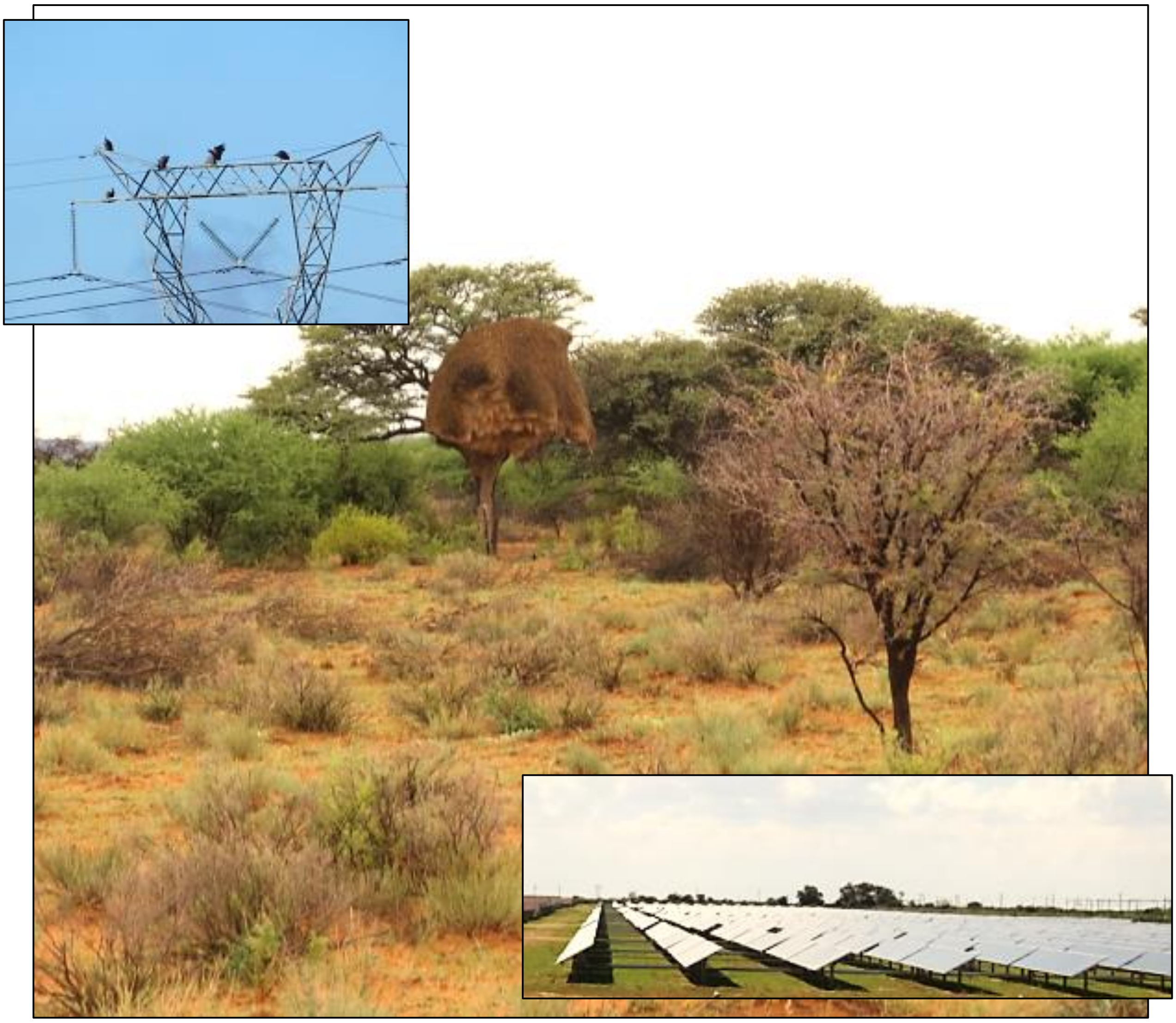
Pre-construction Avian Impact Assessment of the Lutzburg Solar (RF) (Pty) Ltd PV plant, near Olifantshoek, Northern Cape: March 2016



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1 SUMMARY

This study reports on avian monitoring in the wet-season for the proposed Lutzburg Solar (RF) (Pty) Ltd. PV project located on the farm "Ruby Vale" south of Olifantshoek, 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 and alternative area of 300 ha each 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 *Rhigozum* shrubs in the Eastern Kalahari Bioregion had 44 avian species recorded in or around Ruby Vale farm of which 4 were collision-prone (Cape Vulture *Gyps coprotheres,* White-backed Vulture *G. africanus*, Kori Bustard *Ardeotis kori* and Black-chested Snake-Eagle *Circaetus pectoralis*; the first three species are also red-listed.

In our 1 km surveys we recorded a relatively healthy species richness of smaller birds at an average of 20.5 species km^{-1} and 68.5 birds km^{-1}. The **Passage rate** of larger collision-prone birds was 0.5 birds per hour of observation. Other species that may be attracted to the panels such as wetland birds and sandgrouse were not recorded. Territorial pairs of Yellow-billed Hornbills *Tockus leucomelas* that may pose a risk to the panels by attacking their own reflections, were recorded on site in low numbers.

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) all power lines – *present and future* – must be marked with bird diverters to reduce the possible impact of the raptorial species; (iii) PV panels are constructed with non-reflective surfaces to reduce the risk of hornbills attacking their reflections in the panels, and (iv) any Sociable Weaver nests built on the PV infra-structure should be removed as they are started. On present evidence, the preferred site will cause less avian disruption than the alternative.

If these mitigation measures are followed to minimize any impacts to the threatened species highlighted here, our preliminary recommendation is that this solar 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 Subsolar. 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 Lutzburg (Pty) Ltd, south of Olifantshoek, 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, also 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 https://www.linkedin.com/in/marlei-martins-a0374a27?trk=nav_responsive_tab_profile

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 Lutzburg Solar (RF) (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 Lutzburg Solar (RF) (Pty) Ltd solar development.

2.2 POTENTIAL AVIAN IMPACTS

As with any type of large scale development, habitat will be permanently disturbed, displacing the resident and migrant species. Up to 300 ha of area is planned in the operation of the PV facility, and this will reduce habitat availability for birds where construction takes place. 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, roost sites 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 migrant, the highest among those reviewed.

