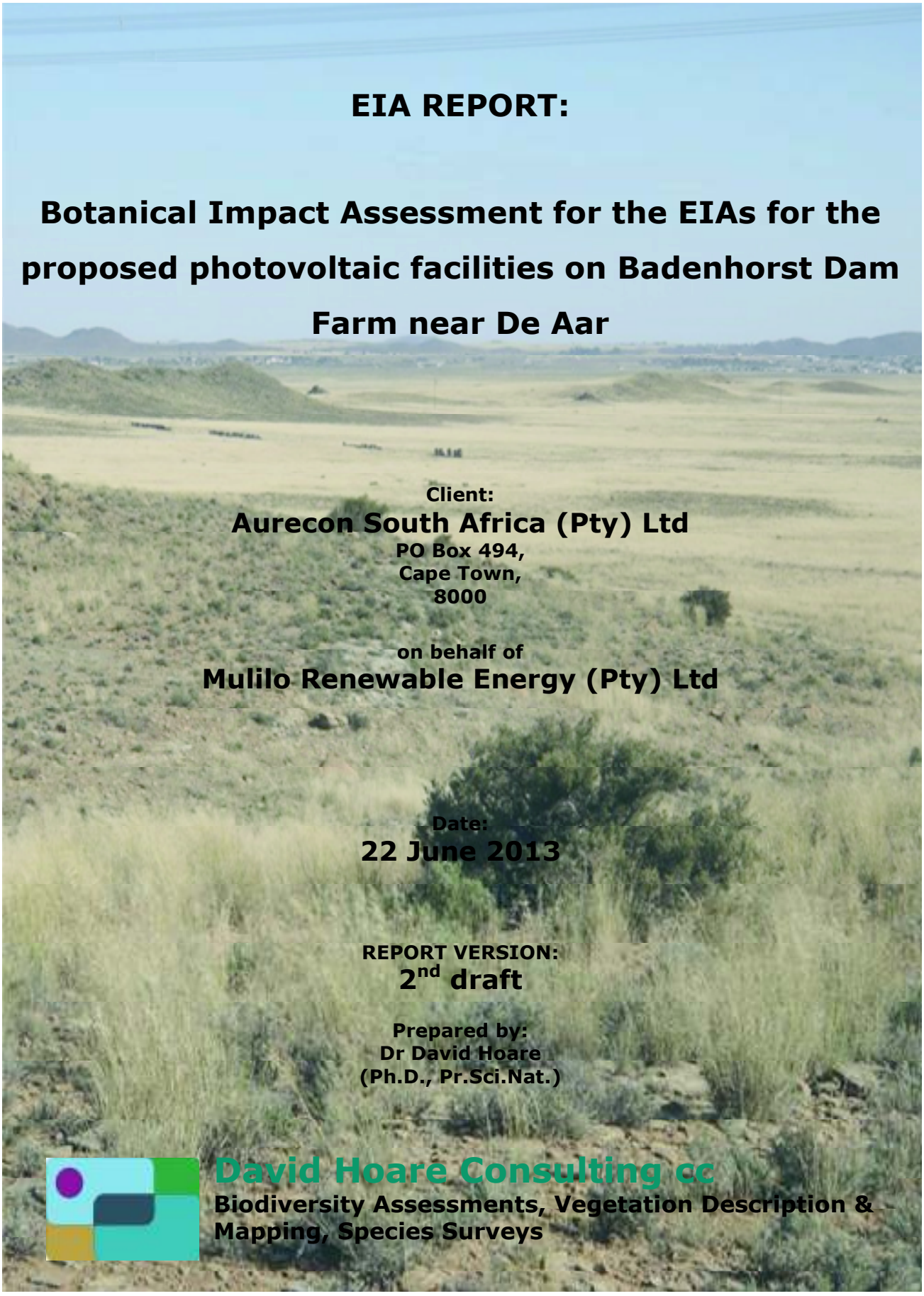

EIA REPORT:

Botanical Impact Assessment for the EIAs for the proposed photovoltaic facilities on Badenhorst Dam Farm near De Aar

Client:

Aurecon South Africa (Pty) Ltd

PO Box 494,
Cape Town,
8000

on behalf of

Mulilo Renewable Energy (Pty) Ltd

Date:

22 June 2013

REPORT VERSION:

2nd draft

Prepared by:
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(Ph.D., Pr.Sci.Nat.)

David Hoare Consulting cc
Biodiversity Assessments, Vegetation Description & Mapping, Species Surveys

APPOINTMENT OF SPECIALIST

David Hoare of David Hoare Consulting cc was commissioned by Aurecon South Africa (Pty) Ltd to provide specialist consulting services for the Environmental Impact Assessment for the proposed Botanical Impact Assessment services for the EIAs for the proposed photovoltaic facilities on Badenhorst Dam Farm near De Aar. The consulting services comprise an assessment of potential impacts on the flora and vegetation in the study area by the proposed project.

Details of specialist

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Summary of expertise

Dr David Hoare:

- Has majors in Botany and Zoology with distinction from Rhodes University, Grahamstown, an Honours Degree (with distinction) in Botany from Rhodes University, an MSc (cum laude) from the Department of Plant Science, University of Pretoria, and a PhD in Botany from the Nelson Mandela Metropolitan University, Port Elizabeth with a focus on species diversity.
- Registered professional member of The South African Council for Natural Scientific Professions (Ecological Science, Botanical Science), registration number 400221/05.
- Founded David Hoare Consulting cc, an independent consultancy, in 2001.
- Ecological consultant since 1995, with working experience in Gauteng, Mpumalanga, Limpopo, North West, Eastern Cape, Western Cape, Northern Cape and Free State Provinces, Tanzania, Kenya, Mozambique and Swaziland.
- Conducted, or co-conducted, over 330 specialist ecological surveys as an ecological consultant. Areas of specialization include general ecology, biodiversity assessments, vegetation description and mapping, plant species surveys and remote sensing of vegetation. Has undertaken work in grassland, thicket, forest, savannah, fynbos, coastal vegetation, wetlands and nama-karoo vegetation, but has a specific specialization in grasslands and wetland vegetation.
- Published six technical scientific reports, 15 scientific conference presentations, seven book chapters and eight refereed scientific papers.
- Attended 15 national and international congresses & 5 expert workshops, lectured vegetation science / ecology at 2 universities and referee for 2 international journals.

Independence

David Hoare Consulting cc and its Directors have no connection with Mulilo Renewable Energy (Pty) Ltd. David Hoare Consulting cc is not a subsidiary, legally or financially, of the proponent. Remuneration for services by the proponent in relation to this project is not linked to approval by decision-making authorities responsible for authorising this proposed project and the consultancy has no interest in secondary or downstream developments as a result of the authorisation of this project. David Hoare is an independent consultant to Aurecon South Africa (Pty) Ltd and has no business, financial, personal or other interest in the activity, application or appeal in respect of which he was 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.

Conditions relating to this report

The findings, results, observations, conclusions and recommendations given in this report are based on the author's best scientific and professional knowledge as well as available information. David Hoare Consulting cc and its staff reserve the right to modify aspects of the report including the recommendations if and when new information may become available from on-going research or further work in this field, or pertaining to this investigation.

This report must not be altered or added to without the prior written consent of the author. This also refers to electronic copies of this report which are supplied for the purposes of inclusion as part of other reports, including main reports. Similarly, any recommendations, statements or conclusions drawn from or based on this report must make reference to this report. If these form part of a main report relating to this investigation or report, this report must be included in its entirety as an appendix or separate section to the main report.

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INTRODUCTION

Terms of reference and approach

On 14 March 2013 David Hoare Consulting cc was appointed by Aurecon South Africa (Pty) Ltd to undertake a botanical assessment of the study area. The intention is to compile one EIA report per farm. The EIA report was to include the assessment of the projects individually and cumulatively per farm. The specific terms of reference for the EIA study are as follows:

DESKTOP STUDY:

A description and characterisation of the broad study area is to be undertaken. A description of the receiving environment must be provided and any major sensitivities within the study area in the form of a desktop study, as follows:

1. Description of the broad vegetation types and/or habitats for the area, including any areas of potential conservation value. This is to be based on published sources, including the vegetation map of South Africa (Mucina et al. 2006), the National Spatial Biodiversity Assessment and any Biodiversity Conservation Plans that exist for the Province.
2. The national conservation status of major vegetation types in which the study sites are located is to be provided, as listed in the National List of Ecosystems that are Threatened and need of protection (GN1002 of 2011), published under the National Environmental Management: Biodiversity Act (Act No. 10, 2004).
3. Investigation into the Red Data (threatened and endangered) flora species within the Province and more specifically the project study area, including information on habitats in which they are most likely to be encountered.
4. The potential presence/absence of Red Data species is to be assessed by means of assessments of the presence, status and linkage of available habitat in the study area. These attributes are to be rated for each Red Data species that has a geographical distribution including the sites using the available literature and personal field experience. Three parameters are to be used to assess the probability of occurrence for each species:
    a. *Habitat requirements*: most Red Data species have very specific habitat requirements and the presence of these habitat characteristics within the study area will be assessed;
    b. *Habitat status*: in the event that available habitat is considered suitable for these species, the status or ecological condition is assessed. Often, a high level of degradation of a specific habitat type will negate the potential presence of Red Data species (especially wetland-related habitats where water-quality plays a major role); and
    c. *Habitat linkage*: for animals, movement between areas used for breeding and feeding purposes forms an essential part of ecological existence of many species. The connectivity of the study area to these surrounding habitats and adequacy of these linkages are assessed for the ecological functioning Red Data species within the study area.
5. Investigation into the potential presence of trees protected according to the National Forests Act (Act 84, 1998) and fauna and flora protected under the National Environmental Management: Biodiversity Act (Act No. 10, 2004).
6. An assessment of the general status of vegetation on site in order to provide a description of which areas contain natural habitat versus those that are transformed and/or degraded.
7. Potential impacts on biodiversity, sensitive habitats and ecosystem function are to be listed and described. These are to be compiled from a generic list of possible impacts derived from previous projects of this nature and from a literature review of the potential impacts of such development on the ecological environment.

These descriptive components are to be incorporated into a single Sensitivity Analysis for the site. An indication of major sensitivities is to be provided, including a description of sensitive features that could potentially occur as well as a map of the potential location of these features.

FIELD DATA COLLECTION

The study area is to be visited and assessed to confirm patterns identified from the desktop assessment. Specific features of potential concern are to be investigated in the field, including the following:

- General vegetation status;
- Presence of habitats of conservation concern;
- Presence of protected trees;
- Potential presence of species of concern.

ASSESSMENT OF IMPACTS:

Impacts identified are to be assessed according to standard criteria (nature, extent, duration, magnitude, probability, significance, status as well as the degree to which impacts can be reversed, the degree to which impacts will cause irreplaceable loss of resources and the degree to which impacts can be mitigated).

This report provides details of the results of the EIA specialist study. The findings of the study are based on a combination of a desktop assessment of the study area, interpretation of aerial photography and fieldwork undertaken on site.

METHODOLOGY

The assessment is to be undertaken in a single phase, an Environmental Impact Assessment phase. This report contains descriptive information on flora and fauna for the study area as well as an assessment of potential impacts.

Assessment philosophy

Many parts of South Africa contain high levels of biodiversity at species and ecosystem level. At any single site there may be large numbers of species or high ecological complexity. Sites also vary in their natural character and uniqueness and the level to which they have been previously disturbed. Assessing the potential impacts of a proposed development often requires evaluating the conservation value of a site relative to other natural areas and relative to the national importance of the site in terms of biodiversity conservation. A simple approach to evaluating the relative importance of a site includes assessing the following:

- Is the site unique in terms of natural or biodiversity features?
- Is the protection of biodiversity features on the site of national/provincial importance?
- Would development of the site lead to contravention of any international, national or provincial legislation, policy, convention or regulation?

Thus, the general approach adopted for this type of study is to identify any critical biodiversity issues that may lead to the decision that the proposed project cannot take place, i.e. to specifically focus on red flags and/or potential fatal flaws. Biodiversity issues are assessed by documenting whether any important biodiversity features occur on site, including species, ecosystems or processes that maintain ecosystems and/or species. These can be organised in a hierarchical fashion, as follows:

Species

1. threatened plant species

2. protected trees

Ecosystems
1. threatened ecosystems
2. protected ecosystems
3. critical biodiversity areas
4. areas of high biodiversity
5. centres of endemism

Processes
1. corridors
2. mega-conservancy networks
3. rivers and wetlands
4. important topographical features

It is not the intention to provide comprehensive lists of all species that occur on site, since most of the species on these lists are usually common or widespread species. Rare, threatened, protected and conservation-worthy species and habitats are considered to be the highest priority, the presence of which are most likely to result in significant negative impacts on the ecological environment. The focus on national and provincial priorities and critical biodiversity issues is in line with National legislation protecting environmental and biodiversity resources, including, but not limited to the following which ensure protection of ecological processes, natural systems and natural beauty as well as the preservation of biotic diversity in the natural environment:
1. Environment Conservation Act (Act 73 of 1989)
2. National Environmental Management Act, 1998 (NEMA) (Act 107 of 1998)
3. National Environmental Management Biodiversity Act, 2004 (Act 10 0f 2004).

Plant species of conservation concern

There are two types of species of concern for the site under investigation, (i) those listed by conservation authorities as being on a Red List and are therefore considered to be at risk of extinction, and (ii) those listed as protected according to National and/or Provincial legislation.

Red List plant species
Determining the conservation status of a species is required in order to identify those species that are at greatest risk of extinction and, therefore, in most need of conservation action. South Africa has adopted the IUCN Red List Categories and Criteria to provide an objective, rigorous, scientifically founded system to identify Red List species. A published list of the Red List species of South African plants (Raimondo *et al.* 2009) contains a list of all species that are considered to be at risk of extinction. This list is updated regularly to take new information into account, but these are not published in book/paper format. Updated assessments are provided on the SANBI website (http://redlist.sanbi.org/). According to the website of the Red List of Southern African Plants (http://redlist.sanbi.org/), *the conservation status of plants indicated on the Red List of South African Plants Online represents the status of the species within South Africa's borders. This means that when a species is not endemic to South Africa, only the portion of the species population occurring within South Africa has been assessed. The global conservation status, which is a result of the assessment of the entire global range of a species, can be found on the International Union for the Conservation of Nature (IUCN) Red List of Threatened Species: http://www.iucnredlist.org*. The South African assessment is used in this study.

The purpose of listing Red List plant species is to provide information on the potential occurrence of species at risk of extinction in the study area that may be affected by the proposed infrastructure. Species appearing on these lists can then be assessed in terms of their habitat requirements in order to determine whether any of them have a likelihood of occurring in habitats that may be affected by the proposed infrastructure.

Lists were compiled specifically for any species at risk of extinction (Red List species) previously recorded in the area. Historical occurrences of threatened plant species were obtained from the South African National Biodiversity Institute (http://posa.sanbi.org) for the quarter degree square/s within which the study area is situated. Habitat information for each species was obtained from various published sources. The probability of finding any of these species was then assessed by comparing the habitat requirements with those habitats that were found, during the field survey of the site, to occur there.

Protected trees

Regulations published for the National Forests Act (Act 84 of 1998) as amended, provide a list of protected tree species for South Africa. The species on this list were assessed in order to determine which protected tree species have a geographical distribution that coincides with the study area and habitat requirements that may be met by available habitat in the study area. The distribution of species on this list was obtained from published sources (e.g. van Wyk & van Wyk 1997) and from the SANBI Biodiversity Information System website (http://sibis.sanbi.org/) for quarter degree grids in which species have been previously recorded. Species that have been recorded anywhere in proximity to the site (within 100 km), or where it is considered possible that they could occur there, were listed and were considered as being at risk of occurring there. The site was searched for these species during the field survey and any individuals or concentrations noted.

Other protected plant species

National legislation was evaluated in order to provide lists of any plant or animal species that have protected status. The most important legislation is the following:

- *National Environmental Management: Biodiversity Act (Act No 10 of 2004)*

This legislation contains lists of species that are protected. These lists were scanned in order to identify any species that have a geographical range that includes the study area and habitat requirements that are met by those found on site. These species were searched for within suitable habitats on site or, where relevant, it was stated that it was considered possible that they could occur on site.

There is additional legislation that provides lists of protected species, but the legislation to which these are attached deal primarily with harvesting or trade in listed species and do not seem to specifically address transformational threates to habitat or individuals. This includes the following legislation:

- *Northern Cape Nature Conservation Act (Act No 9 of 2009)*
- *CITES: Convention on the Trade in Endangered Species of Wild Fauna and Flora*.

Species probability of occurrence

Some species of plants may be cryptic, difficult to find, rare, ephemeral or generally not easy to spot while undertaking a survey of a large area. An assessment of the possibility of these species occurring on the site was therefore provided. For all threatened or protected flora that occur in the general geographical area of the site, a rating of the likelihood of it occurring on site is given as follows:

- LOW: no suitable habitats occur on site / habitats on site do not match habitat description for species;

- MEDIUM: habitats on site match general habitat description for species (e.g. karoo shrubland), but detailed microhabitat requirements (e.g. mountain shrubland on shallow soils overlying sandstone) are absent on the site or are unknown from the descriptions given in the literature or from the authorities;
- HIGH: habitats found on site match very strongly the general and microhabitat description for the species (e.g. mountain shrubland on shallow soils overlying sandstone);
- DEFINITE: species found in habitats on site.

Habitat sensitivity

The purpose of producing a habitat sensitivity map is to provide information on the location of potentially sensitive features in the study area. This was compiled by taking the following into consideration:

1. The general status of the vegetation of the study area was derived by compiling a landcover data layer for the study area (*sensu* Fairbanks et al. 2000) using available satellite imagery and aerial photography. From this it can be seen which areas are transformed versus those that are still in a natural status.
2. Various provincial, regional or national level conservation planning studies have been undertaken in the area, e.g. the National Spatial Biodiversity Assessment (NSBA). The mapped results from these were taken into consideration in compiling the habitat sensitivity map.
3. Habitats in which various species of plants or animals occur that may be protected or are considered to have high conservation status are considered to be sensitive.

An explanation of the different sensitivity classes is given in Table 1. Areas containing untransformed natural vegetation of conservation concern, high diversity or habitat complexity, Red List organisms or systems vital to sustaining ecological functions are considered potentially sensitive. In contrast, any transformed area that has no importance for the functioning of ecosystems is considered to potentially have low sensitivity.

Table 1: Explanation of sensitivity ratings.

Sensitivity	Factors contributing to sensitivity	Example of qualifying features
VERY HIGH	Indigenous natural areas that are highly positive for any of the following: • presence of threatened species (Critically Endangered, Endangered, Vulnerable) and/or habitat critical for the survival of populations of threatened species. • High conservation status (low proportion remaining intact, highly fragmented, habitat for species that are at risk). • Protected habitats (areas protected according to national / provincial legislation, e.g. National Forests Act, Draft Ecosystem List of NEM:BA, Integrated Coastal Zone Management Act, Mountain Catchment Areas Act, Lake Areas Development Act) And may also be positive for the following: • High intrinsic biodiversity value (high species richness and/or turnover, unique	• CBA 1 areas. • Remaining areas of vegetation type listed in Draft Ecosystem List of NEM:BA as Critically Endangered, Endangered or Vulnerable. • Protected forest patches. • Confirmed presence of populations of threatened species.

Sensitivity	Factors contributing to sensitivity	Example of qualifying features
	ecosystems) • High value ecological goods & services (e.g. water supply, erosion control, soil formation, carbon storage, pollination, refugia, food production, raw materials, genetic resources, cultural value) • Low ability to respond to disturbance (low resilience, dominant species very old).	
HIGH	Indigenous natural areas that are positive for any of the following: • High intrinsic biodiversity value (moderate/high species richness and/or turnover). • presence of habitat highly suitable for threatened species (Critically Endangered, Endangered, Vulnerable species). • Moderate ability to respond to disturbance (moderate resilience, dominant species of intermediate age). • Moderate conservation status (moderate proportion remaining intact, moderately fragmented, habitat for species that are at risk). • Moderate to high value ecological goods & services (e.g. water supply, erosion control, soil formation, carbon storage, pollination, refugia, food production, raw materials, genetic resources, cultural value). And may also be positive for the following: • Protected habitats (areas protected according to national / provincial legislation, e.g. National Forests Act, Draft Ecosystem List of NEM:BA, Integrated Coastal Zone Management Act, Mountain Catchment Areas Act, Lake Areas Development Act)	• CBA 2 "critical biodiversity areas". • Habitat where a threatened species could potentially occur (habitat is suitable, but no confirmed records). • Confirmed habitat for species of lower threat status (near threatened, rare). • Habitat containing individuals of extreme age. • Habitat with low ability to recover from disturbance. • Habitat with exceptionally high diversity (richness or turnover). • Habitat with unique species composition and narrow distribution. • Ecosystem providing high value ecosystem goods and services.
MEDIUM-HIGH	Indigenous natural areas that are positive for one or two of the factors listed above, but not a combination of factors.	• CBA 2 "corridor areas". • Habitat with high diversity (richness or turnover). • Habitat where a species of lower threat status (e.g. (near threatened, rare) could potentially occur (habitat is suitable, but no confirmed records).
MEDIUM	Other indigenous natural areas in which factors listed above are of no particular concern. May also	

Sensitivity	Factors contributing to sensitivity	Example of qualifying features
	include natural buffers around ecologically sensitive areas and natural links or corridors in which natural habitat is still ecologically functional.	
MEDIUM-LOW	Degraded or disturbed indigenous natural vegetation.	
LOW	No natural habitat remaining.	

Any natural vegetation within which there are features of conservation concern will be classified into one of the high sensitivity classes (MEDIUM-HIGH, HIGH or VERY HIGH). The difference between these three high classes is based on a combination of factors and can be summarised as follows:

1. Areas classified into the VERY HIGH class are vital for the survival of species or ecosystems. They are either known sites for threatened species or are ecosystems that have been identified as being remaining areas of vegetation of critical conservation importance. CBA1 areas would qualify for inclusion into this class.
2. Areas classified into the HIGH class are of high biodiversity value, but do not necessarily contain features that would put them into the VERY HIGH class. For example, a site that is known to contain a population of a threatened species would be in the VERY HIGH class, but a site where a threatened species could potentially occur (habitat is suitable), but it is not known whether it does occur there or not, is classified into the HIGH sensitivity class. The class also includes any areas that are not specifically identified as having high conservation status, but have high local species richness, unique species composition, low resilience or provide very important ecosystem goods and services. CBA2 "irreplaceable biodiversity areas" would qualify for inclusion into this class, if there were no other factors that would put them into the highest class.
3. Areas classified into the MEDIUM-HIGH sensitivity class are natural vegetation in which there are one or two features that make them of biodiversity value, but not to the extent that they would be classified into one of the other two higher categories. CBA2 "corridor areas" would qualify for inclusion into this class.

Assessment of impacts

For each impact, the EXTENT (spatial scale), MAGNITUDE and DURATION (time scale) were described (see Table 2 for a description of these criteria and ratings). These criteria were used to ascertain the SIGNIFICANCE of the impact, firstly in the case of no mitigation and then with the most effective mitigation measure(s) in place.

The tables on the following pages show the scale used to assess these variables, and defines each of the rating categories.

Table 2: Assessment criteria for the evaluation of impacts

Criteria	Category	Description
Extent or spatial influence of impact	Regional	Beyond a 10 km radius of the site
	Local	Within a 10 km radius of the site.
	Site-specific	On site or within 100 m of the site.
Magnitude of impact (at the indicated spatial scale)	High	Natural functions and/or processes are *severely* altered
	Medium	Natural functions and/or processes are *notably* altered
	Low	Natural functions and/or processes are *slightly* altered
	Very low	Natural functions and/or processes are *negligibly* altered

	Zero	Natural functions and/or processes remain *unaltered*
Duration of impact	Construction period	Up to four years if PV facilities are constructed consecutively
	Short term	Up to 5 years after construction
	Medium term	5-15 years after construction
	Long term	More than 15 years after construction

The SIGNIFICANCE of an impact is derived by taking into account the temporal and spatial scales and magnitude. The means of arriving at the different significance ratings is explained in Table 3.

Table 3: Definition of significance ratings.

Significance rating	Level
HIGH	High magnitude with a regional extent and long term duration
	High magnitude with either a regional extent and medium term duration or a local extent and long term duration
	Medium magnitude with a regional extent and long term duration
	High magnitude with a local extent and medium term duration
MEDIUM	High magnitude with a regional extent and construction period or a site specific extent and long term duration
	High magnitude with either a local extent and construction period duration or a site specific extent and medium term duration
	Medium magnitude with any combination of extent and duration except site specific and construction period or regional and long term
	Low magnitude with a regional extent and long term duration
LOW	High magnitude with a site specific extent and construction period duration
	Medium magnitude with a site specific extent and construction period duration
	Low magnitude with any combination of extent and duration except site specific and construction period or regional and long term
	Very low magnitude with a regional extent and long term duration
VERY LOW	Low magnitude with a site specific extent and construction period duration
	Very low magnitude with any combination of extent and duration except regional and long term
NEUTRAL	Zero magnitude with any combination of extent and duration

Once the significance of an impact had been determined, the PROBABILITY of this impact occurring as well as the CONFIDENCE in the assessment of the impact were determined using the rating systems outlined in Table 4 and Table 5 respectively. Lastly, the REVERSIBILITY of the impact is estimated using the rating system outlined in Table 6.

Table 4: Definition of probability ratings.

Probability rating	**Criteria**
Definite	Estimated greater than 95 % chance of the impact occurring
Probable	Estimated 5 to 95 % chance of the impact occurring
Unlikely	Estimated less than 5 % chance of the impact occurring

Table 5: Definition of confidence ratings.

Confidence rating	**Criteria**

Certain	Wealth of information on and sound understanding of the environmental factors potentially influencing the impact
Sure	Reasonable amount of useful information on and relatively sound understanding of the environmental factors potentially influencing the impact.
Unsure	Limited useful information on and understanding of the environmental factors potentially influencing this impact

Table 6: Definition of reversibility ratings

Reversibility	**Criteria**
Irreversible	The activity will lead to an impact that is in all practical terms permanent.
Reversible	The impact is reversible within 2 years after the cause or stress is removed.

Limitations

- Red List species are, by their nature, usually very rare and difficult to locate. Compiling the list of species that could potentially occur in an area is limited by the paucity of collection records that make it difficult to predict whether a species may occur in an area or not. The methodology used in this assessment is designed to reduce the risks of omitting any species, but it is always possible that a species that does not occur on a list may be unexpectedly located in an area.

PROJECT DESCRIPTION AND ALTERNATIVES

During the Scoping Phase, various alternatives were screened to derive a list of feasible alternatives that need to be assessed in further detail in the EIA Phase. Subsequently, the following types of alternatives are the most pertinent to the proposed project:

- Layout alternative dependent on the scale and magnitude alternative;
- Technology alternative;
- Transmission line routing alternative; and
- Scale and magnitude alternative.

The alternative types pertinent to this project are described in the subsequent sections.

Location alternative

It is proposed that four PV facilities be constructed at Badenhorst Dam farm (Portion 1 of Farm 180). A previous EIA, similar to this study, was undertaken at the same location (Aurecon, 2012). After completion of the EIA (DEA Reference Number: 12/12/20/2499), the Department of Environmental Affairs (DEA) authorised a PV facility with 100MW capacity (Environmental Authorisation (EA) dated 9 July 2012). The approved PV facility will herein after be referred to as Badenhorst PV1. Therefore, information is readily available (Hoare 2012) and environmental sensitive areas have been identified. These sensitive areas were taken into consideration in the preliminary designs. It therefore makes sense to further develop a site which is already well studied, suitable for the proposed development, located close to existing and proposed Eskom infrastructure, and where no fatal flaws have been identified.

It is also more economically feasible to group developments to promote infrastructure sharing. As mentioned in Section 1.2, Mulilo already received an EA for one PV facility on this farm (referred to as PV1) which is further motivation for this location alternative as it could result in the following benefits:

- Sharing of supply infrastructure including water, sewage and electricity;
- Reducing the impact on the environment due to combining infrastructure and footprints;
- Utilizing a single laydown area and construction camp minimizing traffic and associated impacts with multiple camps;
- Allowing phased approach to construction activities thereby extending the construction period for employment and creating more long term employment jobs;
- Reducing the need for multiple electricity grid connection points and transmission lines;
- Motivation for the creation of an industrial zone within De Aar whereby specialised services and manufacturing processes are able to develop in response to consistent demand; and
- Improved accuracy in terms of assessing cumulative impacts during the EIA phase.

The selection of this preferred and only location alternative was furthermore based on the following characteristics of the site:

- Solar resource potential based on historic satellite data;
- Grid connectivity and close proximity to strong grid access;
- Flat, level, and open land;
- Little environmentally and socially sensitive areas; and
- Non-arable or low arable potential of the land.

Based on the above motivation, it was proposed to only assess one location alternative namely Badenhorst Dam Farm (Portion 1 of Farm 180), De Aar. The location of the proposed PV facilities on Badenhorst Dam Farm is shown in Figure 1.

Layout alternatives (dependent on the scale and magnitude alternatives)

The Department of Energy (DoE) introduced a capacity limit of 75MW for solar facilities. The proponent is hopeful that the DoE will realise the benefits of having combined facilities and are therefore proposing two scale and magnitude alternatives. In other words, the capacity (MW) of the facilities will determine the layout of the facilities.

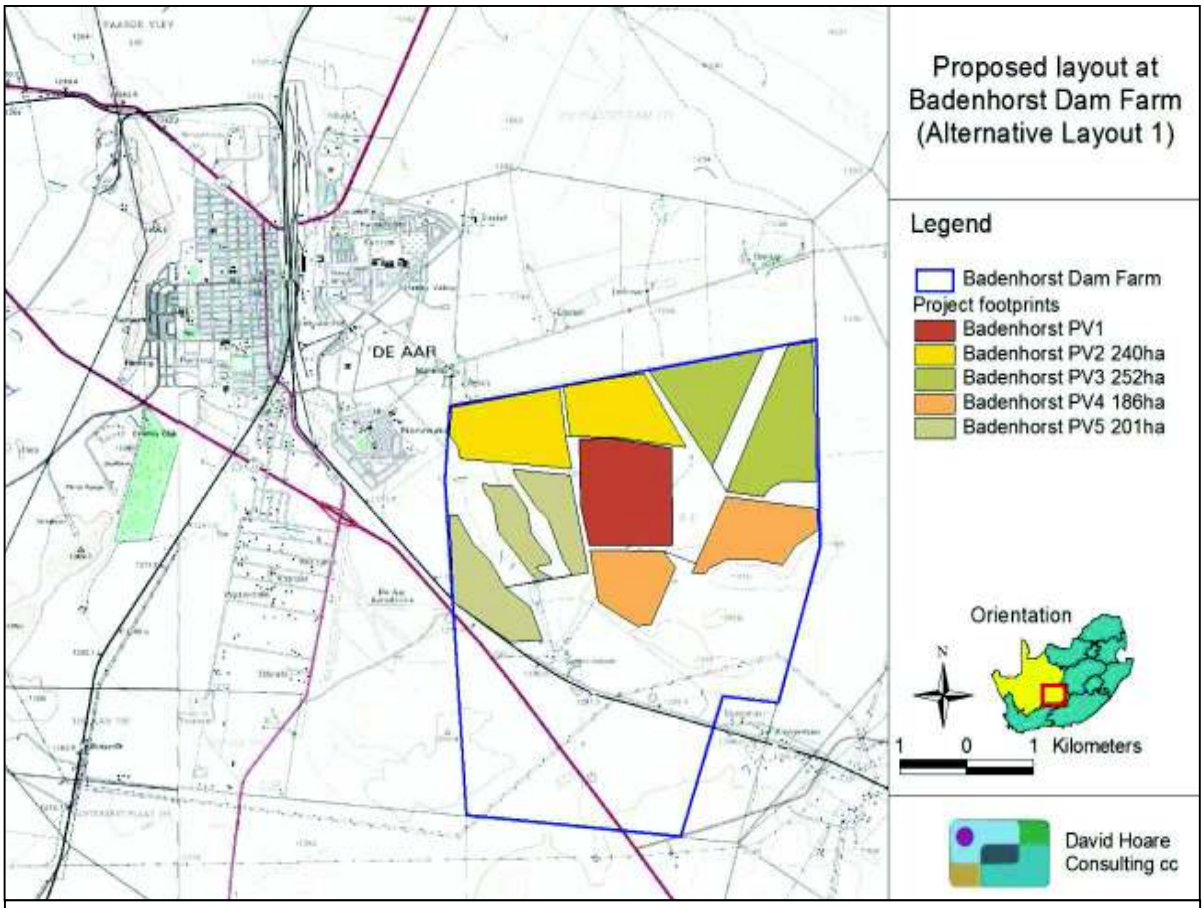

Figure 1: Location of the proposed pv Solar facilities (layout alternative 1).

Layout Alternative 1

This alternative consists of the four proposed 75MW PV facilities and associated infrastructure as indicated in Figure 1 referred to as PV2, PV3, PV4 and PV5. These layouts take cognisance of the 75MW DoE cap and the environmentally sensitive areas as identified by Aurecon (2012).

Layout Alternative 2

This alternative consists of three 150MW PV facilities. The layout for these was developed by extending and combining some of the proposed 75MW facilities as indicated in Figure 2. This alternative is thus not limited to the DOE's 75MW cap per project. However, the site layout does take cognisance of the environmentally sensitive areas as identified by Aurecon (2012). By increasing the capacities it has the benefit of utilising industries at scale thereby reducing associated development and construction costs which reduces lending rates and essentially lower the tariff of electricity sold.

The layouts of Alternative 2 more or less overlap with the Alternative 1 layouts, with the exception of PV4. Extended PV2 is approximately the same extent as PV2 and PV5 combined and extended PV3 is similar to the combined layout of PV3 and PV4. The proposed layout for extended PV4 is located at the southern boundary of the farm.

