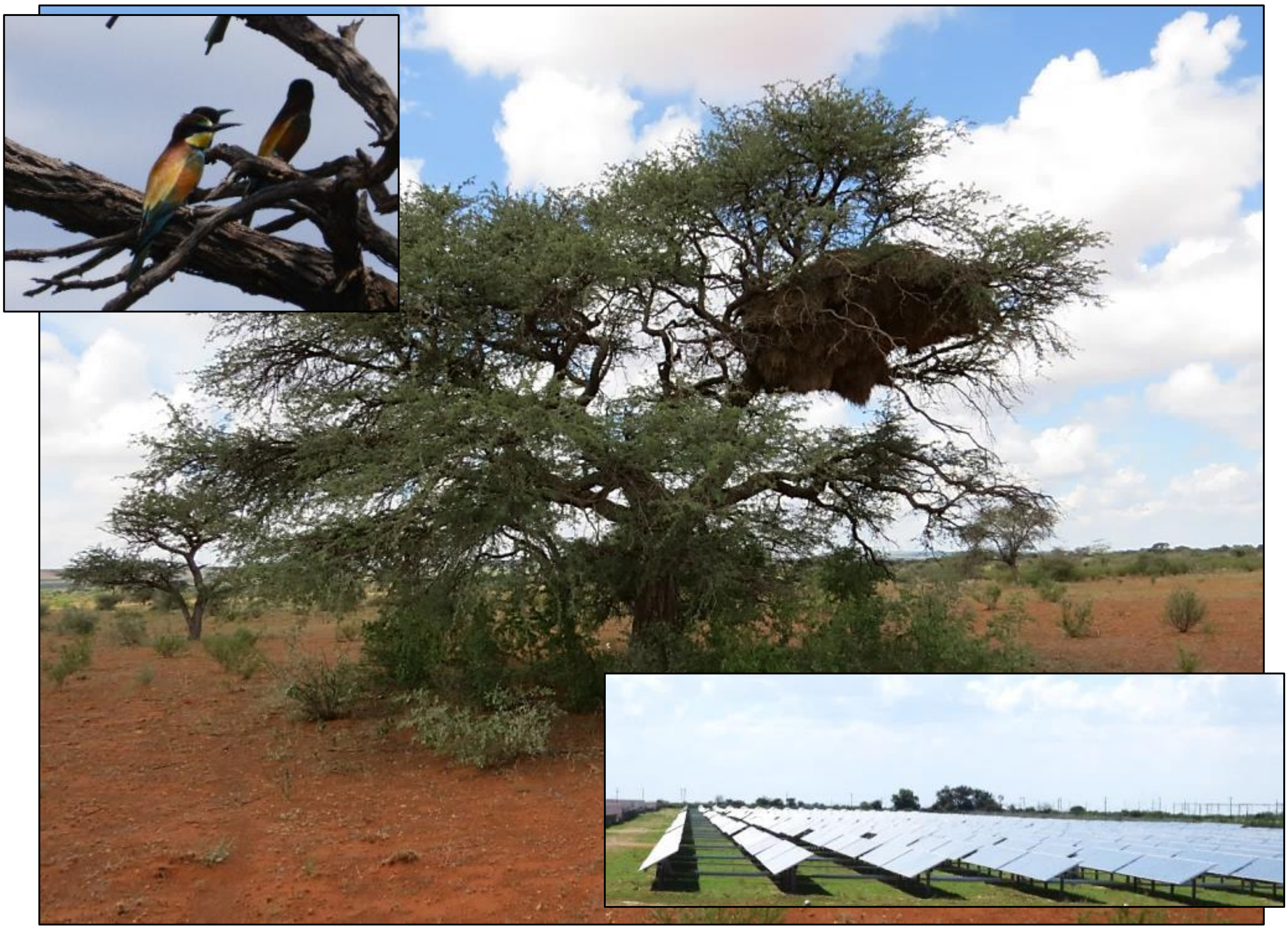
Pre-construction Avian Impact Assessment of the Tshepo Solar Power Plant (RF) (Pty) Ltd., near Hotazel, Northern Cape: March 2016



Prepared for:

On behalf of :

Subsolar

Prepared by:

BIRDS & BATS UNLIMITED
Environmental Consultants
www.birds-and-bats-unlimited.com

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1 SUMMARY

This study reports on avian monitoring in the wet-season for the proposed Tshepo Solar Power Plant (RF) (Pty) Ltd. project located on the farm "London" south of Hotazel, Northern Cape. Its specific objective is to determine the numbers of birds attracted to the proposed solar farm after rains in March 2016. The project investigated a preferred (290 ha) and alternative area (260 ha) for a pre-construction assessment of the impacts to birds. The possible impacts are: (i) collision with the PV facility itself from birds perceiving the panels as open water – the "Lake Effect"; (ii) disturbance by construction and maintenance activities, (iii) displacement through habitat removal and construction work and (iv) direct collision with the power line network.

Our observations indicate that the well-grazed habitat, dominated by *Acacia* trees and *Rhus* bushes in the Eastern Kalahari Bioregion had 84 avian species recorded in or around London farm of which 5 were collision-prone (Lanner Falcon *Falco biarmicus,* Pale chanting Goshawk *Melierax canorus* and migrant White Storks *Ciconia ciconia* recorded by us and White-backed Vulture *Gyps africanus*, and Lappet-faced Vulture *Torgos tracheliotus* recorded in previous atlas data). The two vultures and the Lanner comprised the three red-listed species.

In our 1 km survey in the preferred and alternative areas we recorded a relatively healthy species richness of smaller birds at an average of 16.0 species km^{-1} and 53.5 birds km^{-1}. The alternative area had lower numbers of birds making it the best of the two sites to develop from an avian perspective, The **Passage rate** of larger collision-prone birds was, however, very low at 0.08 birds per hour of observation. Other species that may be attracted to the panels such as wetland birds were not recorded and sandgrouse were present, but in low numbers. Two hornbill species may pose a risk to the panels (by attacking their reflections) but only if the panels have reflective surfaces.

To mitigate the possible problems of impacts with the solar panels, we recommend that: (i) bird scaring techniques including rotating prisms and experimental use of Torri lines are used if birds are found to impact the PV panels; (ii) construct the solar panels as far as possible from the pans that could attract any wetland species and sandgrouse; (iii) all power lines – *present and future* – must be marked with bird diverters to reduce the possible impact of the raptorial species; and (iv) use non-reflective panels to reduce the possibility of hornbills smashing the panels. On present evidence the alternative site will cause less avian disruption than the preferred site.

If these mitigation measures are followed to minimize any impacts to the threatened vultures and raptors highlighted here, our preliminary recommendation is that this solar site development can go ahead, with a full post-construction monitoring protocol in place as it does so.

1.1 Consultant's declaration of Independence

Birds & Bats Unlimited are independent consultants to Tshepo Solar Power Plant (RF) (Pty) Ltd. They have no business, financial, personal or other interest in the activity, application or appeal in respect of which they were appointed other than fair remuneration for work performed in connection with the activity, application or appeal. There are no circumstances that compromise the objectivity of this specialist performing such work.

1.2 Qualifications of Specialist Consultant

Birds & Bats Unlimited Environmental Consultants (http://www.birds-and-bats-unlimited.com/), were approached to undertake the specialist avifaunal assessment for the pre-construction phase of the Photovoltaic solar parks proposed by Tshepo Solar Power Plant (RF) (Pty) Ltd., south of Hotazel, Northern Cape. Dr Rob Simmons is an experienced ornithologist, with 30 years' experience in avian research and impact assessment work. He has published over 100 peer-reviewed papers and 2 books, (see www.fitzpatrick.uct.ac.za/docs/robert.html for details). More than forty avian impact assessments have been undertaken throughout Namibia and South Africa. He also undertakes long-term research on threatened species (raptors, flamingos and terns) and their predators (cats) at the FitzPatrick Institute, UCT.

Marlei Martins, co-director of Birds & Bats Unlimited, has over 5 years' consultancy experience in avian wind farm impacts as well as environmental issues, and has been employed by several other consultancy companies all over South Africa because of her expertise in this field. She has published papers on her observations including a new species of raptor to South Africa (http://www.birds-and-bats-unlimited.com/).

2 BACKGROUND

2.1 PHOTO-VOLTAIC SOLAR POWER

Renewable energy is generally provided either by water, wind or solar power and has the potential to supply the human population with unlimited non-polluting power. As a major greenhouse gas emitter, South Africa is signatory of the Kyoto Protocol and is committed to turning to green energy sources that emit no greenhouse gases or other pollution. Southern Africa's Kalahari region is one of the Earth's hot spots for solar radiation because deserts provide some of the longest periods of continuous sunlight in the world http://www.iir-sa.gr/files/news/PV.pdf. This makes it the ideal hub for solar projects that capture the sun's energy to provide an energy-hungry South Africa with the power it requires.