Tabulating fatalities of birds at solar sites is not enough 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 Lutzburg Solar (RF) (Pty) Ltd 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 2-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 critical factors were then extrapolated to all South African species based on wing loading, aerial flights, nocturnal activity, red-data status (Taylor et al. 2015) 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 bustard 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 Lutzburg Solar (RF) (Pty) Ltd at Ruby Vale farm near Olifantshoek, Northern Cape are to:

1. Determine the densities of birds regularly present, or resident, within the impact area of the PVs before the construction phase;
2. Document the patterns and movements of birds in the vicinity of the proposed PVs 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. Quantify the impacts before and after mitigation;
6. 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. Because of the remoteness of the area no SABAP2 data http://sabap2.adu.org.za/index.php was available for this region.

We therefore used our own pre-construction (wet-season) site visit in March 2016 for all subsequent analyses; this will be followed by a (dry-season) visit in August 2015 to again survey avifauna in both the preferred and alternative solar park areas on Ruby Vale 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 no cards in the two pentads that cover the solar park itself;
- Use of the older SABAP 1 data set will include species that are found in an area 9-fold larger (i.e. 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 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 and 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 300 ha solar park to be developed by Lutzburg Solar (RF) (Pty) Ltd is located on the remaining extent of Portion 2 of the farm Ruby Vale No. 266, approximately 33 km south-west of Olifantshoek in the Northern Cape. The farm Ruby Vale 671/RE/1, is centred on S28° 13' 23.81" E 22° 34' 0.95" An alternative area of 300 ha (hereafter Lutzburg 2), about 2.0 km east was simultaneously assessed for avian species and possible impacts.

2.4.1 Vegetation of the study area

The study area occurs in Kalahari Savannah biome on red Kalahari sand and is classified as Olifantshoek Bushveld (Mucina and Rutherford 2006, p522). Vegetation is dominated by dense stands of *A. melifera* and an intermittent number of tall Camelthorn trees (A*cacia erioloba*). The shrub *Rhigozum* often reached high densities in some areas, suggesting high grazing pressure by livestock (sheep and goats) on the property. 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. All trees were in leaf and some grass sward layer was apparent. Thus we can classify this as a wet-season assessment.

2.4.2 Avian microhabitats

Bird habitat in the region consists mainly of bush-thickened *Acacia mellifera*, (some of which had been poisoned and were dead and moribund), Camelthorn *Acacia erioloba* and less often Shepherd trees *Boscia albitrunca.* Open ground was sometimes grassland (and grazed) and sometimes supported dense patches of Rhigozum shrubs. Taller trees and those growing near farm reservoirs are regularly used by passerine birds as nest sites, for perch sites (for foraging) and for shade and roosting in the hottest times of day. Two studies in the Kalahari have indicated that taller trees add significantly to the avian species richness of an area (because of the diverse niches they offer) and their removal therefore can reduce species richness (Seymour and Simmons 2008, Seymour and Dean 2010). Mature camelthorn trees are favoured by Sociable Weavers to construct their nests in and this species occurred on site. Artificial habitats are provided by land owners in the form of windmills, farm reservoirs and the power line and pylons that bisect the site. The pylons provide perch sites for both vultures and raptors, and nest sites for Sociable Weavers *Philetairus socius*. No pans were found in the study area.

Photo 1: Habitat in the more open areas of Ruby Vale showing the *Acacia erioloba* (foreground), Rhigozum shrubs (central) and the pylons used by nesting Sociable Weavers in the background.

2.5 ON–SITE METHODS

On 16 and 17 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 (Lutzburg 1) and alternative (Lutzburg 2) sites.

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

All **1-km bird transects** took place in the morning (bird-active) hours. Each transect was walked slowly over 40- to 60-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 some species were identified by call and the distance to them estimated if they were not 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 vultures and raptors) and noted and recorded the position of any nests found. Over 130 individual birds were recorded in the PV areas in these transects alone.

The most important aspect of this monitoring are **Vantage Point (VP) surveys,** that 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. As suggested by the draft BARESG guidelines, (Jenkins et al. 2015), 12 hours per VP is the minimum recommended observation time for each VP. Each VP should have a view-shed (area of observation) not exceeding 2 km. Because of the flat nature of the terrain we walked some areas not well covered by the VP points and observed from the rooftop of our vehicle at other sites.

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. vultures and raptors), but could include wetland species attracted by the panels. No data were available from bird atlas cards of Southern African Bird Atlas Projects (SABAP), website (http://sabap2.adu.org.za/index.php). We relied, therefore, on our own March 2016 records.

Our vulture observations were augmented by vulture tracking data supplied by Dr Louis Phipps. These are sub-continent-wide tracks for Cape Vultures, the most collision-prone species in South Africa (BARESG 2014). The tracks are derived from 10 adult and immature Cape Vultures captured in Mankwe Wildlife Reserve (North West Province) and followed from 2009 – 2011 (Phipps et al. 2013).

3.2 AVIAN SPECIES RICHNESS AND RED DATA SPECIES

A total of 44 bird species were recorded around the Ruby Vale farm from our records combined with Phipps' et al. (2013) vulture records. Of these, 4 species (Cape Vulture, White-backed Vulture, Kori Bustard *Ardeotis kori,* and Pale chanting Goshawk *Melierax canorus*) are collision-prone and the former three species are red-listed (Table 2).

Table 2. Red-listed (**in red**) and collision-prone bird species (**in bold**) known to occur over the proposed PV Lutzburg Solar (RF) (Pty) Ltd development at Ruby Vale farm drawn from our 2-day March 2016 site visit.

Common name	Scientific name	Red-list status	Reporting Rate*	Collision Rank**	Disturbance
Cape Vulture	*Gyps coprotheres*	Critically Endangered	-	1	High
White-backed Vulture	*Gyps africanus*	Endangered	50%	21	High
Kori Bustard	*Ardeotis kori*	Near Threatened	50%	37	High
Pale chanting Goshawk	*Melierax canorus*	Least threatened	50%	73	low

*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.

The vultures were recorded on the first morning some 3 km south of the site perched motionless in heavy rain on top of the transmission line pylons that bisect the site (see Figure 3). When they moved into the study on 17 March, some could be identified as White-backed Vultures. Data supplied by Louis Phipps on the Cape Vultures indicated that the young birds were relatively common just north and south of the study site. They were tracked here in 2010 but some birds stayed 2-3 months foraging in the area. The positions of all those closest to the study area are plotted in Figures 2 and 3. The Kori Bustard was flushed from the northern edge of the Alternative area during transects there.

