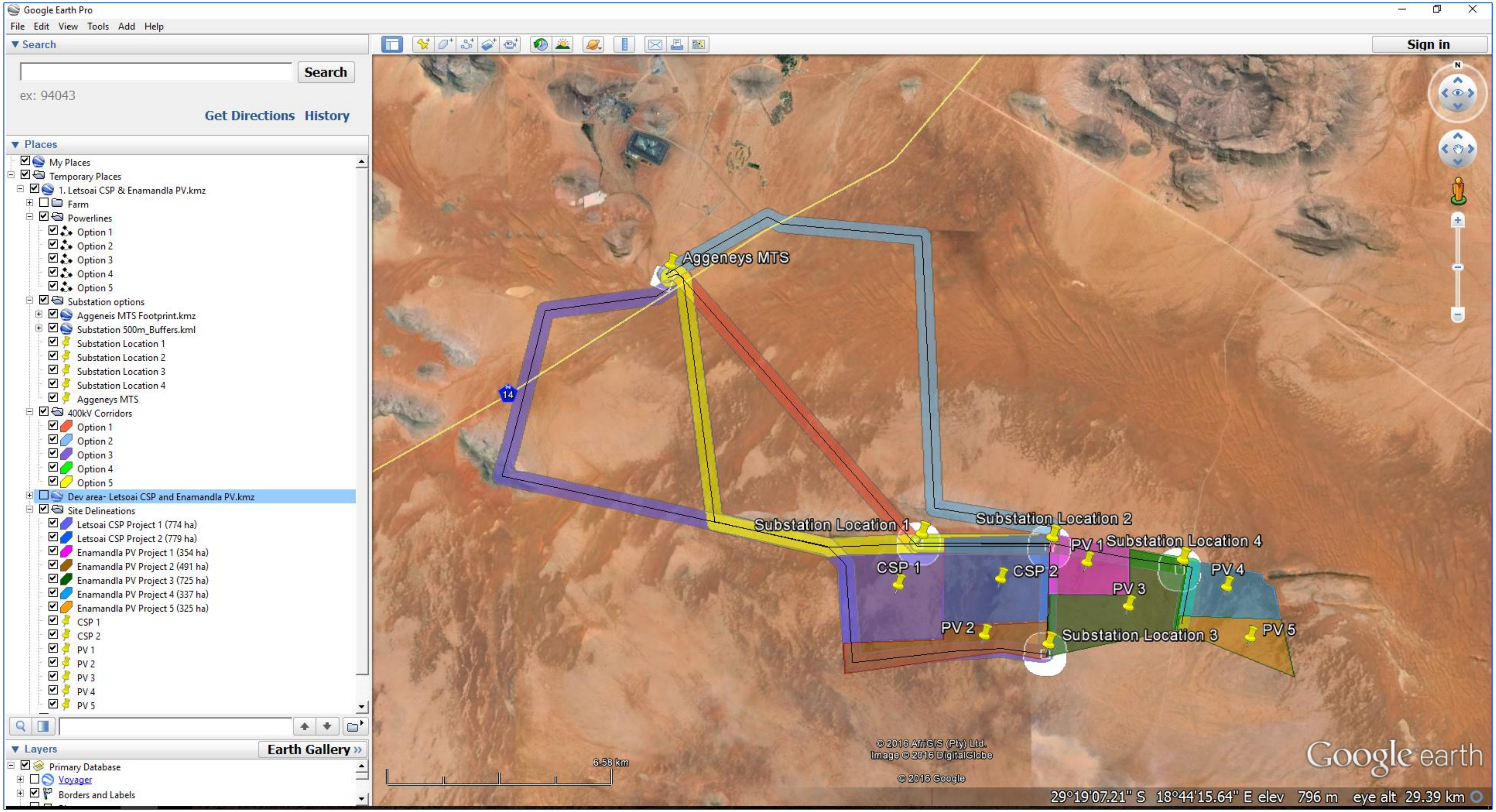

Figure 1: Map of the study area indicating all the various project components.

1.1. SCOPE AND LIMITATIONS

1.1.1 INFORMATION SOURCES

The study made use of the following information sources:

- Bird distribution data of the Southern African Bird Atlas Project2 (SABAP 2) sabap2.adu.org.za.
- The power line bird mortality incident database of the Endangered Wildlife Trust (1996 to 2008) (Jenkins *et al.* 2010).
- Atlas of Southern African Birds 1 (SABAP1) (Harrison *et al.*1997)
- 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 recorded by the Kalahari Raptor Project (Maritz 2009).
- Red Data Book of Birds of South Africa, Lesotho and Swaziland (Taylor 2015),
- Roberts Birds of Southern Africa VII (Hockey *et al.* 2005).
- (2015.4) IUCN Red List of Threatened Species (http://www.iucnredlist.org/).
- The BirdLife South Africa (BLSA) Important Bird Areas of Southern Africa directory (http://www.birdlife.org.za/conservation/important-bird-areas) (Marnewick et al. 2015).
- Satellite imagery from Google Earth.
- An intensive internet search was conducted to source information on the impacts of solar facilities on avifauna (see references).
- A site visit conducted on 16-19 November 2015, to get an overview of the habitat at the site.
- Information on bird diversity and abundance at the site is being obtained through a 12-months monitoring programme which is currently underway at the site. Data is collected through transect counts, incidental sightings, inspection of focal points and the recording of flight behaviour from vantage points.

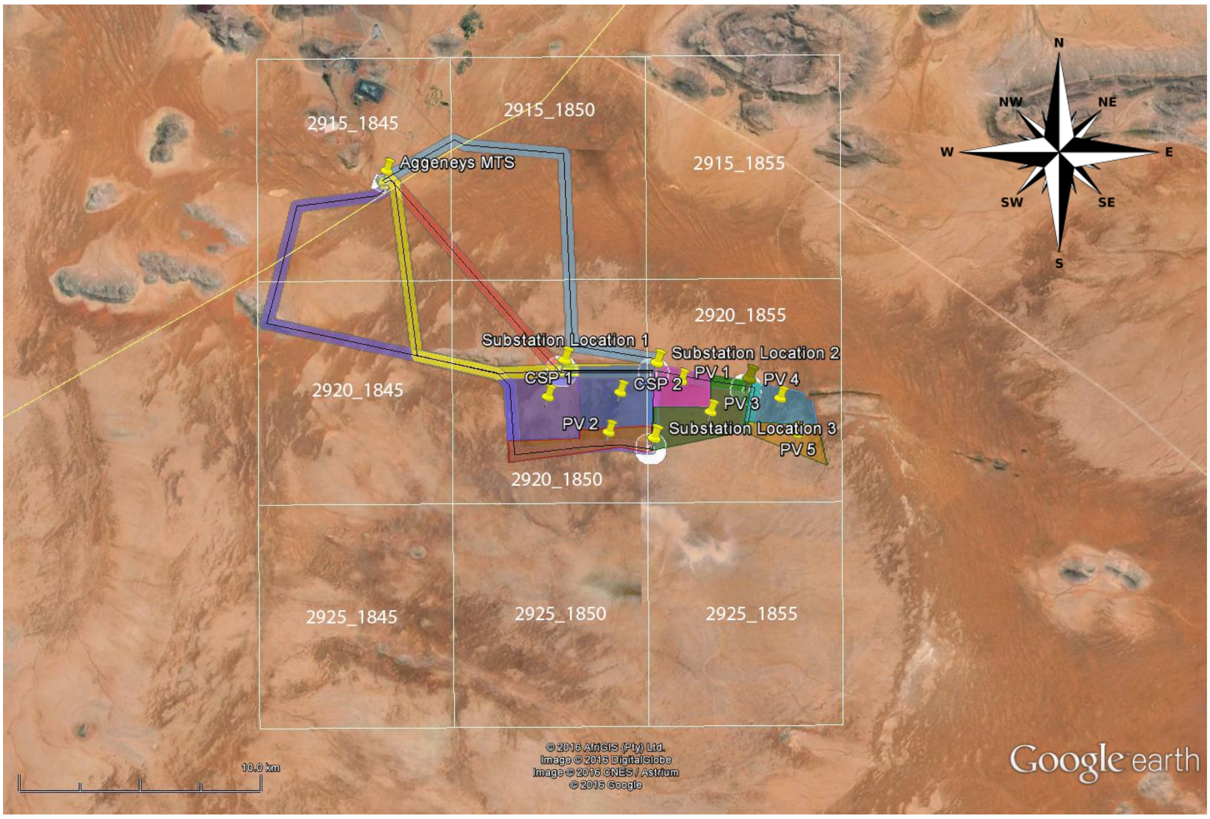

Figure 2: Area covered by the SABAP2 pentads.