Three options are generally employed to capture solar energy: (i) Concentrated Solar Plants (CSPs) using heliostats that focus the sun's energy onto a central tower that heats a salt or oil liquid that drives a turbine (CSP tower); (ii) a CSP using trough technology with smaller parabolic mirrors that capture and focus the energy onto a central pipe that also employs a heat-transfer liquid to drive a turbine; or (iii) the preferred option by Tshepo (Pty) Ltd that captures the sunlight using conventional **Photovoltaic (PV) technology**. This technology does not use concentrated heat but uses sunlight directly to create electricity. There are fewer direct risks associated with this from an avian perspective other than birds possibly perceiving the shiny mirror-surfaces for water, and being drawn to them (the so-called "Lake Effect" – Kagan et al. 2014). This latter technology is the only one assessed in this report for the Tshepo development.

2.2 POTENTIAL AVIAN IMPACTS

As with any type of large scale development, habitat may be permanently disturbed, displacing the resident and migrant species. Up to 290 ha of area is assessed in the preferred area for a lay-down area of 226 ha for the operation of the PV facility; this will reduce habitat availability for birds where construction takes place. The alternative area is 250 ha with a similar footprint size (226 ha). It is a simple exercise to calculate the numbers potentially lost from our estimates of birds per unit area. These are likely to be minimal considerations given that smaller birds generally occur at higher densities than larger birds, breed faster, and are less likely to suffer high population reduction.

However, avoidance of some habitats will reduce the impact.

The main avian impacts according to a position paper on the subject by Birdlife SA (http://www.birdlife.org.za/images/stories/conservation/birds_and_wind_energy/solar_power.pdf) are:

(i) displacement of nationally important species from their habitats;
(ii) loss of habitats for such species;
(iii) disturbance during construction, and operation of the facility;
(iv) collision with the photovoltaic panels (mistaking them for water bodies); or
(v) collision with associated infra-structure.

The nature and magnitude of impacts to birds from solar facilities is related to three factors: (i) location, (ii) size of the facility, and (iii) the technology involved (i.e. Photovoltaic *vs* CSP trough *vs* CSP tower). Thus, the location in relation to avian flyways, wetlands, riparian vegetation and the habitat removed in the footprint may have an important effect on the impact to birds of the solar site. The size of the footprint will be directly related to the negative impact on birds, thus habitat of range-restricted or collision-prone species around the site must be determined with accuracy.

Avian fatalities at PV sites have been summarised from those investigated in the USA by two recent reports (Kagan et al. 2014, Walston et al. 2015). Of the three types of solar energy capture (Photo-voltaic, CSP troughs and CSP towers) the Photo-voltaic sites recorded medium levels of avian fatalities relative to the CSP trough and CSP towers in one review (Kagan et al. 2014).

Given that impact trauma was the most common cause of mortality at two of the three solar sites investigated, minimising the reasons for the cause of that trauma are paramount. Biologists believe that birds mistake the panels in the solar arrays for a body of water (the Lake effect – Kagan et al. 2014) and suffer physical trauma when they attempt to land on it. Birds, particularly wetland species, are the main victims of this sort of impact.

In a comprehensive review of all bird fatalities at large scale operational solar plants across the world (mainly the USA but one in Israel) Walston et al. (2015) found that few solar plants had undertaken systematic monitoring of bird fatalities (Table 1).

Table 1. Summary of all avian fatality data from large-scale solar facilities from the USA (after Walston et al. 2015). The results for PV technology are given in **bold**.

Project Name	Avian Fatality Data – systematic or incidental?	Survey Period	Incidental Fatalities	Systematic Fatalities (Unadjusted)**
Mohave Solar (CSP trough)	Yes – Incidental	Aug. 2013–March 2014	14	None collected
Genesis (CSP trough)	Yes – Incidental	Jan. 2012–May 2014	183	None collected
California Valley Solar Ranch (PV)	Yes – Systematic	Aug. 2012–Aug. 2013	Not Available	368
Desert Sunlight (PV)	Yes – Incidental	Sept. 2011–March 2014	154	None collected
Topaz Solar Farm (PV)	Yes – Incidental and Systematic	Jan. 2013 –Jan. 2014	19	41
California Solar One (CSP tower)	Yes – Systematic	May 1982–May 1983 (40visits)	Not Available	70 (114 birds)
Crescent Dunes (CSP tower)	Yes - systematic	Under construction	Not available	Not available
Ivanpah (CSP Tower)	Yes – Systematic	Oct. 2013–March 2014	159	376 (includes 7 injured birds)

*Causes of death include: solar flux, impact trauma, predation, electrocution and emaciation

** Unadjusted refers to the fact that numbers are not adjusted for biases resulting from predator removal or human observer bias

In summarising the avian species found, Walston et al. (2015) noted

- most birds were small passerines (40%-63% at 7 solar farms);
- Kagan et al. (2014) also found 20 of the 30 birds identified at the Genesis (trough) site in California were smaller passerine birds or swallows;
- Waterbirds such as grebes, herons and gulls were also killed suggesting these species may be attracted by the *perceived* availability of water or the lake effect (Kagan et al. 2014);
- waterbirds averaged 11% of the fatalities at solar farms, but reached 46% of all fatalities at one solar PV facility (Desert Sunlight) in California;
- Too few fatalities at different types of facilities occur to test the Lake Effect of Kagan et al. (2014) (i.e. wetland birds are attracted to the mirrors because they mistake them for open water);
- there was a clear trend at all solar facilities for resident species to dominate the fatalities. For example at the Genesis facility 64% of the fatalities were resident species, meaning that 36% were migrants (Walston et al. 2015), the highest among those reviewed.

Tabulating fatalities of birds at solar sites is insufficient to determine the impact to birds of conservation significance. They must be collected systematically and account for human error in (not) finding carcasses, and the rate of carcass removal by scavengers.

In an arid environment where sensitive species may not occur at all if rains do not fall, even a full year's monitoring is unlikely to be sufficient. Thus, visits must be timed to coincide with the most productive time of year – even if they are minimal rains as in an El Niño year.

Therefore, this Tshepo site will have to be closely and *systematically* monitored by ornithologists familiar with these birds, to determine movements occurring through the proposed sites just before, and during, rain events. More importantly, appropriate mitigation measures would need to be sought if significant mortalities of sensitive species were found. As a relatively new field, and with the burgeoning solar farm industry in South Africa focussed on the Kalahari Desert, we need to be pro-active in our research and innovative designs to reduce mortality. However, some methods are being used at facilities in the USA and these include audible bird scaring devices, visual devices to reduce attraction, and mechanical spikes and other measures to prevent birds from perching on dangerous surfaces (treated below).

2.2.1 Habitat loss – Destruction, Disturbance and Displacement

The construction and maintenance of PV technology causes mainly permanent habitat destruction and disturbance. Maintenance activities are likely to cause some disturbance to birds in the general surrounds, and especially the shy or ground-nesting species resident in the area. Mitigation of such effects requires that best-practice principles be rigorously applied – i.e. sites are selected to avoid the destruction of key habitats for red data species, and the disturbance and construction and the final footprint size, for key species, should all be kept to a minimum. Construction time for each facility is unknown.

From the habitat destruction point of view, it is a simple exercise to calculate the numbers of birds potentially lost from our density estimates of important species/birds per unit area of habitat. These are likely to be minimal considerations given that smaller birds are generally more common than larger birds, breed faster, and are less likely to suffer high population reduction. However, where range-restricted species occur on sites ear-marked for development this can have a larger impact.

During our brief 3-day site visit in March 2016 we encountered over 40 resident species that could be displaced by habitat destruction (Appendix1).

Because photo-voltaic facilities are relatively new in South Africa, and there are no *published* studies of avian mortalities here and few in other parts of the world (Table 1), this section is necessarily brief and is in need of further study in southern Africa.

2.2.2 Collision – with reticulation lines and PV panels

Several bird species are well known to collide with overhead power lines, fences, towers and other aerial objects (Jenkins et al. 2010). These have been tabulated and the reasons for their propensity for collision investigated (Martin and Shaw 2010). The extenuating factors were then extrapolated to all South African species based on wing loading, aerial flights, nocturnal activity and several other contributing factors (BARESG 2014). We have used Birdlife South Africa's list and taken the top 100 species as the most likely to collide with power lines. The most collision-prone species are generally the larger scavenging species such as vultures, but also raptors and wetland species. It is somewhat surprising that birds also collide with ground-based structures and, as mentioned above (Table 1), these include passerine and wetland birds in collision with photo-voltaic panels in the USA. While we do not know which species will be similarly prone in South Africa, they are likely to be a similar suite of birds (i.e. wetland and aerial species) and it is these we looked for during our surveys.