In summary, a total of four **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). 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 20.0 species km^{-1} and 68.5 birds km^{-1} (Table 3), the highest species diversity counts recorded in any of the six sites surveyed in the Northern Cape in March. These species comprised typical thornveld birds such as hornbills, korhaans, scrub-robins, larks, chats, prinias, finches and migrant cuckoos and shrikes, and also Sociable Weavers.

At the preferred and the alternate sites, we recorded similar numbers of species (20 spp km^{-1} at each site) but more birds (82 km^{-1}) in the alternative than the preferred (35 km^{-1}) (Table 3). The latter was a reflection of the greater number of mature camel thorn and Boscia trees in the alternative site (Lutzburg 1).

Table 3: Bird species and numbers recorded over 1 km at the preferred and alternative Lutzburg PV sites on 16 – 17 March 2016.

Summary	Species	Birds	Habitat
Lutzburg 1 (transect 1) alternative	20	82	Mature Acacia mellifera, grasses
Lutzburg 2 (transect 1) preferred	20	55	Rhigozum shrubs, grasses
Means	**20.5**	**68.5**	

The VP observations totalling 12 h at each site on 16 and 17 March revealed 12 collision-prone birds inside the borders: seven White-backed Vultures perched then soaring over the site, a Black-chested Snake-Eagle acting similarly and one Pale Chanting. The 12 birds in 24 h of observation gives a Passage Rate for the collision-prone species of 0.5 birds h^{-1} (Appendix 1).

Photo 2: Adult and juvenile White-backed Vultures roosting on the pylons on the Lutzburg Solar (RF) (Pty) Ltd solar site.

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

Yellow-billed Hornbills *Tockus leucomelas* are unknown entities as far as PV solar farms are concerned, and occur in the area. Hornbills have powerful bills (Kemp 2005), and have the potential to cause damage to the PV panels if they attack their own reflections in shiny surfaces - mistaking them for territorial intruders during the breeding season (Dr A Kemp pers comm.). There is a low risk of this given that the PV panels are likely to have non-reflective surfaces.

Photo 3: Yellow-billed Hornbills were recorded on both the preferred and alternative Lutzburg PV sites and may cause damage to the PV panels if they have reflective surfaces.

The only other species of note that may create some issues for the developers is the Sociable Weaver *Philetairus soceus* that occurs on site. They typically target mature trees but here they have learned to build on the metal pylons that bisect the site. They may try to nest on the structures supporting the PV panels and nests would have to be cleared on a regular basis.

Photo 4: Colonies of Sociable Weavers build their massive grass nests on the pylons that bisect the Lutzburg development area. This is the only area we have seen them use metal pylons in this manner and therefore, they may attempt to use the structures beneath the PV panels also.

In summary, four collision-prone species have been recorded over the site, and the presence of the social vultures gives a medium passage rate of 0.50 birds $hour^{-1}$. The number of smaller birds recorded per kilometre was relatively high at an average of 68.5 birds km^{-1}. Comparing the two sites the preferred site had two collision prone species present (White-backed Vulture, Black-chested Snake Eagle), and the Alternative one (Kori Bustard).

The Cape Vulture tracking data (Phipps et al. 2013) suggest that these birds (and the White-backed Vultures) are equally likely to fly over either development. The two sites also shared equal numbers of smaller species per kilometre (20 each), but a lower density of birds per kilometre (55 vs. 82) occurred on the Preferred. Thus, on present (wet-season) evidence development on the preferred site will cause slightly less disruption to the resident avifauna than that on the Alternative site.