Alternative Layout 1		PV2	PV5		PV3	PV4		-
Alternative Layout 2		**Extended PV2**			**Extended PV3**			**Extended PV4**
								Southern section of the farm

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Facility	Footprint	Capacity	Coordinates of middle point
Extended PV2	572ha	150MW	30°40'48.69"S; 24°2'37.61"E
Extended PV3	519ha	150MW	30°40'55.63"S; 24°4'32.49"E
Extended PV4	723ha	150MW	30°42'38.28"S; 24°3'5.45"E

Layout of additional infrastructure

It is proposed that one layout for the proposed roads and water pipeline be assessed. The layouts provided took the environmentally sensitive areas into consideration and follows the shortest viable route as shown in Figure 3.

Technology alternative

A number of sites are proposed for wind energy facilities in the surrounding area which

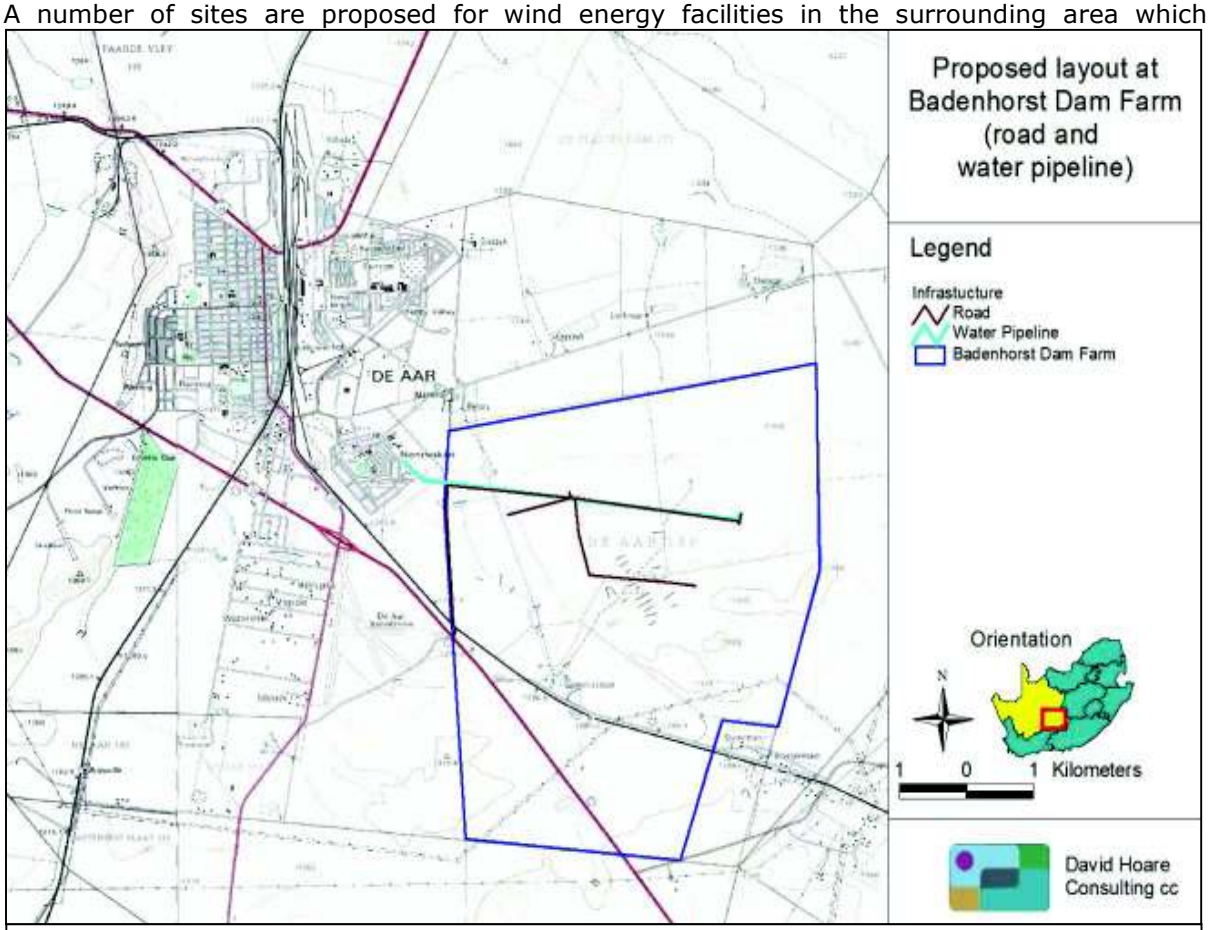

Figure 3: Location of proposed road and water pipeline.

indicates that the proposed site could also be suitable for wind power. However, the selection of the Badenhorst Dam farm was based on the requirements for solar energy. Therefore, all of the technology alternatives considered revolves around the Solar PV technologies.

Solar panel alternatives

Three solar panel types were considered for the proposed plants: concentrated photovoltaic (CPV), concentrated solar power (CSP) and conventional PV solar cells. Information gathered through previous EIAs (Aurecon, 2012), as well as the recent technology advances informed this investigation.

The conventional PV and CPV technologies require less water (19L/MWh of water per day) than the CSP system which needs approximately 3,420L/MWh of water per day during the operational period. Therefore, due to the scarcity of water in this area, and the large volume of water required for the CSP system, only conventional PV and CPV technologies will be considered for the proposed solar facilities.

Mounting Alternatives

In terms of the mounting alternatives, single axis tracking systems will be considered along with fixed axis tracking systems. This decision will be made by the proponent closer to detail design phase after taking into consideration the economic viability, water requirements, land requirements, efficiency and potential environmental impacts of the proposed solar panel types. In a fixed axis tracking system the PV panels are installed at a set tilt and cannot move, whereas in a single axis tracking system the panels follow the sun to ensure maximum exposure to sunlight.

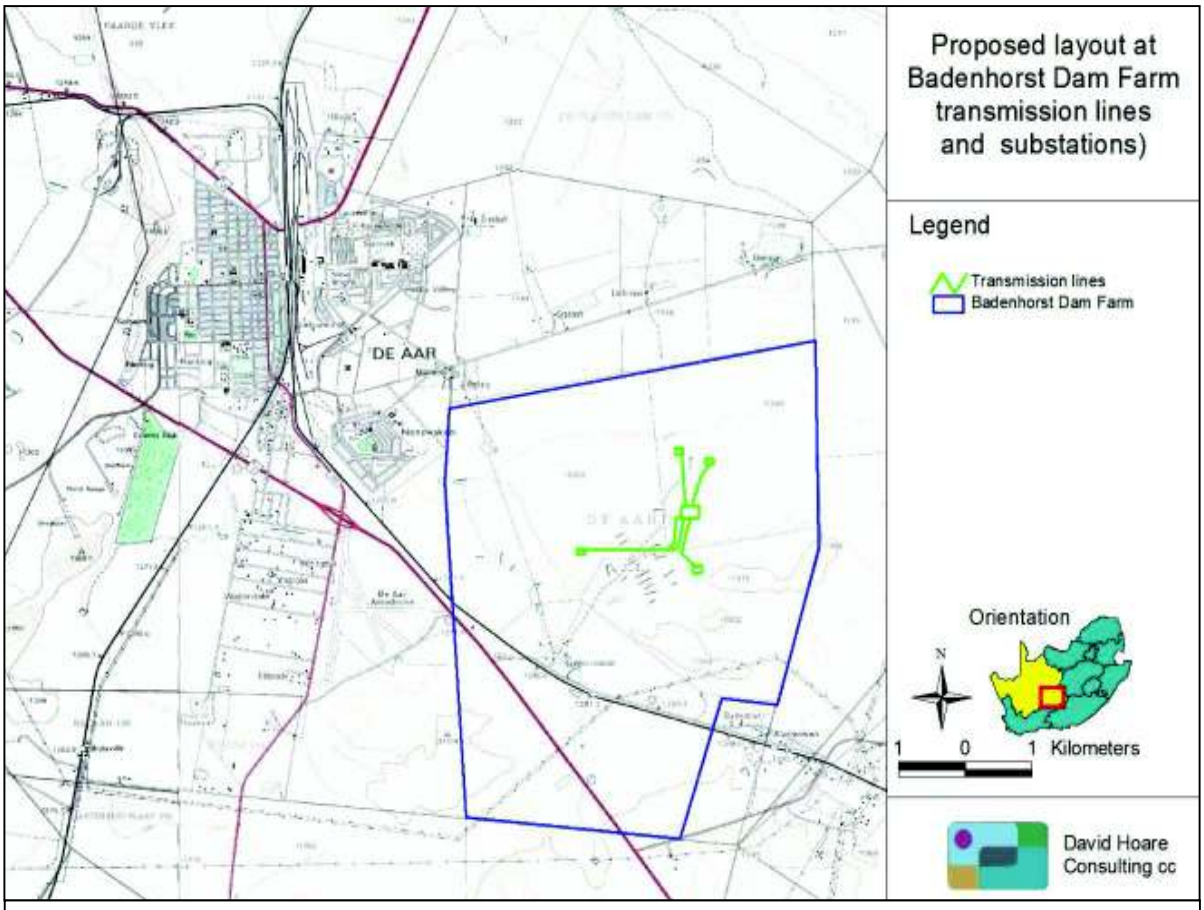

Figure 4: Location of proposed transmission lines and substations.

The photovoltaic single axis tracking technology has the following benefits:

- The panels are the highest efficiency panels with the highest efficiency inverter, maximizing the system output. The installation costs are less as fewer panels are required.
- The panel's anti-reflective glass and exceptional low-light performance characteristics enhances energy delivery; and
- By minimising shading and grouping trackers closer together, this highly efficient technology produces the most energy per hectare of any tracking system. It requires up to 20% less land than conventional crystalline fixed tilt systems and up to 60% less than thin film technology.

These highly efficient panels not only require less land, but also less concrete, steel and cabling per MW.

Transmission line routing and substations alternative

It is envisaged that each PV facility would require an onsite substation specific to each PV facility i.e. four onsite substations. These substations would feed into one central onsite substation by means of onsite overhead 132kV transmission lines.

Based on the uncertainties regarding the capacity of Eskom's substations and transmission lines, it is proposed to assess a transmission line corridor instead of assessing the preliminary layouts which could be subject to changes. The width of the proposed transmission corridor ranges from 150m to 350m. The proposed transmission corridor is shown in Figure 4.

No-Go alternative

The "no-go" option is taken to be the existing rights on the property, including the approved PV facility, and this includes all the duty of care and other legal responsibilities that apply to the owner of the property.

DESCRIPTION OF STUDY AREA

Topography

The study sites are located on plains and the topography of the sites is therefore relatively gentle. There is a low, narrow ridge that cuts diagonally through the centre of the site. There is also a range of low hills on the eastern side of the site. The remainder of the site is gently sloping. The elevation on site varies from 1255 to 1308 m above sea level.

Land types and soils

Detailed soil information is not available for broad areas of the country. As a surrogate, landtype data was used to provide a general description of soils in the study area (landtypes are areas with largely uniform soils, topography and climate). There is one land type in the study area, namely the Ae land type (Land Type Survey Staff, 1987). The Ae land type covers the entire site.

The A-group of land types refer to yellow and red soils without water tables belonging to one or more of the following soil forms: Inanda, Kranskop, Magwa, Hutton, Griffin, Clovelly. The Ae landtype consists of red, high base status, > 300 mm deep soils and no dunes (MacVicar et al. 1974).

Climate

The climate is arid to semi-arid. Rainfall occurs from November to March, but peaks in mid- to late summer (February / March). Mean annual rainfall is approximately 200 mm per year. All areas with less than 400 mm rainfall are considered to be arid. The study area can therefore be considered to be arid.

Broad vegetation types of the region

The study area falls within the Nama-Karoo Biome (Rutherford & Westfall 1986, Mucina & Rutherford 2006). The most recent and detailed description of the vegetation of this region is part of a national map (Mucina, Rutherford & Powrie, 2005; Mucina *et al*. 2006). This map shows one vegetation type occurring within or close to the study sites, namely Northern Upper Karoo. No other vegetation type occurs anywhere near to the site. The Northern Upper Karoo vegetation type is described in more detail below.

Northern Upper Karoo
This vegetation type occurs in the northern parts of the Upper Karoo Plateau, with its southern extent ending near De Aar. It is a shrubland dominated by dwarf karoo shrubs, grasses and some low trees, including *Acacia mellifera* subsp. *detinens* (Mucina et al. 2006). There are five known endemics in this vegetation (Mucina *et al*. 2006), namely the succulent shrubs, *Lithops hookeri* and *Stomatium pluridens*, the low shrubs, *Atriplex spongiosa* and *Galenia exigua* and the herb, *Manulea deserticola*. At a national scale this vegetation type has been transformed only a small amount (approximately 4%) and none is conserved; it is considered to be a Least Threatened vegetation type (Mucina *et al*. 2006).

Conservation status of broad vegetation types

On the basis of a recently established approach used at national level by SANBI (Driver *et al*. 2005), vegetation types can be categorised according to their conservation status which is, in turn, assessed according to the degree of transformation relative to the expected extent of each vegetation type. The status of a habitat or vegetation type is based on how much of its original area still remains intact relative to various thresholds. The original extent of a vegetation type is as presented in the most recent national vegetation map (Mucina, Rutherford & Powrie 2005) and is the extent of the vegetation type in the absence of any historical human impact. On a national scale the thresholds are as depicted in Table 8, as determined by best available scientific approaches (Driver *et al*. 2005).

The level at which an ecosystem becomes Critically Endangered differs from one ecosystem to another and varies from 16% to 36% of the ecosystem still remaining in a natural state (Driver et al. 2005). The vegetation types occurring in the study area (Table 8) are classified as Least Threatened (Driver *et al*. 2005; Mucina *et al*., 2006).

Table 8: Determining ecosystem status (from Driver et al. 2005). *BT = biodiversity target (the minimum conservation requirement).

Habitat remaining (%)		
80–100	least threatened	LT
60–80	vulnerable	VU
*BT–60	endangered	EN
0–*BT	critically endangered	CR

The National List of Ecosystems that are Threatened and need of protection (GN1002 of 2011), published under the National Environmental Management: Biodiversity Act (Act No. 10, 2004), lists national vegetation types that are afforded protection on the basis of rates of transformation. The thresholds for listing in this legislation are higher than in the scientific literature, which means there are fewer ecosystems listed in the National Ecosystem List versus in the scientific literature. The vegetation types occurring on site are not listed in the National List of Ecosystems that are Threatened and need of protection (GN1002 of 2011).

Table 9: Conservation status the vegetation types occurring in the study area, according to Driver *et al*. 2005 and Mucina *et al*. 2005.

Vegetation Type	Target (%)	Conserved (%)	Transformed (%)	Conservation status	
				Driver *et al*. 2005; Mucina *et al*., 2006	Draft Ecosystem List (NEMBA)
Northern Upper Karoo	21	0	4	Least Threatened	Not listed

Critical Biodiversity Areas have been identified for all municipal areas of the Northern Cape Province and are published on the SANBI website (bgis.sanbi.org). These maps identify no areas of concern in the current study area. This is consistent with patterns identified from other sources within the current scoping document.

Landuse and landcover of the study area

A landcover map of the study area (Fairbanks *et al*. 2000) indicates that the site consists primarily of natural vegetation, classified as "shrubland and low fynbos". This is confirmed from 1:50 000 topo-cadastral maps (see Figure 1), Google imagery of the sites and the site visits. The exceptions are small areas of degraded vegetation in the north-western parts of the site.

The farm is used as grazing for domestic and wild livestock. It is probable that it has been used for cattle, sheep and/or goats at some stage in the past.

The vegetation on site is dominated by grasses, with a significant number of karoo shrubs of low stature amongst the grasses. Vegetation in the rocky areas on the ridges was more dominated by dwarf shrubs than on the lowlands. A general view of the site from the eastern side is shown in Figure 5. The lowlands tend to have relatively deep soils and are primarily grass-covered.

The vegetation on site is in moderate condition. There were also areas on the lowlands that had been exposed to earth-moving activities, probably in order to manage potential erosion. There are patches in poor condition closer to the town of De Aar, where the vegetation was grazed short and was heavily affected by strewn rubbish and blown plastic bags. There are

small numbers of alien species present on site, including *Opuntia ficus-indica* (sweet prickly pear), *Agave americana* (sisal) and *Echinopsis spechiana* (torch cactus). There were no trees on site.

Red List plant species of the study area

Lists of plant species of conservation concern previously recorded in the quarter degree grids in which the study area is situated were obtained from the South African National Biodiversity Institute (SANBI). These are listed in Appendix 1. Additional species that could occur in similar habitats, as determined from database searches and literature sources, but have not been recorded in these grids are also listed.

There is one species incorrectly listed on this list, *Protea subvestita*, which is listed as Vulnerable. This species occurs along the southern and eastern Great Escarpment of the country in montane habitats, particularly highland grassland and fynbos. The record from the adjacent grid is an incorrect database record and this species does not occur anywhere near to the site. There are, therefore, no threatened, near threatened, declining or rare plant species that could occur on site.

Protected plants (National Environmental Management: Biodiversity Act)

Plant species protected under NEM:BA are listed in Appendix 4. One plant species that appears on this list that could potentially occur in the region, although it has not previously been

Figure 5: View of the vegetation of the site from a low ridge.

recorded in the grid, is *Hoodia gordonii*. This species is currently listed in Appendix II to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), which includes species not currently considered endangered but are at risk if trade is not controlled. *Hoodia gordonii* has a wide tolerance of growing habitats and is found in deep Kalahari sands, on dry stony slopes or flats and under the protection of xerophytic bushes. Suitable conditions do occur on site and it is considered possible that this species could occur on site. However, it was not found during the field survey.

Another protected species that could potentially occur in the region, although it has not previously been recorded in the grid, is *Harpagophytum procumbens* (devil's claw). This species is associated mainly with dry sandveld on deep Kalahari sand. It usually occupies plains, dune bases and interdunes. Soils are usually sandy but can be rocky. They are generally nutrient poor, often with lime. The soil conditions expected on site do not co-incide with the habitat requirements for this species and it is not considered likely that it occurs on site. It was not found during the field survey.

Protected trees

Tree species protected under the National Forest Act are listed in Appendix 2. The only one that has a geographical distribution that includes the study area is *Boscia albitrunca* (Shepherd's Tree / Witgatboom / !Xhi). *Boscia albitrunca* occurs in semi-desert areas and bushveld, often on termitaria, but is common on sandy to loamy soils and calcrete soils. This species is usually quite common where it is found, but was not recorded on site.

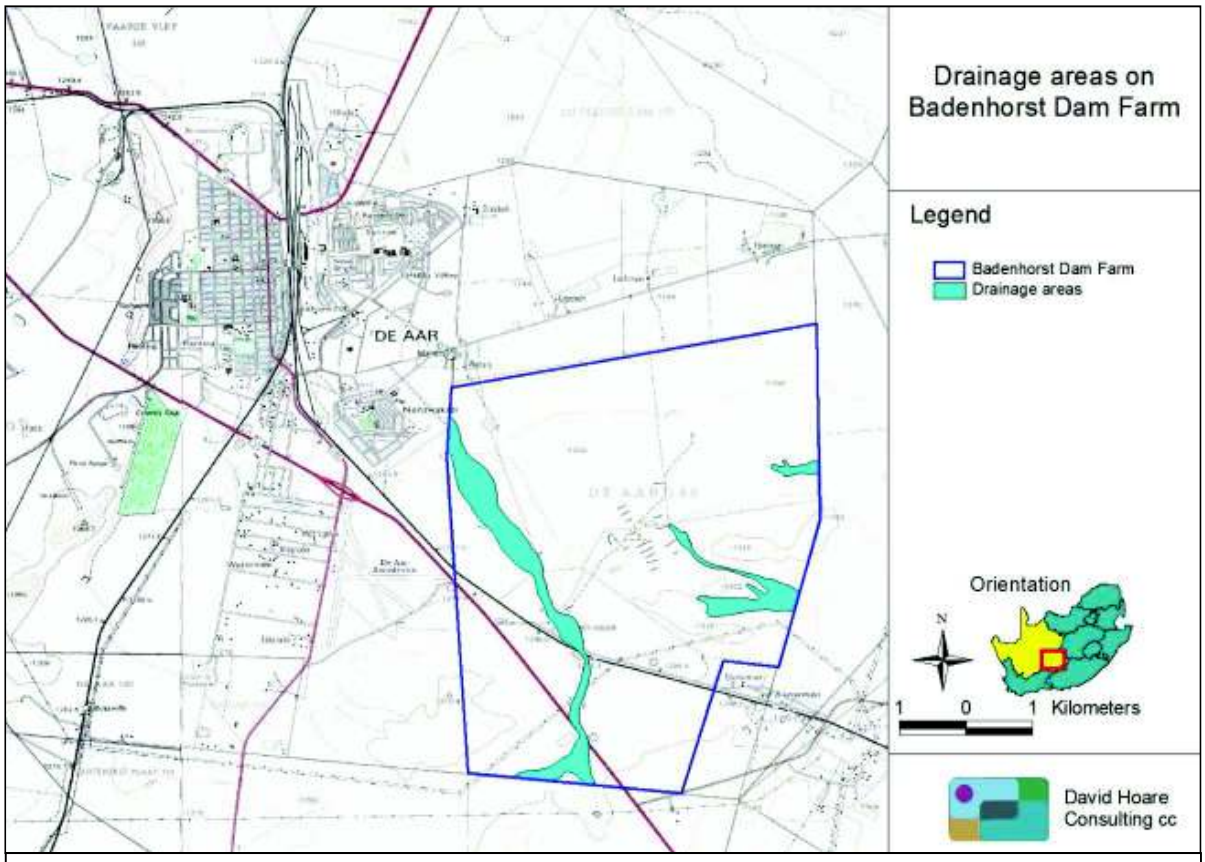

Figure 7: Watercourses and drainage areas of the study area.

The tree, *Acacia haematoxylon*, has been previously recorded within 100 km of the site to the north (near Hopetown). The potential presence of this species is, therefore, also assessed for this site. *Acacia haematoxylon* occurs on deep Kalahari sand between dunes or along dry watercourses. Collection records for this species obtained from the SANBI website (http://sibis.sanbi.org/) indicate that this species does not occur anywhere near to the site. No individuals were observed on site or in the surrounding areas during this and other field assessments.

Sensitivity assessment

The sensitivity assessment identifies those parts of the study area that have high conservation value or that may be sensitive to disturbance. Areas of sensitivity are shown in Figure 8. There are features that need to be taken into account in order to evaluate sensitivity in the study area. These include the following:

1. Non-perennial streams and drainage lines: this represents a number of ecological processes including groundwater dynamics, hydrological processes, nutrient cycling and wildlife dispersal. Wetlands are protected according to the National Water Act and the NEMA.

These factors have been taken into account in evaluating sensitivity within the study area (Figure 8). The sensitivity classification is as follows:

1. MEDIUM-HIGH: All of the drainage lines on site are classified as having medium-high sensitivity (see Figure 8). They are protected according to the National Water Act (Act 36 of 1998). Ecologically, they are areas that provide moderate value ecosystem goods and services.
2. MEDIUM: The majority of the study area is classified as having medium sensitivity (see Figure 8). These are areas of natural vegetation which harbour no particular features of conservation concern.

LEGISLATIVE AND PERMIT REQUIREMENTS

Relevant legislation is provided in this section to provide a description of the key legal considerations of biodiversity importance to the proposed project. The applicable legislation is listed below.

Legislation

National Environmental Management Act, Act No. 107 of 1998 (NEMA)

NEMA requires, inter alia, that:

- "development must be socially, environmentally, and economically sustainable",
- "disturbance of ecosystems and loss of biological diversity are avoided, or, where they cannot be altogether avoided, are minimised and remedied." ,
- "a risk-averse and cautious approach is applied, which takes into account the limits of current knowledge about the consequences of decisions and actions",

NEMA states that "the environment is held in public trust for the people, the beneficial use of environmental resources must serve the public interest and the environment must be protected as the people's common heritage."

Environment Conservation Act No 73 of 1989 Amendment Notice No R1183 of 1997

The ECA states that:

Development must be environmentally, socially and economically sustainable. Sustainable development requires the consideration of inter alia the following factors:

- that pollution and degradation of the environment is avoided, or, where they cannot be altogether avoided, are minimised and remedied;
- that the use and exploitation of non-renewable natural resources is responsible and equitable, and takes into account the consequences of the depletion of the resource;
- that the development, use and exploitation of renewable resources and the ecosystems of which they are part do not exceed the level beyond which their integrity is jeopardised; and
- that negative impacts on the environment and on peoples' environmental rights be anticipated and prevented, and where they cannot be altogether prevented are minimised and remedied.

The developer is required to undertake Environmental Impact Assessments (EIA) for all projects listed as a Schedule 1 activity in the EIA regulations in order to control activities which might have a detrimental effect on the environment. Such activities will only be permitted with written authorisation from a competent authority.

National Forests Act (Act no 84 of 1998)

Protected trees

According to this act, the Minister may declare a tree, group of trees, woodland or a species of trees as protected. The prohibitions provide that 'no person may cut, damage, disturb, destroy or remove any *protected tree*, or collect, remove, transport, export, purchase, sell, donate or in any other manner acquire or dispose of any protected tree, except under a licence granted by the Minister'.

Forests

Prohibits the destruction of indigenous trees in any natural forest without a licence.

National Environmental Management: Biodiversity Act (Act No 10 of 2004)

In terms of the Biodiversity Act, the developer has a responsibility for:

- The conservation of endangered ecosystems and restriction of activities according to the categorisation of the area (not just by listed activity as specified in the EIA regulations).
- Promote the application of appropriate environmental management tools in order to ensure integrated environmental management of activities thereby ensuring that all development within the area are in line with ecological sustainable development and protection of biodiversity.
- Limit further loss of biodiversity and conserve endangered ecosystems.

Chapter 4 of the Act relates to threatened or protected ecosystems or species. According to Section 57 of the Act, "Restricted activities involving listed threatened or protected species":

- (1) A person may not carry out a restricted activity involving a specimen of a listed threatened or protected species without a permit issued in terms of Chapter 7.

Such activities include any that are "of a nature that may negatively impact on the survival of a listed threatened or protected species".

Chapter 5 of the Act relates to species and organisms posing a potential threat to biodiversity. According to Section 75 of the Act, "Control and eradication of listed invasive species":

- (1) Control and eradication of a listed invasive species must be carried out by means of methods that are appropriate for the species concerned and the environment in which it occurs.

- (2) Any action taken to control and eradicate a listed invasive species must be executed with caution and in a manner that may cause the least possible harm to biodiversity and damage to the environment.
- (3) The methods employed to control and eradicate a listed invasive species must also be directed at the offspring, propagating material and re-growth of such invasive species in order to prevent such species from producing offspring, forming seed, regenerating or re-establishing itself in any manner.

Government Notice No. 1002 of 2011: National List of Ecosystems that are Threatened and in need of protection

Published under Section 52(1)(a) of the National Environmental Management: Biodiversity Act (Act No. 10 of 2004). This Act provides for the listing of threatened or protected ecosystems based on national criteria. The list of threatened terrestrial ecosystems supersedes the information regarding terrestrial ecosystem status in the National Spatial Biodiversity Assessment (2004).

The Environmental Impact Assessment (EIA) Regulations include three lists of activities that require environmental authorisation:

• Listing Notice 1: activities that require a basic assessment (R544 of 2010),

• Listing Notice 2: activities that require seeping and environmental impact report (EIR) (R545 of 201 0),

• Listing Notice 3: activities that require a basic assessment in specific identified geographical areas only (R546 of 2010).

Activity 12 in Listing Notice 3 relates to the clearance of 300m2 of more of vegetation, which will trigger a basic assessment within any critically endangered or endangered ecosystem listed in terms of S52 of the Biodiversity Act. This means any development that Involves loss of natural habitat In a listed critically endangered or endangered ecosystem Is likely to require at least a basic assessment in terms of the EIA regulations.

It is important to note that while the original extent of each listed ecosystem has been mapped, a basic assessment report in terms of the EIA regulations is triggered only in remaining natural habitat within each ecosystem and not in portions of the ecosystem where natural habitat has already been irreversibly lost.

GNR 151: Critically Endangered, Endangered, Vulnerable and Protected Species List

Published under Section 56(1) of the National Environmental Management: Biodiversity Act (Act No. 10 of 2004).

GNR 1187: Amendment of Critically Endangered, Endangered, Vulnerable and Protected Species List

Published under Section 56(1) of the National Environmental Management: Biodiversity Act (Act No. 10 of 2004).

Conservation of Agricultural Resources (Act No. 43 of 1983) as amended in 2001

Declared Weeds and Invaders in South Africa are categorised according to one of the following categories:

- Category 1 plants: are prohibited and must be controlled.
- Category 2 plants: (commercially used plants) may be grown in demarcated areas providing that there is a permit and that steps are taken to prevent their spread.
- Category 3 plants: (ornamentally used plants) may no longer be planted; existing plants may remain, as long as all reasonable steps are taken to

prevent the spreading thereof, except within the floodline of watercourses and wetlands.

National Water Act

Wetlands, riparian zones and watercourses are defined in the Water Act as a water resource and any activities that are contemplated that could affect the wetlands requires authorisation (Section 21 of the National Water Act of 1998). A "watercourse" in terms of the National Water Act (act 36 of 1998) means:

- River or spring;
- A natural channel in which water flows regularly or intermittently;
- A wetland, lake or dam into which, or from which, water flows; and

Any collection of water which the Minister may, by notice in the gazette, declare to be a watercourse, and a reference to a watercourse includes, where relevant, its bed and banks.

National Veld and Forest Fire Act (Act No. 101 of 1998)

Provides requirements for veldfire prevention through firebreaks and required measures for fire-fighting. Chapter 4 of the Act places a duty on landowners to prepare and maintain firebreaks. Chapter 5 of the Act places a duty on all landowners to acquire equipment and have available personnel to fight fires.

Northern Cape Nature Conservation Act, No. 9 of 2009

This Act provides for the sustainable utilisation of wild animals, aquatic biota and plants; provides for the implementation of the Convention on International Trade in Endangered Species of Wild Fauna and Flora; provides for offences and penalties for contravention of the Act; provides for the appointment of nature conservators to implement the provisions of the Act; and provides for the issuing of permits and other authorisations. Amongst other regulations, the following may apply to the current project:

- Boundary fences may not be altered in such a way as to prevent wild animals from freely moving onto or off of a property;
- Aquatic habitats may not be destroyed or damaged;
- The owner of land upon which an invasive species is found (plant or animal) must take the necessary steps to eradicate or destroy such species.

The Act provides lists of protected species for the Province.

Other Acts

Other Acts that may apply to biodiversity issues, but which are considered to not apply to the current site are as follows:

- National Environmental Management Protected Areas Act (Act No. 57 of 2003)
- Marine Living Resources Act (Act No. 18 of 1998)
- Sea Birds and Seals Protection Act (Act No. 46 of 1973)
- Lake Areas Development Act (Act No. 39 of 1975)
- Mountain Catchment Areas Act (Act No. 63 of 1970)
- Integrated Coastal Zone Management Act (Act No. 24 of 2008)

IDENTIFICATION OF RISKS AND POTENTIAL IMPACTS

Potential issues relevant to potential impacts on the ecology of the study area include the following:

- Impacts on biodiversity: this includes any impacts on populations of individual species of concern (flora), including protected species, and on overall species richness. This includes impacts on genetic variability, population dynamics, overall species existence or health and on habitats important for species of concern.
- Impacts on sensitive habitats: this includes impacts on any sensitive or protected habitats, including indigenous forest, fynbos and wetland vegetation that leads to direct or indirect loss of such habitat.
- Impacts on ecosystem function: this includes impacts on any processes or factors that maintain ecosystem health and character, including the following:

    - Disruption to nutrient-flow dynamics;
    - Impedance of movement of material or water;
    - Habitat fragmentation;
    - Changes to abiotic environmental conditions;
    - Changes to disturbance regimes, e.g. Increased or decreased incidence of fire;
    - Changes to successional processes;
    - Effects on pollinators;
    - Increased invasion by alien plants.

    Changes to factors such as these may lead to a reduction in the resilience of plant communities and ecosystems or loss or change in ecosystem function.
- Secondary and cumulative impacts on ecology: this includes an assessment of the impacts of the proposed project taken in combination with the impacts of other known projects for the area or secondary impacts that may arise from changes in the social, economic or ecological environment.
- Impacts on the economic use of vegetation: this includes any impacts that affect the productivity or function of ecosystems in such a way as to reduce the economic value to users, e.g. reduction in grazing capacity, loss of harvestable products. It is a general consideration of the impact of a project on the supply of so-called ecosystem goods and services.

A number of direct risks to ecosystems that would result from **construction** of the proposed solar energy facility are as follows:

- Clearing of land for construction.
- Construction of access roads.
- Placement of power lines, cables and water pipelines.
- Establishment of borrow and spoil areas.
- Chemical contamination of the soil by construction vehicles and machinery.
- Operation of construction camps.
- Storage of materials required for construction.

Description of potential impacts

Major potential impacts are described briefly below. These are compiled from a generic list of possible impacts derived from previous projects of this nature and from a literature review of the potential impacts of solar energy facilities on the ecological environment. The major expected negative impact will be due to loss of habitat which may have direct or indirect impacts on individual organisms or on ecosystems as a whole.

Impact 1: Loss or fragmentation of indigenous natural vegetation (terrestrial)
Nature: Construction of infrastructure may lead to direct loss of vegetation. This may lead to localised or more extensive reduction in the overall extent of vegetation. There are factors that may aggravate this potential impact. For example, where this vegetation has already been stressed due to degradation and transformation at a regional level, the loss may lead to increased vulnerability (susceptibility to future damage) of the habitat and a change in the conservation status (current conservation situation). Consequences of the potential impact of loss of indigenous natural vegetation occurring may include:

1. Negative change in conservation status of habitat (Driver et al. 2005);
2. Increased vulnerability of remaining portions to future disturbance;
3. General loss of habitat for sensitive species;
4. Loss in variation within sensitive habitats due to loss of portions of it;
5. General reduction in biodiversity;
6. Increased fragmentation (depending on location of impact);
7. Disturbance to processes maintaining biodiversity and ecosystem goods and services; and
8. Loss of ecosystem goods and services.

The vegetation type site is Northern Upper Karoo, classified nationally as Least Threatened. The Northern Upper Karoo vegetation type occurs across an extensive area (covers an area of almost 42 000 km^2). The regional impact on the vegetation type as a whole therefore appears to be insignificant. Nevertheless, the local impact (at the farm scale) is potentially significant.