2.3 Study methods

2.3.1 Aims, methods and Terms of Reference

The primary aims of the avian pre-construction monitoring at the PV site proposed by Tshepo Solar Power Plant (RF) (Pty) Ltd., at London farm near Hotazel, Northern Cape are to:

1. Determine the densities of birds regularly present, or resident, within the impact area of the PVs and Photovoltaic areas before the construction phase.
2. Document the patterns and movements of birds in the vicinity of the proposed PVs and PV areas before their construction.
3. Monitor the patterns and movements of birds in the PV areas in relation to time of day, and over a wet and dry season when bird numbers and species richness may change.

4. Establish a pre-impact baseline for all Red data and endemic bird species including all breeding birds within the study area.
5. Inform final design, construction and management strategy of development with a view to mitigating potential impacts.

We consulted several published sources of bird data including the Coordinated Waterfowl Counts (CWAC), Coordinated Avifaunal Road Count (CAR) of the Animal Demography Unit, University of Cape Town, the Important Bird Areas Programme (IBA) of Birdlife South Africa, and the Southern African Bird Atlas Programme (SABAP) to determine if previous data was available for this area. Only limited SABAP2 data http://sabap2.adu.org.za/index.php was available for this remote region.

We augmented these data with our own pre-construction (wet-season) site visit in March 2016 to be followed up by a (dry-season) visit in August 2015 to survey avifauna in both the preferred and alternative solar park areas on the London farm.

We spent 2 full days on site, recording bird presence and activity throughout the designated preferred and alternative PV areas. This report provides the first results of the bird monitoring undertaken in March 2016.

2.3.2 Limitations and assumptions

Inaccuracies in the above sources of information can limit or bias this study in the following ways:

- The SABAP1 data for this area is over 20 years old (Harrison *et al.* 1997), so we have used only the new SABAP 2 data set. This has a higher spatial resolution specific to the power lines and is up to date (2007 to 2015). However, there were only 9 cards in the pentads that cover the solar park itself and *none* were full protocol - this limits the overall species totals;
- Use of the older SABAP 1 data set will include species that are found in an area 9-fold larger (in a quarter-degree square) than found in a smaller pentad of 9 km x 8 km, artificially inflating the species totals given;
- Our own additional data derived from one dry-season and one wet-season site visit is still insufficient to cover all areas of the farm in any depth. We may miss certain rare species or nocturnal species that a longer visit to the sites would uncover;
- We operate in a near complete vacuum of data on the effects of solar farms on Southern African avifauna. This arises mainly through the recent advent of solar

farms in South Africa (13 are in operation in 2016 in the Northern Cape but none have released data on what species are being killed or displaced).

While no data set can be a perfect representation of what is present and at risk on a site, our familiarity with arid systems and wide-scale surveys of the avifauna in wet and dry periods elsewhere (Seymour et al. 2015), means we are unlikely to have missed many important species in the surveys reported below.

2.4 Study area

The solar park to be developed by Tshepo Solar Power Plant (RF) (Pty) Ltd, is located on the farm site "London", approximately 14km south of Hotazel in the Northern Cape. The farm London RE/275, is centred on S 27°13'43.09" E 23° 03' 30.48" and the preferred area is 290 ha in size. An alternative area of 250 ha (hereafter London 2), about 1.5 km west was simultaneously assessed for avian species and possible impacts. The laydown area will be 226 ha in size, whichever site is chosen. We compare the two sites to determine which poses the least impact from an avian perspective.

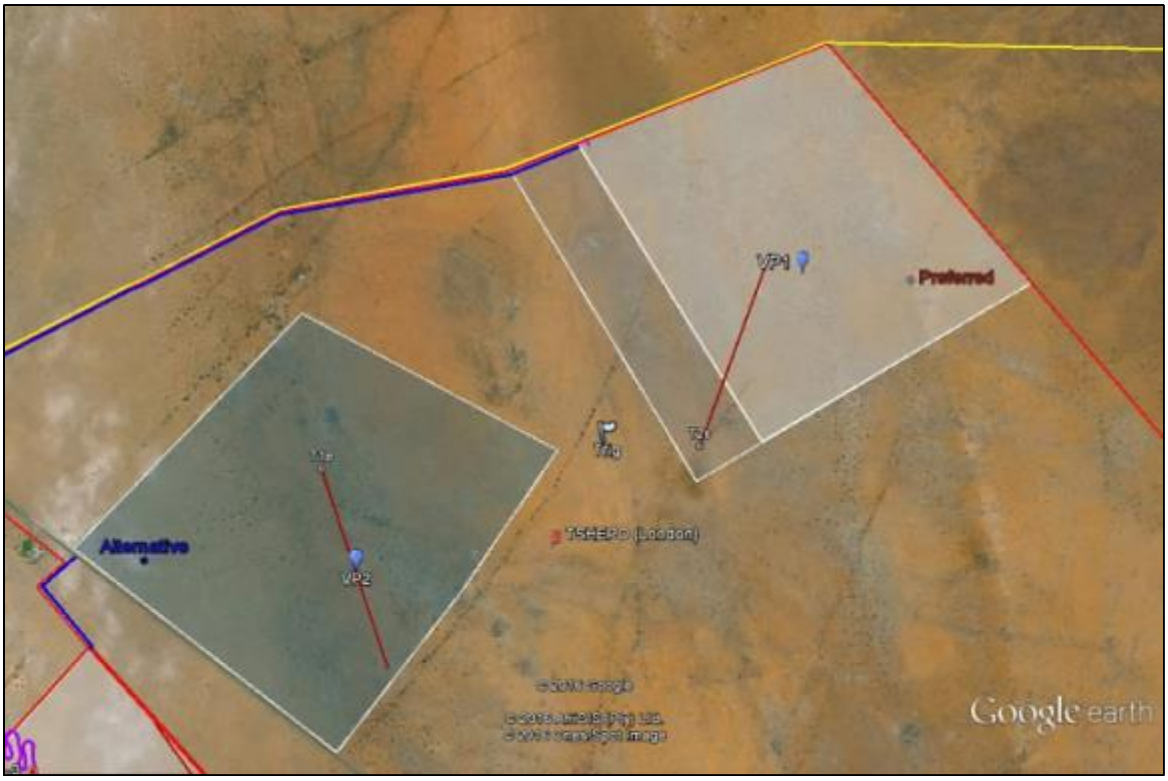

Figure 1: The preferred solar park study area (pale area-right) on London farm in relation to the alternative (grey–left). The red lines represent our 1 km transects and the Vantage Points are shown as blue balloons (VP1-2).

2.4.1 Vegetation of the study area

The study area occurs in Savannah biome on red Kalahari Sand and is classified as Hotazel Bushveld (Mucina and Rutherford 2006, p522). Vegetation in the preferred area was dominated by Camelthorn (A*cacia erioloba)* and Blackthorn (*Acacia mellifera*) trees and Rhus bushes with open areas interspersed with *Rhigozum* shrubs. Fewer mature Acacia trees were apparent in the alternative site. Grass cover is highly variable depending on rain and grazing pressure. The study area experiences summer rainfall averaging 220-380 mm per annum, with high variability. High day-time temperatures occur in summer (mean 37°C) and minimum temperature average below zero in July (Mucina and Rutherford 2006).

During our visit, rain had fallen, thunderstorms were active in the area and the veld was green, the trees were in leaf and some grass sward layer was apparent. Thus, we can classify this as a wet-season assessment with a flush of vegetation and grass.

2.4.2 Avian microhabitats

Bird habitat in the region consists mainly of mature camel thorn and *Boscia* trees. These are important for bird communities because two studies in the Kalahari indicate that taller trees add significantly to the avian species richness of an area (because of the diverse niches they offer) and their removal can radically reduce species richness (Seymour and Simmons 2008, Seymour and Dean 2010). Taller *Acacia* trees and those growing near farm reservoirs are regularly used by passerine birds as nest sites (e.g. Sociable Weavers nest in them), and for perch sites for shade and roosting in the hottest times of day. Artificial habitats are provided by land owners in the form of windmills and associated farm reservoirs and power line poles. Some pans occurred within the immediate study area. These can attract arid-adapted birds including sandgrouse, doves, finches, weavers, sparrow-larks and raptors to drink.

2.5 On–site methods

On 13 and 14 March 2016 we surveyed birds in two 1-km transects in areas proposed for the PV solar arrays. These transects covered the main habitat types present in the areas in both the preferred (London 1) and alternative (London 2) sites.

We undertook walking surveys of areas that were not well-covered in the VP-watches (below).