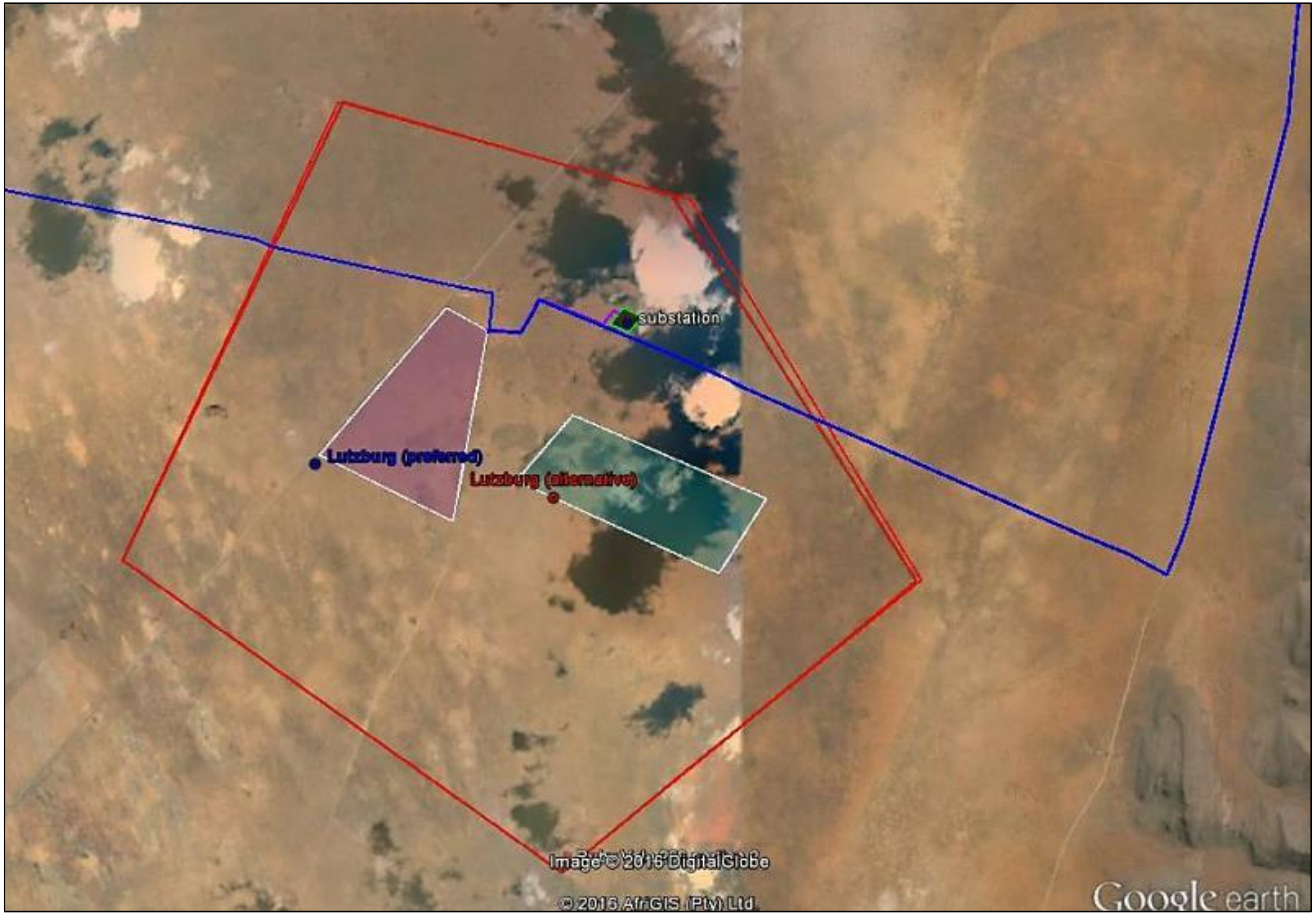

Figure 1: Layout of the preferred (left) and alternative (right) Lutzburg Solar (RF) (Pty) Ltd solar plant on the farm Ruby Vale near Olifantshoek. The Ruby Vale farm boundary (red boundary) and the substation are also indicated.

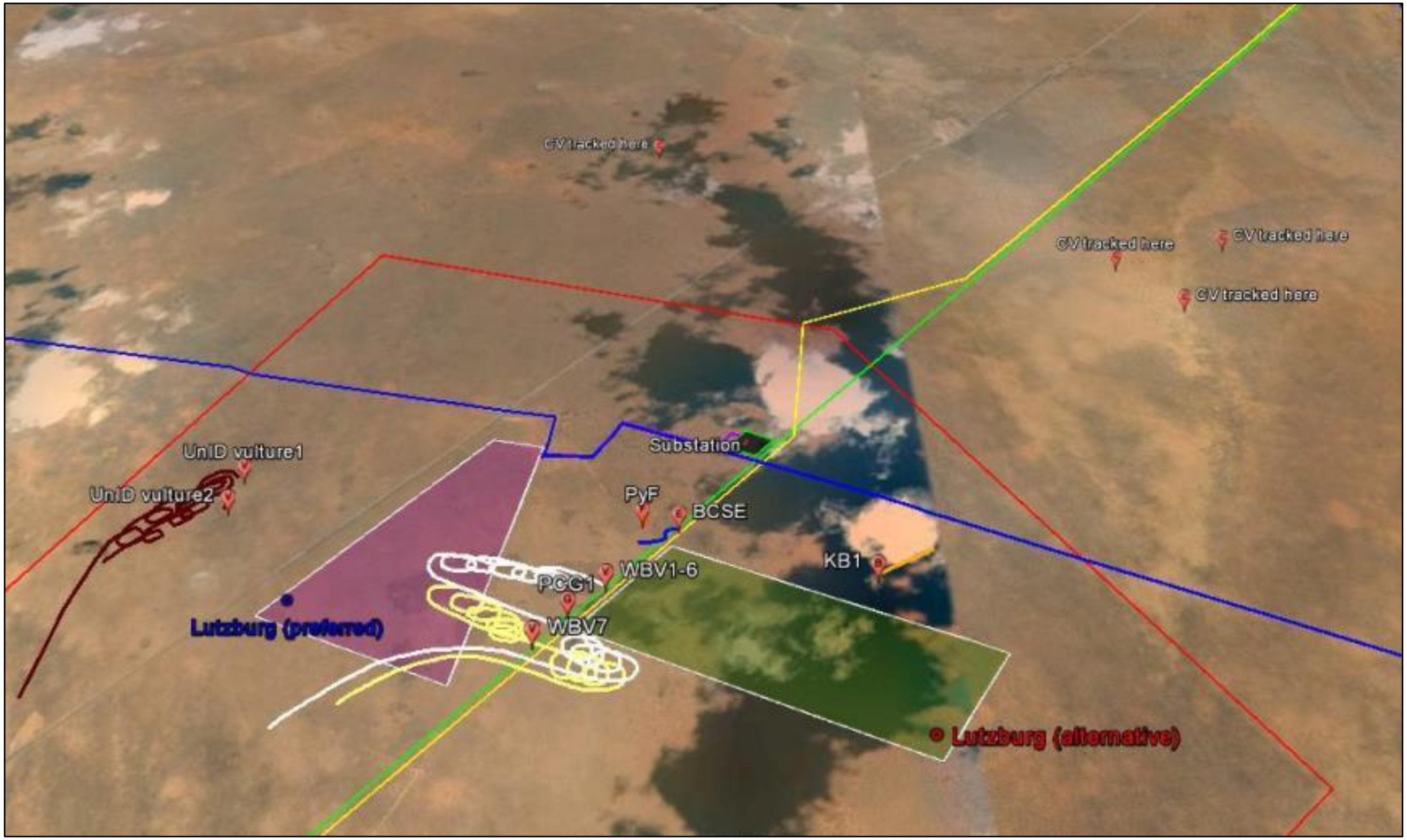

Figure 2: Bird movements and perch sites in the preferred (left) and alternative (right) Lutzburg Solar (RF) (Pty) Ltd PV solar plant on the farm Ruby Vale near Olifantshoek, 16-17 March 2016. The White-backed Vultures (WBV1-7) were perched on the pylons in the morning and their flights are shown (white lines). The Kori Bustard (KB – orange line) was close to the Lutzburg alternative border. A Pale chanting Goshawk (=PCG) and Black-chested Snake Eagle (=BCSE) were also present near the pylons. Three immature Cape Vultures tracked in this area in 2010 (Phipps et al. 2013) are shown north of the site ("CV tracked here") to indicate their presence in the area.