Impact 2: Loss of individuals of threatened plants
Nature: Plant species are especially vulnerable to infrastructure development due to the fact that they cannot move out of the path of the construction activities, but are also affected by overall loss of habitat.

Threatened species include those classified as critically endangered, endangered or vulnerable. For any other species a loss of individuals or localised populations is unlikely to lead to a change in the conservation status of the species. However, in the case of threatened plant species, loss of a population or individuals could lead to a direct change in the conservation status of the species, possibly extinction. This may arise if the proposed infrastructure is located where it will impact on such individuals or populations. Consequences may include:

1. Fragmentation of populations of affected species;
2. Reduction in area of occupancy of affected species; and
3. Loss of genetic variation within affected species.

These may all lead to a negative change in conservation status of the affected species, which implies a reduction in the chance of survival of the species.

There are no threatened, near threatened or rare plant species that occur on site. This potential impact is therefore not applicable to the current proposal and is not evaluated further.

Impact 3: Loss of individuals of protected tree species
There are a number of tree species that are protected according to Government Notice no. 1012 under section 12(I)(d) of the National Forests Act, 1998 (Act No. 84 of 1998). In terms of section1 5(1) of the National Forests Act, 1998 "no person may cut, disturb, damage or destroy any protected tree or possess, collect, remove, transport, export, purchase, sell donate or in any other manner acquire or dispose of any protected tree or any forest product derived from a protected tree, except under a license granted by the Minister to an (applicant and subject to such period and conditions as may be stipulated".

One species has a geographic distribution that includes the study area, *Boscia albitrunca*. This species does not occur in any part of the study area. This potential impact is therefore not applicable to the current proposal and is not evaluated further.

Impact 4: Loss of individuals of protected plant species
There are two plant species that are protected according to National Environmental Management: Biodiversity Act (Act No. 10 of 2004) and are known to occur in the general geographical area that includes the site. According to this Act, "*a person may not carry out a restricted activity involving a specimen of a listed threatened or protected species without a permit issued in terms of Chapter 7*". Such activities include any that are "*of a nature that may negatively impact on the survival of a listed threatened or protected species*". This implies that any negative impacts on habitats in which populations of protected species occur or are dependent upon would be restricted according to this Act.

The species that have a geographic distribution that includes the study area are *Hoodia gordonii* and *Harpagophytum procumbens*. No individuals were found during the field survey and it is considered unlikely that they occur on site. This potential impact is therefore not applicable to the current proposal and is not evaluated further.

Impact 5: Establishment and spread of declared weeds and alien invader plants
Major factors contributing to invasion by alien invader plants includes *inter alia* high disturbance (such as clearing for construction activities) and negative grazing practices (Zachariades *et al*. 2005). Exotic species are often more prominent near infrastructural disturbances than further away (Gelbard & Belnap 2003, Watkins *et al*. 2003). Consequences of this may include:

1. Loss of indigenous vegetation;
2. Change in vegetation structure leading to change in various habitat characteristics;
3. Change in plant species composition;
4. Change in soil chemical properties;
5. Loss of sensitive habitats;
6. Loss or disturbance to individuals of rare, endangered, endemic and/or protected species;
7. Fragmentation of sensitive habitats;
8. Change in flammability of vegetation, depending on alien species;
9. Hydrological impacts due to increased transpiration and runoff; and
10. Impairment of wetland function.

Potential weeds with a distribution centred on arid regions of the country include *Salsola kali*, *Atriplex lindleyi*, *Opuntia ficus-indica, Opuntia imbricata, Prosopis glandulosa, Prosopis velutina, Atriplex numularia,* and *Nicotiana glauca*. Species observed during the field survey on the three sites include *Agave americana*, *Prosopis glandulosa*, *Opuntia ficus-indica*, *Datura ferox*, *Argemone ochroleuca* and *Echinopsis spechiana*. The shrub, *Prosopis glandulosa*, is

potentially the most problematic in the study area and is widely distributed in the Northern Upper Karoo vegetation type. It was found at a relatively high frequency on site and in immediately adjacent areas. This species invades riverbeds, riverbanks and drainage lines in semi-arid and arid regions. There is therefore the potential for alien plants to spread or invade following disturbance on site.

Impacts to be assessed for the current project

The impacts to be assessed for the current project are as follows:

- Loss or fragmentation of indigenous natural vegetation (terrestrial)
- Establishment and spread of declared weeds and alien invader plants

ASSESSMENT OF IMPACTS

Impacts are assessed for each component of infrastructure for the proposed solar energy facilities. There is therefore a separate assessment for the solar arrays (including alternative layouts), roads and water pipeline together, overhead power lines and substations together and the no-go alternative.

Solar arrays (layout option 1)

There are arrays proposed in different parts of the sites (see Figure 1). These are in areas of natural vegetation, and may also indirectly affect some drainage areas, identified as being sensitive. The impacts of potential concern are therefore on natural vegetation, drainage areas and due to the potential establishment and spread of alien plants.

It's important to note that the total area for option 1 is less than option 2.

Differences due to different technology alternatives and mounting alternatives are considered to be irrelevant due to the fact that construction activities (for example, clearing and trampling of vegetation) will extend beyond indivudal components of infrastructure. It is expected that the entire area under the solar panels will be completely cleared of vegetation. For the purposes of undertaking this assessment, it is assumed that the entire footprint of the solar array area will be disturbed and/or lost.

Impact 1: Loss or fragmentation of indigenous natural vegetation
The vegetation type on site that will be affected by construction of infrastructure is Northern Upper Karoo.

Extent: The impact will occur at the site of the proposed solar arrays. The construction of the arrays potentially affects a high proportion of natural vegetation on site and is scored as ***site specific***.

Magnitude: At a site specific scale, the vegetation will probably be almost entirely lost. Natural functions and/or processes will therefore be severely altered. The magnitude of the impact is therefore scored as ***high***.

Duration: The impact will occur during construction, but cause effects that will last longer than 15 years (probably longer than 100 years). It is therefore scored as ***long term***.

Significance: On the basis of the impact being of high magnitude at a site specific scale and of long term duration, the impact is scored as having a significance of ***medium***. Mitigation measures will not reduce the extent, magnitude or duration of the impact. The significance will, therefore, remain ***medium*** after mitigation measures have been implemented.

Probability: According to the provided layout, it is ***definite*** that the impact will occur.

Confidence: There is a reasonable to high amount of useful information on and relatively sound understanding of the environmental factors potentially influencing the impact. The confidence in the assessment is therefore rated as ***sure***.

Reversibility: The activity will lead to an impact that is in all practical terms permanent. The impact is therefore considered to be ***irreversible***.

Mitigation measures:

1. Unnecessary impacts on surrounding natural vegetation must be avoided. The construction impacts must be contained to the footprint of the solar array and other associated infrastructure.
2. Areas outsie the construction footprint should be fenced and access to these areas should be limited as much as possible.

Impact 5: Establishment and spread of declared weeds and alien invader plants

There are existing infestations of weeds on site and in immediately adjacent areas. There is therefore the potential that activities on site could promote the spread of these onto the site and/or into other natural areas.

Extent: The impact will occur at the site of the proposed solar arrays and in surrounding areas, but could potentially spread into the surrounding landscape, depending on the habitat and the alien species that could potentially invade the site. The impact is therefore scored as ***local***.

Magnitude: At a local scale, natural functions and/or processes will possibly be notably altered. The magnitude of the impact is therefore scored as ***medium***.

Duration: The impact will occur during construction, but cause effects that will last longer than 15 years, if not controlled. It is therefore scored as ***long term***.

Significance: On the basis of the impact being of medium magnitude at a local scale and of long term duration, the impact is scored as having a significance of ***medium***. Mitigation measures will reduce the extent to site specific, the magnitude to very low and the duration of the impact to short term. The significance will, therefore, be reduced to ***very low*** after mitigation measures have been implemented.

Probability: On the basis of known patterns of alien invasions, it is ***probable*** that the impact will occur.

Confidence: There is a reasonable to high amount of useful information on and relatively sound understanding of the environmental factors potentially influencing the impact. The confidence in the assessment is therefore rated as ***sure***.

Reversibility: The activity will lead to an impact that could be reversed, if identified and managed. Impacts are possibly reversible within 2 years after the cause or stress is removed. The impact is therefore considered to be ***reversible***.

Mitigation measures:

1. Disturbance of indigenous vegetation outside of the footprint of construction must be kept to a minimum.
2. Where disturbance is unavoidable, disturbed areas should be rehabilitated as quickly as possible.
3. Any alien plants within the control zone of the company must be immediately controlled to avoid establishment of a soil seed bank. Control measures must follow established norms and legal limitations in terms of the method to be used and the chemical substances used.
4. An on-going monitoring programme should be implemented to detect and quantify any aliens that may become established and provide information for the management of aliens.

Solar arrays (layout option 2)

There are arrays proposed in different parts of the sites (see Figure 2). These are in areas of natural vegetation, and may also indirectly affect some drainage areas, identified as being sensitive. The impacts of potential concern are therefore on natural vegetation, drainage areas and due to the potential establishment and spread of alien plants.

Differences due to different technology alternatives and mounting alternatives are considered to be irrelevant due to the fact that construction activities (for example, clearing and trampling of vegetation) will extend beyond indivudal components of infrastructure. It is expected that the entire area under the solar panels will be completely cleared of vegetation. For the purposes of undertaking this assessment, it is assumed that the entire footprint of the solar array area will be disturbed and/or lost.

Impact 1: Loss or fragmentation of indigenous natural vegetation
The vegetation type on site that will be affected by construction of infrastructure is Northern Upper Karoo.

Extent: The impact will occur at the site of the proposed solar arrays. The construction of the arrays potentially affects a high proportion of natural vegetation on site and is scored as ***site specific***.

Magnitude: At a site specific scale, the vegetation will probably be almost entirely lost. Natural functions and/or processes will therefore be severely altered. The magnitude of the impact is therefore scored as ***high***.

Duration: The impact will occur during construction, but cause effects that will last longer than 15 years (probably longer than 100 years). It is therefore scored as ***long term***.

Significance: On the basis of the impact being of high magnitude at a site specific scale and of long term duration, the impact is scored as having a significance of ***medium***. Mitigation measures will not reduce the extent, magnitude or duration of the impact. The significance will, therefore, remain ***medium*** after mitigation measures have been implemented.

Probability: According to the provided layout, it is ***definite*** that the impact will occur.

Confidence: There is a reasonable to high amount of useful information on and relatively sound understanding of the environmental factors potentially influencing the impact. The confidence in the assessment is therefore rated as ***sure***.

Reversibility: The activity will lead to an impact that is in all practical terms permanent. The impact is therefore considered to be ***irreversible***.

Mitigation measures:

1. Unnecessary impacts on surrounding natural vegetation must be avoided. The construction impacts must be contained to the footprint of the solar array and other associated infrastructure.
2. Areas outsie the construction footprint should be fenced and access to these areas should be limited as much as possible.

Impact 5: Establishment and spread of declared weeds and alien invader plants

There are existing infestations of weeds on site and in immediately adjacent areas. There is therefore the potential that activities on site could promote the spread of these onto the site and/or into other natural areas.

Extent: The impact will occur at the site of the proposed solar arrays and in surrounding areas, but could potentially spread into the surrounding landscape, depending on the habitat and the alien species that could potentially invade the site. The impact is therefore scored as ***local***.

Magnitude: At a local scale, natural functions and/or processes will possibly be notably altered. The magnitude of the impact is therefore scored as ***medium***.

Duration: The impact will occur during construction, but cause effects that will last longer than 15 years, if not controlled. It is therefore scored as ***long term***.

Significance: On the basis of the impact being of medium magnitude at a local scale and of long term duration, the impact is scored as having a significance of ***medium***. Mitigation measures will reduce the extent to site specific, the magnitude to very low and the duration of the impact to short term. The significance will, therefore, be reduced to ***very low*** after mitigation measures have been implemented.

Probability: On the basis of known patterns of alien invasions, it is ***probable*** that the impact will occur.

Confidence: There is a reasonable to high amount of useful information on and relatively sound understanding of the environmental factors potentially influencing the impact. The confidence in the assessment is therefore rated as ***sure***.

Reversibility: The activity will lead to an impact that could be reversed, if identified and managed. Impacts are possibly reversible within 2 years after the cause or stress is removed. The impact is therefore considered to be ***reversible***.

Mitigation measures:

1. Disturbance of indigenous vegetation outside of the footprint of construction must be kept to a minimum.
2. Where disturbance is unavoidable, disturbed areas should be rehabilitated as quickly as possible.
3. Any alien plants within the control zone of the company must be immediately controlled to avoid establishment of a soil seed bank. Control measures must follow established norms and legal limitations in terms of the method to be used and the chemical substances used.

4. An on-going monitoring programme should be implemented to detect and quantify any aliens that may become established and provide information for the management of aliens.

Roads and water pipelines

The proposed access road and water pipeline are shown in Figure 3. These are relatively limited in extent.

Impact 1: Loss or fragmentation of indigenous natural vegetation
The vegetation type on site that will be affected by construction of infrastructure is Northern Upper Karoo. The access road and water pipeline will affect very small, localised areas of vegetation.

Extent: The impact will occur at the site of the proposed access road and water pipeline. The construction potentially affects a small proportion of natural vegetation on site and is scored as ***site specific***.

Magnitude: At a site specific scale, the vegetation will be affected in localised areas. Natural functions and/or processes will therefore be slightly altered. The magnitude of the impact is therefore scored as ***low***.

Duration: The impact will be initiated during construction, but may only result in effects that are evident during operation. It will probably cause effects that will last longer than 15 years. It is therefore scored as ***long term***.

Significance: On the basis of the impact being of low magnitude at a site specific scale and of long term duration, the impact is scored as having a significance of ***low***. Mitigation measures will not reduce the extent, magnitude or duration of the impact. The significance will, therefore, remain ***low*** after mitigation measures have been implemented.

Probability: According to the provided layout, it is ***definite*** that the impact will occur.

Confidence: There is a reasonable to high amount of useful information on and relatively sound understanding of the environmental factors potentially influencing the impact. The confidence in the assessment is therefore rated as ***sure***.

Reversibility: The activity will lead to an impact that is in all practical terms permanent. The impact is therefore considered to be ***irreversible***.

Mitigation measures:
1. Unnecessary impacts on surrounding natural vegetation must be avoided. The construction impacts must be contained to the footprint of the tower structures and/or the servitude of the power line.

Impact 5: Establishment and spread of declared weeds and alien invader plants
There are existing infestations of weeds on site and in immediately adjacent areas. There is therefore the potential that activities on site could promote the spread of these onto the site and/or into other natural areas.

Extent: The impact will occur at the site of the proposed road and water pieline and in surrounding areas, but could potentially spread into the surrounding landscape, depending on

the habitat and the alien species that could potentially invade the site. The impact is therefore scored as ***local***.

Magnitude: At a local scale, natural functions and/or processes will possibly be notably altered. The magnitude of the impact is therefore scored as ***medium***.

Duration: The impact will occur during construction, but cause effects that will last longer than 15 years, if not controlled. It is therefore scored as ***long term***.

Significance: On the basis of the impact being of medium magnitude at a local scale and of long term duration, the impact is scored as having a significance of ***medium***. Mitigation measures will reduce the extent to site specific, the magnitude to very low and the duration of the impact to short term. The significance will, therefore, be reduced to ***very low*** after mitigation measures have been implemented.

Probability: On the basis of known patterns of alien invasions, it is ***probable*** that the impact will occur.

Confidence: There is a reasonable to high amount of useful information on and relatively sound understanding of the environmental factors potentially influencing the impact. The confidence in the assessment is therefore rated as ***sure***.

Reversibility: The activity will lead to an impact that could be reversed, if identified and managed. Impacts are possibly reversible within 2 years after the cause or stress is removed. The impact is therefore considered to be ***reversible***.

Mitigation measures:

1. Disturbance of indigenous vegetation outside of the footprint of construction must be kept to a minimum.
2. Where disturbance is unavoidable, disturbed areas should be rehabilitated as quickly as possible.
3. Any alien plants within the control zone of the company must be immediately controlled to avoid establishment of a soil seed bank. Control measures must follow established norms and legal limitations in terms of the method to be used and the chemical substances used.
4. An on-going monitoring programme should be implemented to detect and quantify any aliens that may become established and provide information for the management of aliens.

Overhead power lines and substations

The proposed overhead power lines will, in most cases, be adjacent to existing Eskom overhead power lines. Substations will affect only very small local areas of habitat.

Impact 1: Loss or fragmentation of indigenous natural vegetation
The vegetation type on site that will be affected by construction of infrastructure is Northern Upper Karoo. Power line tower structures will affect very small, localised areas of vegetation. Access roads may affect larger areas.

Extent: The impact will occur at the site of the proposed power line tower structures and access roads. The construction of the power line infrastructure potentially affects a small proportion of natural vegetation on site and is scored as ***site specific***.

Magnitude: At a site specific scale, the vegetation will be affected in localised areas. Natural functions and/or processes will therefore be slightly altered. The magnitude of the impact is therefore scored as ***low***.

Duration: The impact will occur during construction. Indications from existing power lines on site are that the base of tower structures becomes re-vegetated. The impact will therefore be ***medium-term***.

Significance: On the basis of the impact being of low magnitude at a site specific scale and of medium term duration, the impact is scored as having a significance of ***low***. Mitigation measures will reduce the magnitude to very low and the duration of the impact to short term. The significance will, therefore, be reduced to ***very low*** after mitigation measures have been implemented.

Probability: According to the provided layout, it is ***probable*** that the impact will occur.

Confidence: There is a reasonable to high amount of useful information on and relatively sound understanding of the environmental factors potentially influencing the impact. The confidence in the assessment is therefore rated as ***sure***.

Reversibility: The activity will lead to an impact that is in all practical terms permanent. The impact is therefore considered to be ***irreversible***.

Mitigation measures:

1. Unnecessary impacts on surrounding natural vegetation must be avoided. The construction impacts must be contained to the footprint of the tower structures and/or the servitude of the power line.
2. Existing access roads must be used, where possible.
3. Service roads in the servitude must be properly maintained to avoid erosion impacts.

Impact 5: Establishment and spread of declared weeds and alien invader plants

There are existing infestations of weeds on site and in immediately adjacent areas. There is therefore the potential that activities on site could promote the spread of these onto the site and/or into other natural areas.

Extent: The impact will occur at the site of the proposed solar arrays and in surrounding areas, but could potentially spread into the surrounding landscape, depending on the habitat and the alien species that could potentially invade the site. The impact is therefore scored as ***local***.

Magnitude: At a local scale, natural functions and/or processes will possibly be notably altered. The magnitude of the impact is therefore scored as ***medium***.

Duration: The impact will occur during construction, but cause effects that will last longer than 15 years, if not controlled. It is therefore scored as ***long term***.

Significance: On the basis of the impact being of medium magnitude at a local scale and of long term duration, the impact is scored as having a significance of ***medium***. Mitigation measures will reduce the extent to site specific, the magnitude to very low and the duration of the impact to short term. The significance will, therefore, be reduced to ***very low*** after mitigation measures have been implemented.

Probability: On the basis of known patterns of alien invasions, it is ***probable*** that the impact will occur.

Confidence: There is a reasonable to high amount of useful information on and relatively sound understanding of the environmental factors potentially influencing the impact. The confidence in the assessment is therefore rated as ***sure***.

Reversibility: The activity will lead to an impact that could be reversed, if identified and managed. Impacts are possibly reversible within 2 years after the cause or stress is removed. The impact is therefore considered to be ***reversible***.

Mitigation measures:

1. Disturbance of indigenous vegetation outside of the footprint of construction must be kept to a minimum.
2. Where disturbance is unavoidable, disturbed areas should be rehabilitated as quickly as possible.
3. Any alien plants within the control zone of the company must be immediately controlled to avoid establishment of a soil seed bank. Control measures must follow established norms and legal limitations in terms of the method to be used and the chemical substances used.
4. An on-going monitoring programme should be implemented to detect and quantify any aliens that may become established and provide information for the management of aliens.

The 'no-go' option

Assessment of the 'no-go' option is as if current activities continue on site. This includes mostly animal husbandry.

Impact 1: Loss or fragmentation of indigenous natural vegetation
The vegetation type on site is Northern Upper Karoo. This will remain intact, although local degradation due to over-utilization could potentially occur.

Extent: The impact will occur at the site of the farm and is scored as ***site specific***.

Magnitude: At a site specific scale, the vegetation will be affected in localised areas. Natural functions and/or processes will therefore be negligibly altered. The magnitude of the impact is therefore scored as ***very low***.

Duration: The existing land-use has been ongoing for many decades. Any impacts will be due to judgement errors by land-users, most of whom have a good understanding on how to manage the land. However, any impact is likely to be ***long-term***.

Significance: On the basis of the impact being of very low magnitude at a site specific scale and of long term duration, the impact is scored as having a significance of ***very low***.

Probability: According to the current land-use, it is ***probable*** that the impact will occur.

Confidence: There is a reasonable to high amount of useful information on and relatively sound understanding of the environmental factors potentially influencing the impact. The confidence in the assessment is therefore rated as ***sure***.

Reversibility: The activity will lead to an impact that is in all practical terms ***reversible***.

Impact 5: Establishment and spread of declared weeds and alien invader plants
There are existing infestations of weeds on site and in immediately adjacent areas. There is therefore the potential that activities on site could promote the spread of these onto the site and/or into other natural areas, although the lack of major earth disturbance due to existing activities means that any spreading of invasive species is likely to be slow.

Extent: The impact will occur on the farm, but could potentially spread into the surrounding landscape, depending on the habitat and the alien species that could potentially invade the site. The impact is therefore scored as ***local***.

Magnitude: At a local scale, natural functions and/or processes will possibly be slightly altered. The magnitude of the impact is therefore scored as ***low***.

Duration: The impact will cause effects that will last longer than 15 years, if not controlled. It is therefore scored as ***long term***.

Significance: On the basis of the impact being of low magnitude at a local scale and of long term duration, the impact is scored as having a significance of ***low***. Management measures could reduce the extent to site specific, the magnitude to very low and the duration of the impact to short term. The significance will, therefore, be reduced to ***very low*** after mitigation measures have been implemented.

Probability: On the basis of known patterns of alien invasions, it is ***probable*** that the impact will occur.

Confidence: There is a reasonable to high amount of useful information on and relatively sound understanding of the environmental factors potentially influencing the impact. The confidence in the assessment is therefore rated as ***sure***.

Reversibility: The activity will lead to an impact that could be reversed, if identified and managed. Impacts are possibly reversible within 2 years after the cause or stress is removed. The impact is therefore considered to be ***reversible***.

DISCUSSION AND CONCLUSIONS

There is one major vegetation types that occurs in the study area, namely Northern Upper Karoo. This vegetation type is classified as Least Threatened and also has a wide distribution and extent. The natural vegetation in the study area is therefore not considered, from this perspective, to have high conservation status.

Local factors that may lead to parts of the study area having elevated ecological sensitivity are the presence of watercourses / drainage areas. The assessment of impacts on these areas has been undertaken in a separate aquatic specialist study.

There is one protected tree species that occurs in the area, *Boscia albitrunca* (Shepherd's Tree). It has been evaluated as having a moderate probability of occurring in the general area, but was not found on site.

There are no threatened, near threatened, declining or rare plant species that occur in the area.

There are two protected plant species that have a geographical distribution that includes the area, but neither species was found on site and, based on a field evaluation of the site, neither species is likely to occur there.

The study area is in a mostly natural condition, but there is some degradation of habitat in parts of the sites evidenced by the common occurrence of alien plants on site and the low vegetation cover due to overgrazing in places. All of the drainage lines / watercourses on the sites are classified as having medium-high sensitivity. The majority of the study area is classified as having medium sensitivity.

A risk assessment was undertaken which identified two main potential negative impacts on the receiving environment. The identified potential impacts are the following:

1. Impacts on indigenous natural vegetation
2. Establishment and spread of declared weeds and alien invader plants

Impacts were assessed after collection of relevant data in the field. A summary of the significance of impacts is given in Table 10 below. This shows that the potential impact on natural vegetation by the solar arrays (same for both option 1 and 2) is the only impacts with a significance of "medium". This significance score is due to the fact that the impact will be long-term and will definitely occur. The assessment methodology masks the fact that the vegetation type is very extensive and, although the impact will occur at a site specific scale, the regional effect is very low. No mitigation measures will reduce the significance of this impact. Other potential impacts are either "low" or can be reduced to "very low" with mitigation.

In terms of the option between the two solar array layout options, either option is acceptable, although Option 1 affects a slightly lesser amount of natural vegetation.

Conclusion

The overall impacts of this proposed project are of low or moderate significance. With mitigation measures implemented, it should be possible to reduce all negative impacts to low significance, except for the significance of impacts on natural vegetation, which remains

medium. Relative to other parts of the country where similar assessments have been conducted, this site has low sensitivity and few conservation issues. Taking this assessment into consideration and the relatively low sensitivity and conservation value of the site, this project is supported from an ecological point of view.

Table 10: Summary of significance of impacts

Impact	Solar arrays (option 1)		Solar arrays (option 2)		Roads and water pipeline		Overhead power lines & substations		No-go option
	Without mitigation	With mitigation	Without mitigation	With mitigation	Without mitigation	With mitigation	Without mitigation	With mitigation	Without mitigation
1. Loss or fragmentation of vegetation	Medium	Medium	Medium	Medium	Medium	Medium	Low	Very low	Very low
2. Spread of alien plants	Medium	Very low	Medium	Very low	Medium	Very low	Medium	Very low	Low

REFERENCES:

ALEXANDER, G. & MARAIS, J. 2007. A guide to the reptiles of southern Africa. Struik, Cape Town.

BARNES, K.N. (ed.) (2000) The Eskom Red Data Book of Birds of South Africa, Lesotho and Swaziland. Birdlife South Africa, Johannesburg.

BRANCH, W.R. (1988) South African Red Data Book—Reptiles and Amphibians. South African National Scientific Programmes Report No. 151.

CHITTENDEN, H. 2007. Roberts bird guide: a comprehensive field guide to over 950 bird species in southern Africa. John Voelcker Bird Book Fund, Cape Town.

DENT, M.C., LYNCH, S.D. & SCHULZE, R.E. 1989. Mapping mean annual and other rainfall statistics in southern Africa. Department of Agricultural Engineering, University of Natal. ACRU Report No. 27. Massachusetts: Clark University.

DRIVER, A., MAZE, K., ROUGET, M., LOMBARD, A.T., NEL, J., TURPIE, J.K., COWLING, R.M., DESMET, P., GOODMAN, P., HARRIS, J., JONAS, Z., REYERS, B., SINK, K and STRAUSS, T. 2005. National Spatial Biodiversity Assessment 2004: priorities for biodiversity conservation in South Africa. Strelitzia 17. South African National Biodiversity Institute, Pretoria.

DU PREEZ, L. & CARRUTHERS, V. 2009. A complete guide to the frogs of southern Africa. Random House Struik, Cape Town.

FAIRBANKS, D.H.K., THOMPSON, M.W., VINK, D.E., NEWBY, T.S., VAN DEN BERG, H.M & EVERARD, D.A. 2000. The South African Land-Cover Characteristics Database: a synopsis of the landscape. *S.Afr.J.Science* 96: 69-82.

FRIEDMANN, Y. & DALY, B. (eds.) 2004. The Red Data Book of the Mammals of South Africa: A Conservation Assessment: CBSG Southern Africa, Conservation Breeding Specialist Group (SSC/IUCN), Endangered Wildlife Trust, South Africa.

GERMISHUIZEN, G., MEYER, N.L., STEENKAMP, Y and KEITH, M. (eds.) (2006). A checklist of South African plants. Southern African Botanical Diversity Network Report No. 41, SABONET, Pretoria.

HARTMANN, M.O. 1988. The soils of the Eastern Cape. In: M.N. Bruton & F.W. Gess. (ed.) Towards an environmental plan for the Eastern Cape. Rhodes University, Grahamstown.

HENNING, S.F. & HENNING, G.A. 1989. South African Red Data Book - Butterflies. *South African National Scientific Programmes* No. 158, Foundation for Research Development, CSIR, Pretoria.

IUCN (2001). *IUCN Red Data List categories and criteria: Version 3.1*. IUCN Species Survival Commission: Gland, Switzerland.

MACVICAR, C. N., SCOTNEY, D. M. SKINNER, T. E. NIEHAUS, H. S. & LOUBSER, J. H., 1974. A classification of land (climate, terrain form, soil) primarily for rainfed agriculture. S. Afr. J. Agric. Extension, 3(3): 1-4.

MARAIS, J. 2004. A complete guide to the snakes of southern Africa. Struik Publishers, Cape Town.

MILLS, G. & HES, L. 1997. The complete book of southern African mammals. Struik Publishers, Cape Town.

MINTER, L.R., BURGER, M., HARRISON, J.A., BRAACK, H.H., BISHOP, P.J. and KLOEPFER, D. (eds.) 2004. Atlas and Red Data Bookof the Frogs of South Africa, Lesotho and Swaziland. SI/MAB Series #9. Smithsonian Institution, Washington, DC.

MONADJEM, A., TAYLOR, P.J., COTTERILL, E.P.D. & SCHOEMAN, M.C. 2010. Bats of southern and central Africa. Wits University Press, Johannesburg.

MUCINA, L, BREDENKAMP, G.J., **HOARE, D.B** & MCDONALD, D.J. 2000. A National Vegetation Database for South Africa *South African Journal of Science* 96: 1–2.

MUCINA, L. AND RUTHERFORD, M.C. (editors) (2006). Vegetation map of South Africa, Lesotho and Swaziland: an illustrated guide. *Strelitzia* 19, National Botanical Institute, Pretoria.

MUCINA, L. AND RUTHERFORD, M.C. (editors) 2006. Vegetation map of South Africa, Lesotho and Swaziland: an illustrated guide. *Strelitzia* 19, South African National Biodiversity Institute, Pretoria.

MUCINA, L., RUTHERFORD, M.C. AND POWRIE, I.W. (editors) 2005. Vegetation map of South Africa, Lesotho and Swaziland, 1:1 000 000 SCALE SHEET MAPS South African National Biodiversity Institute, Pretoria.

MUCINA, L., RUTHERFORD, M.C., **HOARE, D.B**. & POWRIE, L.W. 2003. VegMap: The new vegetation map of South Africa, Lesotho and Swaziland. In: Pedrotti, F. (ed.) Abstracts: Water Resources and Vegetation, 46th Symposium of the International Association for Vegetation Science, June 8 to 14 – Napoli, Italy.

MUCINA, L., RUTHERFORD, M.C., PALMER, A.R., MILTON, S.J., SCOTT, L., VAN DER MERWE, B., **HOARE, D.B.**, BEZUIDENHOUT, H., VLOK, J.H.J., EUSTON-BROWN, D.I.W., POWRIE, L.W. & DOLD, A.P. 2006. *Nama-Karoo Biome.* In: Mucina, L. & Rutherford, M.C. (eds.) The vegetation of South Africa, Lesotho and Swaziland. *Strelitzia* 19. South African National Biodiversity Institute, Pretoria.

MUELLER-DOMBOIS, D. AND ELLENBERG, H. 1974. Aims and methods of vegetation ecology. Wiley, New York.

PASSMORE, N.I. & CARRUTHERS, V.C. (1995) South African Frogs; a complete guide. Southern Book Publishers and Witwatersrand University Press. Johannesburg.

RUTHERFORD, M.C. & WESTFALL, R.H. (1994). Biomes of southern Africa: an objective categorization. *Memoirs of the Botanical Survey of South Africa* No. 63.

TOLLEY, K. & BURGER, M. 2007. Chameleons of southern Africa. Struik Publishers, Cape Town.

APPENDICES:

Appendix 1: Plant species of conservation importance (Threatened, Near Threatened and Declining) that have historically been recorded in the study area.

Sources: South African National Biodiversity Institute in Pretoria.

Family	Taxon	Status	Habitat	Likelihood of occurrence on site
PROTEACEAE	Protea subvestita	VU	Found primarily in the eastern and southern Great Escarpment region of South Africa. Montane areas, mostly highland grassland and fynbos. Collection in grid 3024CC was from 1886 - no locality information is provided for this specimen and it is possibly incorrectly linked to this grid (no other records are in similar geographical location or habitat and typical habitat does not match anything found in grid).	LOW

* Conservation Status Category assessment according to IUCN Ver. 3.1 (IUCN, 2001), as evaluated by the Threatened Species Programme of the South African National Biodiversity Institute in Pretoria. *IUCN (3.1) Categories: VU = Vulnerable, EN = Endangered, CR = Critically Endangered, NT = Near Threatened.

Appendix 2: List of protected tree species (National Forests Act).

Acacia erioloba	*Acacia haematoxylon*
Adansonia digitata	*Afzelia quanzensis*
Balanites subsp. *maughamii*	*Barringtonia racemosa*
Boscia albitrunca	*Brachystegia spiciformis*
Breonadia salicina	*Bruguiera gymnhorrhiza*
Cassipourea swaziensis	*Catha edulis*
Ceriops tagal	*Cleistanthus schlectheri* var. *schlechteri*
Colubrina nicholsonii	*Combretum imberbe*
Curtisia dentata	*Elaedendron (Cassine) transvaalensis*
Erythrophysa transvaalensis	*Euclea pseudebenus*
Ficus trichopoda	*Leucadendron argenteum*
Lumnitzera racemosa var. *racemosa*	*Lydenburgia abottii*
Lydenburgia cassinoides	*Mimusops caffra*
Newtonia hildebrandtii var. *hildebrandtii*	*Ocotea bullata*
Ozoroa namaensis	*Philenoptera violacea* (*Lonchocarpus capassa*)
Pittosporum viridiflorum	*Podocarpus elongatus*
Podocarpus falcatus	*Podocarpus henkelii*
Podocarpus latifolius	*Protea comptonii*
Protea curvata	*Prunus africana*
Pterocarpus angolensis	*Rhizophora mucronata*
Sclerocarya birrea subsp. *caffra*	*Securidaca longependunculata*
Sideroxylon inerme subsp. *inerme*	*Tephrosia pondoensis*
Warburgia salutaris	*Widdringtonia cedarbergensis*
Widdringtonia schwarzii	

Boscia albitrunca has a geographical distribution that coincides with the study area.