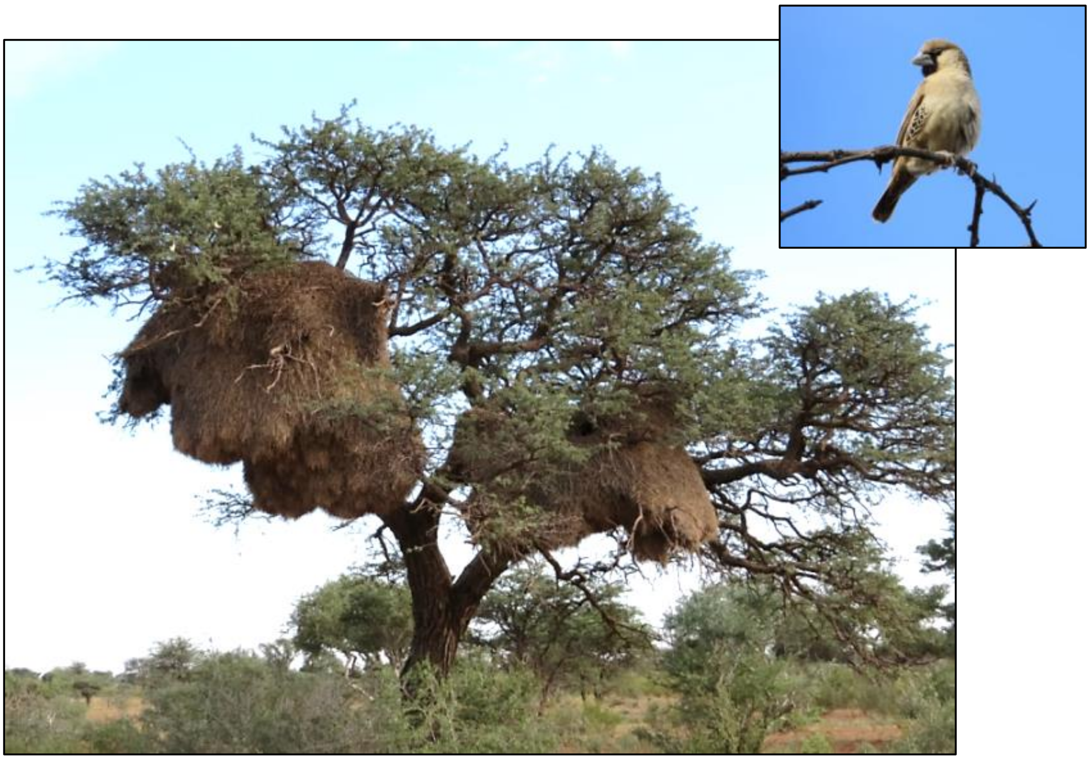

Photo 1: Sociable Weavers (inset) were common on the preferred London site and built four large nests in mature camelthorn trees as shown here. None were recorded on the alternative site.

All **1-km bird transects** took place in the morning (bird-active) hours.

- Each transect was walked slowly over 35- to 50-minute duration (depending on terrain and number of birds present).
- All species were identified where possible using Swarovski 8.5 x 42 binoculars, and the number of individual birds and the perpendicular distance to them, recorded.
- In dense habitat many species are identified by call and the distance to them estimated if they cannot be observed. This allows an estimate of the density (birds per unit area and km) and the species richness in each area.
- We simultaneously recorded all large birds (mainly raptors) and noted and recorded the position of any nests found.
- Over 100 individual birds were recorded in the preferred and alternative PV areas in these transects alone.

The most important aspect of this monitoring is **Vantage Point (VP) observations.**

- VPs determine the number of flights **of collision-prone species** per hour through the possible area of impact.

- This gives an indication of the collision-risk to larger species that may impact the infrastructure in the solar park.
- 12 hours per VP is the minimum recommended observation time (Jenkins et al. 2015);
- Each VP should have a view-shed (area of observation) not exceeding 2 km.

3 RESULTS

3.1 PRESENCE AND MOVEMENTS OF SENSITIVE SPECIES

Large sensitive species, observed from our walking transects or VPs, are defined as those species that are known, or expected, to be at risk from the PV infrastructure, or attracted by the reflective surfaces of the PV panels. These species are typically threatened red data species that occur in the study areas (e.g. falcons), but could include wetland species attracted by the panels. Data were available from 15 bird atlas cards of Southern African Bird Atlas Projects (SABAP), which were obtained from the Animal Demography Unit website (http://sabap2.adu.org.za/index.php) for the relevant "pentads" of 5′ x 5′ (Table 2). From these data we compiled a list of the avifauna likely to occur within the impact zone of the proposed PV site. These data were augmented by our March 2016 visit undertaken to the proposed site.

3.2 AVIAN SPECIES RICHNESS AND RED DATA SPECIES

A total of 84 bird species were recorded around the London farm from our records combined with bird atlas cards. Of these, 62 species were recorded on the 15 bird atlas cards submitted from 2007 to 2016 (Appendix 1). Of these, 2 species (White-backed and Lappet-faced Vulture) were collision-prone as ranked by the BARESG (2014), and both were red-listed. While we did not record the vultures on site, three additional collision-prone species were seen in our 2-day visit: the Vulnerable-ranked Lanner Falcon *Falco biarmicus* (hunting through the area: Photo 1), Pale Chanting Goshawk *Melierax canorus* and 3 migrant European Storks *Ciconia ciconia*. All occurred within the boundary of the proposed solar farm. Therefore, a total of five **collision-prone species** potentially occur on the site, **of which three are red-listed.**

Seasonal differences in the composition of the bird community are expected to be large in an arid environment (Dean 2004). This arises for several reasons for different groups of birds: wetland species (e.g. geese, stilts and crakes) are attracted by the sudden appearance of wetlands that were not available prior to pans flooding. They follow rain fronts to find such ephemeral wetlands (Simmons et al. 1999, Henry et al. 2016). Other birds, including sandgrouse, will use pans that fill with water. For other nomadic species (e.g. bustards, larks) they are attracted to high rainfall areas because of the flush of insects that follow rains (Allan and Osborne 2005).

Table 2. Red-listed (**in red**) and collision-prone bird species (**in bold**) known to occur over the proposed PV Tshepo development at London farm drawn from SABAP2 atlas cards for 4 pentads (2715_2255, 2715_2300, 2710_2305, 2710_2300). These are based on 15 cards, submitted to the SABAP2 project from 2007 to 2016. Those shaded in the table were seen in our 2-day March 2016 site visit but not previously recorded.

Common name	Scientific name	Red-list status	Reporting Rate*	Collision Rank**	Disturbance
White-backed Vulture	*Gyps africanus*	**Endangered**	**13.3%**	**16**	**High**
Lappet-faced Vulture	*Torgos tracheliotus*	**Endangered**	**6.7%**	**21**	**High**
Lanner Falcon	*Falco biarmicus*	**Vulnerable**	**50%**	**22**	**Medium**
Pale Chanting Goshawk	*Melierax canorus*	Least threatened	**50%**	**73**	**low**
European Stork	*Ciconia ciconia*	Least threatened	**50%**	**59**	**-**

*Reporting rate is a measure of the likelihood of occurrence, as recorded in the atlas period.
For the Lanner, Goshawk and Stork, we saw them once in 2 days' work giving them a 50% reporting rate.
** Collision rank derived from the BAWESG 2014 guidelines. Smaller numbers denote more collision-prone.

Thus, an arid area such as the Kalahari Desert is very much a "boom or bust" landscape and one dry season visit can give a biased impression relative to the explosion in biodiversity that can follow high rainfall events (Lloyd 1999). This visit measures the avian diversity after good rains that fell in February 2016 and continued into March at the time of our visit. Thus the species richness values will be close to their maximum.

3.2.1 Density of birds recorded within the proposed PV sites

In two 1-km transects we recorded an average of 16.0 species km^{-1} and 53.5 birds km^{-1} (Table 2). These comprised typical thornveld birds such as hornbills, korhaans, scrub-robins, larks, chats, prinias, finches and migrant shrikes, and also Sociable Weavers *Philetairus socius.*

At the preferred site we recorded more species (18 vs 14 km^{-1}) and twice as many individual birds (72 vs 35 km^{-1}) per kilometre than in the alternative site (Table 2). The latter was a reflection of the greater number of mature camel thorn and *Boscia* trees in the preferred site (London 1).

Table 2: Bird species and numbers recorded over 1 km at the preferred and alternative London PV, 13-14 March 2016.

Summary	Species	Birds	Habitat
London 1 (preferred)	18	72	Mature *Acacia erioloba*, *Boscia* and Rhigozum
London 2 (alternative)	14	35	*Acacia erioloba*,, Rhigozum, sparse grasses
Means	16.00	53.5	

The VP observations totalling 12 h at each site on 13 and 14 March revealed two collision-prone birds inside the borders: a hunting immature Lanner Falcon (photo 2) flying low and fast through the preferred area and a Pale chanting Goshawk flying slowly over the same site.

Photo 2: Three species of raptors were recorded on the Tshepo solar sites and two species, including this immature Lanner Falcon, were seen hunting in the preferred site.

The only raptor seen in the Alternative site was an immature Gabar Goshawk *Micronisus gabar* (photo 3), but this agile species is not considered a highly collision-prone bird.

Photo 3: This immature Gabar Goshawk was the only raptor recorded in the Alternative Tshepo solar site (London 2).

