Annex E

Ecology Specialist Study

GROENWATER SOLAR PV FACILITY,

POSTMASBURG DISTRICT

ECOLOGICAL REPORT

Prepared by:

Prof. P.J. du Preez

Department of Plant Sciences

University of the Free State

P.O. Box 339,

Bloemfontein

9300

Prepared for:

Intikon Solar PV Facilities

17 / 01 / 2011

1. INTRODUCTION

This report was prepared by Johann du Preez, Departmental Chairperson of the Department of Plant Sciences of the University of the Free State. Johann du Preez has a Ph.D. (University of the Free State) and is a Professional Natural Scientist (SACNASP No. 400271/07)(Field of expertise: ecology and botany). He is also a Professional Member of the South African institute of Ecologists & Environmental Scientists (SAIE&ES) as well as BirdLife South Africa. He has 28 years of experience in vegetation science and terrestrial ecology. Since the promulgation of NEMA (National Environmental management Act)(Act 107. of 1998), he is acting as vegetation and ecology specialist.

In order to comply with regulatory requirements of the National Environmental Management Act (Act 107. of 1998) Intikon Solar PV Facilities has appointed Johann du Preez to undertake the following: an assessment of the terrestrial ecology (including the flora and fauna) in The Study Area as well as to investigate the potential impact on the fauna and flora of The Study Area in the Greenwater area (farm: Humansrus) about 25 km east of Postmasburg, Northern Cape province.

The brief for this study can be summarised as follows:

- to undertake a terrestrial flora and fauna assessment of the proposed candidate site;
- to source and review baseline information;
- to undertake the requisite field work and compile a report that considers the following aspects:
    - A broad description of the terrestrial ecological characteristics of the candidate sites and surrounds;
    - Identification and description of biodiversity patterns at community and ecosystem level (main vegetation type, plant and animal communities in vicinity and threatened/ vulnerable ecosystems species), at species level (Red Data Book species, presence of alien species) and in terms of significant landscape features;
    - Identification of potential impacts and recommendations to mitigate these;
    - Comment on whether or not biodiversity processes would be affected by the proposed project, and if so, how these would be affected;
    - Provide a preference ranking of the site in terms of terrestrial fauna and flora, with and without mitigation measures.

2. METHODOLOGY

2.1 Assumptions

Although the construction of the solar PV facility would only result in the destruction of a portion of the preferred site, this study has assumed that the entire site would be destroyed. This is to allow for the movement of infrastructure within the site, should this be required for technical reasons at the detailed design phase of the proposed solar plant. As a result the impacts assessed in this study are considered to be the worst case scenario.

2.2 Limitations

- No detailed information of the vegetation or terrestrial fauna present on The Study Area exists. However general descriptions of the regional fauna and flora are available and were used. These descriptions were ground-truthed through a site visit.
- Not all the species present in these vegetation units could be noted due to the time of year (season), lack of spring rains and large expanse of The Study Area which prevented detailed surveys of the entire area. However, a number of transects were surveyed and this was considered to be a sufficient basis on which to base the conclusions of this study.

2.3 Information Base for Desk Study

The following existing databases and Red Data Books were reviewed for relevant information:

- Vegetation
  - VEGMAP (Mucina *et al.* 2005);
  - Red Data Plant Lists (Raymondo *et al.* 2009);
  - Vegetation descriptions (Mucina & Rutherford 2006; Smit 2000);
  - Field guides and books (Van Wyk & Malan, 1992; Van Wyk & Van Wyk 1997; Van Oudtshoorn 1999; Van Rooyen *et al.* 2001);
- Terrestrial Animals
  - Field guides & books (Branch, 1998; Du Preez & Caruthers 2008; Smithers 1983; Stuart & Stuart 1997; Woodall 2005).

The bird study made use of the following data sources:

- The sites were visited by foot and vehicle;

- Bird distribution data of the Southern African Bird Atlas Project (SABAP)(Harrison *et al.* 1997);
- Information on bird occurrence and densities was obtained from the Birds in Reserves. Project of the Avian Demography Unit at the University of Cape Town;
- The conservation status of all bird species occurring in the aforementioned quarter degree squares was determined with the use of The Eskom Red Data book of birds of South Africa, Lesotho and Swaziland (Barnes, 2000);
- Red Data List of Birds (Chitten *et al.* 2005)
- The Important Bird Areas (IBA) project data was consulted to establish if any bird areas are located in The Study Area (Barnes 1998);
- The power line bird mortality incident database of the Eskom-Endangered Wildlife Trust Strategic Partnership (1996 to present) was consulted to determine which of the species occurring in The Study Area are typically impacted upon by power lines.

2.4 Survey

The sites were visited and transects were walked across possible sensitive areas (depressions and surrounding tree communities). The following was noted.

- Veld composition in terms of:
* Vegetative structure and classification (main vegetation types);
* Plant species, including an indication of dominant species, rare and endangered species (Red data species), and exotic and invader species;
* Plant species and the environment;
* Plant species inter-relations;
- Veld condition:
* Assessment of veld condition;
* Interpretation of veld condition assessment;
* Rehabilitation needs and options;
* Conservation status and potential;
- Animal species identification, including an indication of dominant species, rare and endangered species (Red data species), and exotic and invader species;
- Animal species and their habitats;
- Assessment of the habitat condition of the animals;

2.5 Biodiversity Impact Evaluation

Impact assessment must take account of the nature, scale and duration of effects on the environment whether such effects are positive (beneficial) or negative (detrimental). Each issue/ impact is also assessed according to the project stages from planning, through construction and operation to the decommissioning phase. Where necessary, the proposal for mitigation or optimisation of an impact is noted. A brief discussion of the impact and the rationale behind the assessment of its significance has also been included.

A rating system is applied to the potential impact on the receiving environment and includes an objective evaluation of the mitigation of the impact. In assessing the significance of each issue the following criteria (including an allocated point system) is used:

Extent

National	4
Regional	3
Local	2
Site	1

Duration

Permanent	4
Long term	3
Medium term	2
Short term	1

Intensity

Very high	4
High	3
Moderate	2
Low	1

Probability of Occurrence

Definite	4
Highly probable	3
Possible	2
Impossible	1

Criteria for the classification of an impact:

Nature

A brief description of the environmental aspect being impacted upon by a particular action or activity is presented.

Extent (Scale)

Considering the area over which the impact will be expressed. Typically, the severity and significance of an impact have different scales and as such bracketing ranges are often required. This is often useful during the detailed assessment phase of a project in terms of further defining the determined significance or intensity of an impact.

Site	Within the construction site
Local	Within a radius of 2 km of the construction site
Regional	Provincial (and parts of neighbouring provinces)
National	The whole of South Africa

Duration

Indicates what the lifetime of the impact will be

Short-term	The impact will either disappear with mitigation or will be mitigated through natural process in a span shorter than the construction phase
Medium-term	The impact will last for the period of the construction phase, where after it will be entirely negated
Long-term	The impact will continue or last for the entire operational life of the development, but will be mitigated by direct human action or by natural processes thereafter
Permanent	The only class of impact which will be non-transitory. Mitigation either by man or natural process will not occur in such a way or in such a time span that the impact can be considered transient

Intensity

Describes whether an impact is destructive or benign.