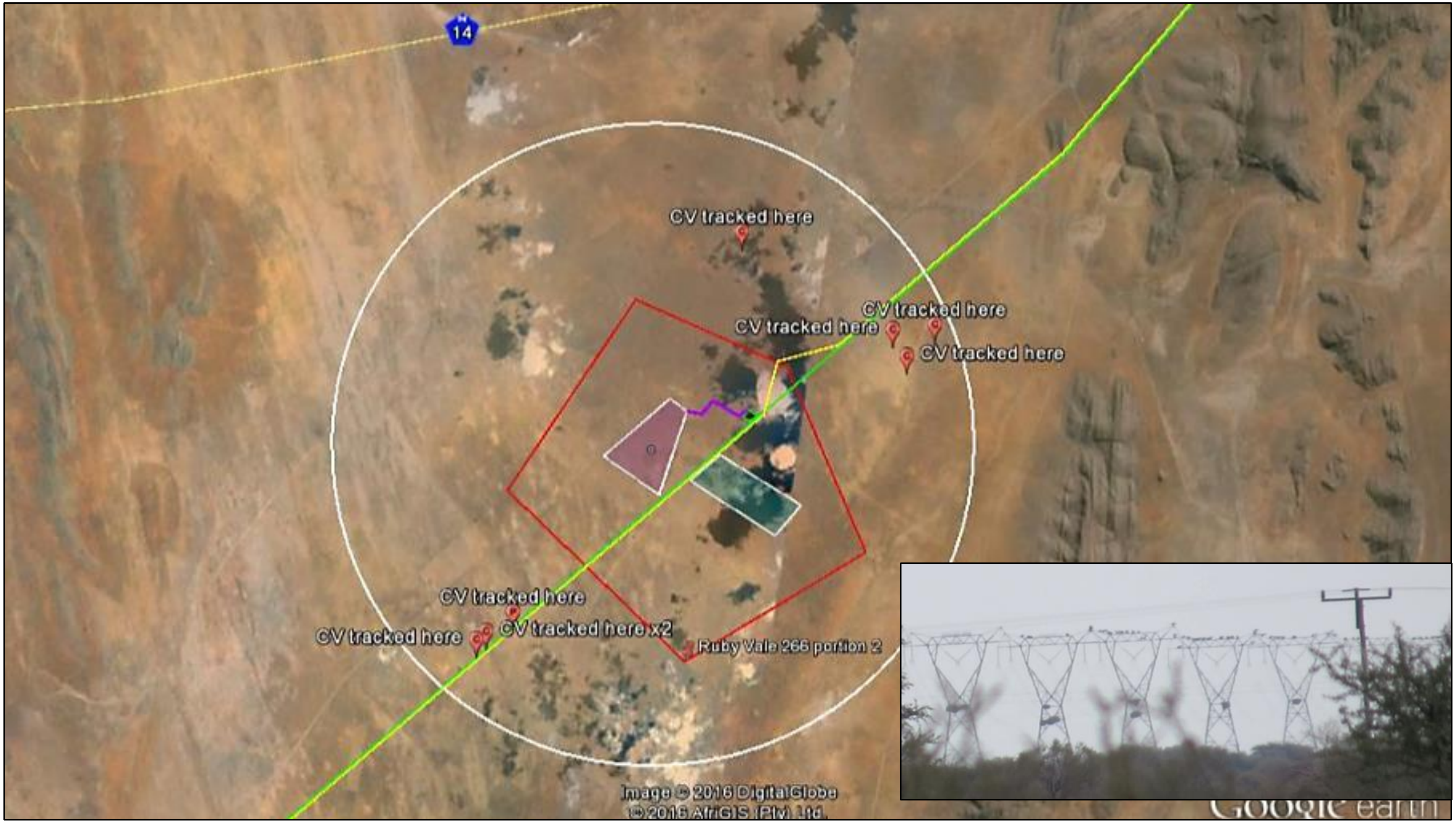

Figure 3: All Cape Vulture tracking data from within 9km of the Lutzburg preferred PV site (purple rhomboid) in 2010 (Phipps et al. 2013). Birds were tracked by GPS to these locations ("CV tracked here") and individual pylons can sometimes be pinpointed as the roost sites. More than 50 vultures were observed roosting on pylons 3.3 km south of the farm on 16 March 2016 (inset) approximately corresponding with the point marked "CV tracked here x2". Their identity was unknown.

4 QUANTIFYING THE IMPACTS

Nature: The impact of the proposed PV areas will generally be negative given the certainty that: (i) 300 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 Hornbills, which were recorded on site, may additionally pose a risk to panels but only if the panels have highly reflective surfaces.

It must be noted that the pylons (as opposed to the transmission lines they carry) can also be considered positive for the raptors and Sociable Weavers given that they provide perching 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 300 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 impact of the PV areas is expected to have a low impact **(2)** for the vultures and raptors; for the transmission line raptors both benefit (perch sites) and may be killed through impact or electrocution, giving a medium-high Magnitude of **(7).**

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). More smaller birds will be displaced by habitat destruction of 300 ha in the Alternative area given the density of birds in the more mature treed habitat that covers the alternative PV area.

The Probability of occurrence (**P,** from 1-5) of the vultures and raptors having a negative interaction with the PV panels is ranked medium low **(2)** but for the transmission lines it is ranked high **(5)** because of their propensity to collide with them. For the wetland birds, the probability of occurrence is very low **(1)** because they were not recorded 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) from 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. (**VRAP**= Vultures+Raptors, **WB** = Wetland birds):		
	Without mitigation	**With mitigation**
Extent	**1**	**1**
Duration	**4**	**4**
Magnitude	**2 (VRAP), 1 (WB)**	**1 (VRAP), 1 (WB)**
Probability	**2 (VRAP), 1 (WB)**	**1 (VRAP), 1(WB)**
Significance (E+D+M)P	**14 (VRAP), 6 (WB)** **Low risk**	**6 (VRAP), 6 (WB)** **Very Low risk**
Status (+ve or –ve)	Negative	Neutral
Reversibility	Low	(mitigations untested)
Irreplaceable loss of species?	Yes, if Critically Endangered Cape Vultures are impacted by the PV panels	
Can impacts be mitigated?	Probably yes: the constructing the PV site in the Preferred area will displace fewer small species. So the Preferred site is a better option.	

Mitigation for impacts for the PV panels

There are two 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 non-reflective surface is recommended.

It is also recommended that Lutzburg Solar (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. See below.

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.