The Passage Rate of collision-prone birds through both sites was 2 birds in 24 h of VP observations or 0.08 birds $hour^{-1}$. Both were recorded in the preferred site. This is a very low rate of movement of collision-prone birds but may change if collision-prone raptors hunt around the artificial water sources in the dry season. Other aerial birds were recorded within the two sites but outside our timed VP-watches. These included the three migrant White Storks (*Ciconia ciconia*), that were observed circling briefly over the alternative site during other observations.

No wetland birds were recorded suggesting that future collisions by these species with the PV panels is unlikely.

Nine Namaqua Sandgrouse were recorded in 24 h of observation present on site, and they may be attracted to the panels as a source of water (Figures 2 and 3). A pair of out-of range Temminck's Courser *Cursorius temminckii* was an unusual species brought in by the rains (photo 4).

Yellow-billed *Tockus leucomelas* and African Grey Hornbills T. *nasutus* are both unknown entities as far as PV solar farms are concerned, and both occur in the area. Both have powerful bills (Kemp 2005), and both have the potential to cause damage to the PV panels because they attack their own reflections in shiny surfaces mistaking them for territorial intruders during the breeding season (Dr A Kemp pers comm.). It is not known if their bills are powerful enough to break the glass but preliminary investigation suggests that the panel surfaces will not be reflective enough to cause problems.

Photo 3: Yellow-billed Hornbills were recorded on both the preferred and alternative Tshepo PV sites and may cause damage to the PV panels in the breeding season.

In summary, two collision-prone species have been recorded over the site, but at a very low frequency giving a passage rate of just 0.08 birds $hour^{-1}$. Given the rains over the site the number of smaller birds recorded per kilometre was relatively high at an average of 53.5 birds km^{-1}.

Of the two sites the preferred site had more collision prone species present (Lanner and Chanting goshawk vs White Stork), more species per kilometre (18 vs. 14), twice the density of birds per kilometre (72 vs. 35), and more Sociable Weaver nests (4 vs 0).

Thus, on present (wet-season) evidence, development of the Preferred site will cause more disruption to the resident avifauna than that on the Alternative site.

Photo 4: This Temminck's Courser (one of a pair) was recorded just outside the western boundary of the preferred Tshepo PV site and is an out-of-range record for this area.

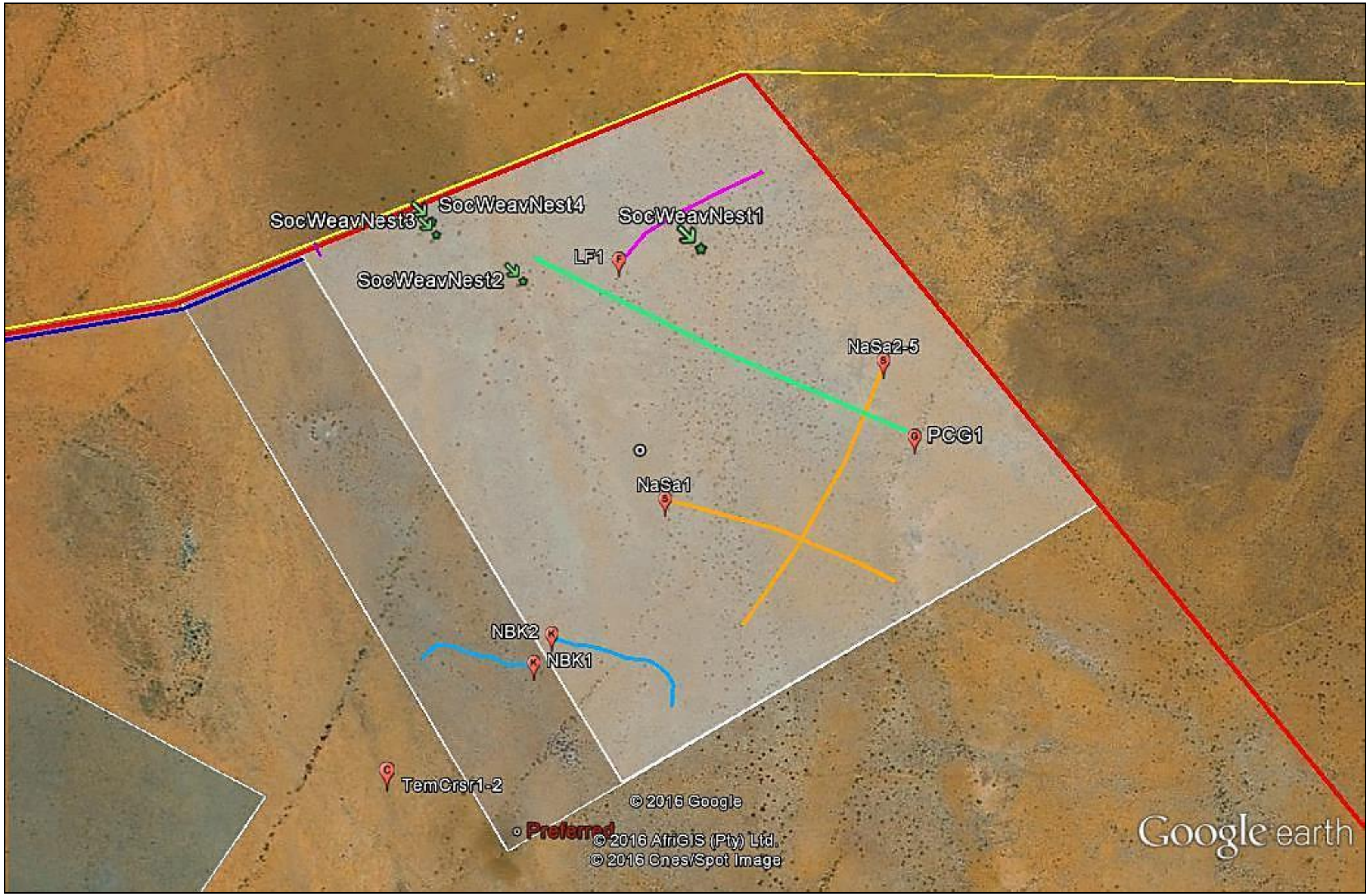

Figure 2: The Preferred site at London 1 indicating bird flights of a red-listed Lanner (LF1–purple line) and a Pale Chanting goshawk (green line), as well as Namaqua Sandgrouse (orange lines) through the site in March 2016. Short display flights of Northern Black Korhaans (NBK1-2) are shown as blue lines. The four Large Sociable Weaver nests in mature camelthorn trees are shown (SocWeavNest 1-4) in the north section of the site.

Figure 3: The Alternate PV site (London 2) indicating flights of 3 migrant White Storks (white lines). No other collision-prone birds were recorded here, but 12 Namaqua sandgrouse (orange lines) were observed in flight towards a water point in the southern corner.

4 QUANTIFYING THE IMPACTS

Nature: The impact of the proposed PV areas will generally be negative given the certainty that: (i) 226 ha will be transformed and the associated bird habitat destroyed; (ii) birds may collide with the panels if they mistakenly perceive them as open water; and (iii) collision-prone species living around the periphery may collide with the power lines linking the solar development to the substation.

Yellow-billed and Grey Hornbills, which were both recorded on site may additionally pose a risk to panels if the surfaces are too reflective.

It must be noted that the pylons (as opposed to the transmission lines they carry) can also be considered positive for the raptors given that they provide perch and nesting sites for them in a tree-less environment.

The Extent (**E,** from 1-5) of the impact will occur within the chosen PV area (of 250 ha) = **(1),** and along the reticulation lines = **(3)**

The Duration (**D**, from 1-5) will be long-term **(4)** for the lifetime of the PV area and the transmission lines for all species.

The Magnitude (**M,** from 0-10) of the PV areas is expected to have a low impact **(1)** for the raptors and the storks **(1)**; for the transmission line raptors both benefit (perch sites) and may be killed in low numbers, giving a low-medium Magnitude of **(3).**

For any wetland birds, some **(1)** may be killed by collision with the panels (Kagen et al. 2014) or the transmission lines (Jenkins et al. 2010). A larger number of smaller birds will be displaced by habitat destruction of 226 ha in the preferred area given the density of birds in the more mature treed habitat that covers the preferred PV area.

The Probability of occurrence (**P,** from 1-5) of the raptors (Lanner and chanting goshawk) having some sort of interaction with the PV panels and transmission line is ranked medium low **(2)** because the farm dams on site may be attractive as a hunting site for the raptors in the dry season. For the wetland birds, the probability of occurrence is very low **(1)** because they were not recorded in the atlas or during our visit.

The Significance S, [calculated as **S = (E+D+M)P**], is as follows (Table 4) for the species identified as at risk in the (i) PV site, and (ii) the adjacent power line.

The scale varies from 0 (no significance) to 100 (highly significant and unacceptable). A score above 50 is considered very high and mitigation is required.