1.1.2 ASSUMPTIONS AND LIMITATIONS

This study made the assumption that the sources of information used in this report are reliable. In this respect, the following must be noted:

- 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; and
  - Raptors
  - IBA trigger species

- 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). 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 are not taken into account. This aspect is dealt with under the section dealing with cumulative impacts.

- The study area was defined as the area taken up by the proposed solar facilities and the grid connections.

- Conclusions in this study are based on experience of these and similar species in different parts of South Africa. Bird behaviour can never be entirely reduced to formulas that will be valid under all circumstances. However, power line impacts can be predicted with a fair amount of certainty.

2. 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 line is 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). The PV site 5 is located in the 2920_1855 pentad. 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.

- The power line bird mortality incident database of the Endangered Wildlife Trust (1996 to 2008) was consulted to determine which of the species occurring in the study area are typically impacted upon by power lines (Jenkins *et al.* 2010).

- 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 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 (2015.4) 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 2016).

- 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 internet 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 site. Subsequent to that, additional information on bird diversity and abundance at the site is being obtained through a 12-months monitoring programme which is currently underway at the site. Data is collected through transect counts, incidental sightings, inspection of focal points and the recording of flight behaviour from vantage points.

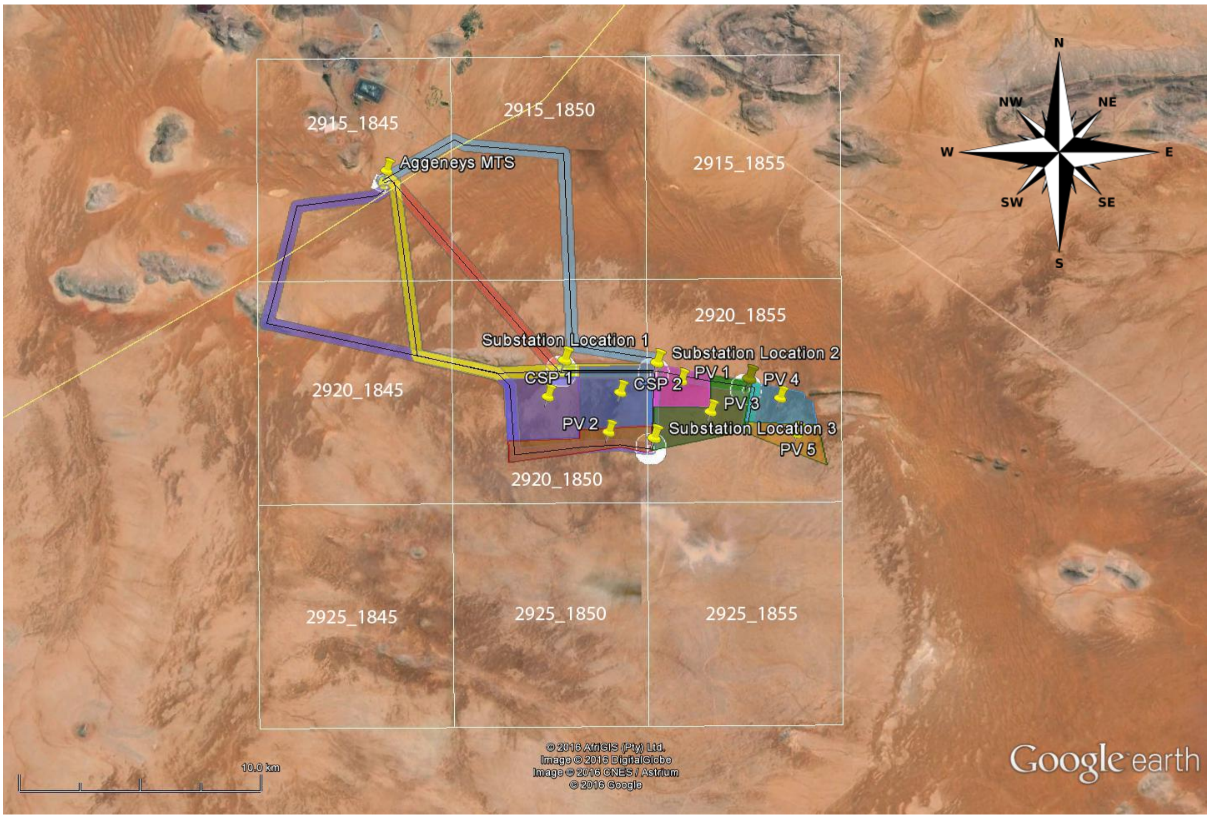

Figure 3: Area covered by the SABAP2 data.

2.1. IMPACT SCREENING TOOL

To ensure a direct comparison between various specialist studies, an impact screening tool has been developed to assess the significance of identified impacts. The screening tool will allow any impacts of very low significance to be excluded from the detailed studies in the impact assessment phase. The screening tool is based on two criteria, namely probability and severity.

Probability Scale	Severity / Beneficial Scale	1	2	3	4
	1	Very Low	Very Low	Low	Medium
	2	Very Low	Low	Medium	Medium
	3	Low	Medium	Medium	High
	4	Medium	Medium	High	High

Probability Scale

4	**Definite**
	Where the impact will occur regardless of any prevention measures
3	**Highly Probable**
	Where it is most likely that the impact will occur
2	**Probable**
	Where there is a good possibility that the impact will occur
1	**Improbable**
	Where the possibility of the impact occurring is very low

Severity / Beneficial Scale

4	**Very severe**	**Very beneficial**
	An irreversible and permanent change to the affected system(s) or party (ies) which cannot be mitigated.	A permanent and very substantial benefit to the affected system(s) or party(ies), with no real alternative to achieving this benefit.
3	**Severe**	**Beneficial**
	A long term impacts on the affected system(s) or party(ies) that could be mitigated. However, this mitigation would be difficult, expensive or	A long term impact and substantial benefit to the affected system(s) or party(ies). Alternative ways of achieving this benefit

	time consuming or some combination of these.	would be difficult, expensive or time consuming, or some combination of these.
2	**Moderately severe**	**Moderately beneficial**
	A medium to long term impacts on the affected system(s) or party (ies) that could be mitigated.	A medium to long term impact of real benefit to the affected system(s) or party(ies). Other ways of optimising the beneficial effects are equally difficult, expensive and time consuming (or some combination of these), as achieving them in this way.
1	**Negligible**	**Negligible**
	A short to medium term impacts on the affected system(s) or party(ies). Mitigation is very easy, cheap, less time consuming or not necessary.	A short to medium term impact and negligible benefit to the affected system(s) or party(ies). Other ways of optimising the beneficial effects are easier, cheaper and quicker, or some combination of these.

3. REGIONAL OVERVIEW

3.1 BIRD HABITATS

The proposed site 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 site itself 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 study area occurs mainly in summer and averages around 71mm per year (see Figure 5), 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).