Low	Impact affects the environment in such a way that natural, cultural and social functions and processes are not affected.
Medium	Effected environment is altered, but natural, cultural and social functions and processes continue albeit in a modified way

High	Natural, cultural and social functions and processes are altered to extent that they temporarily cease
Very high	Natural, cultural and social functions and processes are altered to extent that they permanently cease

Probability

Describes the likelihood of an impact actually occurring

Improbable	Likelihood of the impact materialising is very low
Possible	The impact may occur
Highly probable	Most likely that the impact will occur
Definite	Impact will certainly occur

Significance

Significance is determined through a synthesis of impact characteristics. It is an indication of the importance of the impact in terms of both physical extent and time scale, and therefore indicates the level of mitigation required. The total number of points scored for each impact indicates the level of significance of the impact. Using the scoring from the previous section, the significance of impacts is rated as follows:

Low impact	4-7 points (No permanent impact of significance. Mitigatory measures are feasible and are readily instituted as part of a standing design, construction or operating procedure)
Medium impact	8-10 points (Mitigation is possible with additional design and construction inputs)
High impact	11-13 points (The design of the site may be affected. Mitigation and possible remediation are needed during the construction and/or operational phases. The effects of the impact may affect the broader environment)
Very high impact	14-16 points (The design of the site may be affected. Intensive remediation as needed during construction and/or operational phases. Any activity which results in a “very high impact” is likely to be a fatal flaw)

Status

Denotes the perceived effect of the impact on the affected area

Positive (+)	Beneficial impact
Negative (-)	Deleterious or adverse impact
Neutral Impact	is neither beneficial nor adverse

It is important to note that the status of an impact is assigned based on the *status quo* – i.e. should the project not proceed. Therefore not all negative impacts are equally significant.

The suitability and feasibility of all proposed mitigation measures will be included in the assessment of significant impacts. This will be achieved through the comparison of the significance of the impact before and after the proposed mitigation measure is implemented.

2.6 Criteria Used To Rank Site

In order to rank the suitability of the proposed solar power site's footprint, an assessment was done, based on the vegetation characteristics, vegetation condition, and presence of terrestrial protected animals.

- **Vegetation characteristics**

*** Habitat diversity: Species composition / richness:** Normally a function of locality, habitat diversity and climatic conditions.

[Scoring: High - 1, Medium - 2, Low - 3]

*** Presence of rare and endangered species:** The occurrence or potential occurrence of any of the listed and /or endangered species can play a major role in the decision making process. Depending on the status and provincial conservation policy, presence of a Red Data species can potentially be a fatal flaw.

[Scoring: Occurrence actual or highly likely - 1, Occurrence possible - 2, Occurrence highly unlikely - 3]

*** Ecological function:** All plant communities play a role within the ecosystem. The ecological importance of all areas though, can vary significantly e.g. wetlands, drainage lines, ecotones[1], etc.

[Scoring: Ecological function critical for greater system - 1, Ecological function of medium importance - 2, No special ecological function (system will not fail if absent) - 3]

*** Degree of rarity / conservation value:**

[1] Ecotones are areas of overlap or change between two different ecosystems eg. between veld and pans.

[Scoring: Very rare and / or in pristine condition - 1, Fair to good condition and / or relatively rare - 2, Not rare, degraded and / or poorly conserved - 3]

Vegetation condition

The footprints were compared to a theoretical benchmark site in a good to excellent condition. Vegetation management practices (e.g. grazing regime, fire, management, etc.) can have a marked impact on the condition of vegetation.

* **Percentage ground cover:** Ground cover is under normal and natural conditions a function of climate, and biophysical characteristics of the site. Under poor grazing management, ground cover is one of the first signs of vegetation degradation.
  [Scoring: Good to excellent - 1, Fair - 2, Poor - 3]
* **Vegetation structure:** This is the ratio between tree, shrub, sub-shrubs and grass layers. This ratio could be affected by browsing and grazing by animals.
  [Scoring: All layers still intact and showing specimens of all age classes - 1, Sub-shrubs and / or grass layers highly grazed while tree layer still fairly intact (bush partly opened up) - 2, Mono-layered structure often dominated by a few unpalatable species (presence of barren patches notable) - 3]
* **Infestation with exotic weeds and invader plants or encroachers**

[Scoring: No, or very slight infestation levels by weeds and invaders - 1, Medium infestation by one or more species - 2, Several weed and invader species present and high occurrence of one or more species (eg. Wattle, Mesquite, etc.). - 3]

* **Degree of grazing / browsing impact:**

[Scoring: No, or very slight notable signs of browsing and / or grazing - 1, Some browse lines evident, shrubs shows signs of browsing, grass layer grazed though still intact - 2, Clear browse line on trees, shrubs heavily pruned and grass layer almost absent - 3]

* **Signs of erosion:** The formation of erosion scars can often give an indication of the severity and /or duration of vegetation degradation

[Scoring: No or very little evidence of soil erosion - 1, Small erosion gullies present and / or evidence of slight sheet erosion - 2, Gully erosion well developed (medium to big dongas) and / or sheet erosion removed the topsoil over large areas - 3]

- **Terrestrial animal characteristics**

* **Presence of rare and endangered species:** The occurrence or potential occurrence of any of the listed and /or endangered species can play a major role in the

decision making process. Depending on the status and provincial conservation policy, presence of a Red Data species can potentially be a fatal flaw.

[Scoring: Occurrence actual or highly likely - 1, Occurrence possible - 2, Occurrence highly unlikely - 3]

2.7 Site Preference Rating (SPR)

The total scores for the criteria above were used to determine the preference ranking order for the site investigated. On a scale of 0 – 30, six different classes are described to assess the suitability of the footprint for the development of the proposed new solar power plants. The different classes are described in the table below:

Table 1: Footprint preference ranking

SPR	SPR general flora description	Floral score equating to SPR class
IDEAL (5)	Vegetation is totally transformed or in a highly degraded state, generally has a low level of species diversity, no species of concern and / or has a high level of invasive plants. The area has lost its inherent ecological function. The area has no conservation value and the potential for successful rehabilitation is very low. The site is ideal for the proposed development.	29 – 30
PREFERRED (4)	Vegetation is in an advanced state of degradation, has a low level of species diversity, no species of concern and / or has a high level of invasive plants. The area's ecological function is seriously hampered, has a very low conservation value and the potential for successful rehabilitation is low. The area is preferred for the proposed development.	26 – 28
ACCEPTABLE (3)	Vegetation is notably degraded, has a medium level of species diversity although no species of concern are present. Invasive plants are present but are still controllable. The area's ecological function is still intact but may be hampered by the current levels of degradation. Successful rehabilitation of the area is possible. The conservation value is regarded as low. The area is acceptable for the proposed development.	21 – 25
NOT PREFERRED (2)	The area is in a good condition although signs of disturbance are present. Species diversity is high and species of concern may be present. The ecological functioning is intact and very little rehabilitation is needed. The area is of medium conservation importance. The area is not preferred for the proposed development.	11 – 20

SPR	SPR general flora description	Floral score equating to SPR class
SENSITIVE (1)	The vegetation is in a pristine or near pristine condition. Very little signs of disturbance other than those needed for successful management are present. The species diversity is very high with several species of concern known to be present. Ecological functioning is intact and the conservation importance is high. The area is regarded as sensitive and not suitable for the proposed development.	0 – 10

3 REGULATORY and LEGISLATIVE OVERVIEW

In order to remove or destroy protected species two acts are applicable namely the:
National Environmental Management Biodiversity Act (NEMBA)(Act 10 of 2004) for protected and Red Data species and the National Forest Act (Act 84 of 1998) for the protected tree species. All relevant permits must be obtained before construction commences.