Table 4. A summary of the quantified impacts to the collision-prone raptors and wetland bird species likely to be impacted by the (i) proposed PV plant and (ii) new power lines.

(i) Within the PV site itself **Nature:** Mostly negative due to direct impact mortality (or avoidance of area) around the **PV site** for the Red-listed bird groups identified as at risk above. (**RAP**= raptors, **WB** = Wetland birds):		
	Without mitigation	**With mitigation**
Extent	**1**	**1**
Duration	**4**	**4**
Magnitude	**1 (RAP), 1 (WB)**	**1 (RAP), 1 (WB)**
Probability	**2 (RAP), 1 (WB)**	**1 (RAP), 1(WB)**
Significance (E+D+M)P	**12 (RAP), 6 (WB)** **Low risk**	**6 (RAP), 6 (WB)** **Very Low risk**
Status (+ve or –ve)	Negative	Neutral
Reversibility	Low	(mitigations untested)
Irreplaceable loss of species?	No	
Can impacts be mitigated?	Probably yes: the constructing the PV site in the Alternative area will displace fewer small species, influence fewer collision-prone raptors, and affect no Sociable Weaver nests or the (protected) *Acacia erioloba* trees they build them in. So the Alternative site is a better option.	
(ii) Mitigation for impacts for the PV panels There are three classes of mitigation for the PV panels: (i) move them well away from highly sensitive bird area (especially pans or other well-used bird areas), or (ii) employ bird-diverters to deter birds mistaking the panels for open water. If, in the post-construction monitoring, hornbills are found to attack their own reflections in the panels, and smash them, then covering the affected panels with a fine wire mesh is recommended. It is also recommended that Tshepo Solar Power Plant (RF) (Pty) Ltd. install video cameras above some panels for post-construction monitoring of any mortality of birds in the vicinity, through direct observation and carcass searches in a systematic and regular fashion.		

Cumulative impacts: For the PV itself the mortality and displacement impact on birds is poorly known, but many solar farms are now being constructed in the Kalahari/Karoo and more will occur in the future : thus more research and monitoring of the combined impacts is required.
Residual impacts: After mitigation, direct mortality through collision or area avoidance by the species identified above may still occur. An environmental management programme will assess the efficacy of the mitigations to reduce direct impacts or any problems with hornbills, and further research and mitigation can then be suggested and tested as the need arises.

(ii) Along the reticulation lines from the PV site to the substation **Nature:** Negative due to direct impact mortality due to **new transmission line** for the collision-prone bird groups identified as at risk above. (**RAP** = raptors, **WB** = Wetland birds):		
	Without mitigation	**With mitigation**
Extent	**3**	**2**
Duration	**4**	**4**
Magnitude	**3 (RAP), 2 (WB)**	**2(RAP), 1 (WB)**
Probability	**2(RAP), 1 (WB)**	**1(RAP), 1 (WB)**
Significance (E+D+M)P	**20 (ME), 9 (WB) (Low)**	**8 (ME), 7 (WB) (very Low)**
Status (+ve or –ve)	Negative	Neutral
Reversibility	Medium- High	Medium-High
Irreplaceable loss of species?	No, few raptors or other collision-prone birds occur within either site	
Can impacts be mitigated?	Yes, by marking all existing and all future lines with bird diverters. Experiments in the Karoo by the EWT indicate that mortalities from impacts with transmission lines fitted with bird diverters can reduce mortality by 80% for some bird groups (C. Hoogstadt pers comm.)	

(ii) Mitigation for power lines:

There are three classes of mitigation for birds around **power lines**: (i) re-position the lines to avoid intersecting the movements of the birds, (ii) add bird diverters to all new lines and motivate Eskom to mark all existing lines that are killing substantial numbers of birds, such that collision-prone species more readily detect and avoid contact, or (iii) bury the lines.

We suggest that there is now enough long-term and well-executed research to show that un-marked lines are killing such large numbers of birds (such as bustards) that we recommend that **all new transmission lines be marked with bird diverters,** as they go up. The priority areas - those with the highest mortality rate - should be considered first.

4.1 CUMULATIVE IMPACTS

Cumulative impacts are defined as "Impacts that result from incremental changes caused by either past, present or reasonably foreseeable actions together with the project" (Hyder, 1999, in Masden et al. 2010).

Thus, in this context, cumulative impacts are those that will impact the general avian communities in and around the Tshepo solar development, mainly by other solar farms and associated infrastructure. This will happen via the same factors identified here viz: collision, avoidance and displacement. Therefore, we need to know as a starting point the number of solar farms around the region within 50 km, and secondly, to know their impact on avifauna.

Given the general assumption that footprint size and bird impacts are linearly related for PV and CSP solar farms, a starting point in determining cumulative impacts is to determine:

- the number of bird displaced per unit area, by habitat destruction, or disturbed or displaced by human activity;
- the number of birds killed by collision with the structures on site;
- the number of birds killed by collision with infrastructure leading away from the site;
- the number of birds killed by flying through the solar flux of CSP tower sites.

At this time there are at least 26 proposed or approved renewable energy farms of various sizes within 120 km of Tshepo. We have attached a current status table (Table 5) and map depicting the sites proposed within a 50 km radius, as they are the most likely to have a cumulative impact (Figure 3).

Table 5: Approved/Proposed Renewable Energy sites within a 50km radius of Tshepo.

	Project Title	Distance from Tshepo	Technology	Megawatts	Current Status
1	Portion 2 of Farm East	10,5 km	Solar PV	75	In Process
2	Rhodes 2 Solar Park	12,5 km	Solar PV	75	Approved
3	Adams PV Farm	12,5 km	Solar PV	75	Approved
4	Roma Energy Solar	15,5 km	Solar PV	0	Withdrawn/Lapsed
5	Shirley RE	21,0 km	Solar PV	75	Approved
6	Shirley RE	21,3 km	Solar PV	75	Approved
7	Keren Energy	29,4 km	Solar PV	10	Approved
8	Keren Energy	30,8 km	Solar PV	10	Approved
9	Shishen Solar Farm	38,5 km	Solar PV	0	Withdrawn/Lapsed
10	Kalahari Solar Power	40,5 km	Solar PV	0	Approved
11	San Solar Energy	41,5 km	Solar PV	75	Approved
12	Bestwood	48,9 km	Solar PV	0	Approved

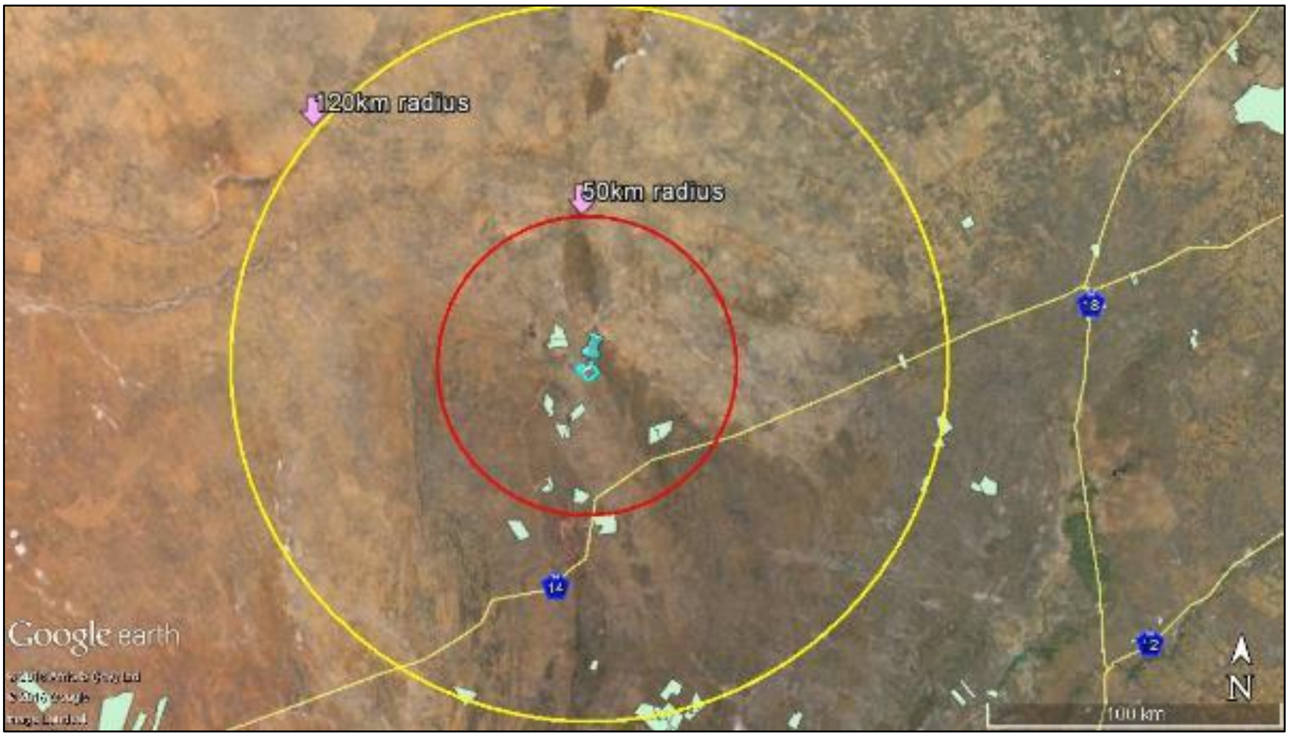

Figure 4: The proposed Tshepo solar site (blue pin in centre) in relation to 26 other proposed or approved renewable energy farms of various sizes within a 50 km (red circle) and 120 km radius (yellow circle).