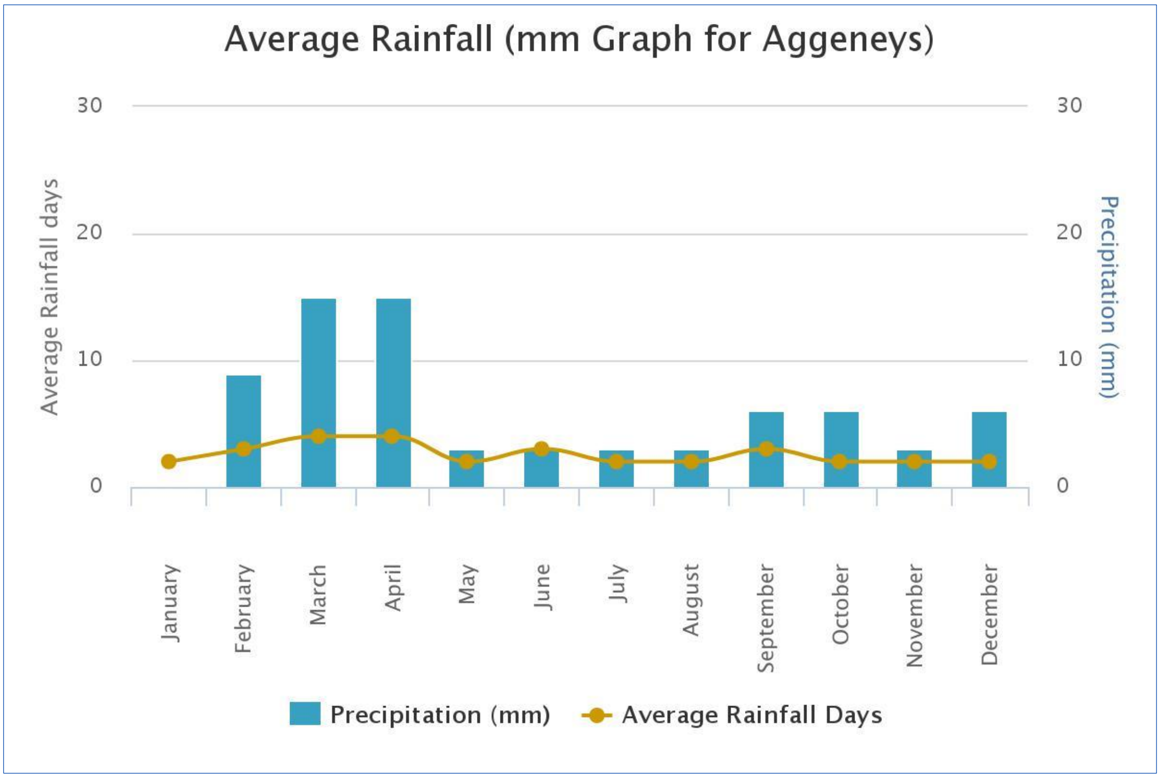

Figure 5: Average rainfall in the study area (http://www.worldweatheronline.com/aggeneys-weather-averages/north-western-province/za.aspx)

Average daily temperatures range between 29 C° in January and 14C° in July (http://www.worldweatheronline.com/aggeneys-weather-averages/north-western-province/za.aspx).

The solar development area borders directly on the Haramoep and Black Mountain (SA035) Important Bird Area (IBA). 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.

This IBA is one of only a few sites protecting the globally threatened Red Lark *Calendulauda burra*, which inhabits the red sand dunes and sandy plains with a mixed grassy dwarf shrub cover; and the near-threatened Sclater's Lark *Spizocorys sclateri*, 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 *Neotis ludwigii* and Kori Bustard *Ardeotis kori* are regularly seen. Martial Eagle *Polemaetus bellicosus*, Secretarybird *Sagittarius serpentarius*, Verreauxs' Eagle *Aquila verreauxii*, Booted Eagle

Hieraaetus pennatus, Cape Eagle-Owl *Bubo capensis* and Spotted Eagle-Owl *Bubo africanus* are present.

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

Globally threatened birds

- Red Lark,
- Sclater's Lark,
- Martial Eagle,
- Kori Bustard,
- Ludwig's Bustard and
- Secretarybird.

Regionally threatened birds

- Karoo Korhaan *Eupodotis vigorsii* and
- Verreauxs' Eagle.

Restricted-range and biome-restricted birds

- Stark's Lark,
- Karoo Long-billed Lark *Certhilauda subcoronata*,
- Black-eared Sparrow-lark *Eremopterix australis*,
- Tractrac Chat *Cercomela tractrac*,
- Sickle-winged Chat *C. sinuata*,
- Karoo Chat *C. schlegelii*,
- Layard's Tit-Babbler *Sylvia layardi*,
- Karoo Eremomela *Eremomela gregalis*,
- Cinnamon-breasted Warbler *Euryptila subcinnamomea*,
- Namaqua Warbler *Phragmacia substriata*,
- Sociable Weaver *Philetairus socius*,
- Pale-winged Starling *Onychognathus nabouroup* and
- Black-headed Canary *Serinus alario.*

Several of the IBA trigger species could potentially occur at the study area (see 2.2 Avifauna below).

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

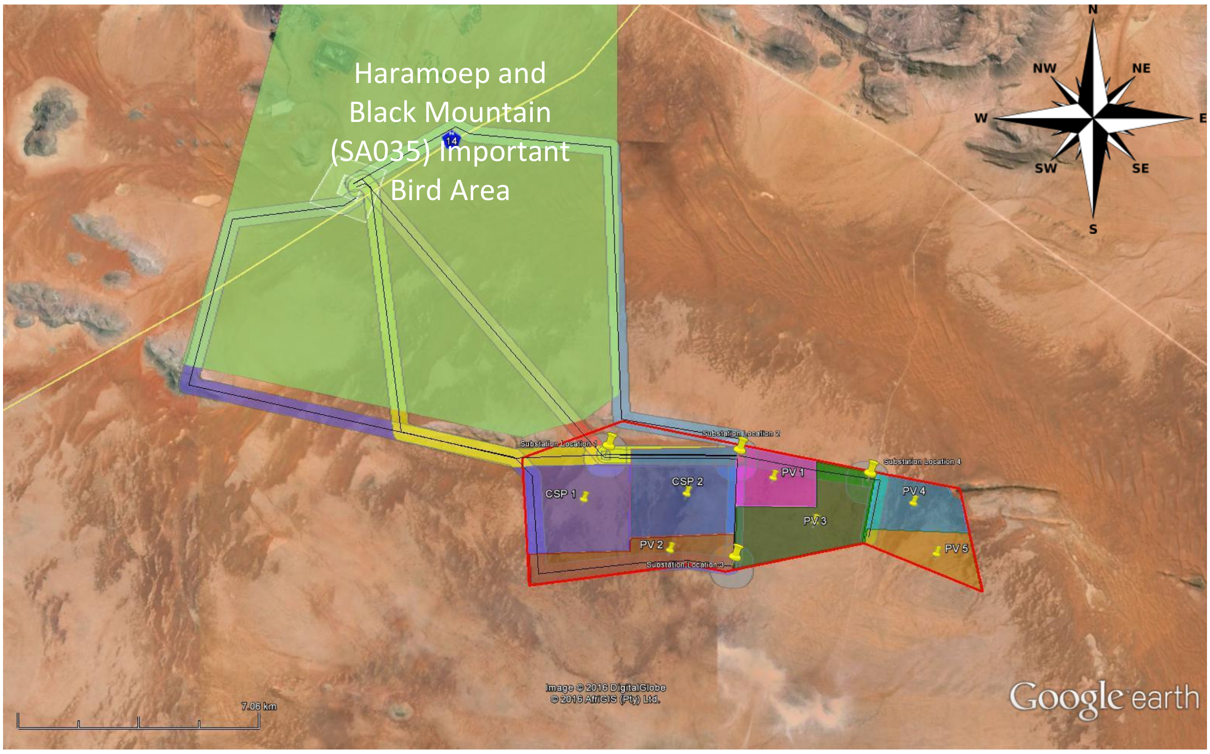

Figure 4: Haramoep and Black Mountain (SA035) Important Bird Area (green).

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 might have relevance for priority species.

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

- Water points: The land use in the study area is mostly sheep farming, with some game and cattle also present. The entire area 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 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 study 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 study 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.