Procedure to obtain documentation:

3.1 National Environmental Management Biodiversity Act (NEMBA)(Act10 of 2004)

Application to remove protected species must be obtained from the following address:
Contact person: Miss Marietjie Smit
e-mail address: msmit@half.ncape.gov.za
EIA reference number must be indicated on permit application form.

3.2 National Forest Act (Act 84 of 1998)

Application to remove protected species as listed under the Forest Act must be obtained from the following address:
Department of Environmental Affairs & Forestry
Private Bag X5912
UPINGTON
8800
Contact person: Me. Jacqueline Mans
Tel: 054 - 3385860

4 DESCRIPTION OF THE AFFECTED ENVIRONMENT

4.1 Study Area

The Study Area is situated on the farm Humansrus about 25 km east of Postmasburg. For a map of The Study Area and the candidate site see **Fig 1.**

Figure 1: Satellite image of the study site (source: Google Earth)

Figure 2: A panoramic view of the proposed Greenwater solar PV facility from the hill near the existing power line.

4.2 Altitude and Geomorphology

The altitude in the area ranges from 1,450 m to 1,550 m. The highest points in the region have altitudes of above 1,600m. The varying topography of the area is a result of the underlying rocks of the Transvaal Sequence. Surface drainage lines occur in the area and several small depressions (pans) occur in the low-lying areas on site as well as between the rocky outcrops to the southwest of the study site.

4.3 Geology and Soils

The site is situated on a relatively thick deposit of aeolian sand which is bounded in the west by outcrops of Andesitic lava (lava imbedded with layers of red jasper). This lava outcrop belongs to the Ongeluk lava formation of the Transvaal Supergroup. To the east, the sand deposit is bounded by outcrops of brown jaspilite and crocodilite with shale. These hills also belong to of the Transvaal Supergroup but to an older formation namely the Asbesheuwels formation.

The soils on the various outcrops are relatively shallow whereas the aeolian sand deposits on the plains are relatively deep and well-drained. In areas the sand is underlain by calcrete.

4.4 Climate

The area receives between 300 and 400mm rain per annum, mainly in the form of thunderstorms during the summer months. The winters are very dry. Average daily maximum temperatures for Postmasburg vary between 2.1^{o}C (winter) and 38.2^{o}C (summer).

4.5 Overview of the Major Vegetation Units in The Study Area

The vegetation of the region falls within the Savanna biome, a broad vegetation unit which is characterized by trees and shrubs of varying heights and a grass-covered ground layer Rutherford and Westfall (1994). The Savanna biome can be subdivided into small units called bioregions.

The Study Area fall within the Eastern Kalahari Bushveld bioregion and the specific vegetation types present at Humansrus (study site) belongs to the Kuruman Mountain Bushveld (SVk10)(rocky outcrops) and the Olifantshoek Plains Thornveld (SVk13)(sand

deposits)(Mucina & Rutherford 2006). Small endorheic[2] pans in the area support a hygrophilous[3] vegetation which can be regarded as typically azonal[4] in character.

According to Mucina & Rutherford (2006) the **Olifantshoek Plains Thornveld** is an open savanna to dense bush usually with a well developed tree layer. The dominant trees are *Acacia erioloba, A. karroo, Boscia albitrunca* and *Ziziphus mucronata*. The shrub layer is moderately developed and the dominant species are *Tarchonanthus camphoratus, Rhigozum trichotomum, Lycium hirsutum, Cadaba aphylla, Diospyros lycioides, Grewia flava, Searsia tridactyla, Acacia mellifera* and *A. hebeclada.*

The grass layer is typical sweet grassland. Grasses such as *Aristida congesta*, *Eragrostis lehmanniana, E. pallens, Schmidtia kalihariensis, Schmidtia pappophoroides,* and *Stipagrostis uniplumis* are some of the dominant grass species.

The herbaceous layer is dominated by the abovementioned grasses as well as species such as *Elephantorrhiza elephantina, Selago densifora, Hermannia tomentosa, Orthanthera jasminiflora, Kohautia caespitosa, Requienia sphaeroserma, Acanthisicyos naudinianus, Commelina benghalensis* and *Harpagophytum procumbens*.

The **Kuruman Mountain Bushveld** (SVk10)(rocky outcrops)(Mucina and Rutherford 2006) is a vegetation unit restricted to rocky outcrops. Tall trees are absent. Common Karee (*Searsia lancea*) is the only notable tree. Other tree species present are Wild Olive (*Olea europaea* subsp. *africana*) but it does grow very tall. Shrubs present are *Tarchonanthus camphoratus, Euclea crispa, Diospyros austro-africana*, and *Searsia pyroides*. Dominant grasses are *Heteropogon contortus, Andropogon shirensis, Aristida congesta, Eustachys paspaloides, Eragrostis nindensis, E. lehmanniana* and *E. chloromelas*. Herbs such as *Dicoma anomala, D. schinzii, Geigeria ornativa, Kypohocarpa angustifolia* and *Helichrysum zeyheri* are also notable.

The character of the savanna in this region is driven by climate and periodic disturbances such as regular droughts, fires, overgrazing and the resultant bush encroachment. The human-induced impact of mines, a few crop fields etc. are to a large extent disastrous for the indigenous vegetation as it destroys the seed bank in the soil and therefore also the natural species composition of those particular sites. Furthermore it creates ideal habitats

[2] Endorrheic means a closed drainage system (no outlet).

[3] Hygrophilous means water-loving.

[4] Azonal means a plant community which does not belong to a particular vegetation type.

for exotic weeds to flourish. The frequent human-induced fires and abnormal grazing pressures, caused by too many herbivore species per hectare, also add to the change in species composition in places.

4.6 Description of Vegetation Types That Occur On The Study Site

In general, vegetation is relatively homogenous, however on a local scale a mosaic of smaller vegetation units do occur. A major floristic feature of this vegetation type is the circular bush clumps which are formed by a endemic karee species namely *Searsia tridactyla*. This low shrub forms an important habitat for small mammals. Because of it density, it protects the smaller mammals from predators.