Because there are no post-construction mortality data or displacement data for any of these aspects in South Africa, it is a futile exercise to attempt to put any figures to the Cumulative Impacts for birds in and around the solar sites. Once the data is collected and published (or released to other specialists) for a minimum of a year's monitoring, we can then quantify this aspect. On present data we cannot even guesstimate the cumulative impact.

5 CONCLUSIONS AND RECOMMENDATIONS

The proposed Tshepo PV Plant on London farm, near Hotazel, is one of many such renewable energy initiatives that are be proposed for this high-flux solar radiation region of South Africa.

The avifauna of the area may be affected by the infrastructure of the Solar Power (PV) plant but our analysis of the number of birds on the two sites suggests the impact will be minimised if the PV solar farm is constructed on the Alternative site based on higher species and bird abundance densities in the Preferred site in this wet season visit. It is important to realise that is a preliminary conclusion because it is based on a limited data set and one visit. Our second dry-season visit will help clarify the use of both sites by collision-prone species in the surrounding area.

We do not know whether the collision-prone birds that were recorded in the area, such as the Vulnerable Lanner Falcon, will continue to hunt in the site in the dry season around the farm dams; or, once the PV panels are in place, whether wetland birds will be attracted to them. Too little research in South Africa is presently available to determine that, and thus, a full 12 months of post-construction monitoring by trained ornithologists is a further recommendation.

We also recommend that all available precautions are taken to avoid the threatened raptors being attracted to the panels. If birds are attracted and collide with the panels by mistaking it for open water, then we recommend that innovative bird deterrent techniques are used such as the Torri lines mentioned in the avian Scoping Report (Simmons and Martins 2016).

If these recommendations can be followed and prove effective, we believe that the Tshepo PV solar park can be allowed to proceed with the least impact to the avifauna of the area.

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Dr R.E. Simmons and M Martins

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5 April 2016

revised: 23 April 2016

7 APPENDICES

Appendix 1: Bird species on the farm London

List of all 61 bird species recorded in the Tshepo PV site at London and their likelihood of occurrence from the bird atlas pentads. These pentads are: 2715_2255, 2715_2300, 2710_2305 and 2710_2300 from the period 2007 - 2016. Extracted from the Animal Demography Unit, University of Cape Town website http://sabap2.adu.org.za and based on 15 cards. **Threatened species are given in red, collision-prone species in bold,** wetland species are highlighted in blue**.** Our own records of species are given in the second Appendix table.

SABAP2 list of birds in pentads 2715_2255, 2715_2300, 2710_2305, 2710_2300 (N= 15 cards) LONDON site		
Common name	Full protocol	Rep Rate (%)
Babbler, Southern Pied	*Turdoides bicolor*	Ad hoc
Barbet, Acacia Pied	*Tricholaema leucomelas*	20
Batis, Pririt	*Batis pririt*	13.33
Bee-eater, European	*Merops apiaster*	Ad hoc
Brubru,	*Nilaus afer*	6.67
Bulbul, African Red-eyed	*Pycnonotus nigricans*	20
Bunting, Golden-breasted	*Emberiza flaviventris*	13.33
Canary, Black-throated	*Crithagra atrogularis*	6.67
Canary, Yellow	*Crithagra flaviventris*	20
Chat, Familiar	*Cercomela familiaris*	13.33
Crombec, Long-billed	*Sylvietta rufescens*	Ad hoc
Crow, Pied	*Corvus albus*	13.33
Dove, Laughing	*Streptopelia senegalensis*	20
Dove, Red-eyed	*Streptopelia semitorquata*	6.67
Dove, Rock	*Columba livia*	6.67
Drongo, Fork-tailed	*Dicrurus adsimilis*	13.33
Finch, Red-headed	*Amadina erythrocephala*	Ad hoc
Finch, Scaly-feathered	*Sporopipes squamifrons*	6.67
Fiscal, Common (Southern)	*Lanius collaris*	13.33
Flycatcher, Chat	*Bradornis infuscatus*	6.67
Flycatcher, Fiscal	*Sigelus silens*	6.67
Flycatcher, Marico	*Bradornis mariquensis*	26.67
Guineafowl, Helmeted	*Numida meleagris*	6.67
Hornbill, African Grey	*Tockus nasutus*	Ad hoc
Hornbill, Southern Yellow-billed	*Tockus leucomelas*	13.33
Lapwing, Crowned	*Vanellus coronatus*	20

Lark, Fawn-coloured	*Calendulauda africanoides*	13.33
Lark, Red-capped	*Calandrella cinerea*	6.67
Martin, Brown-throated	*Riparia paludicola*	6.67
Masked-weaver, Southern	*Ploceus velatus*	13.33
Mousebird, Red-faced	*Urocolius indicus*	6.67
Mousebird, White-backed	*Colius colius*	13.33
Ostrich, Common	*Struthio camelus*	6.67
Pipit, African	*Anthus cinnamomeus*	6.67
Prinia, Black-chested	*Prinia flavicans*	20
Pytilia, Green-winged	*Pytilia melba*	6.67
Robin-chat, Cape	*Cossypha caffra*	6.67
Rock-thrush, Short-toed	*Monticola brevipes*	6.67
Roller, Lilac-breasted	*Coracias caudatus*	13.33
Sandgrouse, Namaqua	*Pterocles namaqua*	6.67
Scimitarbill, Common	*Rhinopomastus cyanomelas*	6.67
Scrub-robin, Kalahari	*Cercotrichas paena*	20
Shrike, Crimson-breasted	*Laniarius atrococcineus*	13.33
Sparrow, Cape	*Passer melanurus*	6.67
Sparrow, House	*Passer domesticus*	6.67
Sparrow, Southern Grey-headed	*Passer diffusus*	13.33
Sparrow-weaver, White-browed	*Plocepasser mahali*	20
Starling, Cape Glossy	*Lamprotornis nitens*	13.33
Starling, Pale-winged	*Onychognathus nabouroup*	13.33
Sunbird, Dusky	*Cinnyris fuscus*	6.67
Sunbird, Marico	*Cinnyris mariquensis*	6.67
Swallow, Greater Striped	*Hirundo cucullata*	6.67
Swift, Little	*Apus affinis*	13.33
Thrush, Groundscraper	*Psophocichla litsipsirupa*	13.33
Tit, Ashy	*Parus cinerascens*	13.33
Vulture, Lappet-faced	*Torgos tracheliotus*	6.67
Vulture, White-backed	*Gyps africanus*	13.33
Waxbill, Black-faced	*Estrilda erythronotos*	13.33
Waxbill, Violet-eared	*Granatina granatina*	6.67
White-eye, Orange River	*Zosterops pallidus*	13.33
Woodpecker, Cardinal	*Dendropicos fuscescens*	6.67
61 species : 2 red data species		

APPENDIX 2: BIRD DENSITIES BY HABITAT

Species recorded on site in 1-km transects on the London PV site 13-14 March 2016