3.2 AVIFAUNA

A total of 113 species could potentially occur in the study area. Of these, 42 are classified as priority species. Table 2 below lists the priority species that could potentially occur in the study area, as well as the potential impact on the species in the study area.

Table 2: Priority species that could potentially occur in the study area. **EN = Endangered VU = Vulnerable NT = Near threatened LC = Least concern**

Family name	Taxonomic name	Reporting rate	Global status	Regional status	Endemic - South Africa	Endemic - Southern Africa	Priority species	Recorded during pre-construction monitoring	Displacement due to disturbance	Displacement due to habitat transformation	Collision with PV panels	Collisions with heliostats	Burning through solar flux	Collision with powerlines
Bustard, Ludwig's	*Neotis ludwigii*	7.41	EN	EN		Near-endemic	x	x	x	x			x	x
Chat, Tractrac	*Cercomela tractrac*	14.81				Near-endemic	x	x	x	x	x	x		
Harrier, Montagu's	*Circus pygargus*						x	x		x		x	x	x
Kestrel, Greater	*Falco rupicoloides*	37.04					x	x	x	x	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	x	x		
Secretarybird	*Sagittarius serpentarius*	0	VU	VU			x	x	x	x			x	x
Snake-eagle, Black-chested	*Circaetus pectoralis*	7.41					x	x	x	x			x	
Sparrowlark, Black-eared	*Eremopterix australis*	11.11			Near endemic	Endemic	x	x	x	x	x	x		
Buzzard, Jackal	*Buteo rufofuscus*	3.7			Near endemic	Endemic	x		x	x			x	
Canary, Black-headed	*Serinus alario*	11.11			Near endemic	Endemic	x		x	x	x	x		
Chat, Karoo	*Cercomela schlegelii*	44.44				Near-endemic	x		x	x	x	x		
Chat, Sickle-winged	*Cercomela sinuata*	7.41			Near endemic	Endemic	x		x	x	x	x		

Family name	Taxonomic name	Reporting rate	Global status	Regional status	Endemic - South Africa	Endemic - Southern Africa	Priority species	Recorded during pre-construction monitoring	Displacement due to disturbance	Displacement due to habitat transformation	Collision with PV panels	Collisions with heliostats	Burning through solar flux	Collision with powerlines
Coot, Red-knobbed	*Fulica cristata*	11.11					x				x	x		x
Duck, Maccoa	*Oxyura maccoa*	7.41	NT	NT			x				x	x		x
Duck, Yellow-billed	*Anas undulata*	3.7					x				x	x		x
Eagle, Booted	*Hieraaetus pennatus*	3.7					x		x	x	x	x	x	
Eagle, Martial	*Polemaetus bellicosus*	3.7	VU	EN			x		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	x		
Falcon, Lanner	*Falco biarmicus*	3.7	LC	VU			x		x	x	x	x	x	
Falcon, Pygmy	*Polihierax semitorquatus*	7.41					x			x	x	x		
Flamingo, Greater	*Phoenicopterus roseus*		LC	NT			x				x	x	x	x
Flamingo, Lesser	*Phoenicopterus minor*		LC	NT			x				x	x	x	x
Flycatcher, Fairy	*Stenostira scita*	3.7			Near endemic	Endemic	x		x	x	x	x		
Goose, Egyptian	*Alopochen aegyptiaca*	11.11					x				x	x	x	x
Grebe, Little	*Tachybaptus ruficollis*	11.11					x				x	x		x
Kestrel, Rock	*Falco rupicolus*	40.74					x	x	x	x	x	x	x	
Kite, Black-shouldered	*Elanus caeruleus*	3.7					x		x	x	x	x	x	

Family name	Taxonomic name	Reporting rate	Global status	Regional status	Endemic - South Africa	Endemic - Southern Africa	Priority species	Recorded during pre-construction monitoring	Displacement due to disturbance	Displacement due to habitat transformation	Collision with PV panels	Collisions with heliostats	Burning through solar flux	Collision with powerlines
Lark, Cape Clapper	*Mirafra apiata*	11.11			Near endemic	Endemic	x		x	x	x	x		
Lark, Karoo Long-billed	*Certhilauda subcoronata*	48.15				Endemic	x		x	x	x	x		
Lark, Stark's	*Spizocorys starki*	14.81				Near-endemic	x		x	x	x	x		
Ruff	*Philomachus pugnax*	3.7					x				x	x		
Sandpiper, Common	*Actitis hypoleucos*	3.7					x				x	x		
Sandpiper, Wood	*Tringa glareola*	3.7					x				x	x		
Shelduck, South African	*Tadorna cana*	14.81				Endemic	x				x	x		x
Shoveler, Cape	*Anas smithii*	7.41				Near-endemic	x				x	x		x
Starling, Pale-winged	*Onychognathus nabouroup*	77.78				Near-endemic	x		x		x	x		
Stilt, Black-winged	*Himantopus himantopus*	7.41					x				x	x		
Stint, Little	*Calidris minuta*	3.7					x				x	x		
Teal, Cape	*Anas capensis*	11.11					x				x	x		
Weaver, Sociable	*Philetairus socius*	77.78				Endemic	x		x	x	x	x		

4. IMPACTS AND ISSUES IDENTIFICATION

4.1 IMPACTS OF SOLAR FACILITIES AND ASSOCIATED INFRASTRUCTURE ON AVIFAUNA

The full spectrum of impacts of solar facilities on birds is only now starting to emerge from compliance reports at solar facilities. These can be summarised as follows:

- Temporary displacement due to disturbance associated with the construction of the solar plant and associated infrastructure;
- Collisions with the heliostats or solar panels;
- Permanent displacement due to habitat transformation; and
- Collisions with the associated power lines resulting in mortality.

4.1.1 IMPACTS OF THE SOLAR INFRASTRUCTURE ON BIRDS

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

- Collision-related fatality — fatality resulting from the direct contact of the bird with a project structure(s). This type of fatality has been documented at solar projects of all technology types.
- Solar-flux-related fatality — fatality resulting from the burning/singeing effects of exposure to concentrated sunlight. Passing through the area of solar flux may result in: (a) direct fatality; (b) singeing of flight feathers that cause loss of flight ability, leading to impact with other objects; or (c) impairment of flight capability to reduce the ability to forage or avoid predators, resulting in starvation or predation of the individual (Kagan *et al.* 2014). Solar-flux-related fatality has been observed only at facilities employing central receiver (power tower) technologies and not PV technologies.

A literature review reveals a scarcity of published, scientifically vetted information regarding large-scale solar plants and birds. To date, only one published scientific study has been conducted on the direct impacts of solar facilities on avifauna, namely “Avian mortality at a solar energy power plant” by McCrary, McKernan, Schreiber, Wagner & Sciarrotta 1986. This describes the results of monitoring at the experimental Solar One solar power plant in southern California (now de-commissioned), which was a 10 megawatt, central receiver solar power plant consisting of a 32-ha field of 1 818, 6.9 x 6.9m mirrors (heliostats) which concentrates sunlight on a centrally located, tower-mounted boiler, 86m in height. Since then, several much larger plants have been constructed in the Desert Southwest of the USA namely:

- the 250MW, 1 300ha California Valley Solar Ranch (CVSR) PV plant (completed in 2013),
- the 377 MW, 1 600ha Ivanpah central receiver CSP plant (completed in 2014),
- the 550MW, 1 600ha Desert Sunlight PV plant (completed in 2015) and
- the 250MW, 1 880ha Genesis Solar Energy parabolic trough Concentrated Solar Power plant (completed in 2014).