In general the patchy appearance of the vegetation can be ascribed to competition for resources and changes in gradients of environmental factors (driving forces). These environmental factors are soil depth, soil types, lime and clay content of the A horizon, moisture regimes, local disturbances, etc.

4.6.1 Areas Impacted by Anthropogenic Influences (Disturbed Areas)

A significant impact on the vegetation dynamics of The Study Area is grazing practices. Cattle and game farming practices and fencing practices have resulted in successional changes to the vegetation. Palatable climax grass species have been selectively removed by the game and cattle over time. This usually results in an increase in unpalatable species. Trampling and overgrazing of the vegetation around watering points was noted. The fence-line effect was also noted where differences in vegetation could be seen on opposite sides of a fence indicating different grazing pressures in different camps and neighbouring farms.
Areas, in The Study Area, where the human impact is notable are roads, tracks, farmsteads, crop fields, etc. These areas are usually denuded of most of the natural plant species. Around these disturbed sites exotic species were noted.

A few borrow pits and prospecting pits were also noted in the area. A low floristic status is attributed to these disturbed areas.

The disturbed grassland mostly has low species richness, with only a few other species able to establish or survive in the shade of the dense tall grass. Most of these species are relict pioneers or species that replaced the pioneer species. The most prominent species include

the grasses *Aristida congesta, Cynodon dactylon*, *E. curvula* and *Urochloa panicoides*. A few forbs occur and the notable ones are *Tribulus terrestris and Chrysocoma ciliata.*

At the kraal and watering point at the foot of the eastern hills are a couple of exotic Mesquite (*Prosopis velutina*)(Fig. 3) as well as Camel Thorns (*Acacia erioloba*)(Fig. 4). These trees are, according to the Forest Act (Act 84 of 1998) a protected species.

A low floristic status is attributed to this vegetation type.

Figure 3: A few individuals of Mesquite (*Prosopis velutina*) an exotic encroacher.

Figure 4: A number of Camel Thorns. Note the degraded area in the foreground.

4.6.2 Shrub Community on Sandy Soils.

This is open shrubland, dominated by a whole range of shrubs. Scattered individuals of Wild Olive (*Olea europaea* subsp. *africana*) occur on shallow sandy soils which are underlain by calcrete or lava. *Ziziphus mucronata, Searsia burchellii* and *Grewia flava* occur scattered through the community. *Acacia mellifera* forms dense thickets in places while *Searsia tridactyla* that forms circular thickets (Fig 5).

Figure 5: *Searsia tridactyla* bushclumps (arrows)

The herbaceous component is relatively species poor. The prominent species include *Chaetacanthus costatus, Cucumis zeyheri, Gossypium herbaceum, Heliotropium lineare, Hibiscus micranthus, Indigofera* species, *Merremia sp, Rhynchosia* species, *Sida dregei* and *Talinum caffrum.*

The grass component is dominated by grasses such as *Digitaria eriantha, Eragrostis pallens, Enneapogon scoparius, Eragrostis lehmanniana, Pogonarthria squarrosa, Schmidtia pappophoroides*, and *Stipagrostis uniplumis.*

4.6.3 Shrub community on Rocky Outcrops.

This community belongs to the Kuruman Mountain Bushveld (SVk10). This is also an open shrubland. Scattered individuals of Wild Olive (*Olea europaea* subsp. *africana*) occur on the rocky outcrops together with *Gymnosporea hetrophylla, Searsia burchelli, Lebeckia macrantha, Tarchonanthus camphoratus* and *Rhigozum obovatum*. *Acacia mellifera* form dense thickets in places (Fig 6).

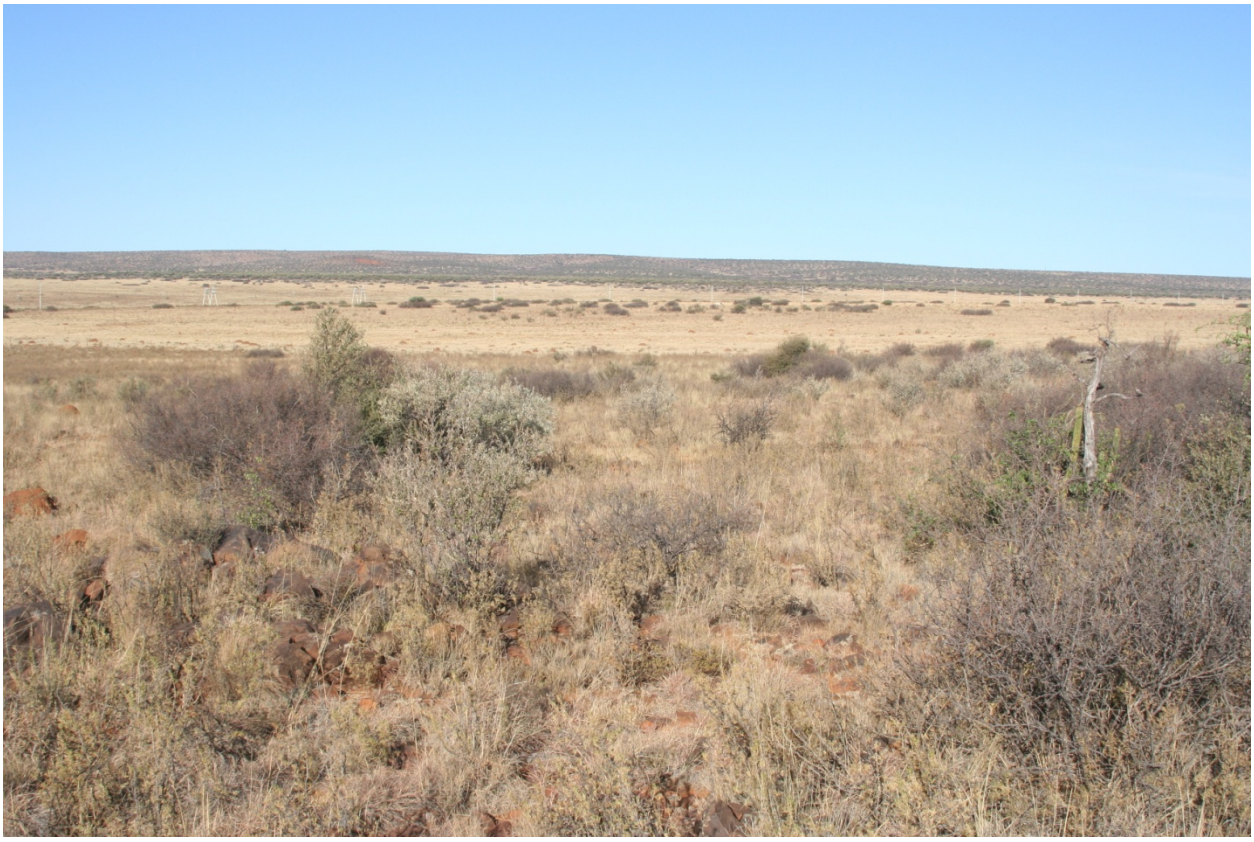

Figure 6: An example of the Kuruman Mountain Bushveld on a rocky outcrop at Humansrus.