(**VRAP** = vultures+raptors, **WB** = Wetland birds):

	Without mitigation	**With mitigation**
Extent	**3**	**2**
Duration	**4**	**4**
Magnitude	**7(VRAP)**, **2 (WB)**	**5(VRAP), 1 (WB)**
Probability	**5(VRAP), 1 (WB)**	**3(VRAP), 1 (WB)**
Significance (E+D+M)P	**70 (VRAP), 9 (WB)** **(very high for vultures– mitigation required)**	**33 (VRAP), 7 (WB)** **(medium)**
Status (+ve or –ve)	Negative	Neutral
Reversibility	Medium- High	Medium-High
Irreplaceable loss of species?	Yes, if juvenile Cape Vultures, which are both naive and highly collision-prone birds occur within either site, they have a high probability of mortality by collision/electrocution.	
Can impacts be mitigated?	Yes, by marking the earth wire of 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 vultures and 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 Lutzburg 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 120 km, and secondly, to know their impact on avifauna.

Given the general assumption that footprint size and bird impacts are linearly related for 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.

By the end of 2015 there were at least 42 proposed or approved renewable energy farms of various sizes within 120 km of Lutzburg. We have attached a current status table (Table 5) and map (Figure 3) depicting the sites proposed within a 50 km radius, as they are the most likely to have a cumulative impact

Table 5: Approved/Proposed Renewable Energy sites within a 50km radius of Lutzburg. Source: http://egis.environment.gov.za/frontpage.aspx?m=27 Directorate of Environmental Affairs) last quarter 2015.

	Project Title	Distance from Lutzburg	Technology	Megawatts	Current Status
1	Jasper Power	4,5 km	Solar PV	75	Approved
2	Inyanga Energy	46,1 km	Solar PV	75	Approved
3	Postmasburg CSP	49,8 km	Solar CSP	100	Approved

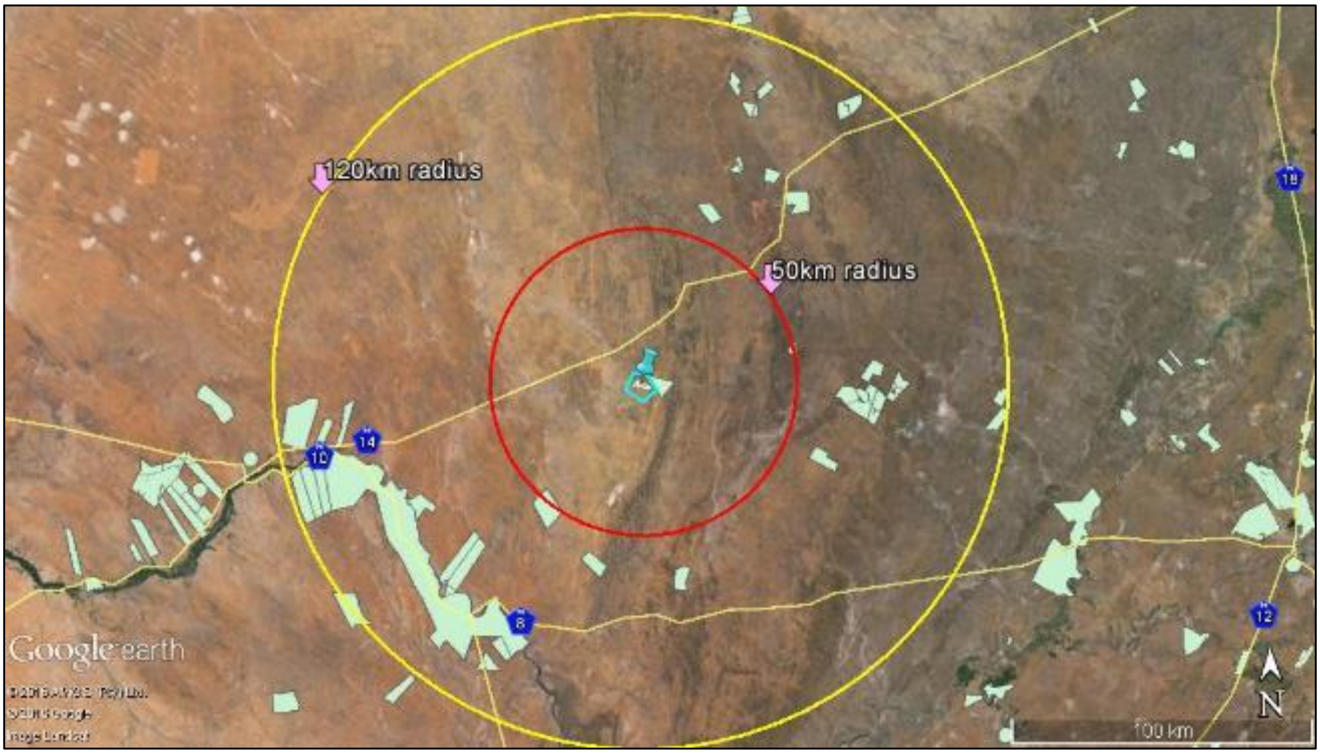

Figure 4: The proposed Lutzburg solar site (blue pin in centre) in relation to 42 other proposed or approved renewable energy farms of various sizes within 120km radius (yellow circle). Three sites occur within 50 km (red circle).

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 Lutzburg Solar (RF) (Pty) Ltd PV plant on Ruby Vale farm, near Olifantshoek, 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 and 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 Preferred (western) site based on higher bird densities in the Alternative site in this wet season visit.

More importantly, we know the area is regularly used by South Africa's most collision prone and highly threatened red-data species – the Cape Vulture. All transmission lines in this area should therefore be marked with bird diverters on the earth wires. While these are preliminary conclusion, because they are based on a limited data set and one visit, the certainty of knowledge of susceptibility to collisions is high (e.g. Phipps et al. 2013). Thus, all lines used by the birds should be marked. Our second dry-season visit will help clarify the use of both sites by all the collision-prone species in the surrounding area.

We do not know whether the collision-prone birds recorded in the area, such as the critically Endangered Cape Vulture and Endangered White-backed Vulture, will continue to hunt in the site in the dry season; 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 at this site by trained ornithologists (able to distinguish Cape Vultures from White-backed Vultures) 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 Lutzburg PV solar park can be allowed to proceed with the least impact to the avifauna of the area.

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7 APPENDICES

APPENDIX 1: ALL BIRD SPECIES ON THE FARM RUBY VALE.