McCrary *et al.* (1986) searched for dead birds amongst the heliostat mirrors and around the central receiver tower at Solar One, and they estimated a bird fatality rate caused by bird collisions with heliostat mirrors and the tower, and by heat encountered when birds flew through the concentrated sunlight reflected toward the tower. Their forty visits (one week apart) to the facility over a two-year period revealed 70 bird carcasses involving 26 species. It was estimated that between 10% and 30% of carcasses were removed by scavengers in between visits, so the actual mortality figure may have been slightly higher. They estimated that 57 (81%) of these birds died through collision with infrastructure, mostly the heliostats. Species killed in this manner included waterbirds, small raptors, gulls, doves, sparrows and warblers. Thirteen (19%) of the birds died through burning in the standby points. Species killed in this manner were mostly swallows and swifts. However, they appeared to have under-appreciated the magnitude of the impacts caused by Solar One, likely because they did not know as much as scientists know today about scavenger removal rates and searcher detection error (Smallwood 2014). Their search pattern was not fixed, so it was not as rigorous as modern searches at wind energy projects and other energy generation and transmission facilities. They placed 19 bird carcasses to estimate the proportion remaining over the average time span between their visits to the project site, though they provided few details about their scavenger removal trial. It is known today that the results of removal trials can vary substantially for many reasons, including the species used, time since death, and the number of carcasses placed in one place at one time, etc. (Smallwood 2007). They also performed no searcher detection trials, because they concluded that the ground was sufficiently exposed that all available bird carcasses would have been found. This conclusion would not be accepted today, based on modern fatality search protocols. Smallwood (2014) recalculated the estimated fatality rate at Solar One, but this time using US national averages to represent scavenger removal rates and searcher detection rates (see Smallwood 2007, 2013). He re-calculated it as 87.4 mortalities per year with an 80% confidence interval (CI) of 69.6 to 105.5.

Systematic avian monitoring surveys were conducted at the 1 600ha Ivanpah Solar Electric Generating System CSP (Ivanpah) central receiver facility in accordance with the Project's Avian & Bat Monitoring and Management Plan over four seasons from 29 October 2013 to 20 October 2014 (Harvey & Associates 2015). These surveys included avian point counts, raptor/large bird surveys and facility monitoring for avian fatalities. Overall, approximately 29.2% of the facility was searched (not including offsite transects, which are outside the facility). A total of 695 avian mortalities (including 25 injured birds that died), and eight injured birds were found over the first four seasons. These avian fatality search results, along with searcher efficiency carcass removal rates from trials conducted onsite, were input into a fatality estimator model (Huso 2010) to provide an estimate of the fatalities for the facility. Overall, the estimated avian mortality was 1492 or 42.6% of birds (90% confidence interval 1,046-2,371) from known causes and 2012 or 57.4% of birds (90% confidence interval 1,450-3,334) from unknown causes. The sources of mortality for known causes were 47.4% singed, 51.9% with evidence of collision effects, and 0.7% from other project causes. For the fatalities from unknown causes, the estimate was driven by a high number of feather spots (47.2% of all detections) which may have led to over-estimation of the number of unknowns.

The estimate of 3 504 mortalities at Ivanpah contrasts markedly with an earlier estimate by Smallwood (2014). Smallwood calculated the estimated annual mortality at Ivanpah to be potentially as high as 28 380 birds per year. In his testimony to the California Energy Commission he explains as follows: "The April searches turned up 101 fatalities and the May searches discovered another 82 fatalities. If the searches were performed according to document TB201315, which summarised a monitoring plan for Ivanpah, then weekly searches were performed at 20% of the heliostat mirrors at Ivanpah during April and May 2014. Given the size range of the birds found, including many hummingbirds, swallows and warblers, I would predict that the overall adjustment rate for searcher detection and carcass persistence would be no greater than 20%. That means the number of fatalities found would be divided by 0.2 to arrive at an adjusted estimate of 473 fatalities per month within the search areas. This number then would be divided by 0.2 (corresponding with 20% of the project being searched) to extrapolate the fatality estimate to the rest of Ivanpah, yielding 2,365 birds per month during April and May 2014. If this rate persisted yearlong, then Ivanpah might be killing 28,380 birds, which would be 3.6 times greater than the fatality rate I predicted." With such widely differing estimates, it is clear that systematic study and efforts to standardize data through the development of systematic monitoring protocols are needed to make any conclusions about the avian risks of utility-scale solar development.

Weekly mortality searches at 20% coverage are also being conducted at the 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 2:

Table 2: 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

When the results of the three solar plants are pooled, collisions with reflective surfaces (impact trauma) emerge as the highest identifiable cause of avian mortality, but most mortality could not be traced to an identifiable cause.

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 at the two power tower solar facilities (Ivanpah and Solar One). Collision ranked second at Desert Sunlight, CVSR, and Genesis. 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.

Ho (2015) presented a summary of avian mortality at five CSP plants, and concluded that based on available evidence, the risk of burning due to solar flux are associated with standby points, and not when the heliostats are focussed on the receiver. At the solar receiver, flux levels can reach near 1,000 kW/m2, or about 1,000 suns, and the flux drops off as one moves away from the receiver. Any object (e.g., receiver pipe, dust particle, bird) exposed to solar flux will absorb energy and be affected by that energy based on the object's size and optical properties (dark objects absorb sunlight better than light objects), its mass and thermal heat capacity (how much absorbed energy is required to generate a temperature increase), and its duration in the flux zone. The air temperature itself is virtually unaffected except in the immediate vicinity of the receiver. This is because air absorbs very little of the solar energy, and only air directly contacting the receiver is heated to any significant degree (Walston *et al*. 2015).

The amount of solar energy absorbed by an object in the region of solar flux can be calculated based on the area of the object exposed, intensity of the light, absorptivity of the object, length of exposure time, and mass of the object. However, predicting the amount of energy absorbed by a bird flying through the solar flux region is difficult given the variability of these many factors (Walston *et al.* 2015).

BrightSource Energy and the US Fish and Wildlife Service (USFWS) have performed preliminary tests on the effect of sunlight or heat, respectively, on bird feathers. The BrightSource study indicated no observable effects on feathers exposed to 50 kW/m2 of solar flux for 30 seconds. Higher flux levels caused visible effects within 20 to 30 seconds. The USFWS work, reported in Kagan *et al*. (2014), exposed feathers to hot air for 30-second durations. Visible effects were noted starting at temperatures of 400°C. Recall that air temperature in a zone of high flux is virtually unchanged from ambient conditions. Rather, these combined results suggest that the feathers themselves absorb sufficient energy during the 30-second test to reach a temperature sufficient to cause damage. Although these results are preliminary, they suggest that zones with flux greater than 50 kW/m2 represent the region of concern for flux effects on birds. The actual effect on a given bird depends on a number of variables, including flight path, species, ambient conditions, and light intensity; further study is necessary to understand and refine this hazard threshold. Walston *et al.* (2015) analysed three scenarios at a typical commercial CSP tower, using 50 kW/m² as the threshold for potential harmful effects on birds. They recommend that various aiming strategies should be employed to reduce the airspace where 50 kW/m² or more solar flux is generated during standby mode. In summary, they recommend that any alternative standby aiming methodology should be designed to reduce the peak flux as well as the volume of airspace with flux exceeding the desired minimum threshold level, while at the same time minimizing negative impacts on plant operations.

Initial indications from one such trial, implemented at Ivanpah and Crescent Dunes Solar Energy Project in Nevada, used an aim point strategy that limited flux to less than 5 kW/m2. In the weeks following this practice zero avian fatalities due to high flux were reported. This was achieved by recalibrating the standby algorithm so that fewer mirrors would be focused on any specific focal point during standby, thereby reducing the solar flux (Kraemer 2015).

Sheet glass used in commercial and residential buildings has been well established as a hazard for birds. 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 and heliostats 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). 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. The unusually high number of waterbird mortalities at the Desert Sunlight PV facility (44%) seems to support this hypothesis. 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).

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). This could be an experimental mitigation measure should results of the operational phase monitoring indicate significant mortality of priority avifauna due to collisions at the proposed Sand Draai solar facilities.

It is clear from this brief 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 such time as statistically tested results emerge from existing compliance programmes, conclusions will inevitably be largely speculative and based on professional opinion.

4.1.2 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.