Appendix 3: Checklist of plant species recorded during previous botanical surveys in the study area and surrounds.

This checklist has been compiled from data obtained from the SANBI website (http://posa.sanbi.org/searchspp.php) and includes species from quarter degree grid in which the site is located as well as surrounding grids in which similar vegetation types are found. The checklist provides an indication of the species that occur in the general area and is not a checklist for the site itself.

*Eragrostis tef
*Pennisetum villosum
*Puccinellia distans
*Sorghum halepense
Allophyllus decipiens
Aptosimum procumbens (Lehm.) Steud.
Aptosimum spinescens (Thunb.) F.E.Weber
Arachnioides webbiana subsp. foliosa
Arctotis leiocarpa Harv.
Aristida adscensionis
Aristida congesta subsp. barbicollis
Aristida congesta subsp. congesta
Aristida vestita Thunb.
Asparagus striatus (L.f.) Thunb.
Asparagus suaveolens Burch.
Athanasia minuta (L.f.) Källersjö subsp. minuta
Atriplex vestita (Thunb.) Aellen var. appendiculata Aellen
Barleria rigida
Bassia salsoloides (Fenzl) A.J.Scott
Berkheya eriobasis (DC.) Roessler
Brunsvigia radulosa Herb.
Bulbostylis humilis (Kunth) C.B.Clarke
Calobota spinescens (Harv.) Boatwr. & B.-E.van Wyk
Campylopus robillardei Besch.
Cenchrus ciliaris L.
Chaenostoma halimifolium Benth.
Cheilanthes eckloniana (Kunze) Mett.
Chloris virgata Sw.
Chrysocoma ciliata L.
Clutia impedita
Colchicum asteroides (J.C.Manning & Goldblatt) J.C.Manning & Vinn.
Commelina africana L. var. africana
Crassula corallina Thunb. subsp. corallina
Cucumis africanus L.f.
Cucumis heptadactylus Naudin
Cucumis myriocarpus Naudin subsp. leptodermis (Schweick.) C.Jeffrey & P.Halliday
Cullen tomentosum (Thunb.) J.W.Grimes
Cyanella lutea L.f.
Cynodon incompletus Nees
Daubenya comata (Burch. ex Baker) J.C.Manning & A.van der Merwe
Dianthus micropetalus Ser.
Dicoma capensis Less.
Digitaria erianthe
Dimorphotheca cuneata (Thunb.) Less.
Dimorphotheca zeyheri Sond.
Dipcadi viride (L.) Moench
Disa pulchra
Empodium elongatum
Enneapogon desvauxii P.Beauv.
Enneapogon scaber Lehm.
Enneapogon scoparius Stapf
Eragrostis bergiana (Kunth) Trin.
Eragrostis bicolor Nees
Eragrostis chloromelas Steud.
Eragrostis curvula (Schrad.) Nees
Eragrostis homomalla Nees
Eragrostis lehmanniana Nees var. lehmanniana
Eragrostis nindensis
Eragrostis obtusa Munro ex Ficalho & Hiern
Eragrostis procumbens Nees
Eragrostis truncata Hack.
Erucastrum strigosum (Thunb.) O.E.Schulz
Eulophia foliosa
Euphorbia aequoris N.E.Br.
Euphorbia arida N.E.Br.
Euphorbia pugniformis
Felicia burkei (Harv.) L.Bolus
Felicia filifolia (Vent.) Burtt Davy subsp. filifolia
Felicia muricata (Thunb.) Nees subsp. muricata
Fingerhuthia africana Lehm.
Gazania jurineifolia DC. subsp. jurineifolia
Gazania krebsiana Less. subsp. arctotoides (Less.) Roessler
Geigeria filifolia Mattf.
Geigeria ornativa O.Hoffm. subsp. ornativa
Gisekia pharnacioides L. var. pharnacioides
Gladiolus dalenii subsp. dalenii
Gladiolus ecklonii
Gladiolus permeabilis D.Delaroche subsp. edulis (Burch. ex Ker Gawl.) Oberm.

Gnidia polycephala (C.A.Mey.) Gilg
Grewia flava
Haworthia venosa (Lam.) Haw. subsp. tessellata (Haw.) M.B.Bayer
Helichrysum asperum (Thunb.) Hilliard & B.L.Burtt var. asperum
Helichrysum dregeanum Sond. & Harv.
Helichrysum micropoides
Helichrysum zeyheri Less.
Heliophila minima (Stephens) Marais
Heliotropium ciliatum Kaplan
Heliotropium lineare (A.DC.) Gürke
Hermannia burkei Burtt Davy
Hermannia cuneifolia Jacq. var. cuneifolia
Hermannia erodioides (Burch. ex DC.) Kuntze
Hermannia pulchella L.f.
Hertia kraussii (Sch.Bip.) Fourc.
Hertia pallens (DC.) Kuntze
Heteropogon contortus (L.) Roem. & Schult.
Huernia humilis (Masson) Haw.
Hymenophyllum tunbridgense
Hypericum lalandii
Hypertelis salsoloides var. salsoloides
Indigastrum argyraeum (Eckl. & Zeyh.) Schrire
Jamesbrittenia filicaulis
Kniphofia ensifolia subsp. ensifolia
Ledebouria apertiflora
Lepidostephium denticulatum
Lessertia annularis Burch.
Leysera tenella DC.
Limeum sulcatum (Klotzsch) Hutch. var. sulcatum
Limosella africana var. africana
Lobelia flaccida subsp. flaccida
Lotononis platycarpa (Viv.) Pic.Serm.
Lycium horridum Thunb.
Lycium pumilum Dammer
Manulea fragrans Schltr.
Melianthus dregeanus
Melica decumbens Thunb.
Melolobium candicans (E.Mey.) Eckl. & Zeyh.
Microloma armatum (Thunb.) Schltr. var. armatum
Monopsis scabra
Moraea falcifolia
Nemesia fruticans (Thunb.) Benth.
Oligomeris dipetala (Aiton) Turcz. var. dipetala
Ornithogalum nannodes F.M.Leight.
Ornithoglossum vulgare B.Nord.
Oropetium capense Stapf
Oscularia deltoides (L.) Schwantes
Osteospermum leptolobum (Harv.) Norl.
Osteospermum spinescens Thunb.
Osyris lanceolata Hochst. & Steud.
Othonna pavonia E.Mey.
Oxalis depressa Eckl. & Zeyh.
Pachypodium succulentum (Jacq.) Sweet
Panicum coloratum L. var. coloratum
Panicum impeditum Launert
Pelargonium aestivale
Pelargonium pseudofumarioides
Pelargonium tragacanthoides Burch.
Peliostomum leucorrhizum E.Mey. ex Benth.
Peliostomum origanoides E.Mey. ex Benth.
Pentaschistis airoides (Nees) Stapf subsp. airoides
Pentaschistis setifolia
Pentzia calcarea Kies
Pentzia elegans DC.
Pentzia globosa
Pentzia incana (Thunb.) Kuntze
Pentzia lanata
Pentzia quinquefida (Thunb.) Less.
Pentzia spinescens Less.
Phymaspermum aciculare
Phymaspermum parvifolium (DC.) Benth. & Hook. ex B.D.Jacks.
Polygala ephedroides Burch.
Pseudocrossidium crinitum
Psilocaulon coriarium (Burch. ex N.E.Br.) N.E.Br.
Pteronia glauca Thunb.
Pteronia glaucescens DC.
Pteronia sordida N.E.Br.
Puccinellia acroxantha C.A.Sm. & C.E.Hubb.
Puccinellia distans (L.) Parl.
Radyera urens (L.f.) Bullock
Riccia albornata
Riccia nigrella DC.
Rosenia humilis (Less.) K.Bremer
Rosenia oppositifolia
Rumex lanceolatus Thunb.
Salsola calluna Fenzl ex C.H.Wright
Salsola dealata
Salsola glabrescens Burtt Davy
Salsola humifusa
Salvia verbenaca L.
Satyrium longicaude var. longicaude
Sebaea pentandra E.Mey. var. pentandra
Selago albida Choisy
Selago albida Choisy
Selago paniculata Thunb.

Selago saxatilis E.Mey.
Senecio isatideus
Sesamum capense Burm.f.
Solanum retroflexum
Sporobolus discosporus
Sporobolus fimbriatus (Trin.) Nees
Sporobolus ioclados (Trin.) Nees
Stachys cuneata Banks ex Benth.
Stachys linearis
Stapelia grandiflora Masson var. grandiflora
Stipagrostis ciliata (Desf.) De Winter var. capensis (Trin. & Rupr.) De Winter
Stipagrostis namaquensis (Nees) De Winter
Stipagrostis obtusa (Delile) Nees
Syringodea concolor (Baker) M.P.de Vos
Tetragonia fruticosa L.
Themeda triandra
Thesium congestum
Tortula atrovirens
Tragus berteronianus Schult.
Tragus koelerioides
Tragus racemosus (L.) All.
Trichostomum brachydontium
Tripteris aghillana DC. var. aghillana
Urochloa panicoides P.Beauv.
Wahlenbergia nodosa (H.Buek) Lammers
Zaluzianskya karrooica Hilliard
Zygophyllum microcarpum Licht. ex Cham. & Schltdl.

Appendix 4: Species protected under the National Environmental Management: Biodiversity Act, 2004 (Act 10 of 2004)
(as updated in R. 1187, 14 December 2007)

CRITICALLY ENDANGERED SPECIES
Flora
Adenium swazicum
Aloe pillansii
Diaphananthe millarii
Dioscorea ebutsniorum
Encephalartos aemulans
Encephalartos brevifoliolatus
Encephalartos cerinus
Encephalartos dolomiticus
Encephalartos heenanii
Encephalartos hirsutus
Encephalartos inopinus
Encephalartos latifrons
Encephalartos middelburgensis
Encephalartos nubimontanus
Encephalartos woodii

ENDANGERED SPECIES
Flora
Angraecum africae
Encephalartos arenarius
Encephalartos cupidus
Encephalartos horridus
Encephalartos laevifolius
Encephalartos lebomboensis
Encephalartos msinganus
Jubaeopsis caffra
Siphonochilus aethiopicus
Warburgia salutaris
Newtonia hilderbrandi

VULNERABLE SPECIES
Flora
Aloe albida
Encephalartos cycadifolius
Encephalartos Eugene-maraisii
Encephalartos ngovanus
Merwilla plumbea
Zantedeschia jucunda

PROTECTED SPECIES
Flora
Adenia wilmsii
Aloe simii
Clivia mirabilis
Disa macrostachya
Disa nubigena
Disa physodes
Disa procera
Disa sabulosa
Encephelartos altensteinii
Encephelartos caffer
Encephelartos dyerianus
Encephelartos frederici-guilielmi
Encephelartos ghellinckii
Encephelartos humilis
Encephelartos lanatus
Encephelartos lehmannii
Encephelartos longifolius
Encephelartos natalensis
Encephelartos paucidentatus
Encephelartos princeps
Encephelartos senticosus
Encephelartos transvenosus
Encephelartos trispinosus
Encephelartos umbeluziensis
Encephelartos villosus
Euphorbia clivicola
Euphorbia meloformis
Euphorbia obesa
Harpagophytum procumbens
Harpagophytum zeyherii
Hoodia gordonii
Hoodia currorii
Protea odorata
Stangeria eriopus

PROPOSED PV2-5PHOTOVOLTAICENERGY PLANTS ON THE FARM BADENHORST DAM NEAR DE AAR, NORTHERN CAPE

Avian impact assessment

Andrew Jenkins & Johan du Plessis, May 2013

AVISENSE CONSULTING

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1. EXECUTIVE SUMMARY

This study contains a review of the relevant literature on the impacts on avifauna of solar energy facilities and their associated electrical infrastructure, and identifies potential impacts of the proposed PV2-5 Photovoltaic (PV) Energy Plants on the avifauna of the De Aar area, Northern Cape. The proposed plants are located on the same farm as an approved 100 MW facility (PV1) which was proposed by the same applicant and has already been authorized. The expected impacts are: habitat destruction by the construction of the facilities themselves and their associated power lines or substation/s, disturbance by construction and maintenance activities and possibly by the operation of the facilities, and possible displacement or disturbance of sensitive species, and mortality caused by collision with the associated power line network, and electrocution of avifauna on the required power line and substation infrastructure. In addition, some birds may interfere with the efficient running of the proposed PV installations.

The broader impact zone of the proposed PV facilities is contained within an extensive tract of flat, open grassy Nama Karoo, with scattered small, rocky koppies, while the immediate vicinity features degraded natural veld with some anthropogenic influences. The area potentially supports up to 220 bird species, including 69 endemic or near-endemic species, 15 red-listed species, and four species red-listed endemics. The birds of greatest potential relevance and importance in terms of the possible impacts of the proposed PV development are likely to be resident or seasonal influxes of threatened, large terrestrial birds – Blue Crane *Anthropoides paradiseus*, Ludwig's Bustard *Neotis ludwigii*, Kori Bustard *Ardeotis kori* and possibly Blue Korhaan *Eupodotis caerulescens*, locally resident or passing raptors, especially red-listed species - Martial Eagle *Polemaetus bellicosus*, Tawny Eagle *Aquila rapax* and Lesser Kestrel *Falco naumanni*, local populations of endemic, and possibly red-listed passerines, and possibly over-flights of commuting wetland birds, especially flamingos. Pigeons, crows, weavers, sparrows and some raptor species may perch, roost, forage or even nest on or around the facilities and cause fouling problems.

When assessed in isolation, and given the relative homogeneity of the habitat within and surrounding the site, and its close proximity to the town of De Aar and the associated, existing levels of disturbance prevalent in the area, this proposed complex of solar energy plants is considered unlikely to have any significant, long-term impacts on the local avifauna. However, the considerable spatial extent of this development suggests that it may be an important contributor to the potentially significant, cumulative impacts imposed by this and a number of other planned renewable energy projects on the natural environment of the De Aar area.

A comprehensive programme is put forward to fully monitor and research the actual impacts of this PV proposal on the broader avifauna of the area, from pre-construction and into the operational phase of the development, and the first set of data collected as part of this programme is presented.

2. INTRODUCTION

Mulilo Renewable Energy (Pty) Ltd is planning to construct four photovoltaic (PV) power generation facilities (project name 'Badenhorst DamPV2-5') on portions of the farm De Aar 180, just south-east of the town of De Aar, Northern Cape Province, South Africa. Aurecon South Africa (Pty) Ltd were appointed to do the Environmental Impact Assessment (EIA) study, and subsequently appointed *AVISENSE* Consulting cc to conduct the specialist avifaunal assessment. The present report was compiled by Dr Andrew Jenkins and Johan du Plessis. Dr Jenkins is an established ornithologist, with over 20 years of experience in ornithology and impact assessment work. He has been involved in many power line, and wind and solar farm EIA and EMP studies in South Africa, and also does academic research on raptors, bustards and cranes in various parts of the country. Johan du Plessis holds an MSc degree in Zoology from the University of Stellenbosch. He has over six years of experience as a field biologist, and has assisted with field data collection in support of various zoological surveys and EIA studies, including avifaunal monitoring at various wind energy facilities throughout South Africa.

3. DECLARATION OF INDEPENDENCE

Andrew Jenkins and Johan du Plessis (*AVISENSE* Consulting) are independent consultants to Aurecon South Africa (Pty) Ltd and Mulilo Renewable Energy (Pty) Ltd. They have no business, financial, personal or other interest in the activity, application or appeal in respect of which they were appointed other than fair remuneration for work performed in connection with the activity, application or appeal. There are no circumstances that compromise the objectivity of these specialists in performing such work.

4. TERMS OF REFERENCE

The terms of reference for the full EIA, as supplied by Aurecon, were to:

- Review the latest literature on bird-solar power interactions as a desk-top exercise.
- Undertake the requisite field work to directly assess the habitats present within the inclusive impact zone, and to determine the *in situ* avifauna.
- Integrate the on-site information with bird atlas (Southern African Bird Atlas Project - SABAP - 1 & 2) and any other relevant data available for the general area, to develop and inclusive, annotated list of the birds likely to occur on the site, highlighting red-listed species, endemic, restricted-range or other species of particular concern that may occur in the study area.
- Identify, describe and assess potential direct and indirect and cumulative impacts resulting from the proposed development both on the footprint and the immediate surrounding area during construction and operation.
- Recommend mitigation measures to reduce or eliminate potential negative impacts on avifauna, and improve positive impacts.

5. LIMITATIONS AND ASSUMPTIONS

Any inaccuracies or deficiencies in the primary sources of information used in the compilation of this report could limit its value. The SABAP1 data (see below) for the De Aar area are now >15 years old (Harrison *et al.* 1997), and comprise only 27 bird atlas cards for the relevant quarter-degree square, while there are presently only two SABAP 2 atlas card for the relevant pentad. No more reliable and/or more recent formal data on bird species presence and abundance in the study area currently exist.

The site visit (conducted on 7 May and 8 May 2013), in combination with previous visits to the immediate area for EIA work on neighbouring or associated renewable energy projects (Jenkins 2010, 2011, 2012), goes some way towards remedying this knowledge deficiency. However, with limited time in the field, and no seasonal spread, it is possible that important components of the local avifauna – nest sites, localized areas of key habitat for rare or threatened species – were missed.

Given that there are currently no solar energy facilities operative in South Africa, there are no existing data on the environmental effects of these installations in this country.

6. STUDY METHODOLOGY

6.1 Approach

The study included the following steps:

- A review was done of available published and unpublished literature pertaining to bird interactions with solar energy facilities and associated power infrastructure, summarizing the issues involved and the current level of knowledge in this field. Various information sources (listed below), including data on the birdlife of the area and previous studies of bird interactions with solar energy facilities and electricity infrastructure, were examined.
- A short visit to the development area to determine first-hand the avian habitats present, and to start the process of data collection to quantify aspects of the avifauna as part of a monitoring project spanning the pre-construction to operational phases of the proposed development (see below).
- Compilation of an inclusive, annotated list of the avifauna likely to occur within the impact zone of the proposed PV facilities was compiled using a combination of the existing distributional data, species seen during the site visit, and previous experience of the avifauna of the general area.
- Compilation of a short-list of priority bird species (defined in terms of conservation status and endemism) which could be impacted by the proposed PV facilities was extracted from the total bird list. These species were subsequently considered as adequate surrogates for the local avifauna in general, and mitigation of impacts on these species was considered likely to accommodate any less important bird populations that may also potentially be affected.

- Construction of a matrix of possible impacts on the local avifauna was drawn up for the proposed PV facilities, and the significance of these impacts was assessed in terms of the available suite of mitigation options.

6.2 Data sources used

The following data sources and reports were used in the compilation of this report:

- Bird distribution data of the SABAP (Harrison *et al.* 1997) were obtained from the Animal Demography Unit website (http://sabap2.adu.org.za/index.php) for the SABAP 1 quarter-degree square covering the proposed PV facilities and its associated infrastructure(3024CADe Aar), and for the relevant SABAP 2 pentad (3040_2400). A composite list of species likely to occur in the impact zone of the PV facilities was drawn up as a combination of these data, refined by a more specific assessment of the actual habitats affected, based on general knowledge of the birds of the region (Appendix 1).
- The conservation status and endemism of all species considered likely to occur in the area was determined from the national Red-list for birds (Barnes 2000), and the most recent and comprehensive summary of southern African bird biology (Hockey *et al.* 2005).
- Information on nesting raptors and large bird collision rates on the nearby Eskom Hydra-Droërivier 1-3 and Hydra-Proteus 400 kV transmission lines from the Eskom Electric Eagle Project (Jenkins *et al.* 2007, Jenkins et al. 2013), and recent bustard and crane collision surveys (Jenkins *et al.* 2009, Jenkins *et al.* 2011).
- Lesser Kestrel roost counts for De Aar from the Endangered Wildlife Trust's Migrating Kestrel Project (A.J. Van Zyl pers. comm., https://www.ewt.org.za/programmes/BoPP/kestrel.html).

7. OVERVIEW OF THE PROPOSAL

The Badenhorst Dam PV2-5 Energy Facilities are proposed for the farm De Aar 180, near the town of De Aar, Northern Cape, and in addition to an already authorized 100 MW PV plant on a different portion of the same property. The new proposal is for four additional 75MW PV energy plants (Fig. 1), with a combined extent of approximately 876ha. The proposed alternative to the preferred project (Fig. 1) consists of three separate PV plants, each with a generating capacity of 150MW respectively. This alternative development encompasses the footprint of the preferred layout, with an additional section in the south, and a total footprint of approximately 1300ha. Proposed electrical infrastructure includes a dedicated substation for each of the proposed PV facilities. All substations will connect to a central 3-bay substation via an on-site 132 kV overhead transmission line, which will connect to an existing132 kV overhead transmission line, connecting the facility to the Eskom Hydra substation just to the southeast. Additional infrastructure includes a road network, both for access and internal logistics, and three construction camps.

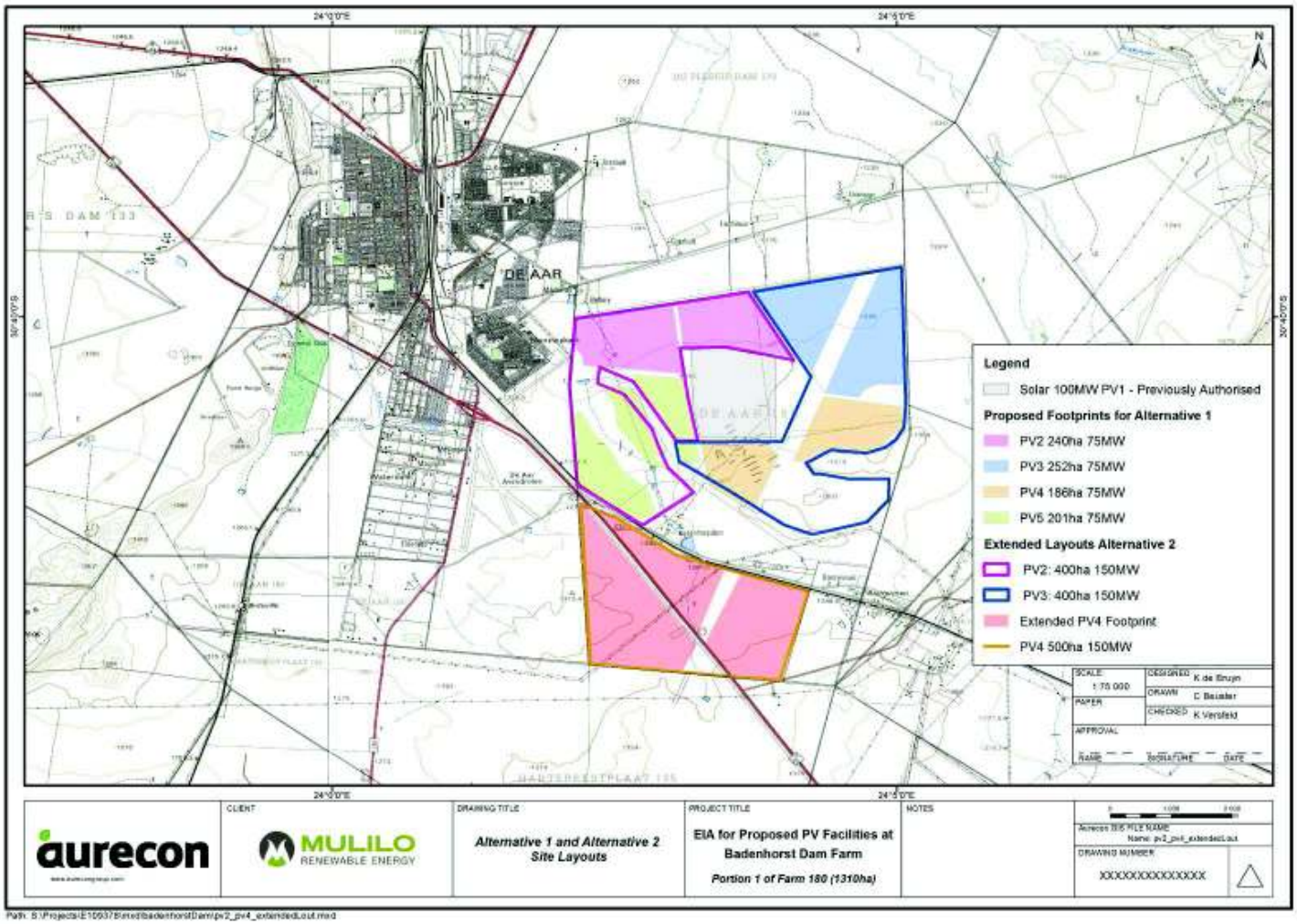

Figure1. The preferred and alternative locations and layouts of the Badenhorst DamPV2-5 Energy Facilities, in relation to the entire contracted property, PV1 (already authorized), and the Eskom Hydra substation.

8. DESCRIPTION OF THE AFFECTED ENVIRONMENT

8.1 Vegetation of the study area

The study area is located in the Upper Karoo Bioregion of the Nama Karoo Biome (Mucina & Rutherford 2006). The natural vegetation is dominated by Northern Upper Karoo – dry Karoo shrubland with drought resistant grasses and scattered low trees (Mucina & Rutherford 2006). Altitude on the site varies very little (1250-1320 metres above sea level). The area receives about 200 mm of rain per annum, most of which falls in autumn (February-March). Temperatures range from a mean winter minimum of about 0.3ºC, to a mean summer maximum of about 30ºC.

8.2 Avian microhabitats

These comprise mainly degraded areas of grassy Karoo veld, with limited amounts of taller vegetation and low trees (including alien spp.) along drainage lines, a line of low, rocky koppies along the southern periphery of the site, and two small artificial waterbodies and possibly some ephemeral wetlands present in wet years. High stocking rates and grazing pressure has resulted in lower vegetation and a generally more open habitat than would naturally occur in the area. The site is adjacent to the town of De Aar and is already subject to significant levels of human disturbance. It is also proximal to the Eskom Hydra substation and a number of major power transmission lines run close to or through the site, including the new Gamma-Perseus 765 kV line. Land-use is primarily small stock and game farming, and the area includes a network of minor farm roads or tracks.

8.3 Avifauna of the impact area

Up to 220 bird species could occur within the anticipated, broader impact zone of the solar energy facility (Appendix 1), including 69 endemic or near-endemic species, 15 red-listed species, and four species – Ludwig's Bustard *Neotis ludwigii*, Blue Korhaan *Eupodotis caerulescens*, Blue Crane *Anthropoides paradiseus* and Black Harrier *Circus maurus* – which are both endemic and red-listed (Barnes 1998, 2000, Table 1).The site falls within the Platberg-Karoo Conservancy Important Bird Area (Barnes 1998), which supports critical or regionally significant populations of a number of potentially collision prone or otherwise sensitive species.

The birds of greatest potential relevance and importance in terms of the possible impacts of the PV facility are likely to be local populations of endemic passerines (including Karoo Long-billed Lark *Certhilauda subcoronata*, Rufous-eared Warbler *Malcorus pectoralis*, and Black-headed Canary *Serinus alario*and possibly African Rock Pipit *Anthus cinnamomeus*), visiting or resident Blue Korhaan, Karoo Korhaan *Eupodotis vigorsii*, Northern Black Korhaan *Afrotis afroides* and Blue Crane, and locally resident or passing raptors, especially red-listed species - Martial Eagle *Polemaetus bellicosus*, Tawny Eagle *Aquila rapax*, Lesser Kestrel *Falco naumanni*, and possibly Peregrine Falcon *Falco peregrines*,

Lanner Falcon *Falco biarmicus*, and regional endemics such as Jackal Buzzard *Buteo rufofuscus* and Pale Chanting Goshawk *Melierax canorus*. Surveys of large raptors nesting in Eskom transmission pylons in this area (Jenkins *et al.* 2007, 2013) suggest that the closest sites to the development area are a recently active Tawny Eagle nest on tower 33 (30° 43.466 S, 23º 58.457 E) of the Hydra-Kronos 400 kV line – 6.9 km to the south-west of the development area, and a recently active Tawny Eagle nest on tower 39 (30° 49.897 S, 24° 02.369 E) of the Droërivier-Hydra 1 400 kV line – 14.7 km to the south. Note that there may be other large eagle nests on un-surveyed pylon lines located closer to the site than these. There is also a large (up to 12 000 birds – A.J. Van Zyl pers. comm.) Lesser Kestrel roost located around the De Aar Hospital about 2.5 km to the north-west of the development area, used by these Palaearctic migrants during the austral summer (October to March).

The birds most likely to proliferate and become active around the facility, possibly causing fouling problems, could include Speckled Pigeon *Columba guinea*, Greater Kestrel *Falco rupicolus*, Pale Chanting Goshawk, Cape Crow *Corvus capensis*, Pied Crow *Corvus albus*, Common Starling *Sturnus vulgaris*, Cape Sparrow *Passer melanurus*, and House Sparrow *Passer domesticus*, and possibly variety of other perch-hunting hunting and insectivorous passerines.

Only 30 species were seen on the study site during the May field visit (Appendix 1), none of which were particularly notable. Secretarybird *Sagittarius serpentarius* has been seen on the site previously (Jenkins 2012), and a flock of six Blue Cranes was seen flying overhead during this visit. Densities of regionally endemic passerines – Large-billed Lark *Galerida magnirostris*, Eastern Clapper Lark *Mirafra fasciolata*, Spike-heeled Lark *Chersomanes albofasciata* and Rufous-eared Warbler were relatively high across much of the development area (see monitoring data in Table 3 and Appendix 2, below). A recent Ludwig's Bustard collision victim was found under the 765 kV transmission line.

Table 1. Priority bird species considered central to the avian impact assessment process for the proposed Badenhorst Dam PV Energy Facilities, selected mainly on the basis of South African (Barnes 2000) or global conservation status (www.iucnredlist.org or http://www.birdlife.org/datazone/species/), level of endemism, relative abundance on site (SABAP reporting rates, direct observation), and estimated conservation or ecological significance of the local population. Red-listed endemic species are shaded in grey.

Common name	Scientific name	SA conservation status/ (Global conservation status)	Regional endemism	Average reporting rate[1] (*n* = 29cards)	Estimated importance of local population	Preferred habitat	Risk posed by		
							Collision	Electro-cution	Disturbance / habitat loss
Ludwig's Bustard	*Neotis ludwigii*	Vulnerable (Endangered)	Near-endemic	6.8	Moderate-High	Open Karoo	High	-	Moderate
Kori Bustard	*Ardeotis kori*	Vulnerable	-	20.7	Moderate	Open Karoo	High	-	Moderate
Blue Korhaan	*Eupodotis caerulescens*	Near-threatened	-	3.4	Moderate	Grassy Karoo	High	-	Moderate
Blue Crane	*Anthropoides paradiseus*	Vulnerable	Endemic	31.0	High		High	-	Moderate
Tawny Eagle	*Aquila rapax*	Vulnerable	-	0.0	Low				
Martial Eagle	*Polemaetus bellicosus*	Vulnerable (Near-threatened)	-	3.4	Moderate-High	Open Karoo, power pylons	High	High	Moderate
Secretarybird	*Sagittarius serpentarius*	Near-threatened (Vulnerable)	-	17.2	Moderate	Open Karoo	High	-	Moderate
Lesser Kestrel	*Falco naumanni*	Vulnerable	-	17.2	Moderate	Open Karoo, power pylons	Moderate	-	Moderate
Lanner Falcon	*Falco biarmicus*	Near-threatened	-	0.0	Moderate	Open Karoo, power pylons	High	Moderate	-
Peregrine Falcon	*Falco peregrinus*	Near-threatened	-	0.0			High	Moderate	-
Greater Flamingo	*Phoenicopterus ruber*	Near-threatened	-	6.9	Low	Wetlands, flying over	High	-	-

[1] Reporting rate calculated as the % of bird lists submitted for a given area which include each species.

On the basis of these observations, in combination with already documented information on the avifauna of the general area, 11 priority species are recognized as key in the assessment of avian impacts of the proposed Badenhorst Dam PV Energy Facilities (Table 1). These are mostly nationally and/or globally threatened species which are known to occur, or could occur, in relatively high numbers in the development area and which are likely to be, or could be, negatively affected by the PV solar power plant project. Three species were included despite the fact that they were not recorded in either SABAP 1 or SABAP 2 data for the area, either because (a) they were seen on site, (b) the site is located within their respective distributions and the available habitat is possibly suitable, or (c) they may occasionally fly over the site *en route* between distant resource areas, and in so doing be exposed possible impacts.

Overall, the avifauna of the development site itself is entirely replaceable, at best replicating that which occurs across huge areas of the Eastern Karoo. However, the considerable spatial extent of this development suggests that it may be an important contributor to the potentially significant, cumulative impacts imposed by this and a number of other planned renewable energy projects on the natural environment of the De Aar area.

9. ASSESSMENT OF IMPACTS

9.1 General assessment of impacts &mitigation

9.1.1 Impacts of solar energy facilities

Habitat loss – destruction, disturbance and displacement

Perhaps the most significant potential impact on birds of any solar energy generation facility is the displacement or exclusion of threatened, rare, endemic or range-restricted species from critical areas of habitat. Given the considerable space requirements of commercially viable facilities (>50-100 ha), this effect could be significant in some instances, particularly given the possibility that the initial footprint of successful facilities may be expanded over time, and allowing for the possible cumulative effects of multiple facilities in one area.

To a lesser extent, construction and ongoing maintenance activities are likely to cause some disturbance of birds in the general surrounds of a solar facility, and especially of shy and/or ground-nesting species resident in the area. Mitigation of such effects requires that generic best-practice principles be rigorously applied - sites are selected to avoid the destruction of key habitats, and construction and final footprints, as well as sources of disturbance of key species, must be kept to an absolute minimum.