The herbaceous component consists of a few karroid shrubs such as *Chrysocoma ciliata, Pentzia globosa, Melolobium candicans* and *Pterothrix spinescens*.

The grass component is poorly represented. Dominant grasses are *Cymbopogon excavatus, Enneapogon scoparius, Eragrostis lehmanniana, Heteropogon contortus, Aristida congesta* and *Tragus koeleroides.*

The area around the old farmstead, near the power line, is severely degraded and it is dominated by *Euryops sulcatus* an unpalatable encroacher (Fig 6). The presence of *Cynodon dactylon* in this area is another indicator of degradation.

Figure 6: The grass *Cynodon dactylon* in the foreground and the karroid shrub *Euryops sulcatus* (arrow) are indicator of severe degradation of the area.

4.6.4 Plant Species of Importance

4.6.4.1 Red Listed species

The Interim Red Data List of South African Plant Species (Threatened Species Programme, 2004) indicates a total of 319 potential red data species for the Limpopo Province. PRECIS data indicate the known presence of 6 Red Listed flora species within the respective ¼ degree grids in which The Study Area is situated (Table 2).

Table 2: Protected flora species for the region

Taxon	Threatened Status
Pachypodium succulentum	Least concern

Seasonal and project limitations placed severe restrictions on the location and identifying of these species. Only *Pachypodium succulentum* (Fig 7) was found on the site. It is situated next to the access road to the old farmstead.

Figure 7: A flowering *Pachypodium succulentum*.

4.6.4.2 Protected tree species in terms of the Forest Act

Protected species do not have a Red Listed status, but have a legal protected status in terms of the Forest Act (Act 84 of 1998) and should be afforded consideration during the construction and operational phases of the project. In the case of unavoidable impacts on individuals of these species, permits need to be obtained by the client prior to these individuals being damaged or removed. Species of importance that were observed during

the site investigation are considered well represented in the general region outside The Study Area. Although the presence of these species will not influence the outcome of this particular assessment, specific recommendations will be made to protect individual plants that will be affected by the proposed development.

Table 3: Protected species in The Study Area in terms of the Forest Act.

Taxon	**English Name**
Acacia erioloba	Camel Thorn
Boscia albitrunca	Shepard's Tree

The trees as listed in Table 3 occur are restricted to a localized area on the study site.

4.7 Overview of the Important Animal Communities in The Study Area

The vegetation is relatively homogenous throughout The Study Area. No areas of faunal significance or sensitivity within the natural habitat were observed within The Study Area.

The savanna biome has the richest bird diversity in comparison to those of the other biomes in South Africa. This biome is particularly rich in large raptors, and forms the stronghold of Red Data species such as the two eagle species, the Martial, and Tawny Eagles, and the following vultures namely Cape, Lappet-faced, and White-backed Vultures. Apart from Red Data species, it also serves as the stronghold of several non-Red Data raptor species, such as the two snake eagles namely the Brown and Black-chested Snake Eagles, and a multitude of medium-sized raptors for example the migratory Steppe Buzzard, African Harrier Hawk (Gymnogene), and Booted Eagle. Besides the large raptor species the savanna biome is relatively poor in terms of the other Red data bird species.

The following fauna species are confirmed for The Study Area (please note that this list is based on local observations and available studies and does not represent exhaustive sampling and observations).

Table 4: Faunal species present in the region

Order	Family	Scientific name	Common name
Phylum Vertebrata; Class Amphibia			
Aneura	Petropedetidae	*Cacosternum nanum*	Bronze Caco
	Breviceptidae	*Breviceps adspersus*	Bushveld Rain Frog
	Bufonidae	*Amietophrynus garmani*	Eastern Olive Toad
		Amietophrynus gutteralis	Gutteral Toad
		Amietophrynus poweri	Western Olive Toad
		Vandijkophrynus gariepensis	Karoo Toad
	Hyperoliidae	*Kassina senegalensis*	Bubbling Kassina
	Pipidae	*Xenopus laevis*	
	Pixycephalidae	*Cacosternum boettgeri*	Boettger's Caco
		Amieta angolensis	Common River Frog
		Pixycephalus adspersus	Giant Bullfrog
		Tomopterna cryptotis	Tremolo Sand Frog
		Tomopterna tandyi	Tandy's Sand Frog
Phylum Vertebrata; Class Reptilia			
Testudines	Testudinidae	*Geochelone pardalis*	Leopard Tortoise
		Psammobates oculiferus	Kalahari Tent Tortoise
	Trionychidae	*Pelomedusa subrufa*	Marsh Terrapin
Squamata	Typhlopidae	*Rhinotyphlops lalandei*	Delalande's Blind Snake
	Leptotyphlopidae	*Leptotyphlops scutifrons*	Peter's Thread Snake
	Leptotyphlopidae	*Leptotyphlops scutifrons*	Peters' Thread Snake
	Boidae	*Python sebae*	Southern African Python
	Atractaspidae	*Atractaspis bibronii*	Bibron's burrowing Asp
	Colubridae	*Lamprophis fuliginosus*	Brown House Snake
		Lamprophis aurora	Aurora House Snake
		Lycophidion capense	Cape Wolf Snake
		Pseudaspis cana	Mole Snake
		Prosymna bivittata	Two-striped Shovel-snout
		Psammophylax	Striped Skaapsteker

		tritaeniatus	
		Psammophis notostrictus	Karoo Sand Snake
		Psammophis leightonii	Cape Fork-marked Snake
		Psammophis crucifer	Cross-marked Snake
		Dasypeltis scabra	Common Egg Eater
		Crotaphopeltis hotamboeia	Red-lipped Snake
		Telescopus semiannulatus	Eastern Tiger Snake
		Dispholidus typus	Boomslang
		Naja nivea	Cape Cobra
	Viperidae	*Bitis arietans*	Puff Adder
	Amphisbaenidae	*Zygaspis quadrifrons*	Kalahari Round-headed Worm Lizard
	Scincidae	*Acontias gracilicauda*	Thin-tailed Legless Skink
		Mabuya capensis	Cape Skink
		Mabuya striata	Striped Skink
	Lacertidae	*Heliobolus lugubris*	Bushveld Lizard
		Ichnotropis squamulosa	Common Rough-scaled Lizard
		Nucras intertexta	Spotted Sandveld-Lizard
		Pedioplanis lineocellata	Spotted Sand lizard
		Pedioplanis namaquensis	Namaqua Sand Lizard
		Gerrhosaurus flavigularis	Yellow-throated Plated Lizard
		Cordylus polyzonus	Karoo Girdled Lizard
	Varanidae	*Varanus albigularis*	Rock Monitor
	Agamidae	*Agama aculeate*	Ground Agama
		Agama atra	Southern Rock Agama
		Agama hispida	Southern Spiny Agama
	Chamaeleonidae	*Chamaeleo dilepis*	Flap-neck Chameleon
	Gekkonidae	*Colopus wahlbergii*	Kalahari Ground Gecko
		Pachydactylus bibronii	Bibron's Thick-toed Gecko
		Pachydactylus capensis	Cape Thick-toed Gecko
		Pachydactylus turneri	Turner's Thick-toed Gecko