List of all bird species that were recorded in the Lutzburg PV sites at Ruby Vale and their likelihood of occurrence from our 2-day sampling 16-17 March 2016. The two pentads our sampling covered were: 2810_2230 and 2810_2235. **Threatened species are given in red, collision-prone species in bold,** wetland species are highlighted in blue**.**

Barbet, Acacia pied	Korhaan, Red-crested
Batis, Pririt	Lark, Cape clapper
Bee-eater, European	Lark, Fawn-coloured
Bokmakierie	Lark, Sabota
Boubou, Crimson-breasted	Mousebird, Red-faced
Bustard, Kori	Pigeon, Speckled
Canary, Yellow	Prinia, Black-chested
Chat, Ant-eating	Scrub-robin, Kalahari
Crombec, Long-billed	Shrike, Lesser-grey
Cuckoo, Black	Shrike, Red-backed
Cuckoo, Diedrick	Sparrow, Cape
Cuckoo, Jacobin	Starling, Glossy
Dove, Cape turtle	Sunbird, Amethyst
Dove, Laughing	Swallow, Barn
Dove, Namaqua	Swallow, Greater-striped
Drongo, Fork-tailed	Swift, Common
Eremomela, Yellow-bellied	Tchagra, Brown-crowned
Falcon, Pygmy	Tit, Ashy
Finch, Scaly-feathered	Titbabbler, Chestnut-vented
Flycatcher, Marico	**Vulture, White-backed**
Goshawk, Pale chanting	Weaver, Sociable
Hornbill, Yellow-billed	**Cape Vulture** *
44 SPECIES	

*Recorded by Phipps et al. (2013) with GPS tags on 10 Cape Vultures from 2009-2011

Appendix 2: Bird densities by habitat

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

Species	Number	PerpDist	Date	Transect	Habitat
Cape turtle dove	3	25	16/03/2016	LZT1	Mature Acacia trees, grass, Rhigozum alien vegetation
Namaqua dove	1	15	16/03/2016	LZT1	Mature Acacia trees, grass, Rhigozum alien vegetation
Laughing dove	1	20	16/03/2016	LZT1	Mature Acacia trees, grass, Rhigozum alien vegetation
Lesser-grey shrike	1	23	16/03/2016	LZT1	Mature Acacia trees, grass, Rhigozum alien vegetation
Kalahari scrub-robin	1	40	16/03/2016	LZT1	Mature Acacia trees, grass, Rhigozum alien vegetation
Kalahari scrub-robin	1	35	16/03/2016	LZT1	Mature Acacia trees, grass, Rhigozum alien vegetation
Acacia pied barbet	1	55	16/03/2016	LZT1	Mature Acacia trees, grass, Rhigozum alien vegetation
Cape turtle dove	2	30	16/03/2016	LZT1	Mature Acacia trees, grass, Rhigozum alien vegetation
Cape sparrow	2	20	16/03/2016	LZT1	Mature Acacia trees, grass, Rhigozum alien vegetation
Lesser-grey shrike	1	48	16/03/2016	LZT1	Mature Acacia trees, grass, Rhigozum alien vegetation
Acacia pied barbet	1	75	16/03/2016	LZT1	Mature Acacia trees, grass, Rhigozum alien vegetation
Red-backed shrike	3	0	16/03/2016	LZT1	Mature Acacia trees, grass, Rhigozum alien vegetation
Cape turtle dove	1	60	16/03/2016	LZT1	Mature Acacia trees, grass, Rhigozum alien vegetation
Acacia pied barbet	1	45	16/03/2016	LZT1	Mature Acacia trees, grass, Rhigozum alien vegetation
Kalahari scrub-robin	1	22	16/03/2016	LZT1	Mature Acacia trees, grass, Rhigozum alien vegetation
Chestnut-vented titbabbler	2	0	16/03/2016	LZT1	Mature Acacia trees, grass, Rhigozum alien vegetation
Acacia pied barbet	1	38	16/03/2016	LZT1	Mature Acacia trees, grass, Rhigozum alien vegetation
Dusky sunbird	1	10	16/03/2016	LZT1	Mature Acacia trees, grass, Rhigozum alien vegetation
Yellow canary	2	5	16/03/2016	LZT1	Mature Acacia trees, grass, Rhigozum alien vegetation
Sabota lark	1	10	16/03/2016	LZT1	Mature Acacia trees, grass, Rhigozum alien vegetation
Long-billed crombec	2	18	16/03/2016	LZT1	Mature Acacia trees, grass, Rhigozum alien vegetation
Sociable weaver	8	25	16/03/2016	LZT1	Mature Acacia trees, grass, Rhigozum alien vegetation
Cape turtle dove	1	60	16/03/2016	LZT1	Mature Acacia trees, grass, Rhigozum alien vegetation
Sociable weaver	30	35	16/03/2016	LZT1	Mature Acacia trees, grass, Rhigozum alien vegetation
Yelow-bellied eremomela	1	8	16/03/2016	LZT1	Mature Acacia trees, grass, Rhigozum alien vegetation
Black-chested prinia	1	12	16/03/2016	LZT1	Mature Acacia trees, grass, Rhigozum alien vegetation
Crimson-breasted boubou	1	15	16/03/2016	LZT1	Mature Acacia trees, grass, Rhigozum alien vegetation
European bee-eaters	3	58	16/03/2016	LZT1	Mature Acacia trees, grass, Rhigozum alien vegetation
Yellow-billed hornbill	1	35	16/03/2016	LZT1	Mature Acacia trees, grass, Rhigozum alien vegetation
Sociable weaver	5	10	16/03/2016	LZT1	Mature Acacia trees, grass, Rhigozum alien vegetation
Marico flycatcher	1	12	16/03/2016	LZT1	Mature Acacia trees, grass, Rhigozum alien vegetation
20 species	**82**	**birds**	**In this trans: Red Data species = 0, Collision-prone species = 0**		
Acacia pied barbet	1	100	17/03/2016	LZT2	Mature Acacia trees, grass, Rhigozum alien vegetation,goats
Lesser-grey shrike	1	60	17/03/2016	LZT2	Mature Acacia trees, grass, Rhigozum alien vegetation,goats
Cape turtle dove	3	100	17/03/2016	LZT2	Mature Acacia trees, grass, Rhigozum alien vegetation,goats
Cape sparrow	2	35	17/03/2016	LZT2	Mature Acacia trees, grass, Rhigozum alien vegetation,goats
Black-chested prinia	1	60	17/03/2016	LZT2	Mature Acacia trees, grass, Rhigozum alien vegetation,goats
Sabota lark	1	15	17/03/2016	LZT2	Mature Acacia trees, grass, Rhigozum alien vegetation,goats
Pygmy falcon	1	10	17/03/2016	LZT2	Mature Acacia trees, grass, Rhigozum alien vegetation,goats
Lesser-grey shrike	1	72	17/03/2016	LZT2	Mature Acacia trees, grass, Rhigozum alien vegetation,goats
Yellow-billed hornbill	1	50	17/03/2016	LZT2	Mature Acacia trees, grass, Rhigozum alien vegetation,goats
Lesser-grey shrike	1	50	17/03/2016	LZT2	Mature Acacia trees, grass, Rhigozum alien vegetation,goats
Cape turtle dove	1	0	17/03/2016	LZT2	Mature Acacia trees, grass, Rhigozum alien vegetation,goats