At the 1 600ha Ivanpah Solar Electric Generating System CSP (Ivanpah) facility, seventeen avian use surveys were conducted at each of 80 survey points (40 in desert bajada habitat and 40 in heliostat arrays), representing more than 350 hours of survey effort. Species composition was compared between these avian use survey results and detections during standardized monitoring surveys. A total of 54 bird species were recorded on avian use surveys during the first four seasons. Total species richness was highest in the desert (47 species), and much lower in the heliostat grids (24 species).

Evidently, the same is true for PV plants. 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 is generally detrimental to wildlife on a local scale. It is highly likely that the same pattern of reduced avifaunal densities will manifest itself at the proposed solar plants.

4.1.3 MORTALITY ON ASSOCIATED TRANSMISSION LINE INFRASTRUCTURE

Negative impacts on birds by electricity infrastructure generally take two forms namely electrocution and collisions (Ledger & Annegarn 1981; Ledger 1983; Ledger 1984; Hobbs and Ledger 1986a; Hobbs & Ledger 1986b; Ledger, Hobbs & Smith, 1992; Verdoorn 1996; Kruger & Van Rooyen 1998; Van Rooyen 1998; Kruger 1999; Van Rooyen 1999; Van Rooyen 2000; Van Rooyen 2004; Jenkins *et al.* 2010). Birds also impact on the infrastructure through nesting and streamers, which can cause interruptions in the electricity supply (Van Rooyen *et al.* 2002).

Electrocution refers to the scenario where a bird is perched or attempts to perch on the electrical structure and causes an electrical short circuit by physically bridging the air gap between live components and/or live and earthed components (Van Rooyen 2004). The electrocution risk is largely determined by the pole/tower design. In the case of the proposed solar facilities, no electrocution risk is envisaged because the design of the steel mono-pole 132kV lines will not pose an electrocution threat to any of the priority species which are likely to occur at the site.

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)."

From incidental record keeping by the Endangered Wildlife Trust, it is possible to give a measure of what species are generally susceptible to power line collisions in South Africa (see Figure 5 below - Jenkins *et al.* 2010).

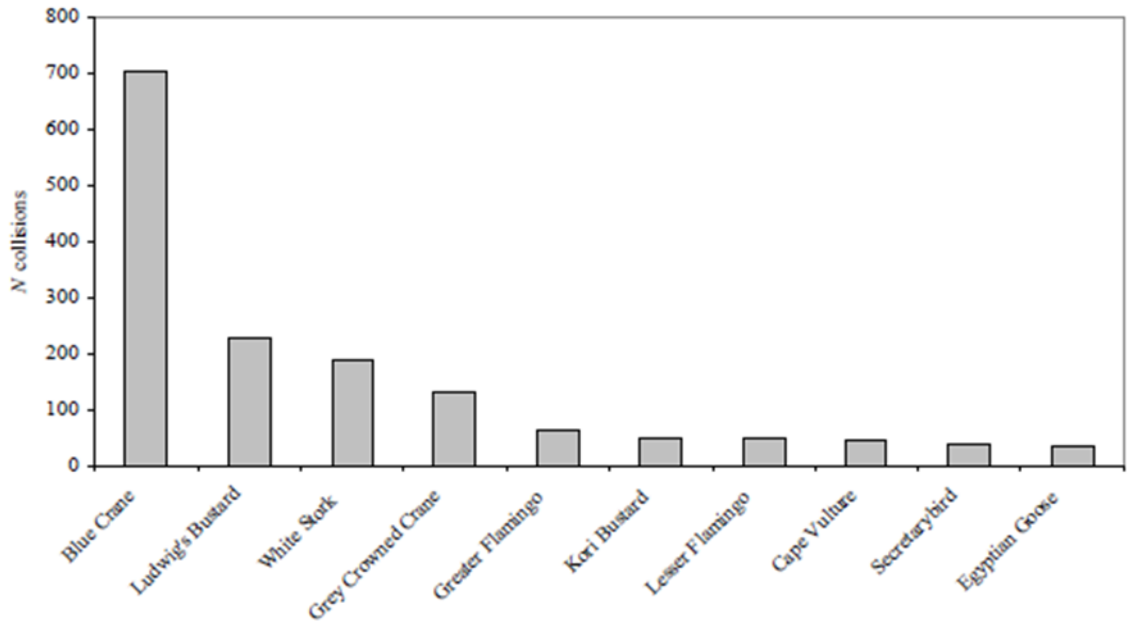

Figure 5: The top 10 collision prone bird species in South Africa, in terms of reported incidents contained in the Eskom/EWT Strategic Partnership central incident register 1996 - 2008 (Jenkins *et al.* 2010)

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).

4.2. ENAMANDLA PV SITE 5

4.2.1 DISPLACEMENT DUE TO DISTURBANCE ASSOCIATED WITH THE CONSTRUCTION AND DE-COMMISSIONING OF THE PV PLANT AND ASSOCIATED ROADS, POWERLINE AND CABLES (CONSTRUCTION AND DE-COMMISSIONING)

The construction (and de-commissioning) of the PV plant and associated infrastructure (roads, powerline and cables) 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.

DISPLACEMENT DUE TO DISTURBANCE ASSOCIATED WITH THE CONSTRUCTION AND DE-COMMISSIONING OF THE PV PLANT, ASSOCIATED ROADS, POWERLINE AND CABLES (CONSTRUCTION AND DE-COMMISSIONING)
Severity / Beneficial Scale

		1	2	3	4
Probability Scale	1	Very Low	Very Low	Low	Medium
	2	Very Low	Low	Medium	Medium
	3	Low	Medium	**Medium**	High
	4	Medium	Medium	High	High

4.2.2 DISPLACEMENT DUE TO HABITAT TRANSFORMATION ASSOCIATED WITH THE PV PLANT AND ASSOCIATED ROAD, POWERLINE AND CABLES (OPERATION)

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 concentrators, but it will be a fraction of what was available before the construction of the plant, and it will contain few shrubs as this will most likely have been cleared prior to construction. 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 passerine species will continue to use the habitat available within the solar facility albeit at lower densities. This will however differ from species to species and it may not be true for all of 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, Lanner Falcon and Pygmy Falcon) the potential availability of carcasses or injured birds due to collisions with the solar panels may actually attract them to the area. The significance of the potential displacement impact is difficult to assess at this stage and will only become clear through operational phase surveys.

DISPLACEMENT DUE TO HABITAT TRANSFORMATION ASSOCIATED WITH THE PV PLANT AND ASSOCIATED ROAD, POWERLINE AND CABLES (OPERATION)

Severity / Beneficial Scale

Probability Scale		1	2	3	4
	1	Very Low	Very Low	Low	Medium
	2	Very Low	Low	Medium	Medium
	3	Low	Medium	Medium	**High**
	4	Medium	Medium	High	High

4.2.3 COLLISIONS WITH THE SOLAR PANELS (OPERATION)

The priority species that were recorded in the study area which 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 flocking species i.e. Grey-backed Sparrow-lark, Namaqua Sandgrouse, Sociable Weaver 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, Lanner Falcon and Pygmy Falcon which will feed on dead and injured birds which could in turn expose them to collision risk, especially when pursuing injured birds. In addition, the “lake effect” produced by the solar panels may potentially draw various water birds to the area. The unusually high number of waterbird mortalities at facilities which are all situated in extremely arid environments i.e. Desert Sunlight facility (44%), Genesis (19%) and Ivanpah (10%) is noted in this respect. The presence of evaporation ponds may be an aggravating factor. The evaporation ponds, in combination with the “lake effect” might attract Greater and Lesser Flamingo. However, it is not possible to tell whether this will actually happen until post-construction monitoring reveals actual mortality at the site.