		Ptenopus carpi	Carp's Barking Gecko
Phylum Vertebrata; Class Mammalia			
Insectivora	Erinaceidae	*Atelerix frontalis*	Hedgehog
	Soricidae	*Crocidura cyanea*	Reddish-grey Musk Shrew
Rodentia	Bathyergidae	*Cryptomys hottentotus*	Common Molerat
	Muridae	*Tatera leucogaster*	Bushveld Gerbil
		Mastomys coucha	Multimammate Mouse
		Saccostomys campestris	Pouched Mouse
	Sciuridae	*Xerus inauris*	Cape Ground Squirrel
	Pedetidae	*Pedetes capensis*	Spring Hare
	Hystricidae	*Hystrix africaeaustralis*	South African Porcupine
Pholidota	Manidae	*Manis temminckii*	Pangolin
Lagomorpha	Leporidae	*Lepus saxatilis*	Scrub Hare
Carnivora		*Lepus capensis*	Cape Hare
	Canidae	*Canis mesomelas*	Black-backed Jackal
		Vulpes chama	Cape Fox
		Otocyon megalotis	Bad-eared Fox
	Herpestidae	*Suricata suricata*	Meerkat
		Cynictis penicillata	Yellow mongoose
		Galerella sanguinea	Slender Mongoose
	Mustelidae	*Ictonix striatus*	Zorilla
		Poecilogale albinucha	Striped Weasel
		Mellivora capensis	Honey Badger
	Hyaenidae	*Hyaena brunnea*	Brown Hyaena
	Protelidae	*Proteles cristatus*	Aardwolf
	Viverridae	*Genetta genetta*	Common genet
	Felidae	*Panthera pardus*	Leopard
		Caracal caracal	Caracal
		Felis nigripes	Black-footed Cat
		Felis sylvestris	Wild Cat
Tubulidentata	Orycteropidae	*Orycteropus afer*	Aardvark
Artiodactyla	Suidae	*Phacochoerus africanus*	Warthog
	Bovidae	*Tragelaphus strepsiceros*	Kudu
		Antidorcas marsupialis	Springbok
		Raphicerus campestris	Steenbok
		Sylvicapra grimmia	Common Duiker

4.7.1 Animal Species of Importance

4.7.1.1 Red Listed Fauna Species

The World Conservation Organization (IUCN) has three threatened categories, namely Critically Endangered (CE), Endangered (EN) and Vulnerable (VU). Species that have been evaluated according to the IUCN criteria and do not fall into one of the threatened categories can be classified as Least Concern (LC), Near Threatened (NT) or Data Deficient (DD). Species classified as Least Concern have been evaluated and do not qualify for the Critically Endangered, Endangered, and Vulnerable or Near Threatened categories. Species that are widespread and abundant are normally included in this category. Table 5 lists red data species found in habitat typical of The Study Area and surrounding areas. Species in **red** are known to occur in the general area.

Table 5: Red Listed fauna species for the region

Scientific name	Common name	Threatened Status
Pyxicephalus adspersus	Giant Bullfrog	NT
Python natalensis	Southern African Python	VU
Atelerix frontalis	South African Hedgehog	NT
Cloeotis percivali	Short-eared Trident Bat	CR
Crocidura cyanea	Reddish-grey Musk Shrew	DD
Crocidura hirta	Lesser Red Musk Shrew	DD
Elephantulus brachyrhynchus	Short-snouted Elephant-shrew	DD
Elephantulus intufi	Bushveld Elephant-shrew	DD
Hyaena brunnea	Brown Hyaena	NT
Laephotis botswanae	Botswana Long-eared Bat	VU
Lemniscomys rosalia	Single-striped Mouse	DD
Leptailurus serval	Serval	NT
Manis temminckii	Pangolin	VU
Mellivora capensis	Honey Badger	NT
Miniopterus schreibersii	Schreiber's Long-fingered Bat	NT
Pipistrellus rusticus	Rusty Bat	NT
Poecilogale albinucha	African Weasel	DD
Rhinolophus clivosus	Geoffroy's Horseshoe Bat	NT

Rhinolophus darlingi	Darling's Horseshoe Bat	NT
Rhinolophus hildebrantii	Hildebrant's Horseshoe Bat	NT
Suncus lixus	Greater Dwarf Shrew	DD
Tatera leucogaster	Bushveld Gerbil	DD

Most of the above-mentioned species are habitat specialists and are restricted to specific sensitive habitat types (ridges, seasonal pans, etc.). A high faunal sensitivity is therefore attributed to these habitat types. Only the Reddish-grey Musk Shrew, Brown Hyaena, Pangolin and Bushveld Gerbil are not specifically linked to restricted habitat such as wetlands or ridges and are found in natural savanna habitat.

4.7.1.2 Birds

In terms of bird species diversity, the savanna biome is the most species-rich biome in southern Africa. However, from a Red Data bird perspective, a relatively low number of bird species is restricted to this biome. Species such as Cape Vulture, Lappet-faced Vulture, White-backed Vulture, Martial Eagle and Tawny Eagle are Red Data species which are to a large extent restricted to this biome. Raptors, which are not Red listed that occur in the Savanna biome are African Harrier Hawk (Gymnogene), African Hawk Eagle, Black-chested Snake Eagle, Brown Snake Eagle, Steppe Buzzard, and Booted Eagle.

The Kori Bustard, Lappet-faced Vulture, White-backed Vulture, Martial Eagle, Tawny Eagle and Secretary Bird are Red Listed Birds with are known to occur in The Study Area. No specific site or habitat in The Study Area can be regarded as important from a bird conservation perspective.

4.7.2 Description of Important Bird Habitats in the Greenwater Area

Much of the distribution and abundance of the bird species in The Study Area can be explained by the description of vegetation types above, it is even more important to examine the micro habitats available to birds. These are generally evident at a much smaller spatial scale than the vegetation types, and are determined by a host of factors such as vegetation type, topography, land use and man-made infrastructure. The following can be described here:

• Rivers: No perennial rivers occur in The Study Area. However a seasonal drainage line runs northwards along the railway line.

• Wetlands (pans) and man-made dams: Both wetlands and rivers are of particular importance for birds in The Study Area, as the area is relatively arid. A few small seasonal pans occur on site as well as in the region south of the proposed site. When inundated these pans and man-made dams are important habitats for a numerous species of water birds.

• Crop fields: Cultivation consists mostly of dry land subsistence. Due to the lack of sufficient surface as well as ground water the crop fields are very limited in The Study Area. However, these crop fields are important for birds such as Secretary birds (fallow fields), Kori bustard, White and Abdim's Stork.

• Shrubland:
The majority of The Study Area encompasses arid shrubland. Vegetation structure, rather than the actual plant species, influences bird species distribution and abundance (in Harrison *et.al.* 1997). In addition to the vegetation description, the micro habitats available to birds in The Study Area are described.