Other effects

Any vertical, reflective surfaces may confuse approaching birds with the result that numbers are killed in collisions with such surfaces. If this source of unnatural mortality is a realistic expectation of a proposed solar installation, efforts should be made to restrict access by birds into the relevant, hazardous areas of the facility. Solar installations generally feature large areas of reflective paneling. It is possible that nearby or overflying birds may be disorientated by the reflected light, and consequently be displaced from an area more extensive than just the developed footprint of the facility. Conversely, certain bird species may be attracted to the solar arrays. The possibility also exists that waterbirds will mistake the reflective surface for an expanse of water, and attempt to land on the panels, incurring injury and/or being disorientated in the process. Other species may seek to benefit from the installations, using the erected structures as prominent

perches, sheltered roost sites or even nesting sites, and possibly foraging around the infrastructure in response to changes in the distribution of preferred foods (plants growing under the paneling, other animals attracted to the facility). Such scenarios might be associated with fouling of critical components in the solar array, bringing local bird populations into conflict with the facility operators. Under these circumstances, specialist advice should be sought in devising effective avian deterrents to minimize associated damage.

9.1.2 Impacts of associated infrastructure

Infrastructure commonly associated with solar energy facilities may also have detrimental effects on birds. The construction and maintenance of substations, power lines, servitudes and roadways causes both temporary and permanent habitat destruction and disturbance, and overhead power lines pose a collision and possibly an electrocution threat to certain species (Van Rooyen 2004a, Lehman *et al.* 2007, Jenkins *et al.* 2010).

Construction and maintenance of power lines and substations

Some habitat destruction and alteration inevitably takes place during the construction of power lines, substations and associated roadways. Also, power line service roads or servitudes have to be cleared of excess vegetation at regular intervals in order to allow access to the line for maintenance, and to prevent vegetation from intruding into the legally prescribed clearance gaps between the ground and the conductors. These activities have an impact on birds breeding, foraging and roosting in or in close proximity to the servitude, and retention of cleared servitudes can have the effect of altering bird community structure along the length of any given power line (e.g. King & Byers 2002).

Collision with power lines

Power lines pose a significant collision risk to birds, affecting a particular suite of collision prone species (Bevanger 1994, 1995, 1998, Janss 2000b, Anderson 2001, van Rooyen 2004a, Drewitt & Langston 2008, Jenkins *et al.* 2010). Mitigation of this risk involves the informed selection of low impact alignments for new power lines relative to movements and concentrations of high risk species, and the use of either static or dynamic marking devices to make the lines, and in particular the earthwires, more conspicuous. While various marking devices have been used globally, many remain largely untested in terms of their efficacy in reducing collision incidence, and those that have been fully assessed have all been found to be only partially effective (Drewitt & Langston 2008, Jenkins *et al.* 2010).

Electrocution on power infrastructure

Avian electrocutions occur when a bird perches or attempts to perch on an electrical structure and causes an electrical short circuit by physically bridging the air gap between live components and/or live and earthed components (van Rooyen 2004b, Lehman *et al.* 2007). Electrocution risk is strongly influenced by the voltage and design of the power lines erected (generally occurring on lower voltage infrastructure where air gaps are relatively small), and mainly affects larger, perching species, such as vultures, eagles and storks, easily capable of spanning the spaces between energised components. Mitigation of electrocution risk involves the use of bird-safe structures (ideally with critical air gaps >2 m), the physical exclusion of birds from high risk areas of live infrastructure, and comprehensive insulation of such areas (van Rooyen 2004b, Lehman *et al.* 2007).

9.2 Project specific impacts

Specific impacts of the proposed Badenhorst Dam PV Energy project are most likely to be manifested in the following ways (summarised in Table 2):

(i) Disturbance and displacement of resident or seasonal influxes of large terrestrial birds - especially Blue Crane, Ludwig's Bustard and possibly Kori Bustard - from nesting and/or foraging areas by construction and/or operation and/or decommissioning of the facilities, and /or mortality of these species in collisions with new power lines while commuting between resource areas.

(ii) Disturbance and displacement of resident or visiting raptors - especially Martial Eagle, Tawny Eagle and Lesser Kestrel - from foraging areas by construction and/or operation and/or decommissioning of the facilities, and /or mortality of these species in collisions with new power lines or by electrocution when perched on power infrastructure.

(iii) Disturbance and displacement of resident/breeding Karoo endemics.

(iv) Injury or mortality of wetland birds (especially flamingos) using possible flight lines in and out of resource areas in the broader vicinity, in collisions with the PV infrastructure or associated new power lines.

Generally, however, the anticipated impacts on birds of the proposed development are not considered to be of any great significance (Boxes 1.1 – 1.3, Table 3). There will be some habitat loss for Karoo endemic species (although the general area at the site is already somewhat degraded and disturbed), some species (Karoo endemics, large terrestrial species, raptors) may be displaced from a broader area either temporarily by construction and maintenance activities, or more permanently by the disruptive, reflective properties of the solar panels, and some species (large terrestrial species, raptors, commuting wetland birds) may be killed in interactions (collisions, electrocutions) with the new power infrastructure, but again, numbers affected are likely to be low.

Table 2. Impact characteristics: Badenhorst Dam PV Energy Facilities – Birds.

Summary	**Construction**	**Operation**	**Decommissioning**
Project Aspect/ activity	(i) Disturbance/displacement associated with noise and movement of construction equipment and personnel. (ii) Loss of vegetation and avian habitat through site clearance, road upgrade and establishment of the camp, lay-down and assembly areas.	(i) Loss of habitat to space occupied by solar panels and associated infrastructure, and disturbance / displacement associated with routine maintenance work. (ii) Mortality in collisions with solar panels and/or power lines, or by electrocution on new power infrastructure.	(i) Disturbance/displacement associated with noise and movement of decommissioning equipment and personnel.
Impact Type	Direct	Direct	Direct
Receptors Affected	(i) All birds on site; key species: Ludwig's Bustard, Kori Bustard, Blue Korhaan, Blue Crane, Martial Eagle, Tawny Eagle, Lesser Kestrel, Blue Crane, Karoo endemics. (ii) All birds on site; key species: Ludwig's Bustard, Kori Bustard, Blue Korhaan, Blue Crane, Martial Eagle, Tawny Eagle, Lesser Kestrel, Karoo endemics.	(iii) All birds on site; key species: Ludwig's Bustard, Kori Bustard, Blue Korhaan, Blue Crane, Martial Eagle, Tawny Eagle, Lesser Kestrel, Blue Crane, Karoo endemics. (i) All birds on site; Ludwig's Bustard, Kori Bustard, Blue Korhaan, Blue Crane, Martial Eagle, Tawny Eagle, Lesser Kestrel, Blue Crane, overflying wetland birds.	(i) All birds on site; key species: Ludwig's Bustard, Kori Bustard, Blue Korhaan, Blue Crane, Martial Eagle, Tawny Eagle, Lesser Kestrel, Blue Crane, Karoo endemics.

Box 1.1. **Pre-mitigation Construction Impact: Badenhorst Dam PV2-5 Energy Facilities – Birds**, with ratings for the alternative proposal (where these differ) in square brackets. Significance ratings ascribed as per the criteria provided by Aurecon South Africa.

(A) Habitat loss

Nature: All construction activities would result in a **negative direct** impact on the avifauna of the Badenhorst Dam site: loss of vegetation and habitat affecting Karoo endemics, raptors and large terrestrial species, through site clearance, road upgrade and establishment of the camp and assembly areas.

Impact Magnitude – Low-Medium [Medium]

- **Extent**: The extent of the impact is **local**.
- **Duration**: The duration would be **short-term** as the ecology of the area may be altered beyond the completion of the project.
- **Probability:** Habitat will **definitely** be lost.

IMPACT SIGNIFICANCE – LOW-MEDIUM [MEDIUM]

Confidence: Certain

Reversibility: Reversible

Cumulative impacts: Could be substantially amplified by multiple renewable energy projects in the area, which seems highly likely.

(B) Disturbance

Nature: All construction activities would result in a **negative direct** impact on the avifauna of the Badenhorst Dam PV site; disturbance associated with noise and movement of construction equipment and personnel, affecting Karoo endemics, raptors and large terrestrial species.

Impact Magnitude –Medium

- **Extent**: The extent of the impact is **local [regional]**.
- **Duration**: The duration will not extend beyond the **construction period**.
- **Probability:** There will **definitely** be disturbance.

IMPACT SIGNIFICANCE – [MEDIUM]

Confidence: Certain

Reversibility: Possibly reversible

Cumulative impacts: Could be substantially amplified by multiple renewable energy projects in the area, which seems highly likely.

Box 1.2. **Pre-mitigation Operation Impact: Badenhorst Dam PV2-5 Energy Facilities – Birds,** with ratings for the alternative proposal (where these differ) in square brackets. Significance ratings ascribed as per the criteria provided by Aurecon South Africa.

(A) Habitat loss and disturbance

Nature: Operational activities would result in a **negative direct** impact on the avifauna of the Badenhorst Dam PV site; loss of habitat for Karoo endemics, raptors and large terrestrial species, to space occupied by solar panels and associated infrastructure, and disturbance or displacement of these birds by routine maintenance activities.

Impact Magnitude – Low-Medium [Medium]

- **Extent**: The extent of the impact is potentially **local**.
- **Duration**: The duration would be **long-term** as the ecology of the area would be affected until the project stops operating and is fully decommissioned.
- **Probability:** Habitat will **definitely** be lost and some priority species will be disturbed/displaced.

IMPACT SIGNIFICANCE – LOW- MEDIUM [MEDIUM]

Confidence: Certain

Reversibility: Possibly reversible

Cumulative impacts: Could be substantially amplified by multiple renewable energy projects in the area, which seems highly likely.

(B) Mortality

Nature: Operational activities would result in a **negative direct** impact on the avifauna of the Badenhorst Dam PV site; mortality of raptors, large terrestrials in collisions with solar panels and/or power lines, or by electrocution on new power infrastructure.

Impact Magnitude – Medium-High

- **Extent**: The extent of the impact is potentially **regional**.
- **Duration**: The duration would be **long-term** as the ecology of the area would be affected at least until the project stops operating and is fully decommissioned.
- **Probability:** It is **probable** that some individuals of priority species will be killed.

IMPACT SIGNIFICANCE – MEDIUM-HIGH

Confidence: Unsure

Reversibility: Irreversible

Cumulative impacts: Could be substantially amplified by multiple renewable energy projects in the area, which seems highly likely.

Box 1.3. **Pre-mitigation Decommissioning Impact: Badenhorst Dam PV2-5 Energy Facilities – Birds**, with ratings for the alternative proposal (where these differ) in square brackets. Significance ratings ascribed as per the criteria provided by Aurecon South Africa.

(A) Disturbance

Nature: All decommissioning activities would result in a **negative direct** impact on the avifauna of the Badenhorst Dam PV site; disturbance associated with noise and movement of decommissioning equipment and personnel, affecting Karoo endemics, raptors and large terrestrial species.

Impact Magnitude – Low-Medium [Medium]

- **Extent**: The extent of the impact is **local [regional]**.
- **Duration**: The duration will not extend beyond the **decommissioning period**.
- **Probability:** There will **definitely** be disturbance.

IMPACT SIGNIFICANCE – LOW-MEDIUM [MEDIUM]

Confidence: Certain

Reversibility: Reversible

Cumulative impacts: Could be substantially amplified by multiple renewable energy projects in the area, which seems highly likely.

Table 3. Pre- and Post- Mitigation Significance: Badenhorst Dam PV2-5 Energy Facilities - Birds; preferred *vs* alternative layout options. Significance ratings ascribed as per the criteria provided by Aurecon South Africa.

Impact	Alternative layout Pre-mitigation	Alternative layout Residual (post-mitigation)	Preferred layout Pre-mitigation	Preferred layout Residual (post-mitigation)
Construction Phase				
Habitat loss	MEDIUM	LOW-MEDIUM	LOW-MEDIUM	LOW
Disturbance	MEDIUM	LOW-MEDIUM	MEDIUM	LOW-MEDIUM
Operation Phase				
Habitat loss & disturbance	MEDIUM	MEDIUM	LOW-MEDIUM	LOW-MEDIUM
Mortality	MEDIUM-HIGH	LOW-MEDIUM	MEDIUM-HIGH	LOW-MEDIUM
Decommissioning Phase				
Disturbance	MEDIUM	LOW-MEDIUM	LOW-MEDIUM	LOW

Note that the anticipated net impacts of this proposed development should ideally be considered in the context of accumulated impacts imposed by multiple other renewable energy projects proposed (and

some already approved and under construction) within a 20 km radius of De Aar (Fig. 2). Furthermore, the project itself comprises a number of potentially independent PV installations, each of which has its own inherent impact profile, contributing to the net aggregate impact of the whole proposed development. While the impact potential of each separate PV array must, by definition, be less than the sum of all the components together, we have assumed here that each component has the same impact as the sum, partly in the interests of conservatism and pragmatism, and partly because the assessment criteria imposed on the study do not allow for a finer scale evaluation of relative impacts.

The negative impacts resulting from all phases of this proposed development (i.e. development to the extent of individual farms) would certainly be substantially amplified by the construction and operation of multiple renewable energy projects in the area (development to the extent of broader localities or even regions). Relatively minor levels of disturbance at the individual project level (i.e. farm) would escalate to combined levels likely to cause complete and possibly long-term evacuation of the locality or region by more sensitive species. These disturbance effects would be exacerbated by the loss or degradation of markedly more habitat to a much larger aggregate construction and operational footprint, possibly resulting in the permanent loss from the affected area of key elements of the avifauna. Bearing this in mind, it is essential that the suitability of this single proposal be considered in the context of broader renewable energy development plans for De Aar and surrounding areas.

10. MITIGATION

Should the proposed PV Facilities be approved, mitigation of impacts on birds should focus on:

(i) Selecting the preferred layout option, given that this occupies a markedly smaller development footprint.

(ii) Minimizing the inclusive construction footprint of the development and abbreviating construction time.

(iii) Minimizing noise and disturbance associated with maintenance activities at the plant once it becomes operational.

(iv) Selecting the PV technology that is least likely to be mistaken for a waterbody by overflying wetland birds.

(v) Minimising the length of any new power lines installed and burying lines wherever possible. If lines cannot be buried, ensure that all new lines are marked with bird flight diverters (Jenkins *et al.* 2010) along their entire length, and that all new power line infrastructure is adequately insulated and bird friendly in configuration (Lehman *et al.* 2007). Note that current understanding of power line collision risk in birds precludes any guarantee of successfully distinguishing high risk from medium or low risk sections of a new line (Jenkins *et al.* 2010). The relatively low cost of marking the entire length of a new line during construction, especially quite a short length of line in an area frequented by collision prone birds, more than offsets the risk of not marking the correct sections, causing unnecessary mortality of birds,

and then incurring the much greater cost of retro-fitting the line post-construction. In situations where new lines run in parallel with existing, unmarked power lines, this approach has the added benefit of reducing the collision risk posed by the older line.

(vi) Minimising the amount of fencing used to enclose the development areas, given that these may present a collision risk for collision-prone birds.

(vii) Instituting a comprehensive impact monitoring scheme, and using the results of this scheme to inform and refine a dynamic approach to mitigation.

11. CONCLUSION

The proposed PV Facilities are likely to have little, if any significant, long-term impact on the avifauna of the area, after mitigation. Careful and responsible implementation of the required mitigation measures, including the selection of the preferred layout over the alternative, and conventional PV technology over concentrated PV, should reduce construction and operational phase impacts to tolerable and sustainable levels. Every effort should be made to monitor impacts throughout, to learn as much as possible about the effects of solar energy developments on South African avifauna, and to implement any further mitigation measures suggested as a result of ongoing monitoring.

Figure 2. The location of the Badenhorst Dam PV Energy Facilities in relation to other renewable energy projects proposed for the De Aar area.

12. LONG-TERM MONITORING

12.1 Rationale for monitoring

Given that solar energy development is relatively new to South Africa, and its potential impacts on birds are generally not well understood, it is strongly recommended that attention be given to improving this understanding by initiating quantitative studies of the avifauna at proposed sites both pre- and post-construction (Smit 2012). The primary aims of such monitoring work would be to:

(i) Determine the densities of birds resident within the impact area of the solar power plant before construction of the plant, and afterwards, once the plant, or phases of the plant, become operational.

(ii) Register and as far as possible document the circumstances surrounding all avian mortalities associated with the ancillary infrastructure of the solar plant for at least six months after the plant becomes operational.

(iii) Register and as far as possible document the circumstances surrounding all other avian interactions with the solar arrays of the solar power plant for at least six months after the plant becomes operational.

Bird density and activity monitoring should focus on rare and/or endemic, potentially disturbance or collision prone species, which occur with some regularity in the area. Ultimately, the study should provide much needed quantitative information on the effects of the solar power plant on the distribution and abundance of birds, and the actual risk it poses to the local avifauna, and serve to inform and improve mitigation measures to reduce this risk.

Monitoring protocols: Avian densities before and after

A set of at least 10 walk-transect routes, each of at least 20 minutes in duration or 750 m in length, should be established in areas representative of all the avian habitats present within an around the periphery of the Badenhorst Dam PV site. Each of these should be walked at least once every two months over the six months preceding construction, and at least once every two months over the same calendar period, at least six months after the PV plant is commissioned. The transects should be walked after 06h00 and before 09h00 in summer, and after 07h00 and before 12h00 in winter, and the species, number and perpendicular distance from the transect line of all birds seen should be recorded for subsequent analysis and comparison.

Monitoring protocols: collisions and fouling

The area within 5 m on either side of any new lengths of power line, should be checked regularly for bird casualties (Anderson *et al.* 1999, Morrison 2002). The frequency of these surveys should be informed by assessments of scavenge and decomposition rates. All suspected mortality incidents should be comprehensively documented, detailing the apparent cause of death, precise location (preferably a GPS reading), date and time at which the evidence was found, and the site of the find should be photographed with all the evidence *in situ*. All physical evidence should then be collected, bagged and carefully labeled, and refrigerated or frozen to await further examination. If any injured birds are recovered, each should be contained in a suitably-sized cardboard box, and the local conservation authority should be notified and

requested to transport casualties to the nearest reputable veterinary clinic or wild animal/bird rehabilitation centre.

These post-construction surveys should also include detailing (location, extent, size, number) of all bird products (e.g. faeces, pellets, nest structures etc) found on and around the solar panels.

12.2 Results of first monitoring iteration

Fifteen walk transects were established within (n = 9) and outside (n = 6) of the proposed development area (Fig. 4), and surveys of small terrestrial bird densities were measured along each of these transect lines as per the stipulated protocols (Table 4, Appendix 2). In combination with the data obtained in two further site visits, these initial density estimates will establish a baseline against which to estimate the numbers of Karoo endemic passerines displaced by the development, and to monitor the effect of the built and operational PV plants on the density and community structure of surrounding passerine populations.

Other results of the first monitoring iteration are integrated into this EIA report.

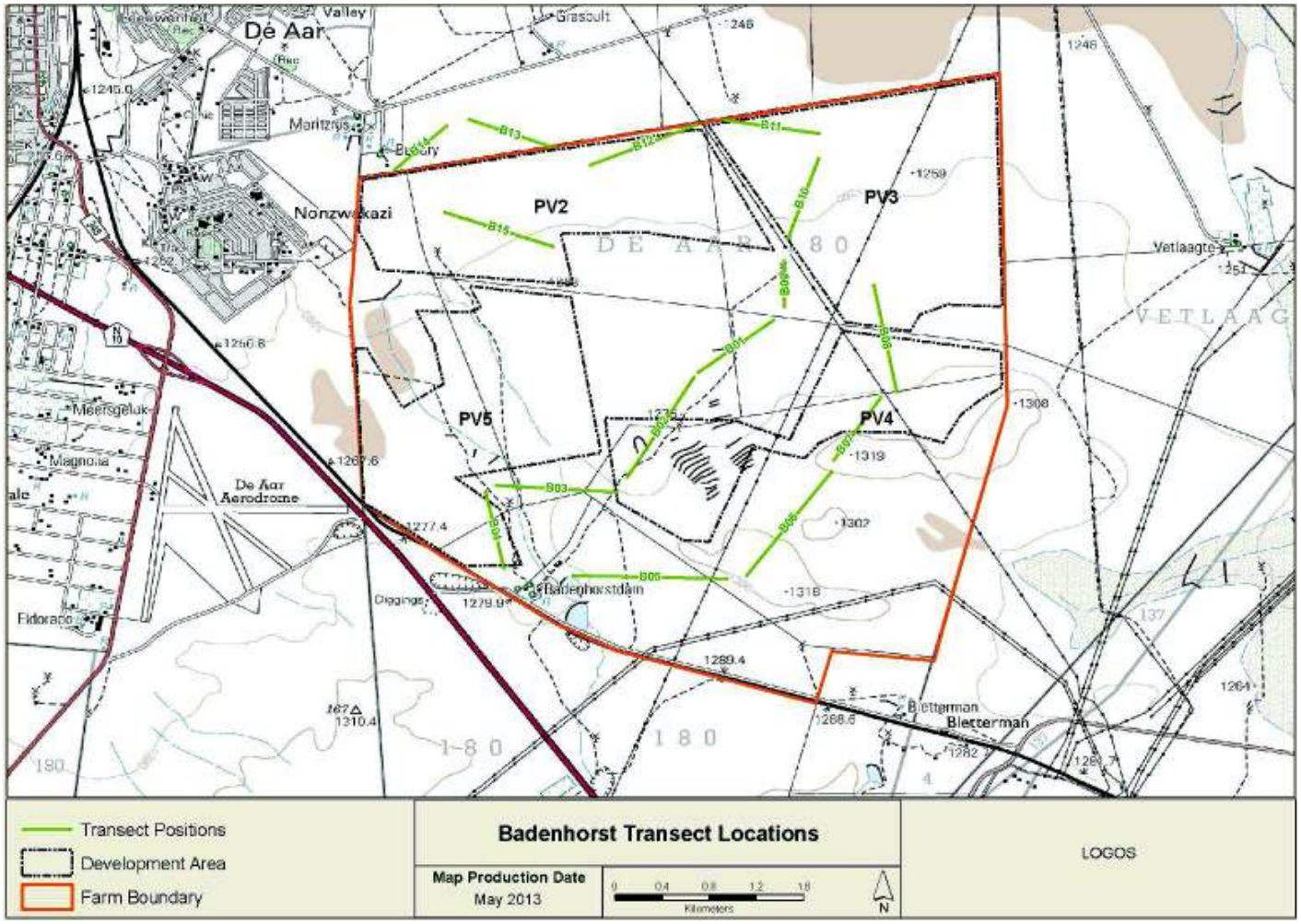

Figure 4. Layout and location of the small terrestrial bird transects walked in and around the Badenhorst Dam PV development area.

Table 4. Parameters describing the 20 min walked transects plotted (see Fig. 4) and sampled in and around the Badenhorst Dam PV development area. Cloud cover: 0-8 eighths; Temp(erature): 1 = cool, 2 = mild, 3 = warm, Wind: 0 = calm, 2 = breeze, 3 = wind, 4 = strong wind.

Transect number	Start time (hh:mm)	Cloud cover	Temp	Wind	Inside PV footprint?	Habitat	Gradient	Length (km)	Mean transect width (m)	*n* sightings	*n* birds	Density (birds.ha^{-1})
B01	08:30	0	2	0	Yes	Grassy	Flat	0.73	15	6	12	10.99
B02	08:45	0	2	1	Yes	Grassy	Flat	1.00	18	8	13	7.12
B03	09:19	0	2	1	No	Grassy/Karoo	Flat	0.91	25	9	14	6.13
B04	09:44	0	2	2	Yes	Grassy/Karoo	Flat	0.69	58	5	8	2.00
B05	10:21	0	2	2	No	Grassy	Hilly	1.14	14	8	19	12.35
B06	10:45	0	2	3	No	Grassy	Hilly	1.10	11	3	4	3.41
B07	11:07	0	2	3	Yes	Grassy	Hilly	0.65	41	2	2	0.75
B08	11:31	0	2	3	Yes	Grassy	Flat	0.94	10	2	2	2.13
B09	08:20	0	2	0	Yes	Grassy	Flat	0.41	25	11	22	21.86
B10	08:50	0	2	1	Yes	Grassy/Karoo	Flat	0.72	30	7	15	6.94
B11	09:25	0	2	1	Yes	Grassy/Karoo	Flat	0.87	43	6	12	3.18
B12	09:55	0	2	2	Yes	Grassy/Karoo	Flat	0.66	45	8	13	4.38
B13	10:30	0	2	3	No	Grassy/Karoo	Flat	0.55	37	3	4	1.98
B14	10:55	0	2	3	No	Grassy/Karoo	Flat	0.73	65	6	9	1.90
B15	11:30	0	2	3	Yes	Grassy/Karoo	Flat	0.86	14	7	14	11.40
Overall								**0.80**	**30.0**	**6.1**	**10.9**	**6.43**

13. REFERENCES

Anderson, R., Morrison, M., Sinclair, K. & Strickland, D. 1999. Studying wind energy/bird interactions: a guidance document. National Wind Coordinating Committee, Washington.

Arcus Gibb. 2009. Photovoltaic Power Generation Facility: De Aar. Unpublished report to Mulilo Renewable Energy Solar PV De Aar (Pty) Ltd.

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

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

Bevanger, K. 1994. Bird interactions with utility structures: collision and electrocution, causes and mitigating measures. *Ibis* 136: 412-425.

Bevanger, K. 1998. Biological and conservation aspects of bird mortality caused by electric power lines. *Biological Conservation* 86: 67-76.

Gunerhan, H., Hepbasli, A. & Giresunli, U. 2009. Environmental impacts from the solar energy systems. *Energy Sources, Part A: Recovery, Utilization and Environmental Effects* 31: 131-138.

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

Hockey, P.A.R., Dean, W.R.J., Ryan, P.G. (Eds) 2005. Roberts – Birds of Southern Africa, VIIth ed. The Trustees of the John Voelcker Bird Book Fund, Cape Town.

Jenkins, A.R. 2010. Prieska PV solar energy facility: Avian impact assessment. Report to DJ Environmental (Pty) Ltd.

Jenkins, A.R. 2011. Copperton wind energy facility: avian impact assessment. Report to Aurecon South Africa (Pty) Ltd.

Jenkins, A.R. 2012. Hoekplaas Photovoltaic Energy Facility: avian impact assessment. Report to Aurecon South Africa (Pty) Ltd.

Jenkins, A.R., de Goede, J.H. & van Rooyen, C. 2007. Improving the products of the Eskom Electric Eagle Project. Report to Eskom.

Jenkins, A., Gibbons, B. & Visagie, R. 2009. Long-term fixed site monitoring of wildlife interactions with power lines across a range of biomes: establishment and maintenance of a long-term bird;power line interaction monitoring site in the De Aar (Hydra) area of the eastern Karoo, Northern Cape. Report to Eskom.

Jenkins, A.R., Smallie, J.J. & Diamond, M. 2010. South African perspectives on a global search for ways to prevent avian collisions with overhead lines. *Bird Conservation International* 20: 263-278.

Jenkins, A.R., Shaw, J.M., Smallie, J.J., Gibbons, B., Visagie, R. & Ryan, P. 2011b. Estimating the impacts of power line collisions on Ludwig's Bustards *Neotis ludwigii*. *Bird Conservation International* 21:303-310.

Jenkins, A.R., de Goede, J.H., Sebele, L. & Diamond, M. 2013. Brokering a settlement between eagles and industry: sustainable management of large raptors nesting on power infrastructure. *Bird Conservation International* 23: 232-246.

King, D.I. & Byers, B.E. 2002. An evaluation of powerline rights-of-way as habitat for early-successional shrubland birds. *Wildlife Society Bulletin* 30: 868-874.

Lehman, R.N., Kennedy, P.L. & Savidge, J.A. 2007. The state of the art in raptor electrocution research: a global review. *Biological Conservation* 136: 159-174.

Morrison, M.L. 2002. Searcher bias and scavenging rates in bird/wind energy studies. National Renewable Energy Report SR-500-30876. NREL, Colorado.

Mucina. L. & Rutherford, M.C. (Eds) 2006. The vegetation of South Africa, Lesotho and Swaziland. *Strelitzia* 19. South African National Biodiversity Institute, Pretoria.

Osborn, R.G, Higgins, K.F., Usgaard, R.E., Dieter, C.D. & Nieger, R.D. 2000. Bird mortality associated with wind turbines at the Buffalo Ridge wind resource area, Minnesota. *Amer. Midland Naturalist* 143:41-52.

RSPB. 2011. Solar Power. Unpublished briefing, March 2011.

Smit, H.A. 2012. Guidelines to minimize the impact on birds of solar facilities and associated infrastructure in South Africa. BirdLife South Africa, Johannesburg.

Tsoutsos, T., Frantzeskaki, N., Gekas, V. 2005. Environmental impacts from solar energy technologies. *Energy Policy* 33: 289-296.

Turney, D. & Fthenakis, V. 2011. Environmental impacts from the installation and operation of large-scale solar power plants. *Renewable and Sustainable Energy Reviews* 15: 3261-3270.

Young, D.J., Harrison, J.A., Navarro, R.A., Anderson, M.D. & Colahan, B.D. (eds). 2003. Big birds on farms: Mazda CAR report 1993-2001. Avian Demography Unit, Cape Town.

Appendix 1. Inclusive, annotated list of the bird species considered likely to occur within the broader impact zone of the proposed locations for the Badenhorst Dam Energy Facilities.