Acacia pied barbet	1	80	17/03/2016	LZT2	Mature Acacia trees, grass, Rhigozum alien vegetation,goats
White-backed vulture	1	250	17/03/2016	LZT2	Mature Acacia trees, grass, Rhigozum alien vegetation,goats
White-backed vulture	7	200	17/03/2016	LZT2	Mature Acacia trees, grass, Rhigozum alien vegetation,goats
Fork-tailed drongo	1	25	17/03/2016	LZT2	Mature Acacia trees, grass, Rhigozum alien vegetation,goats
Lesser-grey shrike	2	38	17/03/2016	LZT2	Mature Acacia trees, grass, Rhigozum alien vegetation,goats
Brown-crown tchagra	1	15	17/03/2016	LZT2	Mature Acacia trees, grass, Rhigozum alien vegetation,goats
Kalahari scrub-robin	2	18	17/03/2016	LZT2	Mature Acacia trees, grass, Rhigozum alien vegetation,goats
Red-backed shrike	1	45	17/03/2016	LZT2	Mature Acacia trees, grass, Rhigozum alien vegetation,goats
Scaly-feathered finch	4	12	17/03/2016	LZT2	Mature Acacia trees, grass, Rhigozum alien vegetation,goats
Red-faced mousebird	1	2	17/03/2016	LZT2	Mature Acacia trees, grass, Rhigozum alien vegetation,goats
Sabota lark	1	25	17/03/2016	LZT2	Mature Acacia trees, grass, Rhigozum alien vegetation,goats
Namaqua dove	1	70	17/03/2016	LZT2	Mature Acacia trees, grass, Rhigozum alien vegetation,goats
Black-chested prinia	4	48	17/03/2016	LZT2	Mature Acacia trees, grass, Rhigozum alien vegetation,goats
Cape sparrow	3	22	17/03/2016	LZT2	Mature Acacia trees, grass, Rhigozum alien vegetation,goats
Bokmakierie	1	53	17/03/2016	LZT2	Mature Acacia trees, grass, Rhigozum alien vegetation,goats
Lesser-grey shrike	1	25	17/03/2016	LZT2	Mature Acacia trees, grass, Rhigozum alien vegetation,goats
Cape sparrow	1	18	17/03/2016	LZT2	Mature Acacia trees, grass, Rhigozum alien vegetation,goats
Lesser-grey shrike	1	0	17/03/2016	LZT2	Mature Acacia trees, grass, Rhigozum alien vegetation,goats
Yellow-bellied eremomela	2	10	17/03/2016	LZT2	Mature Acacia trees, grass, Rhigozum alien vegetation,goats
Kalahari scrub-robin	1	40	17/03/2016	LZT2	Mature Acacia trees, grass, Rhigozum alien vegetation,goats
Diedrick cuckoo	1	50	17/03/2016	LZT2	Mature Acacia trees, grass, Rhigozum alien vegetation,goats
Ant-eating chat	1	0	17/03/2016	LZT2	Mature Acacia trees, grass, Rhigozum alien vegetation,goats
Black-chested prinia	2	65	17/03/2016	LZT2	Mature Acacia trees, grass, Rhigozum alien vegetation,goats
21 species	**55**	**birds**	**In this trans: Red Data species = 2, Collision-prone species = 1**		
Total Birds	**137**				
Total Species	**30**				
Total Red-data Species	**3**	**Cape vulture; White-backed vulture**			
Summary	**Species**	**Birds**	**Habitat**		
RVT1	20	82	Mature Acacia trees, grass, Rhigozum, some alien vegetation		
RVT2	20	55	Mature Acacia trees, grass, higozum, some alien vegetation goats		
Means	**20.00**	**68.50**			

Appendix 3: Passage rates of Collision-prone species

Date	Time	Obsv period	Hrs	Vantage Point	No.	Species	GPS pos on map	Height	Flight duration (s)
16/03/2016		07h00-13h00	6	**VP1**		No Birds			
17/03/2016	10h03	08h00-14h00	6	**VP1**	1	**Unidentified vulture**	UnID vulture1	250-260-270-280-300m	60
	10h03				1	**Unidentified vulture**	UnID vulture2	220-230-240-250-260-270-250- 220m	120
	10h04				6	**White-backed vulture**	WhBaVu1-6	50-50-60-60-70-70-80-80-90-100-100-120-120-130-140-140-150-160-160-170-180-190-200	480
	10h04				1	**White-backed vulture**	CaVu1	50-50-50-50-60-60-70-70-70-80-80-80-90-90-90-100-100-120-120-130-130-140-140m	480

	12h50				1	**Pale-chanting goshawk**	PCG1	30-2m	30
16/03/2016		07h00-13h00	6	**VP2**		No Birds			
17/03/2016	10h24	07h30-13h30	6	**VP2**	1	**Kori bustard**	KoBu1	2-4m	25
	13h20				1	**Black-chested snake-eagle**	BlChSnEa1	25-30-30-30-30m	60
			24	**TOTALS**	**12**	**Birds**	**4 Species**		
Passage rate:		12		birds in 24	hr	0.50	birds/hr	All birds	
Passage rate:		**12**		**birds in24**	**hr**	**0.50**	**birds/hr**	**All collision-prone birds**	