COLLISIONS WITH THE SOLAR PANELS (OPERATION)

Probability Scale \ Severity / Beneficial Scale	1	2	3	4
1	Very Low	Very Low	Low	Medium
2	Very Low	**Low**	Medium	Medium
3	Low	Medium	Medium	High
4	Medium	Medium	High	High

5. TERMS OF REFERENCE FOR THE IMPACT ASSESSMENT PHASE

The Birds and Renewable Energy Specialist Group (BARESG), convened by BirdLife South Africa and the Wildlife and Energy Programme of the Endangered Wildlife Trust, proposes the following guidelines and monitoring protocols for evaluating utility-scale solar energy development proposals. The Guidelines are aimed at environmental assessment practitioners, avifaunal specialists, developers and regulators and propose a tiered assessment process, including:

- Initial screening or scoping – an initial assessment of the likely avifauna and possible impacts, preferably informed by a brief site visit and by desk-top collation of available data; also including the design of a site-specific survey and monitoring project should this be deemed necessary. This has been completed.
- Data collection – further accumulation and consolidation of the relevant avian data, possibly including the execution of baseline data collection work as specified by the scoping study, intended to inform the avian impact study. This is currently happening through an onsite monitoring programme which is aimed at providing a baseline picture of the avifauna over a period of a year.
- Impact assessment - a full assessment of the likely impacts and available mitigation options, based on the results of systematic and quantified monitoring which is currently taking place. This will include the systematic assessment of all the identified impacts, using methodology adapted from T Hacking, AATS-Envirolink,1988: An innovative approach to structuring environmental impact assessment reports. In: IAIA SA 1998 Conference Papers and Notes.

6. CONCLUSIONS AND RECOMMENDATIONS

6.1. ENAMANDLA PV SITE 5

6.1.1 DISPLACEMENT DUE TO DISTURBANCE ASSOCIATED WITH THE CONSTRUCTION AND DE-COMMISSIONING OF THE PV PLANT AND ASSOCIATED ROADS, POWERLINE AND CABLES (CONSTRUCTION AND DE-COMMISSIONING)

The construction (and de-commissioning) of the PV plant and associated infrastructure (roads, powerline and cables) will result in a significant amount of movement and noise, which will lead to displacement of priority avifauna from the site. It is highly likely that most priority species will vacate the area for the duration of these activities. **The impact on priority species is expected to be medium.**

Potential mitigation measures are:

- 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 possible.
- 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.

6.1.2 DISPLACEMENT DUE TO HABITAT TRANSFORMATION ASSOCIATED WITH THE PV PLANT AND ASSOCIATED ROAD, POWERLINE AND CABLES (OPERATION)

The construction of the PV plant and associated infrastructure will result in the radical transformation of the existing natural habitat. 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 passerine species will continue to use the habitat available within the solar facility albeit at lower densities. This will however differ from species to species and it may not be true for all of 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 the potential availability of carcasses or injured birds due to collisions with the solar panels may actually attract them to the area. **The significance of the potential displacement impact is likely to be high**.

Potential mitigation is limited, and includes the following:

- Maximum use should be made of existing access roads and the construction of new roads should be kept to a minimum, as far as possible.
- 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.

6.1.3 COLLISIONS WITH THE SOLAR PANELS (OPERATION)

The so-called “lake effect” could act as a potential attraction to some priority species and it is expected that flocking species 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 which will feed on dead and injured birds which could in turn expose them to collision risk, especially when pursuing injured birds. In addition, the “lake effect” produced by the panels may potentially draw various water birds to the area. The presence of evaporation ponds may be an aggravating factor. The evaporation ponds, in combination with the “lake effect” might attract waterbirds. **Expected impact on priority species is medium.**

Potential mitigation measures are:

- Formal operational phase monitoring should be implemented once the solar arrays have been constructed. The purpose of this would be to establish to what extent displacement of priority species have taken place.
- Carcass searches should be implemented to search the ground between solar arrays.
- 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.

7. EXCLUSION ZONES

There are currently no exclusion zones from an avifaunal impact perspective.

8. REFERENCES

- ALLAN, D.G. 1994. The abundance and movements of Ludwig's Bustard *Neotis ludwigii*. *Ostrich* 65: 95-105
- ANIMAL DEMOGRAPHY UNIT. The southern African Bird Atlas Project 2. University of Cape Town. http://sabap2.adu.org.za. Accessed 02/04/2016.
- AVIAN POWER LINE INTERACTION COMMITTEE (APLIC). 2012. *Mitigating Bird Collisions with Power Lines: The State of the Art in 2012*. Edison Electric Institute. Washington D.C.
- BARNES, K.N. (ed.) 1998. The Important Bird Areas of southern Africa. BirdLife South Africa: Johannesburg.
- BARRIENTOS R, PONCE C, PALACIN C, MARTÍN CA, MARTÍN B, ET AL. 2012. Wire marking results in a small but significant reduction in avian mortality at power lines: A BACI Designed Study. PLoS ONE 7(3): e32569. doi:10.1371/journal.pone.0032569.
- BARRIENTOS, R., ALONSO, J.C., PONCE, C., PALACÍN, C. 2011. Meta-Analysis of the effectiveness of marked wire in reducing avian collisions with power lines. Conservation Biology 25: 893-903.
- BEAULAURIER, D.L. 1981. Mitigation of bird collisions with transmission lines. Bonneville Power Administration. U.S. Dept. of Energy.
- COUNTY OF MERCED. 2014. Draft Environmental Impact Report for the Wright Solar Park Conditional Use Permit Application CUP12-017. Public Draft. July. (ICF 00552.13.) Merced, CA. Prepared by ICF International, Sacramento, CA.
- H. T. HARVEY & ASSOCIATES. 2014a. California Valley Solar Ranch Project Avian and Bat Protection Plan Sixth Quarterly Post construction Fatality Report 16 November 2013 - 15 February 2014.
- H. T. HARVEY & ASSOCIATES. 2014b. California Valley Solar Ranch Project Avian and Bat Protection Plan Sixth Quarterly Post construction Fatality Report 16 February 2014 - 15 May 2014.
- H. T. HARVEY & ASSOCIATES. 2015. Ivanpah Solar Electric Generating System Avian & Bat Monitoring Plan 2013-2014 Annual Report.
- HARRISON, J.A., ALLAN, D.G., UNDERHILL, L.G., HERREMANS, M., TREE, A.J., PARKER, V & BROWN, C.J. (eds). 1997. The atlas of southern African birds. Vol 1 & 2. BirdLife South Africa, Johannesburg.
- HERNANDEZ, R.R., *et al.*, 2014, "Environmental Impacts of Utility-Scale Solar Energy," Renewable and Sustainable Energy Reviews 29: 766–779.