Common name	Scientific name	Conservation status	Regional endemism	Habitat					Susceptibility to		
				Karoo veld	Drainage lines	Rocky koppies	Dams & ephemeral waterbodies	Fly over	Collision	Electrocution	Disturbance / habitat loss
Common Ostrich	*Struthio camelus*	-	-	X					-	-	High
Common Quail	*Coturnix coturnix*	-	-	X					-	-	High
Helmeted Guineafowl	*Numida meleagris*	-	-		X				Moderate	-	High
White-faced Duck	*Dendrocygna viduata*	-	-				X		Moderate	-	-
Maccoa Duck	*Oxyura maccoa*	-	-				X		Moderate	-	-
Egyptian Goose	***Alopochen aegyptiaca***	**-**	**-**				**X**		**High**	**High**	**-**
South African Shelduck	***Tadorna cana***	**-**	**Endemic**				**X**		**High**	**-**	**-**
Spur-winged Goose	*Plectropterus gambensis*	-	-				X		High	Moderate	-
Cape Teal	*Anas capensis*	-	-				X		Moderate	-	-
African Black Duck	*Anas sparsa*	-	-				X		Moderate	-	-
Yellow-billed Duck	*Anas undulata*	-	-				X		Moderate	-	-
Cape Shoveler	*Anas smithii*	-	Endemic				X		Moderate	-	-

Common name	Scientific name	Conservation status	Regional endemism	Habitat					Susceptibility to		
				Karoo veld	Drainage lines	Rocky koppies	Dams & ephemeral waterbodies	Fly over	Collision	Electrocution	Disturbance / habitat loss
Red-billed Teal	*Anas erythrorhyncha*	-	-				X		Moderate	-	-
Southern Pochard	*Netta erythropthalma*	-	-				X		Moderate	-	-
Kurrichane Buttonquail	*Turnix sylvaticus*	-	-	X					-	-	High
Greater Honeyguide	*Indicator indicator*	-	-		X				-	-	-
Lesser Honeyguide	*Indicator minor*	-	-		X				-	-	Moderate
Cardinal Woodpecker	*Dendropicos fuscescens*	-	-		X				-	-	Moderate
Acacia Pied Barbet	*Tricholaema leucomelas*	-	Near-endemic		X				-	-	Moderate
African Hoopoe	*Upupa africana*	-	-		X				-	-	Moderate
European Roller	*Coracias garrulus*	-	-	X	X				-	-	-
Malachite Kingfisher	*Alcedo cristata*	-	-				X		-	-	-
Pied Kingfisher	*Ceryle rudis*	-	-				X		-	-	-
Giant Kingfisher	*Megaceryle maximus*	-	-				X		-	-	-

Common name	Scientific name	Conservation status	Regional endemism	Habitat					Susceptibility to		
				Karoo veld	Drainage lines	Rocky koppies	Dams & ephemeral waterbodies	Fly over	Collision	Electrocution	Disturbance / habitat loss
Swallow-tailed Bee-eater	*Merops hirundineus*	-	-	X	X	X	X		-	-	Moderate
European Bee-eater	*Merops apiaster*	-	-						-	-	-
White-backed Mousebird	*Colius colius*	-	Endemic		X				-	-	Moderate
Red-faced Mousebird	*Urocolius indicus*	-	-		X				-	-	Moderate
Jacobin Cuckoo	*Clamator jacobinus*	-	-		X				-	-	Moderate
Diderick Cuckoo	*Chrysococcyx caprius*	-	-		X				-	-	Moderate
Alpine Swift	*Tachymarptis melba*	-	-					X	-	-	-
Common Swift	*Apus apus*	-	-					X	-	-	-
African Black Swift	*Apus barbatus*	-	-			X		X	-	-	-
Little Swift	*Apus affinis*	-	-			X			-	-	-
White-rumped Swift	*Apus caffer*	-	-					X	-	-	-
Barn Owl	*Tyto alba*	-	-	X	X	X			-	Moderate	Moderate
Southern White-faced Scops-Owl	*Ptilopsis granti*	-	-		X				-	-	Moderate

Common name	Scientific name	Conservation status	Regional endemism	Habitat					Susceptibility to		
				Karoo veld	Drainage lines	Rocky koppies	Dams & ephemeral waterbodies	Fly over	Collision	Electrocution	Disturbance / habitat loss
Cape Eagle-Owl	*Bubo capensis*	-	-			X			-	High	Moderate
Spotted Eagle-Owl	*Bubo africanus*	-	-	X	X	X			-	High	Moderate
Fiery-necked Nightjar	*Caprimulgus pectoralis*	-	-	X	X				-	-	Moderate
Rufous-cheeked Nightjar	*Caprimulgus rufigena*	-	-	X					-	-	Moderate
Rock Dove	*Columba livia*	-	-			X		X	-	-	Moderate
Speckled Pigeon	***Columba guinea***	**-**	**-**			**X**		**X**	**-**	**-**	**Moderate**
Laughing Dove	*Streptopelia senegalensis*	-	-		X				-	-	Moderate
Cape Turtle-Dove	***Streptopelia capicola***	**-**	**-**		**X**				**-**	**-**	**Moderate**
Red-eyed Dove	*Streptopelia semitorquata*	-	-		X				-	-	Moderate
Namaqua Dove	*Oena capensis*	-	-	X	X				-	-	Moderate
Ludwig's Bustard	*Neotis ludwigii*	Vulnerable	Near-endemic	X					High	-	Moderate
Kori Bustard	*Ardeotis kori*	Vulnerable	-	X					High	-	Moderate
Northern Black Korhaan	*Afrotis afraoides*	-	Endemic	X					Moderate	-	Moderate

Common name	Scientific name	Conservation status	Regional endemism	Habitat					Susceptibility to		
				Karoo veld	Drainage lines	Rocky koppies	Dams & ephemeral waterbodies	Fly over	Collision	Electrocution	Disturbance / habitat loss
Karoo Korhaan	*Eupodotis vigorsii*	-	Endemic	X					Moderate	-	Moderate
Blue Korhaan	*Eupodotis caerulescens*	Near-threatened	Endemic	X					Moderate	-	Moderate
Blue Crane	***Anthropoides paradiseus***	**Vulnerable**	**Endemic**	**X**			**X**		**High**	**-**	**Moderate**
Common Moorhen	*Gallinula chloropus*	-	-				X		-	-	-
Red-knobbed Coot	*Fulica cristata*	-	-				X		-	-	-
Namaqua Sandgrouse	*Pterocles namaqua*	-	Near-endemic	X			X		-	-	-
African Snipe	*Gallinago nigripennis*	-	-				X		-	-	-
Marsh Sandpiper	*Tringa stagnatilis*	-	-				X		-	-	-
Common Greenshank	*Tringa nebularia*	-	-				X		-	-	-
Wood Sandpiper	*Tringa glareola*	-	-				X		-	-	-
Common Sandpiper	*Actitis hypoleucos*	-	-				X		-	-	-
Little Stint	*Calidris minuta*	-	-				X		-	-	-
Curlew Sandpiper	*Calidris ferruginea*	-	-				X		-	-	-

Common name	Scientific name	Conservation status	Regional endemism	Habitat					Susceptibility to		
				Karoo veld	Drainage lines	Rocky koppies	Dams & ephemeral waterbodies	Fly over	Collision	Electrocution	Disturbance / habitat loss
Ruff	*Philomachus pugnax*	-	-				X		-	-	-
Spotted Thick-knee	*Burhinus capensis*	-	-	X	X				-	-	-
Black-winged Stilt	*Himantopus himantopus*	-	-				X		-	-	-
Pied Avocet	*Recurvirostra avosetta*	-	-				X		-	-	-
Kittlitz's Plover	***Charadrius pecuarius***	**-**	**-**				**X**		**-**	**-**	**-**
Three-banded Plover	***Charadrius tricollaris***	**-**	**-**				**X**		**-**	**-**	**-**
Blacksmith Lapwing	***Vanellus armatus***	**-**	**-**				**X**		**-**	**-**	**-**
Crowned Lapwing	*Vanellus coronatus*	-	-	X					-	-	-
Double-banded Courser	*Rhinoptilus africanus*	-	-	X					-	-	-
Burchell's Courser	*Cursorius rufus*	-	Near-endemic	X					-	-	-
Whiskered Tern	*Chlidonias hybrida*	-	-				X		-	-	-
White-winged Tern	*Chlidonias leucopterus*	-	-				X		-	-	-

Common name	Scientific name	Conservation status	Regional endemism	Habitat					Susceptibility to		
				Karoo veld	Drainage lines	Rocky koppies	Dams & ephemeral waterbodies	Fly over	Collision	Electrocution	Disturbance / habitat loss
Black-shouldered Kite	*Elanus caeruleus*	-	-	X	X				-	-	Moderate
Black Kite	*Milvus migrans*	-	-	X				X	-	-	-
African Fish-Eagle	*Haliaeetus vocifer*	-	-					X	-	High	-
Black-chested Snake-Eagle	*Circaetus pectoralis*	-	-					X	-	Moderate	Moderate
Black Harrier	*Circus maurus*	Near-threatened	Endemic	X			X		-	-	Moderate
African Harrier-Hawk	*Polyboroides typus*	-	-		X			X	-	-	Moderate
Southern Pale Chanting Goshawk	***Melierax canorus***	**-**	**Near-endemic**	**X**	**X**				**-**	**Moderate**	**Moderate**
Gabar Goshawk	*Melierax gabar*	-	-		X				-	-	Moderate
Rufous-chested Sparrowhawk	*Accipiter rufiventris*	-	-		X				-	-	Moderate
Steppe Buzzard	*Buteo vulpinus*	-	-	X				X	-	Moderate	Moderate
Jackal Buzzard	*Buteo rufofuscus*	-	Endemic	X				X	-	Moderate	Moderate
Tawny Eagle	*Aquila rapax*	Vulnerable	-		X			X	-	High	Moderate

Common name	Scientific name	Conservation status	Regional endemism	Habitat					Susceptibility to		
				Karoo veld	Drainage lines	Rocky koppies	Dams & ephemeral waterbodies	Fly over	Collision	Electrocution	Disturbance / habitat loss
Verreauxs' Eagle	*Aquila verreauxii*	-	-					X	Moderate	High	Moderate
Booted Eagle	*Aquila pennatus*	-	-					X	-	-	Moderate
Martial Eagle	*Polemaetus bellicosus*	Vulnerable	-					X	Moderate	High	Moderate
Secretarybird	*Sagittarius serpentarius*	Near-threatened	-	X				X	High	-	Moderate
Lesser Kestrel	*Falco naumanni*	Vulnerable	-	X	X			X	Moderate	-	Moderate
Rock Kestrel	***Falco rupicolus***	**-**	**-**	**X**		**X**			**-**	**-**	**Moderate**
Greater Kestrel	***Falco rupicoloides***	**-**	**-**	**X**					**-**	**-**	**Moderate**
Lanner Falcon	*Falco biarmicus*	Near-threatened	-	X				X	High	Moderate	-
Peregrine Falcon	*Falco peregrinus*	Near-threatened	-	X				X	High	Moderate	-
Little Grebe	*Tachybaptus ruficollis*	-	-				X		-	-	-
Black-necked Grebe	*Podiceps nigricollis*	-	-				X		-	-	-
African Darter	*Anhinga rufa*	-	-				X		-	-	-
Reed Cormorant	*Phalacrocorax africanus*	-	-				X		-	-	-
White-breasted Cormorant	*Phalacrocorax lucidus*	-	-				X	X	Moderate	-	-
Little Egret	*Egretta garzetta*	-	-				X		-	-	-

Common name	Scientific name	Conservation status	Regional endemism	Habitat					Susceptibility to		
				Karoo veld	Drainage lines	Rocky koppies	Dams & ephemeral waterbodies	Fly over	Collision	Electrocution	Disturbance / habitat loss
Grey Heron	*Ardea cinerea*	-	-				X		Moderate	Moderate	-
Black-headed Heron	*Ardea melanocephala*	-	-	X			X		Moderate	Moderate	-
Goliath Heron	*Ardea goliath*	-	-				X	X	High		
Cattle Egret	*Bubulcus ibis*	-	-				X		-	-	-
Hamerkop	*Scopus umbretta*	-	-				X	X	Moderate	-	-
Greater Flamingo	*Phoenicopterus ruber*	Near-threatened	-					X	High	-	-
Lesser Flamingo	*Phoenicopterus minor*	Near-threatened	-					X	High	-	-
Glossy Ibis	*Plegadis falcinella*	-	-				X	X	Moderate	-	-
Hadeda Ibis	*Bostrychia hagedash*	-	-		X			X	Moderate	-	-
African Sacred Ibis	***Threskiornis aethiopicus***	**-**	**-**				**X**	**X**	**Moderate**	**-**	**-**
African Spoonbill	*Platalea alba*	-	-				X	X	Moderate	-	-
Black Stork	*Ciconia nigra*	Near-threatened	-				X	X	High	Moderate	-
Abdim's Stork	*Ciconia abdimii*	-	-				X	X	Moderate	Moderate	-
White Stork	*Ciconia ciconia*	-	-				X	X	High	High	-
Fork-tailed Drongo	*Dicrurus adsimilis*	-	-		X				-	-	Moderate
Bokmakierie	*Telophorus zeylonus*	-	Near-endemic		X				-	-	Moderate

Common name	Scientific name	Conservation status	Regional endemism	Habitat					Susceptibility to		
				Karoo veld	Drainage lines	Rocky koppies	Dams & ephemeral waterbodies	Fly over	Collision	Electrocution	Disturbance / habitat loss
Pririt Batis	*Batis pririt*	-	Near-endemic		X				-	-	Moderate
Cape Crow	*Corvus capensis*	-	-	X	X				-	-	Moderate
Pied Crow	***Corvus albus***	**-**	**-**	**X**	**X**	**X**			**-**	**-**	**Moderate**
White-necked Raven	*Corvus albicollis*	-	-	X		X			-	-	Moderate
Red-backed Shrike	*Lanius collurio*	-	-	X					-	-	Moderate
Lesser Grey Shrike	*Lanius minor*	-	-	X					-	-	Moderate
Common Fiscal	***Lanius collaris***	**-**	**-**	**X**	**X**				**-**	**-**	**Moderate**
Cape Penduline-Tit	*Anthoscopus minutus*	-	Near-endemic	X					-	-	Moderate
Ashy Tit	*Parus cinerascens*	-	Near-endemic	X					-	-	Moderate
Grey Tit	*Parus afer*	-	Endemic	X					-	-	Moderate
Brown-throated Martin	*Riparia paludicola*	-	-				X	X	-	-	Moderate
Barn Swallow	*Hirundo rustica*	-	-				X	X	-	-	Moderate
White-throated Swallow	*Hirundo albigularis*	-	-				X		-	-	Moderate
Pearl-breasted Swallow	*Hirundo dimidiata*	-	-	X				X	-	-	Moderate

Common name	Scientific name	Conservation status	Regional endemism	Habitat					Susceptibility to		
				Karoo veld	Drainage lines	Rocky koppies	Dams & ephemeral waterbodies	Fly over	Collision	Electrocution	Disturbance / habitat loss
Greater Striped Swallow	*Hirundo cucullata*	-	-				X	X	-	-	Moderate
South African Cliff Swallow	*Hirundo spilodera*	-	Breeding endemic	X		X		X	-	-	Moderate
Rock Martin	***Hirundo fuligula***	**-**	**-**			**X**	**X**	**X**	**-**	**-**	**Moderate**
African Red-eyed Bulbul	*Pycnonotus nigricans*	-	Near-endemic		X				-	-	Moderate
Fairy Flycatcher	*Stenostira scita*	-	Endemic		X				-	-	Moderate
Long-billed Crombec	*Sylvietta rufescens*	-	-	X	X				-	-	Moderate
Yellow-bellied Eremomela	*Eremomela icteropygialis*	-	-	X	X				-	-	Moderate
Karoo Eremomela	*Eremomela gregalis*	-	Endemic	X					-	-	Moderate
African Reed-Warbler	*Acrocephalus baeticatus*	-	-				X		-	-	Moderate
Lesser Swamp-Warbler	*Acrocephalus gracilirostris*	-	-				X		-	-	Moderate
Willow Warbler	*Phylloscopus trochilus*	-	-		X				-	-	Moderate
Layard's Tit-Babbler	*Parisoma layardi*	-	Endemic	X	X				-	-	Moderate

Common name	Scientific name	Conservation status	Regional endemism	Habitat					Susceptibility to		
				Karoo veld	Drainage lines	Rocky koppies	Dams & ephemeral waterbodies	Fly over	Collision	Electrocution	Disturbance / habitat loss
Chestnut-vented Tit-Babbler	*Parisoma subcaeruleum*	-	Near-endemic		X				-	-	Moderate
Orange River White-eye	*Zosterops pallidus*	-	Endemic		X				-	-	Moderate
Grey-backed Cisticola	*Cisticola subruficapilla*	-	Near-endemic	X	X				-	-	Moderate
Levaillant's Cisticola	*Cisticola tinniens*	-	-				X		-	-	Moderate
Neddicky	*Cisticola fulvicapilla*	-	-	X					-	-	Moderate
Zitting Cisticola	*Cisticola juncidis*	-	-				X		-	-	Moderate
Desert Cisticola	***Cisticola aridulus***	**-**	**-**				**X**		**-**	**-**	**Moderate**
Black-chested Prinia	*Prinia flavicans*	-	-		X				-	-	Moderate
Karoo Prinia	*Prinia maculosa*	-	Endemic	X	X				-	-	Moderate
Namaqua Warbler	*Phragmacia substriata*	-	Endemic		X				-	-	Moderate
Rufous-eared Warbler	***Malcorus pectoralis***	**-**	**Endemic**	**X**					**-**	**-**	**Moderate**
Cinnamon-breasted Warbler	*Euryptila subcinnamomea*	-	Endemic	X					-	-	Moderate

Common name	Scientific name	Conservation status	Regional endemism	Habitat					Susceptibility to		
				Karoo veld	Drainage lines	Rocky koppies	Dams & ephemeral waterbodies	Fly over	Collision	Electrocution	Disturbance / habitat loss
Eastern Clapper Lark	***Mirafra fasciolata***	**-**	**Near-endemic**	**X**					**-**	**-**	**Moderate**
Sabota Lark	*Calendulauda sabota*	-	-	X					-	-	Moderate
Karoo Lark	*Calendulauda albescens*	-	Endemic	X					-	-	Moderate
Spike-heeled Lark	***Chersomanes albofasciata***	**-**	**-**	**X**					**-**	**-**	**Moderate**
Karoo Long-billed Lark	*Certhilauda subcoronata*	-	Endemic	X					-	-	Moderate
Black-eared Sparrowlark	*Eremopterix australis*	-	Endemic	X					-	-	Moderate
Grey-backed Sparrowlark	*Eremopterix verticalis*	-	Near-endemic	X					-	-	Moderate
Red-capped Lark	***Calandrella cinerea***	**-**	**-**	**X**					**-**	**-**	**Moderate**
Pink-billed Lark	*Spizocorys conirostris*	-	Near-endemic	X					-	-	Moderate
Large-billed Lark	***Galerida magnirostris***	**-**	**Endemic**	**X**					**-**	**-**	**Moderate**
Cape Rock Thrush	*Monticola rupestris*	-	Endemic	X					-	-	Moderate
Sentinel Rock Thrush	*Monticola explorator*	-	Endemic	X					-	-	Moderate
Short-toed Rock-Thrush	*Monticola brevipes*	-	Near-endemic			X			-	-	Moderate

Common name	Scientific name	Conservation status	Regional endemism	Habitat					Susceptibility to		
				Karoo veld	Drainage lines	Rocky koppies	Dams & ephemeral waterbodies	Fly over	Collision	Electrocution	Disturbance / habitat loss
Karoo Thrush	*Turdus smithi*	-	Endemic		X				-	-	Moderate
Chat Flycatcher	*Bradornis infuscatus*	-	Near-endemic	X					-	-	Moderate
Marico Flycatcher	*Bradornis mariquensis*	-	Near-endemic	X	X				-	-	Moderate
Fiscal Flycatcher	*Sigelus silens*	-	Endemic		X				-	-	Moderate
Spotted Flycatcher	*Muscicapa striata*	-	-		X				-	-	Moderate
Cape Robin-Chat	*Cossypha caffra*	-	-		X				-	-	Moderate
Kalahari Scrub-Robin	*Cercotrichas paena*	-	Near-endemic	X	X				-	-	Moderate
Karoo Scrub-Robin	***Cercotrichas coryphoeus***	**-**	**Endemic**	**X**	**X**				**-**	**-**	**Moderate**
African Stonechat	*Saxicola torquatus*	-	-	X					-	-	Moderate
Mountain Wheatear	*Oenanthe monticola*	-	Near-endemic	X		X			-	-	Moderate
Capped Wheatear	***Oenanthe pileata***	**-**	**-**	**X**					**-**	**-**	**Moderate**
Sickle-winged Chat	***Cercomela sinuata***	**-**	**Endemic**	**X**					**-**	**-**	**Moderate**
Karoo Chat	*Cercomela schlegelii*	-	Near-endemic	X					-	-	Moderate

Common name	Scientific name	Conservation status	Regional endemism	Habitat					Susceptibility to		
				Karoo veld	Drainage lines	Rocky koppies	Dams & ephemeral waterbodies	Fly over	Collision	Electrocution	Disturbance / habitat loss
Tractrac Chat	*Cercomela tractrac*	-	Near-endemic	X					-	-	Moderate
Familiar Chat	*Cercomela familiaris*	-	-	X					-	-	Moderate
Ant-eating Chat	***Myrmecocichla formicivora***	**-**	**Endemic**	**X**					**-**	**-**	**Moderate**
Pale-winged Starling	*Onychognathus nabouroup*	-	Near-endemic			X		X	-	-	Moderate
Cape Glossy Starling	*Lamprotornis nitens*	-	-		X				-	-	Moderate
Pied Starling	*Spreo bicolor*	-	Endemic			X		X	-	-	Moderate
Wattled Starling	*Creatophora cinerea*	-	-	X	X			X	-	-	Moderate
Common Starling	*Sturnus vulgaris*	-	-		X	X			-	-	Moderate
Malachite Sunbird	*Nectarinia famosa*	-	-		X				-	-	Moderate
Southern Double-collared Sunbird	*Cinnyris chalybeus*	-	Endemic		X				-	-	Moderate
Dusky Sunbird	*Cinnyris fuscus*	-	Near-endemic	X	X				-	-	Moderate
Scaly-feathered Finch	*Sporopipes squamifrons*	-	Near-endemic	X					-	-	Moderate

Common name	Scientific name	Conservation status	Regional endemism	Habitat					Susceptibility to		
				Karoo veld	Drainage lines	Rocky koppies	Dams & ephemeral waterbodies	Fly over	Collision	Electrocution	Disturbance / habitat loss
White-browed Sparrow-Weaver	*Plocepasser mahali*	-	-	X	X				-	-	Moderate
Cape Weaver	*Ploceus capensis*	-	Endemic		X		X		-	-	Moderate
Southern Masked-Weaver	*Ploceus velatus*	-	-		X		X		-	-	Moderate
Red-billed Quelea	*Quelea quelea*	-	-	X	X		X	X	-	-	Moderate
Southern Red Bishop	*Euplectes orix*	-	-				X		-	-	Moderate
African Quailfinch	*Ortygospiza atricollis*	-	-	X					-	-	Moderate
Red-headed Finch	***Amadina erythrocephala***	**-**	**Near-endemic**	**X**	**X**				**-**	**-**	**Moderate**
Common Waxbill	*Estrilda astrild*	-	-				X		-	-	Moderate
Red-billed Firefinch	*Lagonosticta senegala*	-	-		X				-	-	Moderate
Pin-tailed Whydah	*Vidua macroura*	-	-		X				-	-	Moderate
House Sparrow	***Passer domesticus***	**-**	**-**		**X**				**-**	**-**	**Moderate**
Cape Sparrow	***Passer melanurus***	**-**	**Near-endemic**	**X**	**X**				**-**	**-**	**Moderate**

Common name	Scientific name	Conservation status	Regional endemism	Habitat					Susceptibility to		
				Karoo veld	Drainage lines	Rocky koppies	Dams & ephemeral waterbodies	Fly over	Collision	Electrocution	Disturbance / habitat loss
Southern Grey-headed Sparrow	*Passer diffusus*	-	-	X	X				-	-	Moderate
African Pied Wagtail	*Motacilla aguimp*	-	-				X		-	-	Moderate
Cape Wagtail	*Motacilla capensis*	-	-				X		-	-	Moderate
Cape Longclaw	*Macronyx capensis*	-	Endemic	X					-	-	Moderate
African Rock Pipit	*Anthus cinnamomeus*	-	Endemic	X					-	-	Moderate
Plain-backed Pipit	*Anthus leucophyrs*	-	-	X					-	-	Moderate
Buffy Pipit	*Anthus vaalensis*	-	-	X					-	-	Moderate
African Pipit	***Anthus cinnamomeus***	**-**	**-**			**X**			**-**	**-**	**Moderate**
Long-billed Pipit	*Anthus similis*	-	-	X					-	-	Moderate
Cape Canary	*Serinus canicollis*	-	Endemic	X					-	-	Moderate
Black-headed Canary	*Serinus alario*	-	Endemic	X					-	-	Moderate
Black-throated Canary	*Crithagra atrogularis*	-	-	X					-	-	Moderate

Common name	Scientific name	Conservation status	Regional endemism	Habitat					Susceptibility to		
				Karoo veld	Drainage lines	Rocky koppies	Dams & ephemeral waterbodies	Fly over	Collision	Electrocution	Disturbance / habitat loss
Yellow Canary	*Crithagra flaviventris*	-	Near-endemic	X					-	-	Moderate
White-throated Canary	*Crithagra albogularis*	-	Near-endemic	X					-	-	Moderate
Lark-like Bunting	***Emberiza impetuani***	**-**	**Near-endemic**	**X**					**-**	**-**	**Moderate**
Cinnamon-breasted Bunting	*Emberiza tahapisi*	-	-	X					-	-	Moderate
Cape Bunting	*Emberiza capensis*	-	Near-endemic	X					-	-	Moderate

Appendix 2. Species, numbers and densities of birds observed during 20 min walked transects in and around the Badenhorst Dam PV development area in May 2013.

Transect number	Length (km)	Species	*n* sightings	*n* birds	Mean transect width (m)	Density (birds.ha^{-1})
B01	0.73	Desert Cisticola	1	1	6.0	2.29
		Eastern Clapper Lark	1	1	40.0	0.34
		Spike-heeled Lark	3	9	4.7	26.50
		African Pipit	1	1	2.0	6.87
B02	1.00	Desert Cisticola	1	1	10.0	1.00
		Eastern Clapper Lark	1	1	20.0	0.50
		Spike-heeled Lark	1	1	2.0	5.00
		Large-billed Lark	2	4	12.5	3.20
		Capped Wheatear	1	1	50.0	0.20
		African Pipit	1	1	4.0	2.50
		unidentified lark sp.	1	1	10.0	1.00
B03	0.91	Eastern Clapper Lark	1	1	40.0	0.27
		Spike-heeled Lark	2	5	6.0	9.16
		Large-billed Lark	2	4	6.0	7.33
		Ant-eating Chat	1	1	120.0	0.09
		Lark-like Bunting	2	2	5.0	4.40
		Cape Bunting	1	1	2.0	5.49
B04	0.69	Rufous-eared Warbler	1	1	160.0	0.09
		Eastern Clapper Lark	1	2	10.0	2.90
		Large-billed Lark	1	2	5.0	5.80
		Cape Sparrow	1	1	80.0	0.18
		Lark-like Bunting	1	2	10.0	2.90
B05	1.14	Eastern Clapper Lark	2	2	5.0	3.51
		Spike-heeled Lark	2	3	2.7	9.87
		Red-capped Lark	1	6	3.3	15.79
		Large-billed Lark	2	3	16.7	1.58
		African Pipit	1	5	4.0	10.96
B06	1.10	Long-billed Pipit	1	2	10.0	1.82
		Lark-like Bunting	2	2	6.0	3.03
B07	0.65	Rufous-eared Warbler	1	1	80.0	0.19
		Eastern Clapper Lark	1	1	2.0	7.69
B08	0.94	African Pipit	1	2	10.0	2.13
B09	0.41	Cape Turtle Dove	1	1	40.0	0.61
		Desert Cisticola	1	1	40.0	0.61
		Eastern Clapper Lark	1	1	40.0	0.61
		Red-capped Lark	2	5	10.0	12.20

Transect number	Length (km)	Species	*n* sightings	*n* birds	Mean transect width (m)	Density (birds.ha^{-1})
		Capped Wheatear	1	1	20.0	1.22
		Sickle-Winged Chat	1	1	10.0	2.44
		Cape Wagtail	2	6	6.7	21.95
		African Pipit	1	1	20.0	1.22
		Lark-like Bunting	1	5	2.0	60.98
B10	0.72	Rufous-eared Warbler	1	1	60.0	0.23
		Spike-heeled Lark	2	6	8.3	10.00
		Red-capped Lark	2	5	10.0	6.94
		African Pipit	1	2	15.0	1.85
		Long-billed Pipit	1	1	20.0	0.69
B11	0.87	Rock Martin	1	1	20.0	0.57
		Rufous-eared Warbler	1	1	100.0	0.11
		Red-capped Lark	1	7	2.9	28.16
		Capped Wheatear	1	1	60.0	0.19
		African Pipit	2	2	30.0	0.77
B12	0.66	Rock Martin	1	1	40.0	0.38
		Desert Cisticola	1	1	80.0	0.19
		Eastern Clapper Lark	1	1	30.0	0.51
		Spike-heeled Lark	1	1	10.0	1.52
		Red-capped Lark	1	6	16.7	5.45
		Ant-eating Chat	1	1	40.0	0.38
		African Pipit	2	2	30.0	1.01
B13	0.55	Eastern Clapper Lark	1	1	20.0	0.91
		Spike-heeled Lark	2	3	30.0	1.82
B14	0.73	Crowned Lapwing	1	2	30.0	0.91
		Spike-heeled Lark	1	2	10.0	2.74
		Large -billed Lark	1	1	30.0	0.46
		Capped Wheatear	1	1	100.0	0.14
		Sickle-Winged Chat	1	1	100.0	0.14
		Cape Sparrow	1	2	40.0	0.68
B15	0.86	Desert Cisticola	1	1	10.0	1.16
		Eastern Clapper Lark	2	2	10.0	2.33
		Spike-heeled Lark	2	4	10.0	4.65
		African Pipit	1	1	20.0	0.58
		Lark-like Bunting	1	6	1.7	41.86

AURECON SOUTH AFRICA (PTY) LTD

PROPOSED PHOTOVOLTAIC (PV) SOLAR ENERGY FACILITIES ON BADENHORST DAM FARM NEAR DE AAR

Soil and Agricultural Assessment Report

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For:	Aurecon South Africa
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Declaration

I, Kurt Barichievy, declare that I –

- act as an independent specialist consultant for the **soil and agricultural assessment report for the proposed Photovoltaic PV Solar Energy Facilities on Farm Badenhorst Dam near De Aar, Northern Cape Province**;
- do not have and will not have any financial interest in the undertaking of the activity, other than remuneration for work performed in terms of the Environmental Impact Assessment Regulations, 2006;
- have and will not have any vested interest in the proposed activity proceeding;
- have no, and will not engage in, conflicting interests in the undertaking of the activity;
- undertake to disclose, to the competent authority, any material information that have or may have the potential to influence the decision of the competent authority or the objectivity of any report, plan or document required in terms of the Environmental Impact Assessment Regulations, 2006; and
- will provide the competent authority with access to all information at our disposal regarding the application, whether such information is favourable to the applicant or not.

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1. INTRODUCTION AND TERMS OF REFERENCE

Aurecon South Africa (Pty) Ltd (Aurecon) on behalf of **Mulilo Renewable Energy (Pty) Ltd** (Mulilo) requested a baseline assessment of the soil, land use and agricultural characteristics for the areas affected by the proposed construction of four separate solar energy facilities, on Badenhorst Dam Farm (Portion 1 of Farm 180), near De Aar in the Northern Cape.

The primary objective of this assessment is to provide specialist soil and agricultural input into the overarching EIA Report. In order to achieve this objective, a study of the climate, soils, terrain, land capability, geology, current agricultural practices and agricultural potential was carried out. This report serves to summarise such a study, present the relevant results and mitigate the predicted impacts on local soil and agricultural resources.

A detailed soil and agricultural report was undertaken for Badenhorst Dam Farm in January 2012, as part of a larger environmental assessment (**SiVEST, 2013**). Environmental Authorisation for a 100 MW Photovoltaic (PV) solar energy facility, known as Badenhorst PV1, and associated infrastructure was granted for this project in July 2012. Mulilo now plans to construct four additional PV facilities on Badenhorst Dam Farm as an attempt to maximise the generation capacity of the farm (**Aurecon, 2013**).

This assessment intends to supplement this previous soil and agricultural study, and along with the other specialist studies, hopes to minimise the predicted potential impacts on the receiving environment. The terms of reference of this study are to:

- Undertake a detailed soil assessment of the sites, incorporating a radius of 50m surrounding the site, on a scale of 1:10 000 or finer. The soil assessment should include:
  - Identification of the soil forms present on sites;
  - The size of the area where a particular soil form is found;
  - GPS readings of soil survey points;
  - The depth of the soil at each survey point;
  - Soil colour;
  - Limiting factors;
  - Clay content;
  - Size of the site;
  - Slope of the site; and
  - A detailed map indicating the locality of the soil forms within the specified areas.
- Provide the exact locality of the site;
- Describe current activities on the sites, developments and buildings;
- Describe surrounding developments/ land uses and activities in a radius of 500m of the sites, access routes and the condition thereof, the current status of the land (including erosion, vegetation and a degradation assessment) and possible land use options for the sites;
- Describe water availability, source and quality (if available);
- Detailed descriptions of why agriculture should or should not be the land use of choice;
- Undertake an assessment of the potential impacts on agriculture at the site in terms of the scale of impact (local, regional, national), magnitude of impact (low, medium or high) and the duration of the impact (construction, up to 10 years after construction, more than 10 years after construction). The assessment is to indicate the potential cumulative impacts;

- Describe potential mitigation measures to reduce or eliminate the potential agricultural impacts identified;
- Provide a shape file containing the soil forms and relevant attribute data as depicted on the map; and
- Provide an erosion management plan for monitoring and rehabilitating of erosion events associated with the facility.

1.1 Brief Description of the Project and Study Area

The purpose of this section is to provide basic site information for later reference. Please note that a more detailed description of the site's characteristics are provided in **Sections 4 through 7** of this report.

The Northern Cape Province is considered to be one of the most suitable regions for the establishment of solar PV facilities due to the overriding climatic and environmental conditions. Accordingly, Badenhorst Dam Farm located outside of De Aar has been identified as a potential site. The Badenhorst Dam Farm (Portion 1 of Farm 180) covers approximately 2588ha and has the following mid-point co-ordinate: 30º41"25.48"S 24º03"26.46"E.

As indicated, the revised project includes the construction of four PV facilities, each with a generation capacity of 75MW AC on Badenhorst Dam Farm. The combined extent of the four additional facilities, for Layout Alternative 1, would be approximately 879ha as summerised in **Table 1,** below.

Table 1: Summary of the PV Facilities on Badenhorst Dam Farm (Layout Alternative 1) (**Aurecon, 2013**)

Facility	Footprint (ha)	Capacity (MW)	Mid-Point Co-Ordinates
PV 2	240	75	30°40'11.54"S; 24° 2'56.25"E
PV 3	252	75	30°40'10.16"S; 24° 4'37.07"E
PV 4	186	75	30°41'14.00"S; 24° 4'8.53"E
PV 5	201	75	30°41'3.40"S; 24° 2'40.53"E

Badenhorst Dam Farm is located approximately 340 m from the Nonzwakazi settlement and approximately 3 km east of De Aar. The farm consists mainly of flat grassy plains with limited kopjes and rolling hills. Due to small stock theft the farm is currently used as grazing land for cattle and Springbok. Access to the site is obtained via the N10 and private farm roads. The access and internal roads are in good condition. Water is the major limiting factor to local agricultural enterprises and the assessed area does not border a perennial river. The surrounding land is comparable to the study area and is dominated by agricultural grazing land.

1.2 Description of Proposed Activities and Technical Details

The technical details provided in this section are primarily extracted from the Draft Scoping Report produced by Aurecon (**2013**).

Each of the four proposed PV facilities would consist of the following:

- **Solar energy facility:** A photovoltaic component comprising of numerous arrays of PV panels and associated support infrastructure to generate up to 75MW per facility, through the photovoltaic effect.
- **Transmission lines:** 132kV overhead transmission lines to connect each facility to the central onsite substation or an existing Eskom substation.
- **Facility substations:** An onsite 132kV, 3 bay substation.
- **Boundary fence:** Each 75MW facility will be fenced for health, safety and security reasons **(Aurecon, 2013)**.

It is proposed that the following infrastructure be shared between the four facilities to lessen the impact on the surrounding environment:

- **Central substation:** One central 132kV substation and connection to Eskom grid. This central substation will connect the PV facilities with Eskom's Hydra substation via either an existing overhead 132kV Eskom line or by constructing a new onsite 132kV transmission line.
- **Roads:** Access road and internal access roads for servicing and maintenance of the site.
- **Water supply infrastructure:** It is proposed that potable water will be obtained from the Emthanjeni Municipality. Water will be transferred to the site via the municipal pipeline from the nearest municipal supply point and will be contained onsite in a jo-jo tank. However, the Municipality would need to confirm availability of capacity to do so.
- **Stormwater infrastructure:** Including drainage channels, berms, detention areas and kinetic energy dissipaters.
- **Buildings:** Buildings would likely include onsite substations, a connection building, control building, guard cabin, an electrical substation and solar resource measuring substation **(Aurecon, 2013)**.

Two proposed PV layouts for the Alternatives have been tabled:

Layout Alternative 1

This alternative consists of the four proposed 75MW PV facilities and associated infrastructure as indicated in **Figure 4** (referred to as PV2, PV3, PV4 and PV5). These layouts take cognisance of the 75MW DoE cap and the environmentally sensitive areas (**Aurecon, 2013**).

Layout Alternative 2

This alternative consists of three 150MW PV facilities with a footprint of approximately 1816 ha. The layout for these was developed by extending and combining some of the proposed 75MW facilities. This alternative is thus not limited to the DOE's 75MW cap per project. By increasing the capacities it has the benefit of utilizing industries at scale thereby reducing associated development and construction costs which reduces lending rates and essentially lower the tariff of electricity sold. (**Aurecon, 2013**).

1.2.1 Single axis tracking PV technology

Photovoltaic solar energy facilities use light energy from the sun to generate electricity through a process known as the PV effect. The PV cells absorb light energy which energises the electrons to produce electricity. **Figure 1** depicts a typical PV facility in a landscape similar to De Aar. The proposed PV panels are approximately 2m wide and 1m long. These panels are arranged into modules that are durable and can last up to 25 years, due to the sturdiness of the structure and few moving parts. The PV modules (which will include a number of PV panels) will be physically mounted to a galvanized steel rotation tube, single axis tracking system to ensure ground connection from the module frames to the structure. The PV modules, fixed to the tracking system, are arranged into tracker blocks as indicated in **Figure 2**. These tracker blocks will be uniformly aligned to facilitate efficient sun-tracking. The dimensions of a tracker block range between 88m and 113m in an east to west direction and 35m to 38m in a north-south direction (**Mulilo, 2013** cited in **Aurecon, 2013)**.