The typical structure of a savanna biome is a grassy under storey and a distinct woody upper story of trees and tall shrubs. Tree cover can range from sparse to almost closed canopy (only along some drainage lines in The Study Area).

As mentioned above, the savanna of The Study Area as well as the surrounding area represents a variety of plant communities. The vegetation varies from a dense, short bushveld to a rather open shrub savanna to cleared patches.

From a power line perspective, the Kori Bustard is one of the most important species in this savanna. It frequents areas relatively free from human pressure. These habitats include areas such as open savanna, grasslands as well as fallow crop fields in savanna areas. These habitats are also regularly frequented by a number of raptor species.

4.7.3 Power Line Sensitive Birds Species Occurring in The Study Area

A total of eight **power line sensitive** Red Data species may occur in The Study Area. The table (Table 6) that follow give a list of **power line sensitive** Red Data species with reported densities (Harrison *et.al*. 1997).

Table 6: Power line sensitive Red Data species that may occur in The Study Area.

No	Bird species	Status	Reporting rate
1.	Cape Vulture	Vulnerable	Low
2.	Lapped-faced Vulture	Near-threatened	Low
3.	Tawny Eagle	Near-threatened	Low
4.	Martial Eagle	Near-threatened	Low
5.	Kori Bustard	Vulnerable	Low
6	Blue Crane	Vulnerable	Low
7	Lesser Flamingo	Near-threatened	Low
8	Greater Flamingo	Near-threatened	Low

5 IMPACT IDENTIFICATION AND ASSESSMENT

5.1 Site preference rating

Table 7: Greenwater Site:

VEGETATION CHARACTERISTICS	LOW (3)	MEDIUM (2)	HIGH (1)
Habitat diversity: Species composition / richness	3		
Presence of rare and endangered species		2	
Ecological function		2	
Uniqueness / conservation value	3		
VEGETATION CONDITION			
Percentage ground cover		2	
Vegetation structure		2	
Negative impact due to the infestation with exotic weeds and invader plants or encroachers	3		
Negative impact due to grazing or browsing		2	
Significance of erosion impacts		2	
TERRESTRIAL ANIMAL CHARACTERISTICS			

VEGETATION CHARACTERISTICS	LOW (3)	MEDIUM (2)	HIGH (1)
Presence of rare and endangered species		2	
Sub total	9	14	0
TOTAL	23		

In view of the score in Table 7 (Site Preference Rating (SPR)) the site can be regarded as suitable for the proposed development (See Table 1).

5.2 Impacts identified & level of significance

Impacts on Southdrift site	Extent	Duration	Severity	Probability	Level of significance
Impact on natural ecosystem functioning	1	3	2	3	**9**
Destruction of habitat	1	3	2	3	**9**
Change in species composition & species richness	1	3	1	3	**8**
Impact on rare and endangered plant and animal species	1	3	1	1	**6**
Potential invasions of exotic species	1	2	1	2	**6**
Creation of an erosion potential	1	1	1	2	**5**
Possible bird collisions with conductors	1	4	3	2	**10**

IMPACT 1: Impact on natural ecosystem functioning:

Significance of impact: - Medium

Status of impact: - Adverse impact

IMPACT 2: Destruction of habitat

Significance of impact: - Medium

Status of impact: - Adverse impact

IMPACT 3: Change in species composition & species richness

Significance of impact: - Medium

Status of impact: - Adverse impact

IMPACT 4: Impact on rare and endangered plant and animal species

Significance of impact: - Medium

Status of impact: - Adverse impact

IMPACT 5 Potential invasions of exotic species

Significance of impact: - Medium

Status of impact: - Adverse impact

IMPACT 6: Creation of an erosion potential

Significance of impact: - Medium

Status of impact: - Adverse impact

IMPACT 7: Possible bird collisions with conductors

Significance of impact: - Medium

Status of impact: - Adverse impact

5.2 Construction Phase

During the construction phase an extensive area of the original site will be cleared of any vegetation. This implies that the habitat on the footprint and a zone around it, and access roads will be destroyed. Here a total loss of the habitat integrity and plant species will take place. Vertebrata (Amphibians, reptiles, birds and mammals) currently present on site will move away and avoid the site during the construction and operational phases.

Barren areas will be created and unless these areas are not soon after clearing become paved, serious erosion might occur during heavy thunderstorms.

5.3 Operational Phase

During the operational phase the footprint area will remain devoid of natural vegetation. The plant species composition will be different. In disturbed areas annual weeds could dominate. Lawns around office buildings and control rooms will probably be Kikuyu grass. In the northern Cape, this exotic species does not pose any threats to the natural vegetation especially site away from water courses. An alternative grass that could be used is Couch grass (*Cynodon dactylon*), which is a cosmopolitan species. If the savanna habitat is going to be disturbed or replaced, the species composition of the Vertebrata (Amphibians, reptiles, birds and mammals) will also change to some extent. The species composition of the Vertebrata (Amphibians, reptiles, birds and mammals) will also change. The existing species will be replaced with species that are better adapted to the changed environment and continuous disturbance. The House Sparrow, Pied Starling, Crowned lapwing and others are possible species that will occupy the transformed site. Owls especially the Barn Owl and Spotted Eagle-owl may use the facility as hunting grounds at night.

5.4 Decommissioning

The decommissioning of the power plants would eventually leave a scar on the site. Rehabilitation of impacted site will never be as it was before the proposed development. Examples of structures that have to be decommissioned are office buildings, power line structures, roads and paved areas and many more.

- During this phase care must be taken not to enlarge the impact footprint.
- Rehabilitation of disturbed areas must be done. Concrete, tar and paving Compacted areas be removed and discarded in a proper manner at the nearest approved landfill site.
- Compacted soil must be ripped and planted with a grass seed mixture of grasses that occur in the region.
- All nearby trees (natural or planted) must be protected against damage during the decommissioning phase.
- Continuous monitoring of the rehabilitated sites must take place.

5.5 Cumulative Impacts

- The presence of the proposed facility, the new sub-station as well as the existing 132kV power line could increase the occurrence of bird collisions in the area. Bird friendly structures must be used and conductors must be made more visible.
- Large paved areas could increase storm water run-off during thunderstorms. A proper storm water drainage system must be designed for the facility.

6. CONCLUSIONS AND RECOMMONDATIONS

6.1 Conclusions

The Greenwater Solar PV Facility is considered to be suitable for the proposed development for the following reasons:

- No extensive areas of particular faunal or floral sensitivity can be highlighted. Protected species are present but in relatively low numbers on site and they also occur elsewhere.

The proposed development will have a medium local impact on the plant and animal communities on-site. This is however, not regarded as a significant threat to the status and presence of these species as they occur abundantly in the general area.

The relative importance of The Study Area in terms of a bird collision perspective (power line sensitive species) can be regarded to have a medium impact. Thus, the expected frequency of the impacts and the significance of those impacts can be regarded as medium for the following reasons:

- No large water bodies are situated near the proposed site.
- No important birding area (IBA) is situated near the proposed site (Barnes 1998).
- The power line corridors that will link up with the existing transmission network will be relatively short.