Species	Number	PerpDist	Date	Transect	Habitat
Northern black korhaan	1	100	13/03/2016	LN1	Boscia, Camelthorn, Rhigozum shrubs on sand
Namaqua dove	4	25	13/03/2016	LN1	Boscia, Camelthorn, Rhigozum shrubs on sand
Black-chested prinia	1	50	13/03/2016	LN1	Boscia, Camelthorn, Rhigozum shrubs on sand
Capped wheatear	1	40	13/03/2016	LN1	Boscia, Camelthorn, Rhigozum shrubs on sand
Kalahari scrub-robin	1	60	13/03/2016	LN1	Boscia, Camelthorn, Rhigozum shrubs on sand
Chestnut-vented titbabbler	1	60	13/03/2016	LN1	Boscia, Camelthorn, Rhigozum shrubs on sand
Yellow-billed hornbill	1	140	13/03/2016	LN1	Boscia, Camelthorn, Rhigozum shrubs on sand
Kalahari scrub-robin	1	80	13/03/2016	LN1	Boscia, Camelthorn, Rhigozum shrubs on sand
Cape turtle dove	1	90	13/03/2016	LN1	Boscia, Camelthorn, Rhigozum shrubs on sand
Lesser-grey shrike	1	160	13/03/2016	LN1	Boscia, Camelthorn, Rhigozum shrubs on sand
Northern black korhaan	1	100	13/03/2016	LN1	Boscia, Camelthorn, Rhigozum shrubs on sand
Black-chested prinia	1	50	13/03/2016	LN1	Boscia, Camelthorn, Rhigozum shrubs on sand
Fawn-coloured lark	2	55	13/03/2016	LN1	Boscia, Camelthorn, Rhigozum shrubs on sand
Chestnut-vented titbabbler	2	25	13/03/2016	LN1	Boscia, Camelthorn, Rhigozum shrubs on sand
Lesser-grey shrike	1	70	13/03/2016	LN1	Boscia, Camelthorn, Rhigozum shrubs on sand
Namaqua dove	2	20	13/03/2016	LN1	Boscia, Camelthorn, Rhigozum shrubs on sand
Ant-eating chat	1	160	13/03/2016	LN1	Boscia, Camelthorn, Rhigozum shrubs on sand
Pipit, African	1	30	13/03/2016	LN1	Boscia, Camelthorn, Rhigozum shrubs on sand
Cape turtle dove	2	50	13/03/2016	LN1	Boscia, Camelthorn, Rhigozum shrubs on sand
Black-chested prinia	1	80	13/03/2016	LN1	Boscia, Camelthorn, Rhigozum shrubs on sand
Lesser-grey shrike	1	20	13/03/2016	LN1	Boscia, Camelthorn, Rhigozum shrubs on sand
Capped wheatear	1	30	13/03/2016	LN1	Boscia, Camelthorn, Rhigozum shrubs on sand
Chestnut-backed sparrowlark	8	25	13/03/2016	LN1	Boscia, Camelthorn, Rhigozum shrubs on sand
Namaqua sandgrouse	4	60	13/03/2016	LN1	Boscia, Camelthorn, Rhigozum shrubs on sand
Fawn-coloured lark	2	90	13/03/2016	LN1	Boscia, Camelthorn, Rhigozum shrubs on sand
Capped wheatear	1	7	13/03/2016	LN1	Boscia, Camelthorn, Rhigozum shrubs on sand
Cape turtle dove	4	1	13/03/2016	LN1	Boscia, Camelthorn, Rhigozum shrubs on sand
Grey-backed sparrowlark	6	30	13/03/2016	LN1	Boscia, Camelthorn, Rhigozum shrubs on sand
Scaly-feathered finch	2	25	13/03/2016	LN1	Boscia, Camelthorn, Rhigozum shrubs on sand
Red-faced mousebird	2	60	13/03/2016	LN1	Boscia, Camelthorn, Rhigozum shrubs on sand
Fawn-coloured lark	2	90	13/03/2016	LN1	Boscia, Camelthorn, Rhigozum shrubs on sand
Black-chested prinia	1	60	13/03/2016	LN1	Boscia, Camelthorn, Rhigozum shrubs on sand
Namaqua dove	3	50	13/03/2016	LN1	Boscia, Camelthorn, Rhigozum shrubs on sand
Ant-eating chat	2	80	13/03/2016	LN1	Boscia, Camelthorn, Rhigozum shrubs on sand
Black-chested prinia	2	45	13/03/2016	LN1	Boscia, Camelthorn, Rhigozum shrubs on sand
Sociable weaver	4	120	13/03/2016	LN1	Boscia, Camelthorn, Rhigozum shrubs on sand
18 species	**72**	**birds**	**In this trans: Red Data species = 0 , Collision-prone species = 0**		
Yellow-billed hornbill	1	90	13/03/2016	LN2	Camelthorn, Rhigozum, Mellifera hookthorn
Red-crested korhaan	1	70	13/03/2016	LN2	Camelthorn, Rhigozum, Mellifera hookthorn
Cape turtle dove	1	60	13/03/2016	LN2	Camelthorn, Rhigozum, Mellifera hookthorn
Namaqua dove	1	30	13/03/2016	LN2	Camelthorn, Rhigozum, Mellifera hookthorn
Northern black korhaan	1	150	13/03/2016	LN2	Camelthorn, Rhigozum, Mellifera hookthorn
Brown-crowned tchagra	1	70	13/03/2016	LN2	Camelthorn, Rhigozum, Mellifera hookthorn
Scaly-feathered finch	3	25	13/03/2016	LN2	Camelthorn, Rhigozum, Mellifera hookthorn
Yellow-bellied eremomela	1	50	13/03/2016	LN2	Camelthorn, Rhigozum, Mellifera hookthorn
Chestnut-vented titbabbler	1	10	13/03/2016	LN2	Camelthorn, Rhigozum, Mellifera hookthorn

Black-chested prinia	1	7	13/03/2016	LN2	Camelthorn, Rhigozum, Mellifera hookthorn
Kalahari scrub-robin	1	25(30)	13/03/2016	LN2	Camelthorn, Rhigozum, Mellifera hookthorn
Fawn-coloured lark	1	90	13/03/2016	LN2	Camelthorn, Rhigozum, Mellifera hookthorn
Cape turtle dove	1	150	13/03/2016	LN2	Camelthorn, Rhigozum, Mellifera hookthorn
Northern black korhaan	1	150	13/03/2016	LN2	Camelthorn, Rhigozum, Mellifera hookthorn
Black-chested prinia	1	50	13/03/2016	LN2	Camelthorn, Rhigozum, Mellifera hookthorn
Chestnut-vented titbabbler	1	70	13/03/2016	LN2	Camelthorn, Rhigozum, Mellifera hookthorn
Scaly-feathered finch	3	10	13/03/2016	LN2	Camelthorn, Rhigozum, Mellifera hookthorn
Black-chested prinia	1	15	13/03/2016	LN2	Camelthorn, Rhigozum, Mellifera hookthorn
Red-crested korhaan	1	90	13/03/2016	LN2	Camelthorn, Rhigozum, Mellifera hookthorn
Ground-scraper thrush	1	200	13/03/2016	LN2	Camelthorn, Rhigozum, Mellifera hookthorn
Fawn-coloured lark	1	80	13/03/2016	LN2	Camelthorn, Rhigozum, Mellifera hookthorn
Yellow-bellied eremomela	1	55	13/03/2016	LN2	Camelthorn, Rhigozum, Mellifera hookthorn
Yellow-billed hornbill	1	35	13/03/2016	LN2	Camelthorn, Rhigozum, Mellifera hookthorn
Red-crested korhaan	1	83	13/03/2016	LN2	Camelthorn, Rhigozum, Mellifera hookthorn
Scaly-feathered finch	2	60	13/03/2016	LN2	Camelthorn, Rhigozum, Mellifera hookthorn
Fawn-coloured lark	1	45	13/03/2016	LN2	Camelthorn, Rhigozum, Mellifera hookthorn
Black-chested prinia	1	70	13/03/2016	LN2	Camelthorn, Rhigozum, Mellifera hookthorn
Cape turtle dove	1	120	13/03/2016	LN2	Camelthorn, Rhigozum, Mellifera hookthorn
Kalahari scrub-robin	2	40	13/03/2016	LN2	Camelthorn, Rhigozum, Mellifera hookthorn
14 species	**35**	**birds**	**In this trans: Red Data species = 0, Collision-prone species = 0**		
Total Birds	**107**				
Total Species	**22**				
Total Red-data Species	**0**				
Summary	**Species**	**Birds**	**Habitat**		
Lond1T1 (preferred)	18	72	Boscia, Camelthorn, Rhigozum shrubs on sand		
Lond2T1 (alternative)	14	35	Camelthorn, Rhigozum, Acacia mellifera		
Means	**16.00**	**53.50**			

APPENDIX 3: PASSAGE RATES OF COLLISION-PRONE SPECIES

Date	Time	Obsv period	Hrs	Vantage* Point	No.	Species	GPS pos on map	Height
13/03/2016	13h50	08h15-14h15	6	**VP1**	**1**	**Pale-chanting goshawk**	PCG1	25-30-30-30-30m
14/03/2016	08h01	06h50-12h50	6	**VP1**	**1**	**Lanner falcon**	LaFa1	5-5m
	08h18				4	Namaqua sandgrouse	NaSa2-5	40-40-40-35-20m
13/03/2016	8h52	06h00-08h00	2	**VP2**	4	Namaqua sandgrouse	NaSa6-9	10-15-20-20m
	10h53	08h30-12h30	4		1	Gabar goshawk	GaGos1	200-200-220-230-240-250-250-300-300-320-350-370-400-400-420-420-430-440-450-450-500
14/03/2016		07h00-13h00	6	**VP2**	0	**No Birds**		
			24	**TOTALS**	**11**	**Birds**	**4 Species**	
Passage rate:		11		birds in 24	hr	0.46	birds/hr	All birds
Passage rate:		**2**		**birds in 24**	**h**	**0.08**	**birds/hr**	**Collision-prone species**

*VP1 on the preferred site, VP2 on the alternative site