The supports of the frame will be fixed on top of the steel piles. Since there is existence of rock (dolerite and siltstone) at shallow depths, the steel piles would be embedded into a concrete pile. However, the final design of the foundations will depend on the geotechnical conditions of the site which will be determined at a later stage **(Aurecon, 2013)**.

Figure 1: Example of a PV facility in a landscape similar to De Aar (image courtesy of Mulilo, cited in **Aurecon, 2013)**.

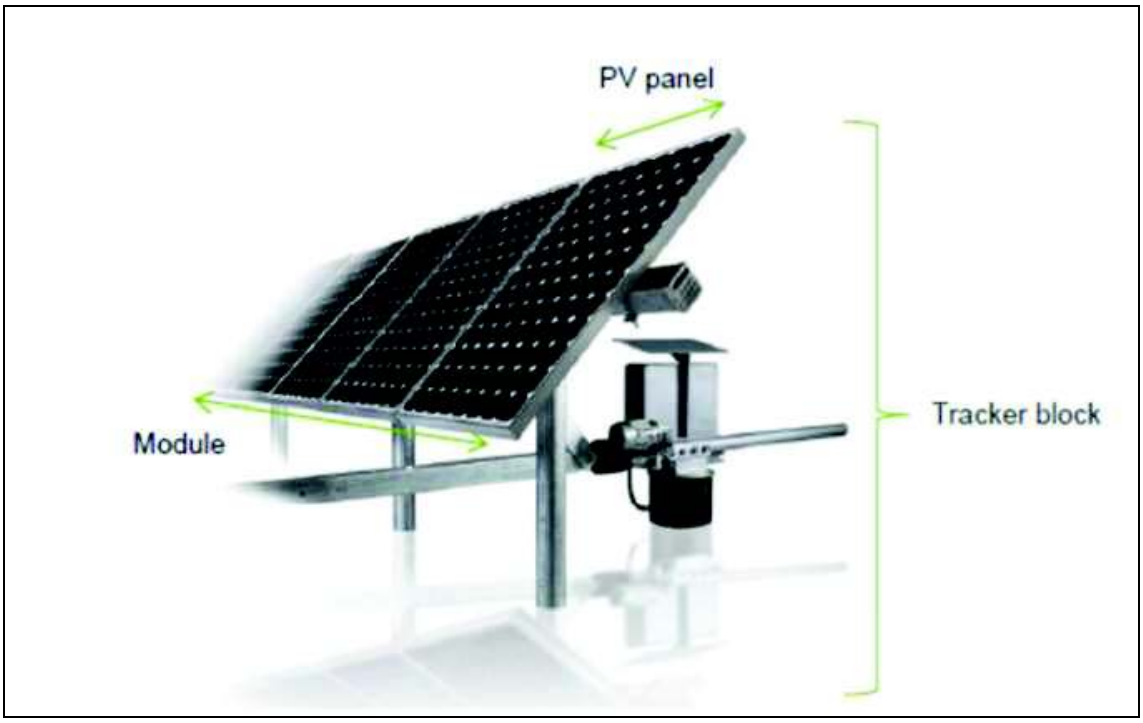

Figure 2: Single axis tracking system (image courtesy of Mulilo cited in **Aurecon, 2013**)

1.2.2 Transmission lines and substations

It is envisaged that each PV facility would require an onsite substation specific to each PV facility i.e. three onsite substations. These substations would feed into one central onsite substation by means of onsite overhead 132kV transmission lines. Based on the uncertainties regarding the capacity of Eskom's substations and transmission lines, it is proposed to assess a transmission line corridor instead of assessing the preliminary layouts which could be subject to changes. The width of the proposed transmission corridor ranges from 150m to 350m. Using the middle of the transmission corridor as a starting point, one arm of the transmission line corridor traverses the site in a north-westerly direction towards the northern boundary of the farm, while the other arm of the transmission line corridor traverses the farm in a south-westerly direction (approximately 5km) to the southern border of the farm. From there it will link up to Eskom infrastructure (as indicated in **Figure 5**) (**Aurecon, 2013**).

1.2.3 Additional infrastructures (road, buildings, stormwater, water pipeline)

A main access road (6m in width and 5.87km long) would be constructed to access the PV facilities from the N10. Internal access gravel roads from the main access roads to the four PV facilities would be required. Where it was possible, the layout of these roads coincide with the existing dirt tracks. The natural water flow of the site will be interrupted by the execution of planned roads, and therefore new stormwater drainage channels will be designed to facilitate natural water flow. The stormwater drainage channels will guide water flow to one of several discharge points which are where rip-rap areas will slow down the velocity of water and disperse the flow to avoid any possible erosion issue in that discharge point **(Aurecon, 2013)**.

It is proposed that potable water be obtained from the Emthanjeni Municipality via a proposed underground pipeline (4.61km in length) from the nearest municipal supply point and will be contained onsite in a jo-jo tank. The Municipality still needs to confirm available capacity to facilitate this water requirement **(Aurecon, 2013)**.

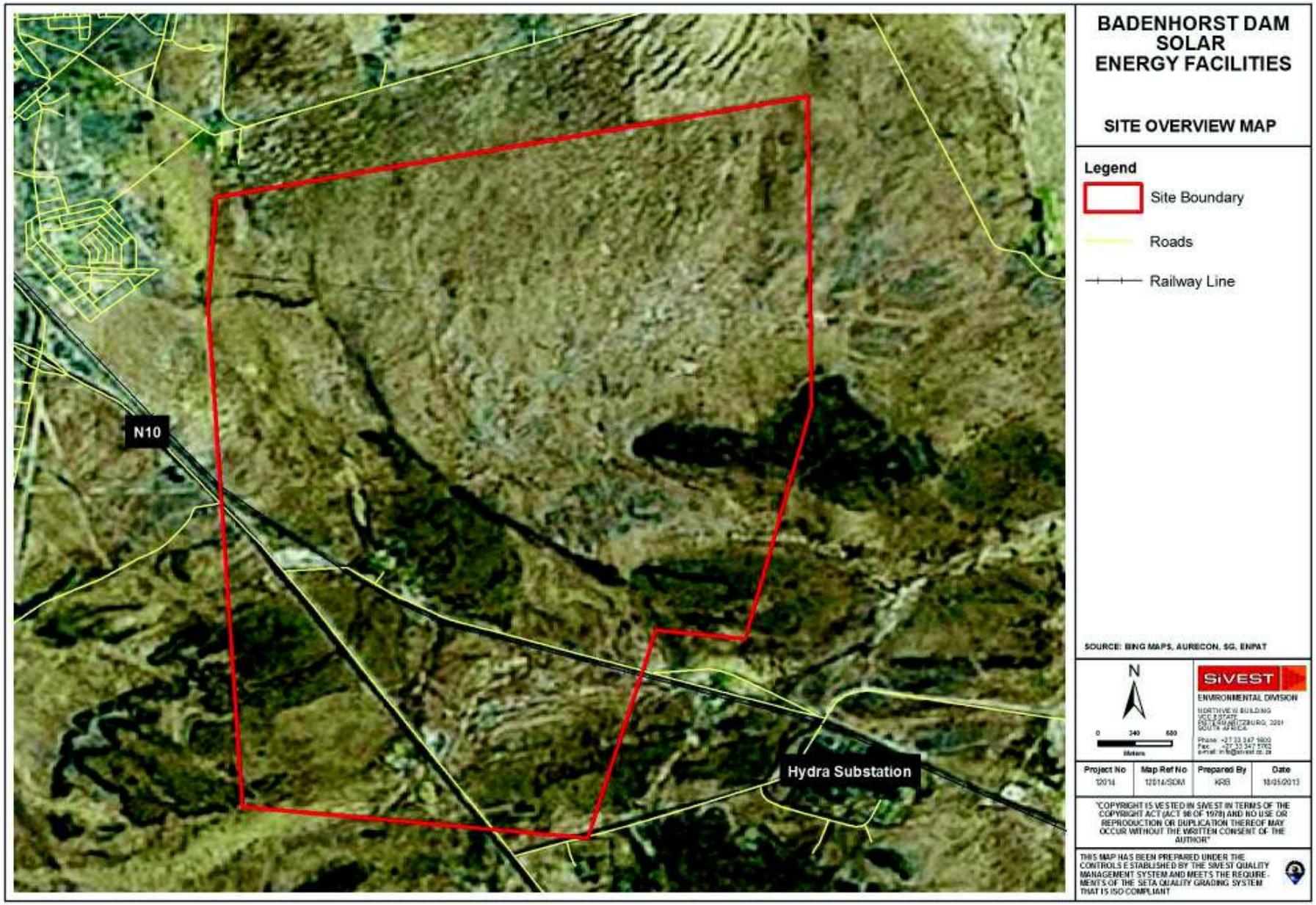

Figure 3: Site overview map (Background Imagery Courtesy of **Bing Maps, Microsoft, 2013**)

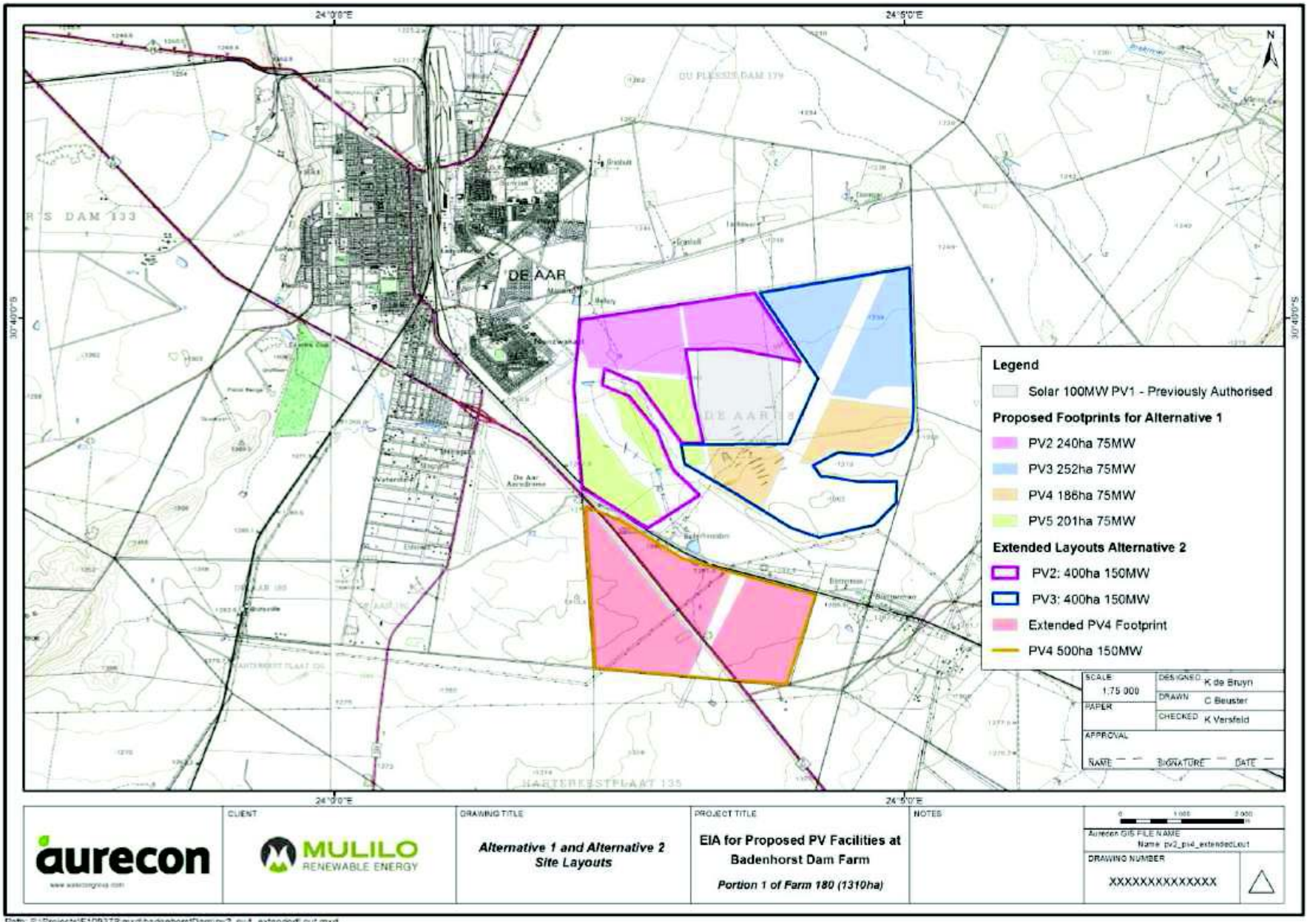

Figure 4: Proposed layout alternatives (**Aurecon, 2013**)

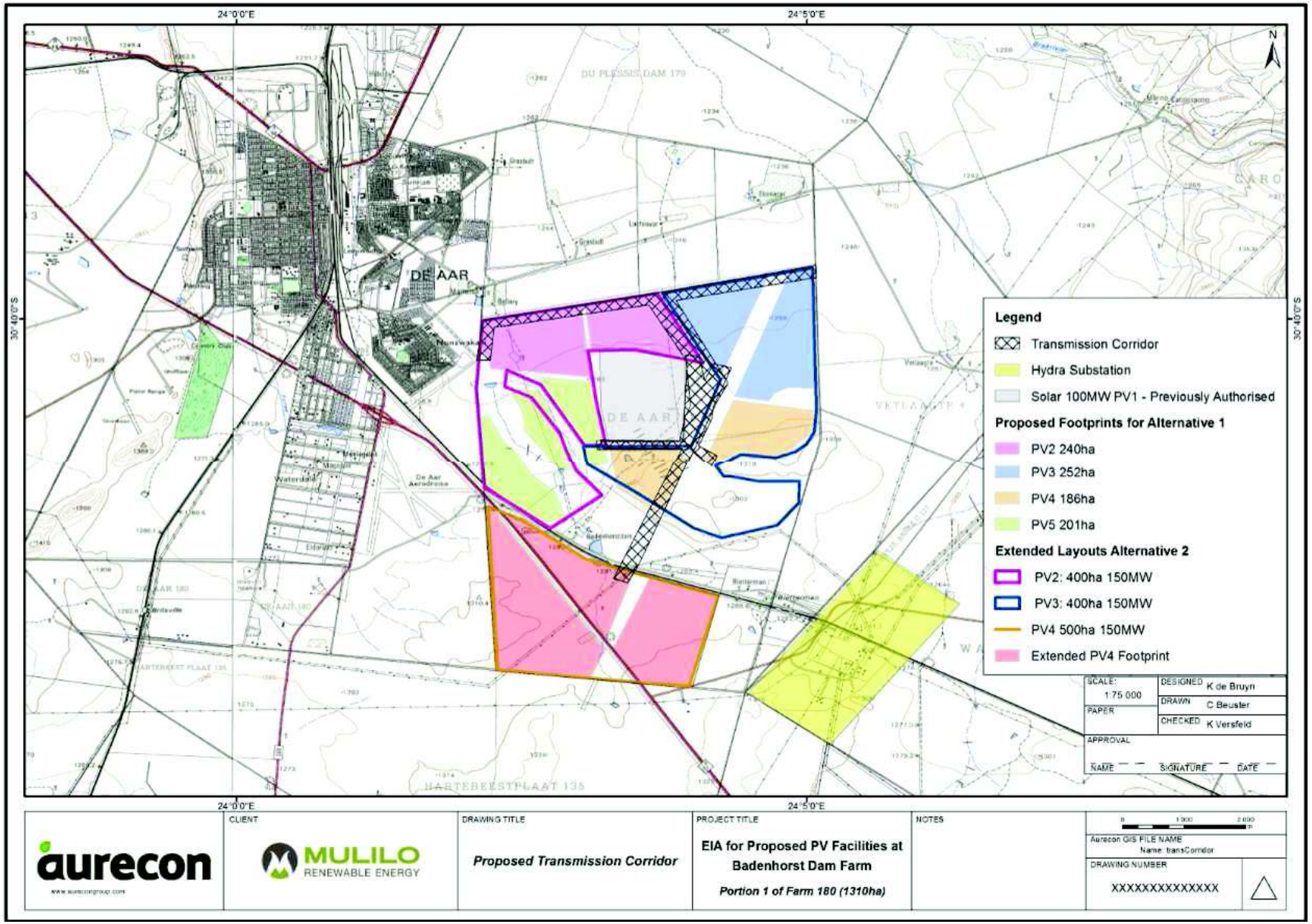

Figure 5: Proposed transmission corridors (**Aurecon, 2013**)

2. METHODOLOGY

The following methodology was followed in order to ascertain the *status quo* of soil and agricultural resources within the study area. Further, to outline the predicted impacts resulting from the proposed development and activities in the in the study area.

2.1 Desktop Study

A detailed desktop assessment was undertaken for the project area. The objective of this study is to broadly evaluate the soil and land use of the sites and receiving environment by interrogating relevant climate, topographic, landuse and soil datasets. By utilising these data resources one is able to broadly assess the current soil, agricultural and land use characteristics and provide a basis for a more detailed and spatially relevant assessment.

2.2 Soil Survey

A detailed soil survey was conducted in late 2012 and the remaining area, not considered during the original EIA, was surveyed in May 2013. At each sample point a hand auger was used to identify and describe the diagnostic horizons to form and family level according to "Soil Classification - A Taxonomic System for South Africa" as well as noting relevant soil characteristics such as depth, texture and limiting layers. At each auger point the relevant soil and land use data were recorded and the location of the auger point captured using a handheld GPS. This information was combined to produce detailed soil polygon maps.

2.4 Agricultural Potential Assessment

In terms of this study, agricultural potential is described as an area's suitability and capacity to sustainably accommodate an agricultural land use. The soil information gained from the survey along with the land use assessment is combined with climate, water resources, crop information and topographic data in order to provide a spatial classification of the land based on its agricultural potential. A study of local agricultural practices was also carried out.

2.5 Impact Assessment

The impact assessment utilises the findings of the soil survey and agricultural potential assessment in order to determine reference conditions of the soil and agricultural resources. Potential soil and agricultural impacts, as a result of the proposed activities, are described in this section and any major impacts/fatal flaws will be identified for consideration by the pertinent authorities.

3. DESKTOP AGRICULTURAL POTENTIAL ASSESSMENT

The objective of the desktop component of this assessment is to provide broad soil and agriculturally related characteristics of the project area. It should be clearly noted that, since the spatial information used to drive this portion of the assessment is of a reconnaissance nature, only large scale climate, land use and soil details are provided. More detailed and site specific information for the study area is provided in subsequent sections of this report (**Sections 4, 5 and 6**).

In order to ascertain the broad soil and agricultural potential characteristics of the project area relevant climate, topographic, landuse and soil datasets were sourced and interrogated. Existing high level GIS data was sourced from National GIS Datasets as well as the Environmental Potential Atlas for South Africa (ENPAT) Database for the Northern Cape Province of South Africa, compiled by the Department of Environmental Affairs and Tourism (**DEAT, 2001**).

The main purpose of ENPAT is to proactively indicate potential conflicts between development plans and critical, endangered or sensitive environments. By combining the aforementioned data resources, one is able to broadly assess the site, receiving environment, and its ability to accept change, in the form of development. More agriculturally relevant spatial information was obtained from the AGIS Database (***http://www.agis.agric.za,*** accessed 15/05/2013).

3.1 Climate

The study area has a semi-arid to arid continental climate with a summer rainfall regime i.e. most of the rainfall is confined to summer and early autumn. Mean Annual Precipitation (MAP) is approximately 300 mm per year (**Figure 6**). An MAP of 300 mm is deemed low as 500 mm is considered the minimum amount of rain required for sustainable dry land farming (**Smith, 2006**). Thus, without some form of supplementary irrigation natural rainfall for the study area is insufficient to produce sustainable harvests. This is reflected in the lack of dry land crop production within the study area De Aar typically experiences hot days and cold nights with the highest maximum temperature of approximately 40 ^{o}C and the lowest minimum temperature of approximately - 8 ^{o}C (**Table 2** and **Figure 7**). Evaporation is estimated to be in the region of 2000 mm per annum and thus the area is characterised by very severe moisture availability restrictions (**AGIS, 2013**)

In summary the climate for the study area is to severely restrictive to arable agriculture which is primarily due to the lack of rainfall and severe moisture availability restrictions.

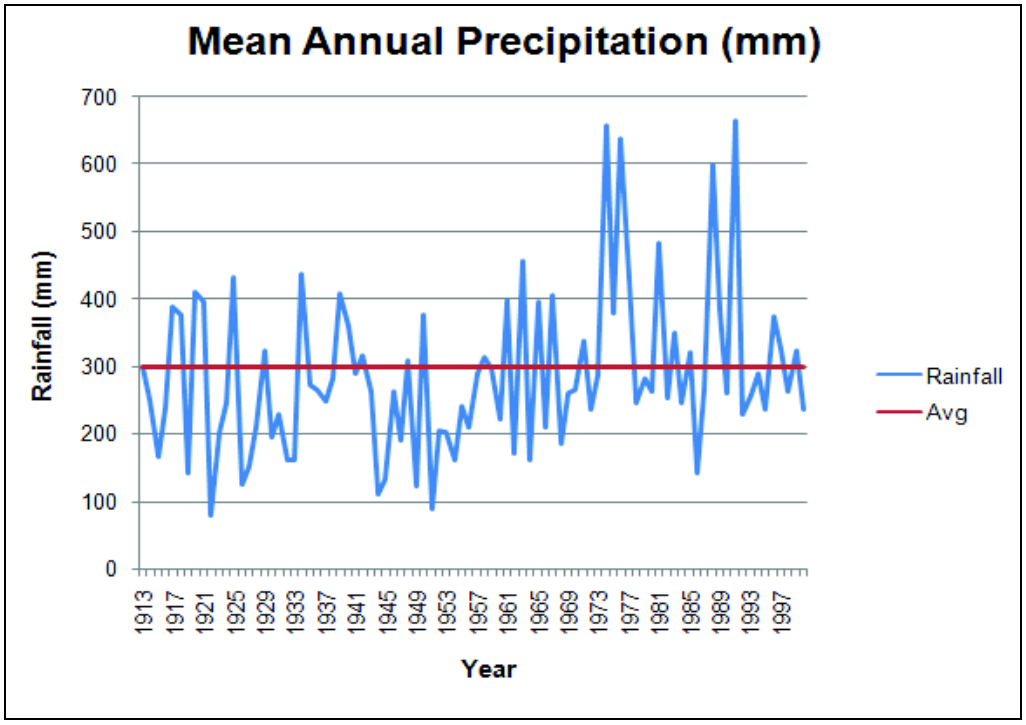

Figure 6: Long term annual rainfall (1913 – 1998) for the study area and long term average (indicated by the red line) (Source: **SAWS, 2010**)

Table 2: Monthly temperature summary for De Aar (**SAWS, 2010**)

Month	Temperature (° C) (1961 – 1990)			
	Highest Recorded	Average Daily Maximum	Average Daily Minimum	Lowest Recorded
January	40	32	16	7
February	38	31	15	4
March	37	28	13	1
April	34	24	9	-1
May	30	20	4	-5
June	26	16	1	-7
July	25	17	1	-8
August	28	19	2	-8
September	35	23	6	-5
October	36	26	9	-3
November	38	29	12	-1
December	39	31	14	3
Year	**40**	**25**	**9**	**-8**

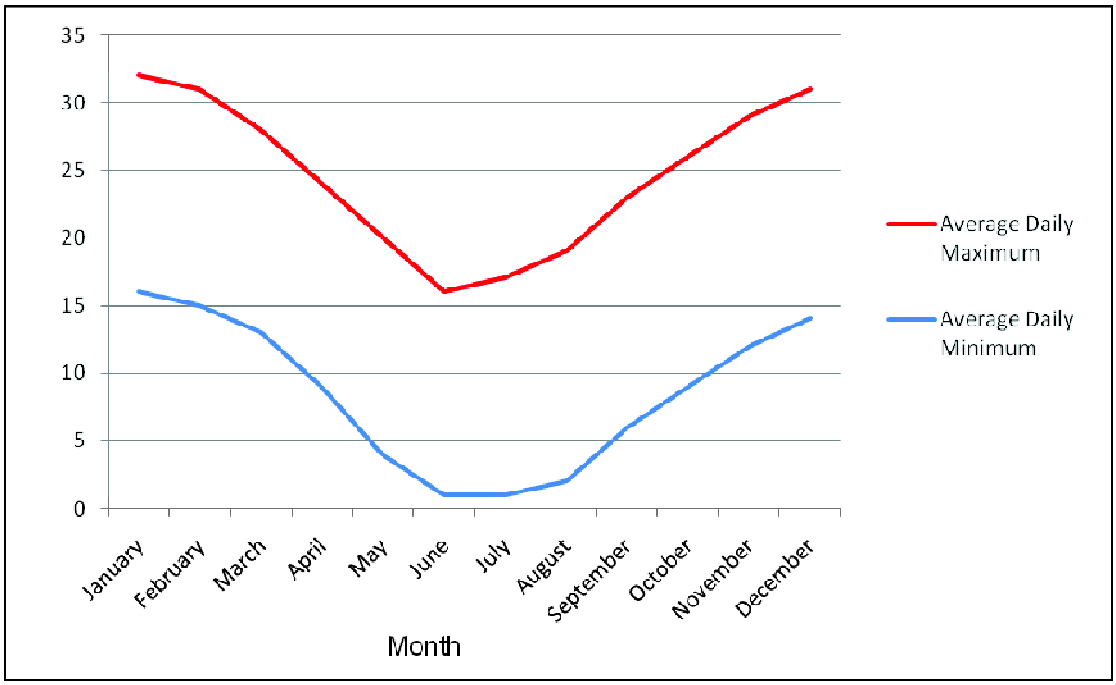

Figure 7: Average daily minimum and maximum temperatures for De Aar **(SAWS, 2010)**

3.2 Geology

The study area is completely underlain by a variety of geological materials (**Figure 8**). Shale underlies the central and northern portions of the site. Shale, a clastic sedimentary rock, is formed by the settling and accumulation of clay rich minerals and other sediments. Due to the settling process this parent material usually takes the form parallel rock layers which lithifies over time. The southern portions of the site are dominated by mudstone, like shale, mudstone is a clastic sedimentary rock which is formed from the lithification of deposited mud and clay. Mudstone consists of a very fine grain size of less than 0.005 mm but unlike shale, it is mostly devoid of bedding. A small area of Tillite underlies the south eastern boundary of the site.

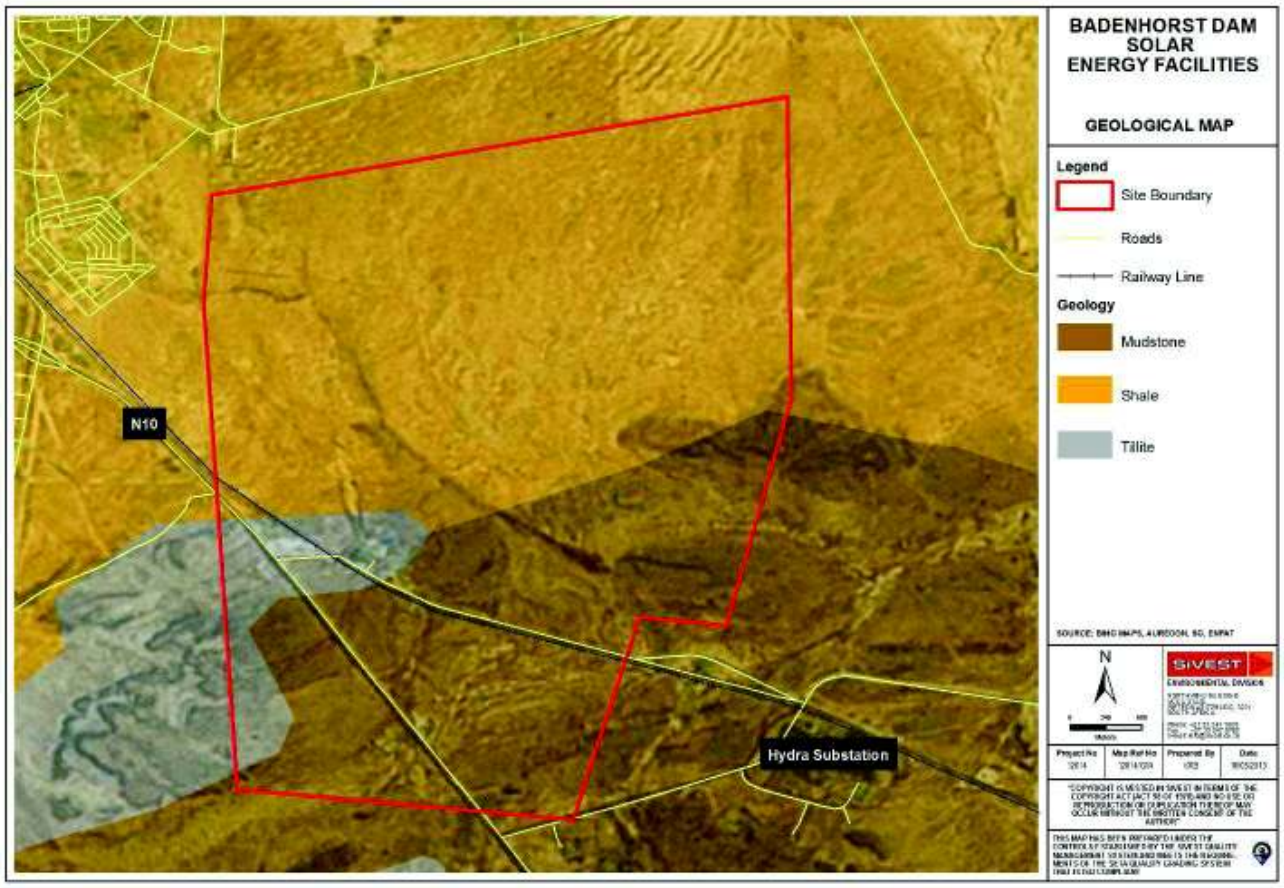

Figure 8: Geological map

3.3 Terrain

Slope or terrain is used to describe the lie of the land. Terrain influences climate, soils characteristics, and thus plays a dominant role in determining whether land is suitable for agriculture. In most cases sloping land is more difficult to cultivate and usually less productive than flatland, and is subject to higher rates of water runoff and soil erosion (**FAO, 2007**).

The study area is dominated by flat and gently sloping topography with an average gradient of less than 5% (**Figure 9**) making this area ideal for intensive agriculture with high potential for large scale mechanisation. The site does, however contain a number of small rocky outcrops and ridges, which are limiting to arable agriculture (**Figure 10**). From a developmental perspective the flat areas, which dominate the site, will also allow for minimal earthworks and site preparation.

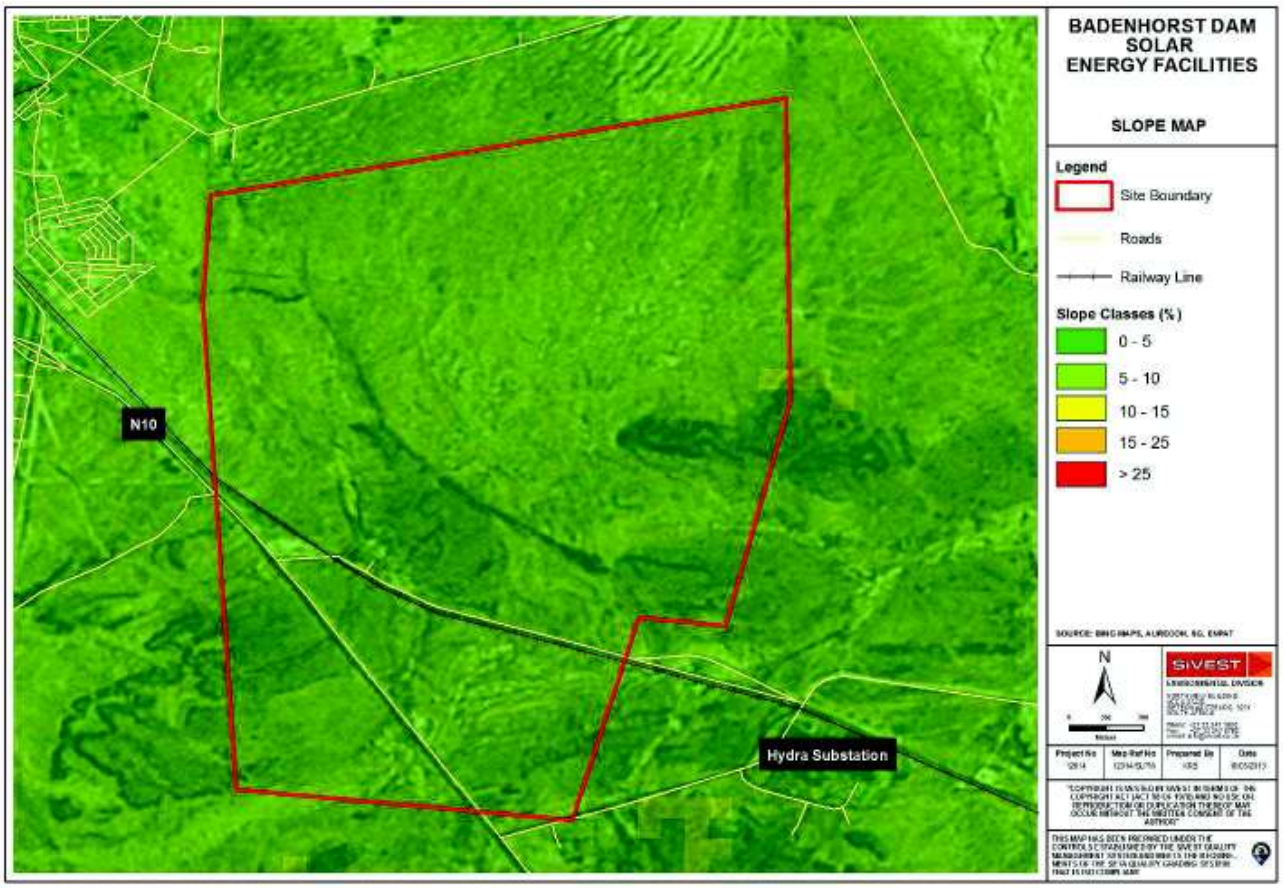

Figure 9: Slope Analysis of the study area

Figure 10: An example of a rocky ridge located on Badenhorst Dam

3.4 Land Use

Mucina and Rutherford (**2006**), classify the site as *Northern Upper Karoo* vegetation type, *which forms part of the Nama-karoo biome*. According to the ENPAT Database and 2010 land cover data, the broad study area consists of a mix of natural veld and unimproved shrub-land which is used as grazing land for cattle and springbok (**Figure 11**). Two small, seasonal water bodies are located in the southern portion of the site. The north western corner of Badenhorst dam borders Nonzwakazi settlement. According to the spatial databases there are no cultivated fields, irrigated lands which could be detrimentally impact upon by the proposed developments. Stocking rates are estimated at 1:4.5 (1 sheep per 4.5 hectares of land) for a small animal unit (sheep) and 1:18 for a large animal unit (cattle).