6.2 Recommendations

Protected species (fauna and flora) were found on the site. Recommended mitigation measures include the following:

- Care should be taken to limit unnecessary destruction of the natural vegetation unnecessary.
- A zone of 10m around ephemeral water bodies (pans) must be kept intact to act as buffer zone.

- Taller tree species (e.g. Camel Thorn, Common Karee, Sweet Thorn, Umbrella Thorn) can be planted to act as visual screens;
- All human movement and activities must be contained within designated construction areas in order to prevent peripheral impacts on surrounding natural habitat;
- No fire-wood may be collected in the veld.
- An alien control and monitoring programme must be developed starting during the construction phase and to be carried over into the operational phase; and
- Lighting fires on the sites must not be allowed. The risk of accidental fires during the construction phase is considered to be high, especially during the dry months (winter and early spring).
- Fire-fighting equipment must be available on site.
- Species, especially grasses, trees and shrubs occurring in the region must be used to rehabilitate disturbed areas.
- A search and rescue exercise, to remove and transplant the *Pachypodium succulentum* specimens, must be conducted before construction commences A permit must be obtained from the Nature Conservation's permit office before commencement of the search and rescue operation

The following are important in terms of birds (Hobbs and Ledger 1986, APLIC 1994, Ferrer and Jenss 1999, Anderson 2001):

- Perching birds, especially vultures, on nearby pylons could be electrocuted and it is therefore important to deter them from perching on the structures by attaching spikes and other deterrents to specific positions on the structures.
- The design of the solar PV facility and associated infrastructure must be bird-friendly. This is to lower the risk of electrocution and collision for large birds. The conductors must be made more visible by means of bird flappers, Bird Flight Diverters (also known as the pigtail), and the reflective stainless steel spheres (Innotec BFD88 Bird Diverter).

Example of a bird flapper (after van Rooyen 2007)

Pig tail (after van Rooyen 2007)

Reflective stainless steel spheres (after van Rooyen 2007)

- The greatest danger is posed by the thin earth wire above the bundles of conductors. A collision is possible when the bird in flight sees the bundled conductors and then gains height to avoid them. It usually collides with the much thinner earth wire (APLIC 1994). These lines must be more visible to birds by attaching bird flappers to the lines.

7 LIST OF DEFINITIONS AND ABBREVIATIONS

APLIC - Avian Power Line Interaction Committee

IBA - Important Birding Area

NEMBA- National Environmental Management Biodiversity Act

SPR - Site Specific Rating

8 REFERENCE LIST

Anderson, M.D. 2001. *The effectiveness of two different marking devices to reduce large terrestrial bird collisions with overhead electricity cables in the eastern Karoo, South Africa.* 135 pp. Draft report to Eskom Resources and Strategy Division. Johannesburg. South Africa.

Avian Power Line Interaction Committee (APLIC). 1994. *Mitigating Bird Collisions with Power Lines: The State of the Art in 1994*. 157 pp. Edison Electric Institute. Washington D.C.

Barnes, K.N. (ed.) 1998. *The Important Bird Areas of southern Africa*. 265 pp. BirdLife South Africa: Johannesburg.

Barnes, K.N. (ed.) 2000. *The Eskom Red Data Book of Birds of South Africa, Lesotho and Swaziland.* 143 pp. BirdLife South Africa: Johannesburg.

Branch, B. 1998. Guide to *Snakes and other reptiles of southern Africa*. 399 pp. Struik Publishers, Cape Town.

Chitten, H. Dean, W.R.J., Gibbon, G. and Upfold, G. 2005. *Roberts Bird Guide*. 456 pp. John Voelcker Bird Book Fund. Cape Town.

Du Preez, L.H. and Carruthers, V. 2009. *A complete guide to the Frogs of southern Africa*. 488 pp. Struik Nature. Cape Town.

Ferrer, M. and Jenss, G.F.E. (ed.) 1999 *Birds and Power Lines: Collision, Electrocution and Breeding.* 139 pp. Quercus, Madrid, Spain.

Harrison, J.A., Allan, D.G., Underhill, L.G., Herremans, M., Tree, A.J., Parker, V and Brown, C.J. (eds). 1997. *The atlas of southern African birds*. Vol. 1 (764 pp) and (2 731 pp). BirdLife South Africa: Johannesburg.

Hobbs, J.C.A. and Ledger J.A. 1986. The Environmental Impact of Linear Developments; Power lines and Avifauna. (Third International Conference on Environmental Quality and Ecosystem Stability. Israel, June 1986).

Mucina, L., Rutherford, M. and Powrie, L.W. 2005. *Vegetation Map of South Africa Lesotho and Swaziland*. SANBI, Pretoria, 0001.

Mucina, L. and Rutherford (eds) 2006. The vegetation of South Africa, Lesotho and Swaziland. 804 pp. *Strelitzia* 19, SANBI, Pretoria.

Raimomdo, D., von Staden, L., Foden, W., Victor, J.E., Helme, N.A., Turner, R.C., Kamundi, D.A. and Manyama, P.A. (eds). 2009. Red List of South African Plants. 668 pp. *Strelitzia* 25. SANBI., Pretoria.

Rutherford, M.C. and Westfall, R.H. 1994. Biomes of southern Africa: An objective categorization. 94 pp. *Mem. Bot. Serv. S Afr*. No 63: 1-93.

Smit, J.H.L. 2000. Fitososiologie en veldbestuur van die oostelike Kalaharidoringveld. 335 pp. M.Sc thesis for Wildlife Management, Univ. of Pretoria.

Smith, G.F., Chesselet, P., van Jaarsveld, E., Hartmann, H., Hammer, S., Van Wyk, B-E., Burgoyne, P. Klak, C. and Kurzweil, H. 1998. *Mesembs of the world*. 405 pp. Briza Publications. Pretoria.

Smithers, R.H.N. 1983. *Die Soogdiere van die Suider Afrikaanse Substreek*. 736 pp. Universiteit van Pretoria, Pretoria.

Stuart C and Stuart T. 1997. *Guide to the Larger mammals of Africa*. 319 pp. Struik Publishers, Cape Town.

Van Oudtshoorn, F. 1999. *Guide to the Grasses of Southern Africa*. 288 pp. Briza Publications. Pretoria.

Van Rooyen, C. 2007. Matimba-Marang 400kV - Bird Impact Assessment Study

Van Rooyen, N., Bezuidenhout, H. and de Kock, E. 2001. *Flowering plants of the Kalahari dunes*. 216 pp. Ekotrust cc, Pretoria.

Van Wyk, A. and Malan, S. 1992. *Flowers of the Pretoria – Witwatersrand region*. 350 pp. Struik Publishers, Cape Town.

Van Wyk, A. and Van Wyk, P. 1997. *Field guide to Trees of southern Africa*. 536 pp. Struik, Cape Town.

Woodall, S. 2005. *Field Guide to Butterflies of South Africa*. 440 pp. Struik Publishers, Cape Town.