- HOBBS, J.C.A. & LEDGER J.A. 1986a. The Environmental Impact of Linear Developments; Power lines and Avifauna. *Proceedings of the Third International Conference on Environmental Quality and Ecosystem Stability*. Israel, June 1986.
- HOBBS, J.C.A. & LEDGER J.A. 1986b. Power lines, Birdlife and the Golden Mean. *Fauna and Flora,* 44:23-27.
- HOOGSTAD, C. Email communication from the manager of the Eskom-EWT Strategic Partnership to the author on 25 June 2015.
- HOCKEY P.A.R., DEAN W.R.J., AND RYAN P.G. 2005. Robert's Birds of Southern Africa, seventh edition. Trustees of the John Voelcker Bird Book Fund, Cape Town.
- HO, K.C. 2015. Review of Avian Mortality Studies at Concentrating Solar Power Plants. Report by Sandia National Laboratories for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.
- HUSO, M. 2010. An estimator of wildlife fatality from observed carcasses. Environmetrics 22(3):318–329. Doi: 10.1002/env.1052
- IVANPAH SOLAR ELECTRIC GENERATING SYSTEM. 2014a. ISEGS Monthly Compliance Report 43 April_2014.
- IVANPAH SOLAR ELECTRIC GENERATING SYSTEM. 2014b. ISEGS Monthly Compliance Report 44 May_2014.
- JENKINS, A., DE GOEDE, J.H. & VAN ROOYEN, C.S. 2006. Improving the products of the Eskom Electric Eagle Project. Unpublished report to Eskom. Endangered Wildife Trust.
- JENKINS, A. & SMALLIE, J. 2009. Terminal velocity: the end of the line for Ludwig's Bustard? Africa Birds and Birding. Vol 14, No 2.
- JENKINS, A.R., SMALLIE, J.J. & DIAMOND, M. 2010. Avian collisions with power lines: a global review of causes and mitigation with a South African perspective. *Bird Conservation International* 20: 263-278.
- KAGAN, R. A., T. C. VINER, P. W. TRAIL, AND E. O. ESPINOZA. 2014. Avian Mortality at Solar Energy Facilities in Southern California: A Preliminary Analysis. National Fish and Wildlife Forensics Laboratory.
- KOOPS, F.B.J. & DE JONG, J. 1982. Vermindering van draadslachtoffers door markering van hoogspanningsleidingen in de omgeving van Heerenveen. Electrotechniek 60 (12): 641 – 646.
- KRAEMER, S. 2015. One weird trick prevents bird deaths at solar towers. Available from: http://cleantechnica.com/2015/04/16/one-weird-trick-prevents-bird-deaths-solar-towers/
- KRUGER, R. & VAN ROOYEN, C.S. 1998. Evaluating the risk that existing power lines pose to large raptors by using risk assessment methodology: The Molopo Case Study. *Proceedings of the 5th World Conference on Birds of Prey and Owls*. August 4-8,1998. Midrand, South Africa.
- KRUGER, R. 1999. *Towards solving raptor electrocutions on Eskom Distribution Structures in South Africa*. Bloemfontein (South Africa): University of the Orange Free State. (M. Phil. Mini-thesis)
- LEDGER, J. 1983. *Guidelines for Dealing with Bird Problems of Transmission Lines and Towers.* Eskom Test and Research Division. (Technical Note TRR/N83/005).
- LEDGER, J.A. & ANNEGARN H.J. 1981. Electrocution Hazards to the Cape Vulture (*Gyps coprotheres*) in South Africa. *Biological Conservation* 20:15-24.
- LEDGER, J.A. 1984. Engineering Solutions to the Problem of Vulture Electrocutions on Electricity Towers. *The Certificated Engineer*, 57:92-95.

- LEDGER, J.A., J.C.A. HOBBS & SMITH T.V. 1992. Avian Interactions with Utility Structures: Southern African Experiences. *Proceedings of the International Workshop on Avian Interactions with Utility Structures*. Miami (Florida), Sept. 13-15, 1992. Electric Power Research Institute.
- LOVICH, J.E. & ENNEN, J.R.2011. Wildlife Conservation and Solar Energy Development in the Desert Southwest, United States. BioScience December 2011 / Vol. 61 No. 12.
- MACLEAN, G.L. 1999. Southern African endemic birds: their distribution and conservation. An invited evening public lecture. http://www.int-ornith-union.org/files/proceedings/durban/South%20African%20Papers/SApaper1.htm.
- MARNEWICK, M.D., RETIEF E.F., THERON N.T., WRIGHT D.R., ANDERSON T.A. 2015. Important Bird and Biodiversity Areas of South Africa. Johannesburg: BirdLife South Africa.
- MARTIN, G., SHAW, J., SMALLIE J. & DIAMOND, M. 2010. Bird's eye view – How birds see is key to avoiding power line collisions. Eskom Research Report. Report Nr: RES/RR/09/31613.
- MCCRARY, M. D., R. L. MCKERNAN, R. W. SCHREIBER, W. D. WAGNER, AND T. C. SCIARROTTA. 1986. Avian mortality at a solar energy plant. J. Field Ornithology 57:135-141.
- MUCINA. L. & RUTHERFORD, M.C. (Eds) 2006. The vegetation of South Africa, Lesotho and Swaziland. *Strelitzia* 19. South African National Biodiversity Institute, Pretoria.
- RAAB, R., JULIUS, E., SPAKOVSZKY, P. & NAGY, S. 2009. Guidelines for best practice on mitigating impacts of infrastructure development and afforestation on the Great Bustard. Prepared for the Memorandum of Understanding on the conservation and management of the Middle-European population of the Great Bustard under the Convention on Migratory species (CMS). BirdLife International. European Dvision.
- RAAB, R., SPAKOVSZKY, P., JULIUS, E., SCHÜTZ, C. & SCHULZE, C. 2010. Effects of powerlines on flight behaviour of the West-Pannonian Great Bustard *Otis tarda* population. Bird Conservation International. BirdLife International.
- LOSS, S.R., WILL, T., LOSS, S.S., & MARRA, P.P. 2014. Bird–building collisions in the United States: Estimates of annual mortality and species vulnerability. The Condor 116(1):8-23. 2014.
- SHAW, J.M. 2013. Power line collisions in the Karoo: Conserving Ludwig's Bustard. Unpublished PhD thesis. Percy FitzPatrick Institute of African Ornithology, Department of Biological Sciences, Faculty of Science University of Cape Town May 2013.
- SMALLWOOD, K.S. 2014. Docket Number: 09-AFC-07C. Project Title: Palen Solar Power Project - Compliance. Exhibit 3128. Testimony of K. Shawn Smallwood, Ph.D. California Energy Commission.
- SMALLWOOD, K. S. 2007. Estimating wind turbine-caused bird mortality. Journal of Wildlife Management 71:2781-2791.
- SMALLWOOD, K.S. 2013. Comparing bird and bat fatality-rate estimates among North American wind-energy projects. Wildlife Society Bulletin 37: 19-33.
- SUMMERS, P.D., CUNNINGTON G. M., and FAHRIG, L. 2011. Are the negative effects of roads on breeding birds caused by traffic noise? Journal of Applied Ecology 2011, 48, 1527–1534.
- VAN ROOYEN, C.S. & LEDGER, J.A. 1999. *Birds and utility structures: Developments in southern Africa*. Pp 205-230, in Ferrer, M. & G.F.M. Janns. (eds.). *Birds and Power lines*. Quercus, Madrid (Spain). Pp 238.
- VAN ROOYEN, C.S. & TAYLOR, P.V. 1999. Bird Streamers as probable cause of electrocutions in South Africa. EPRI Workshop on Avian Interactions with Utility Structures 2-3 December 1999. Charleston, South Carolina.

- VAN ROOYEN, C.S. 1998. Raptor mortality on power lines in South Africa. *Proceedings of the 5th World Conference on Birds of Prey and Owls*. Midrand (South Africa), Aug.4 – 8, 1998. .
- VAN ROOYEN, C.S. 1999. An overview of the Eskom-EWT Strategic Partnership in South Africa. *EPRI Workshop on Avian Interactions with Utility Structures* Charleston (South Carolina), Dec. 2-3 1999.
- VAN ROOYEN, C.S. 2000. An overview of Vulture Electrocutions in South Africa. *Vulture News,* 43: 5-22. (Vulture Study Group, Johannesburg, South Africa).
- VAN ROOYEN, C.S. 2007. Eskom-EWT Strategic Partnership: Progress Report April-September 2007. Endangered Wildlife Trust, Johannesburg.
- VAN ROOYEN, C.S. VOSLOO, H.F. & R.E. HARNESS. 2002. Eliminating bird streamers as a cause of faulting on transmission lines in South Africa. *Proceedings of the IEEE 46th Rural Electric Power Conference.* Colorado Springs (Colorado), May. 2002.
- VERDOORN, G.H. 1996. Mortality of Cape Griffons *Gyps coprotheres* and African Whitebacked Vultures *Pseudogyps africanus* on 88kV and 132kV power lines in Western Transvaal, South Africa, and mitigation measures to prevent future problems. *Proceedings of the 2nd International Conference on Raptors*: Urbino (Italy), Oct. 2-5, 1996.
- WALSTON, L.J., ROLLINS, K.E., SMITH, K.P., LAGORY, K.E., SINCLAIR, K., TURCHI, C., WENDELIN, T., AND SOUDER H. 2015. A Review of Avian Monitoring and Mitigation Information at Existing Utility- Scale Solar Facilities. Argonne National Laboratory and U.S. Department of Energy (DOE). (http://www.osti.gov/scitech/).