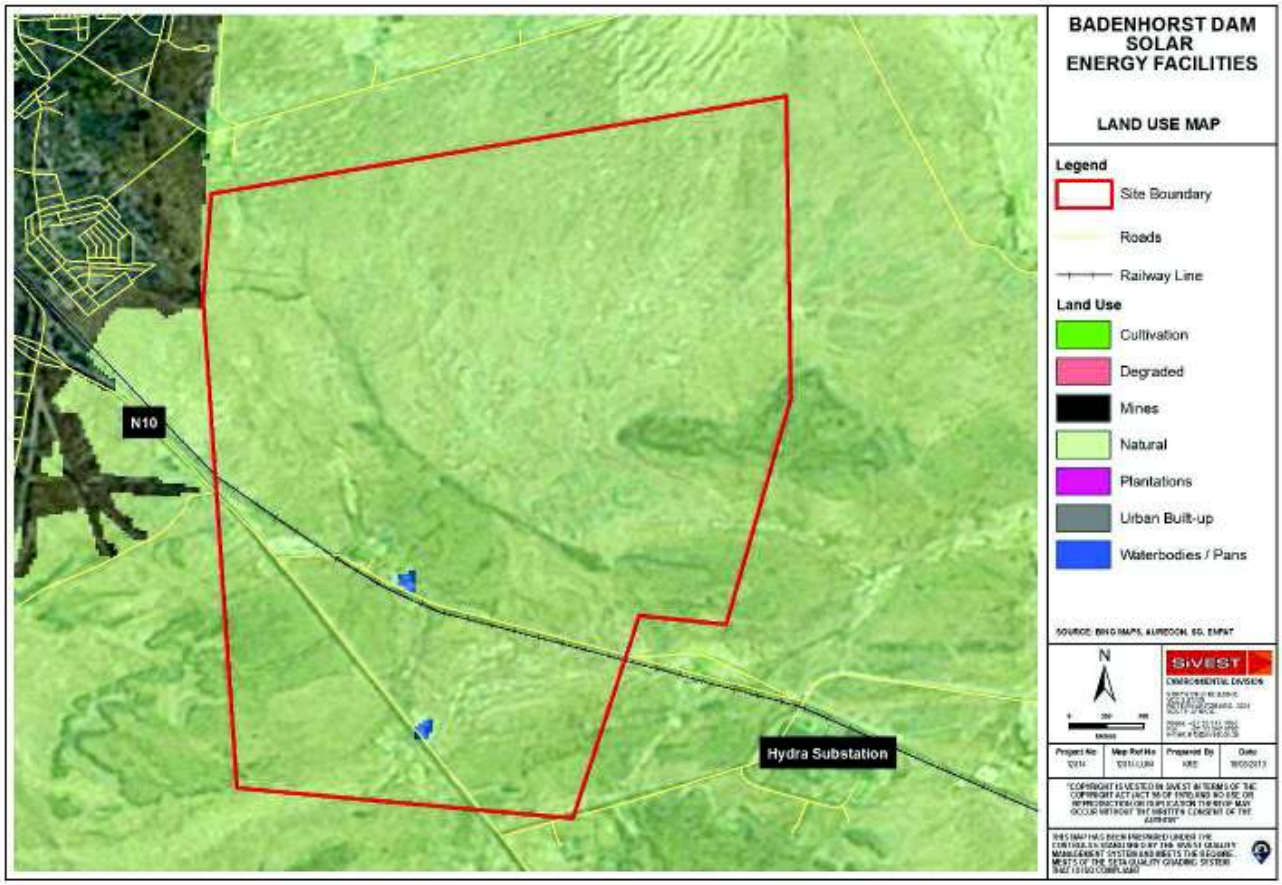

Figure 11: Land Use Map

3.5 Soil Characteristics

The ENPAT spatial dataset for the Northern Cape Province also provides details pertaining to the broad soil type and approximate agricultural potential for the study area. **Figure 12,** provides a spatial characterisation of the major soil groups which underlie Badenhorst Dam Site. According to this dataset the site is dominated by shallow Red Apedal soils with a high base status. Apedal soils lack well formed peds other than porous micro-aggregates and are weakly structured. Apedal soils tend to be freely drained, and due to overriding climate conditions these soils will tend to be Eutrophic (high base status).

The entire study area is classified as having an effective soil depth, depth to which roots can penetrate the soil, of less than 0.45 m deep which is a limiting factor in terms of sustainable crop production (**Figure 13**). According to the AGIS database the project area is associated with soils with a moderately low organic matter content (0.6 - 1%) and an average pH of between 7.5 and 8.4 (basic).

The ENPAT Database provides an overview of the study area's agricultural potential based on its soil characteristics, it should be noted this spatial dataset does not take prevailing climate into account. The northern half of Badenhorst Dam is characterised by soils which are not suitable for arable agriculture but remains suitable to grazing (**Figure 14**). While the southern half is associated with soils which are characterised by having a poor agricultural potential (where climate permits). A severely restrictive climate rating, due to low rainfall and moisture / heat stress further reduces the agricultural potential of the project area.

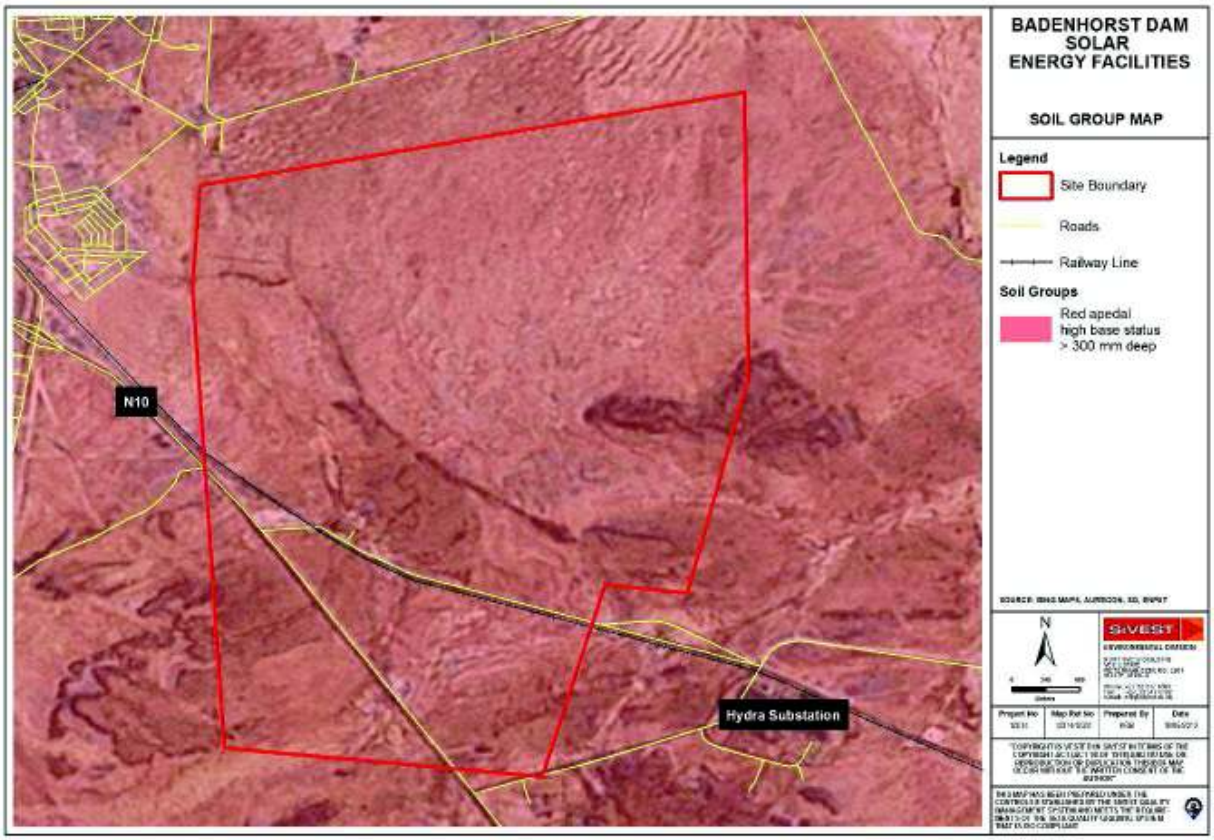

Figure 12: Broad soil type map

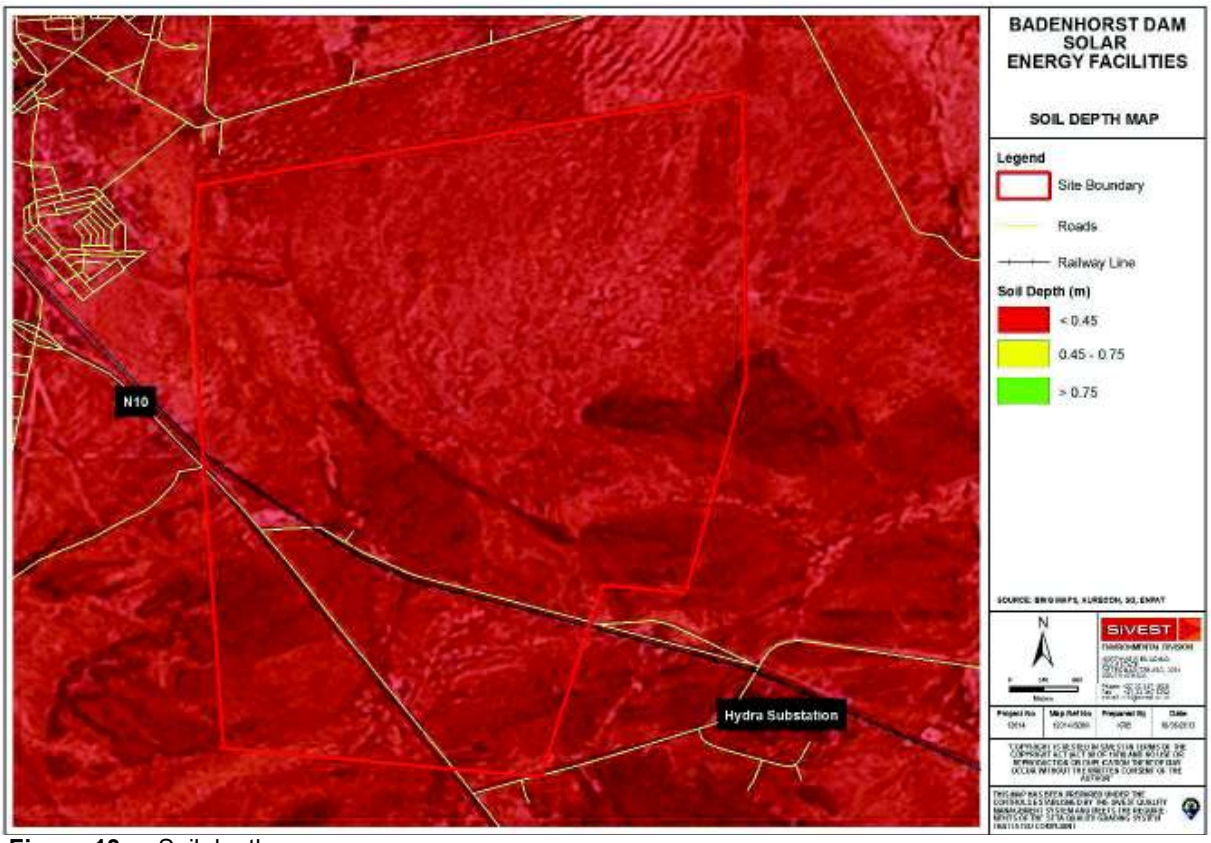

Figure 13: Soil depth map

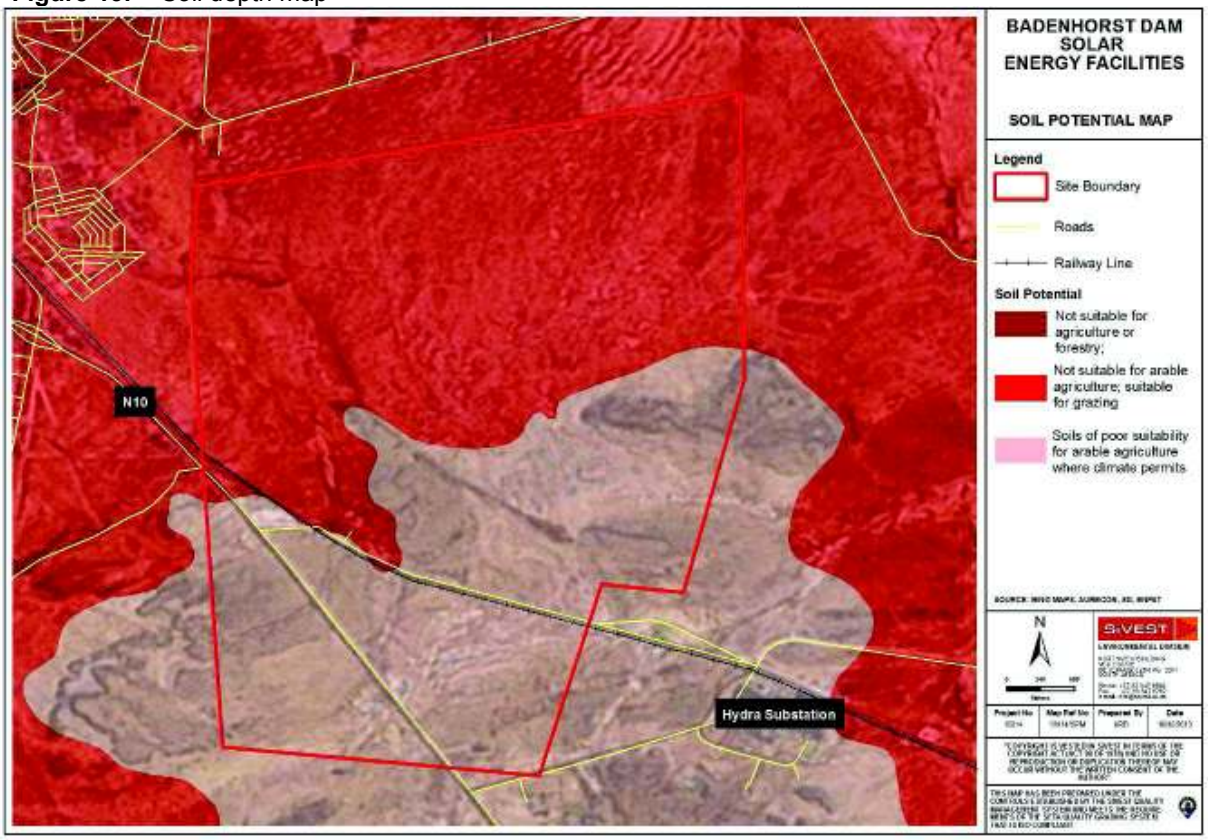

Figure 14: Soil Potential Map

3.6 Desktop Agricultural Assessment: Results Summary

By taking all the site characteristics (climate, geology, land use, slope and soils) into account, the agricultural potential for the majority of the study area is classified as being extremely low for crop production while moderate to moderately low for grazing. This poor agricultural potential rating is primarily due to restrictive climatic characteristics and soil depth limitations. The site is not classified as high potential nor is it a unique dry land agricultural resource.

4. SOIL SURVEY AND FIELD VERIFICATION

A detailed soil survey was undertaken for the Badenhorst Dam Site using a hand auger and GPS to record the location of each of the auger points. At each survey point the soil was described to form and family level according to "Soil Classification - A Taxonomic System for South Africa" (**Soil Classification Working Group, 1991**) and the following properties were noted:

- Estimation of the soils clay content,
- Permeability of upper B horizon,
- Effective rooting depth and pedological depth,
- Limiting layers,
- Soil Colour via the Munsell Soil Colour Charts,
- Signs of wetness,
- Surface rockiness,
- Surface crusting,
- Vegetation cover, and
- Detailed description of the particular area such as slope.

4.1 Soil Descriptions

This Section lists the **major soil forms** encountered during the soil survey along with a site-specific description of each soil form.

4.1.1 Mispah Form

Soil Family: Mostly 1200 (Non bleached, Calcareous), limited bleached and/or non-calcareous
Diagnostic Horizons and Materials:
A-Horizon: Orthic
B-Horizon: Hard Rock

Site Specific Description:
The Mispah soil form falls within the lithic soil group. Lithic soils are associated with shallow soils where parent rock is found close to the soil surface. The A-horizon varied from reddish-brown to ivory in colour and was generally 10-20 cm deep, directly overlying various hard rock materials. In many instances surface rocks are clearly visible (**Figure 15**). Large areas of the site contained non-

contiguous bands of Lithocutanic B horizons overlying hard rock which lead to areas being classified as a Mispah / Glenrosa complex.

Land Use Capability:
This soil has low agricultural potential due to the distinct lack of rooting depth and as such these soils are generally utilised for grazing land. If ripped and cultivated however, precise irrigation scheduling is imperative. These soils also exhibit high soil erosion hazard ratings thus soil conservation practices such as minimum tillage and trash blankets should be employed.

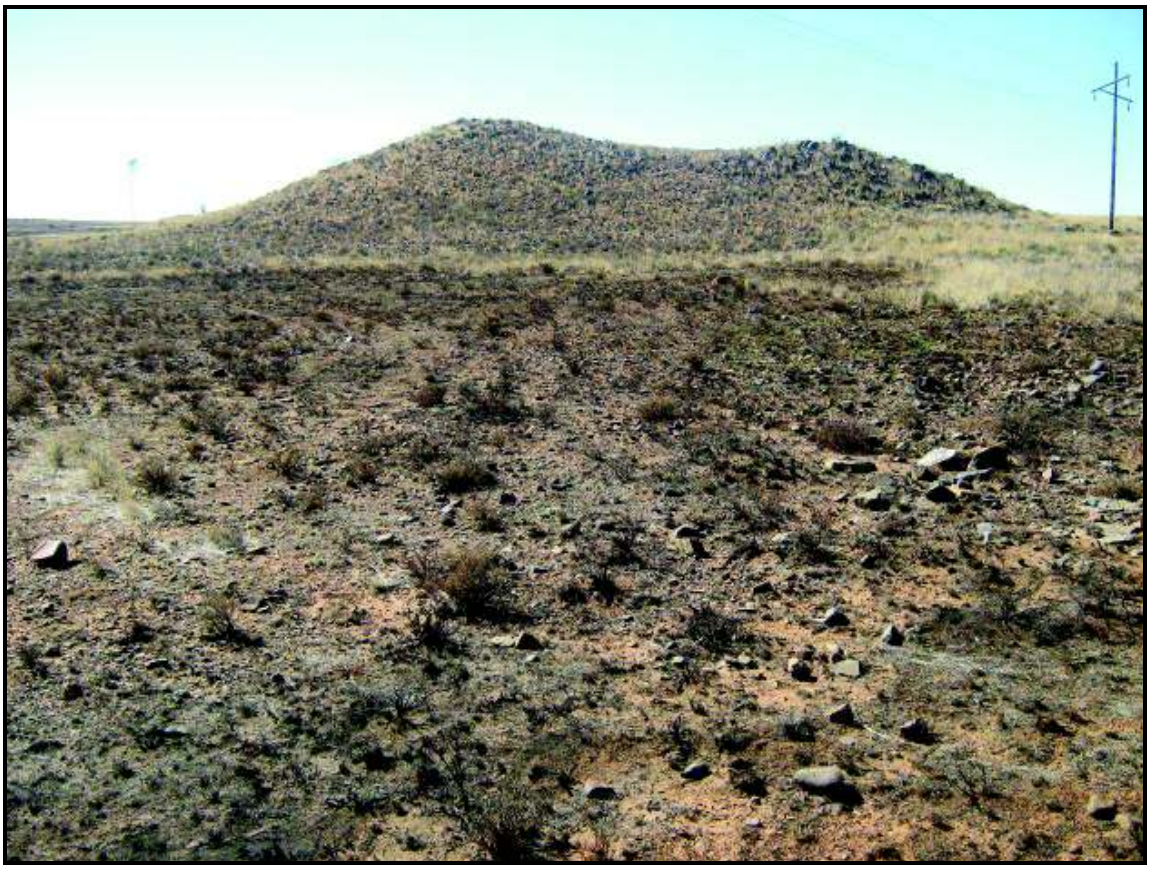

Figure 15: Shallow, rocky soils dominate large areas of the Badenhorst Dam Site

4.1.2 Glenrosa Form

Family: Mostly 1212 (A-horizon not bleached, B1 Hard, no signs of wetness and calcareous)
Diagnostic Horizons and Materials:
A-Horizon: Orthic
B-Horizon: Lithocutanic

Site Specific Description:
Like the Mispah soil form, the Glenrosa form falls within the lithic soil group. This soil form is found throughout the surveyed area, where bands of weathering rock are found close to the soil surface. In most cases the Orthic A is approximately 10-20 cm deep and was generally brown in colour.

The shallow Orthic A horizon overlies a Lithocutanic B-Horizon, which contains a high proportion of weathering rocks (**Figure 16**). The B-Horizon is generally limiting to plant roots but gaps between the weathering rock fragments can be opened by larger tree roots and thus the land use potential of this soil can be higher than expected. The Lithocutanic B merges into solid rock layers which are limiting to plant roots and generally found between 20 and 50 cm below the soil surface. Surface rocks were evident across the land surface where this soil form was found. Large portions of the site contained non-contiguous bands of Lithocutanic B horizons and hard rock which lead to large areas being classified as a Mispah and Glenrosa complex.

Agricultural Potential:
Without careful management or preparation this soil has low agricultural potential as the effective soil depth is approximately 30 cm. If these soils are cultivated, careful irrigation scheduling would be essential. This soil form also exhibits high soil erosion hazard ratings; thus soil conservation practices such as minimum tillage and trash blankets should be employed.

Figure 16: An example of a shallow Glenrosa encountered in the De Aar area

4.1.3 Swartland Form

Soil Family: Various (Bleached and Non-Bleached A, Red / Non Red, Calcareous and Non-Calcareous B)
Diagnostic Horizons and Materials:
A-Horizon: Orthic
B-Horizon: Pedocutanic
C-Horizon: Saprolite

Site Specific Description:

The Swartland soil form falls within the duplex soil group, whose defining characteristic is the enrichment of clay within the soil profile. Duplex soils are mostly found in the drier parts of South Africa and have in common the development of strong structure in the B-horizon and a marked increase in clay compared to the overlying horizon (**Fey, 2010**). This form was commonly found between rocky outcrops and provided deeper routing than the adjacent soils.

The Orthic A Horizon was generally dark brown to bleached grey in colour and was weakly structured. This Orthic A horizon overlies a strongly structured B-Horizon, which contains a high proportion of clay due to illuviation. The B-Horizon has a strong cutanic character which has a blocky structure (**Figure 17**). This soil can be classified as duplex in nature and in certain instances the B-Horizon was considered an impediment to root growth and water movement. The pedocutanic merged into weathering rock. Signs of calcium carbonate were often noted in the lower B horizon.

Agricultural Potential:

Duplex soils occur widely in South Africa and present a variety of management factors to farmers and engineers. This soil form, in the context of this assessment, has a moderately low agricultural potential owing to the strongly structured Pedocutanic B and duplex character of the soil horizon which curtail root growth and water movement. At times the Pedocutanic B was limiting and thus this horizon was recorded as the effective soil depth. This soil form also exhibits high soil erosion hazard ratings; thus soil conservation practices such as minimum tillage and trash blankets should be employed. The main cause of erosion is clay dispersion which gives rise to surface sealing and intensifies surface runoff. If cultivated the chemical properties of duplex soils will most likely also need attention. This could include sodicity and salinity correction.

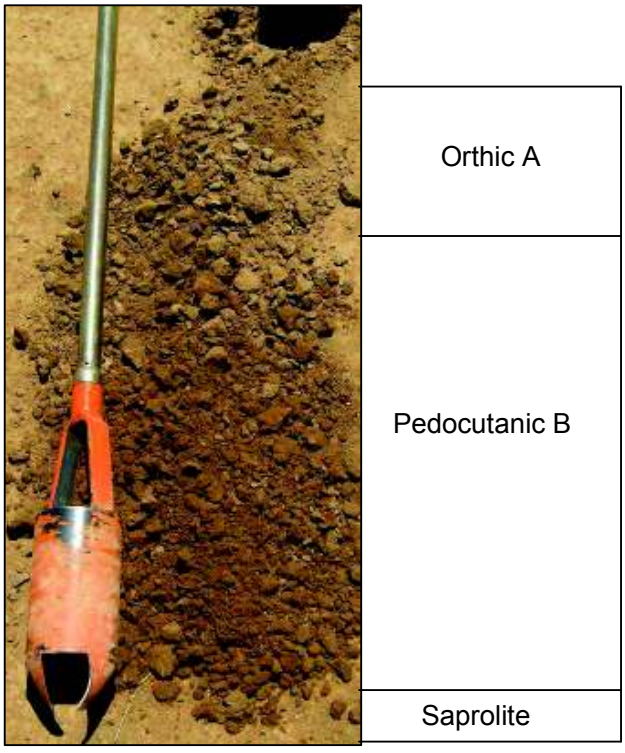

Figure 17: An example of Swartland Soil Form identified on the Badenhorst Dam Site, the underlying Saprolite is not shown

4.1.4 Coega Form

Family: Generally 2000 (Calcareous A Horizon)
Diagnostic Horizons and Materials:
A-Horizon: Orthic
B-Horizon: Hardpan Carbonate

Site Specific Description:
The Coega form is a calcic soil whose profile contains at least one carbonate-rich horizon. Carbonate retention in the soil profile is a result of an arid climate where evaporation far exceeds rainfall. When encountered on the site the A-horizon of this soil form was brown, thin and calcareous. This Orthic A-horizon overlies a hard pan carbonate which was limiting to plant growth. The surface Hard Pan Carbonate horizon was identified near the railway line and N10 highway. The effective soil depth, depth to which roots can penetrate the soil, was generally less than 0.2 m (**Figure 18**).

Agricultural Potential:
Calcic soils are associated with arid regions and thus the use of these carbonate rich soils in South Africa is limited. Limitations in terms of sustainable agricultural use include shallow rooting depth, high pH, high salinity and low Phosphorus available for plant utilisation (**Fey, 2010**). Such limitations restrict calcic soils to extensive grazing unless irrigation is available. These soils also exhibit high soil erosion hazard ratings thus soil conservation practices such as minimum tillage and trash blankets should be employed.

Figure 18: An example of a shallow Coega form

4.2 Soil Summary

The soils identified on the Badenhorst Dam Site are predominantly shallow and rocky with a low agricultural potential. Rocky soils (Mispah and Glenrosa Forms) cover 57% of the surveyed area (**Figure 20**) while shallow duplex soils (Swartland) cover 38%. Most soils contained a layer that was limiting to plant growth and these layers included rock, saprolite, hard pan carbonate and strongly structured cutanic horizons.

The location and description of the sample points are provided in **Appendix A: Soil Properties**. This information was used to create a verified soil map showing homogeneous soil bodies for on the Badenhorst Dam Site (**Figure 19**). Combining the effective depth information (i.e. depth to root limiting layer) and Inverse Distance Weighting one is able to obtain a generalised soil depth for the site (**Figure 21**). Soils with an effective depth of greater than 50 cm were rarely observed during the soil survey.

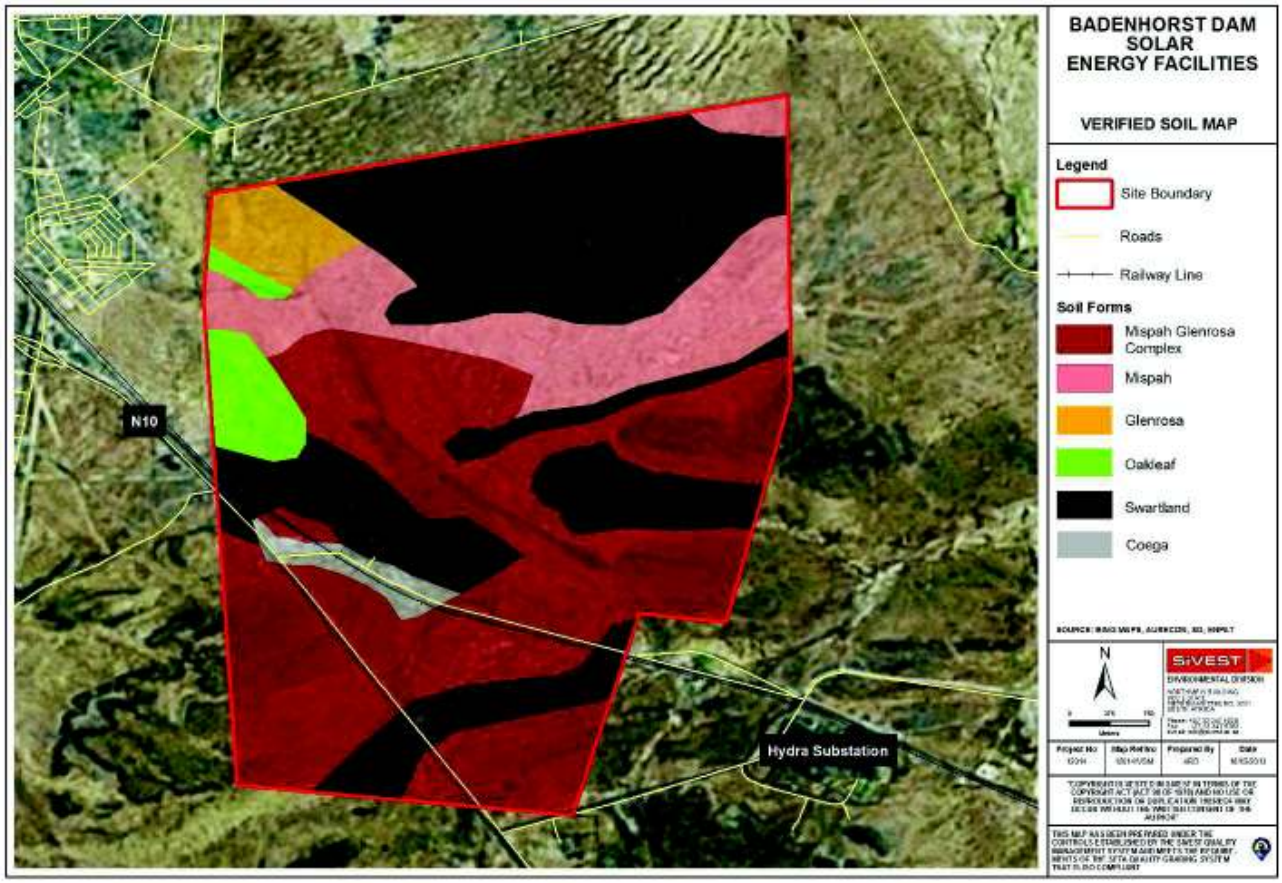

Figure 19: Verified Soil Map for Badenhorst Dam Farm

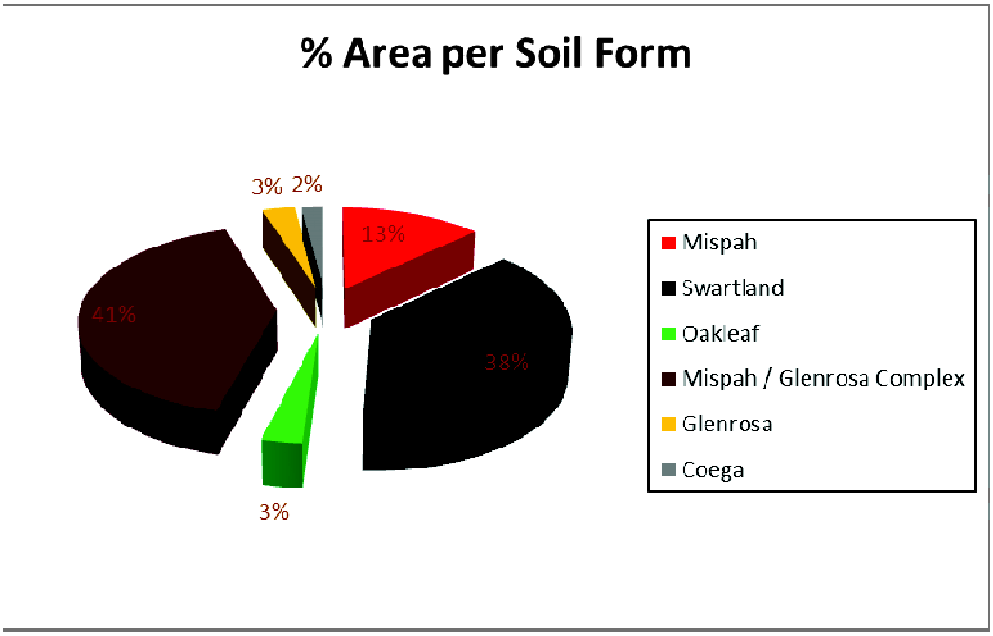

Figure 20: Graph showing the percentage area per soil form

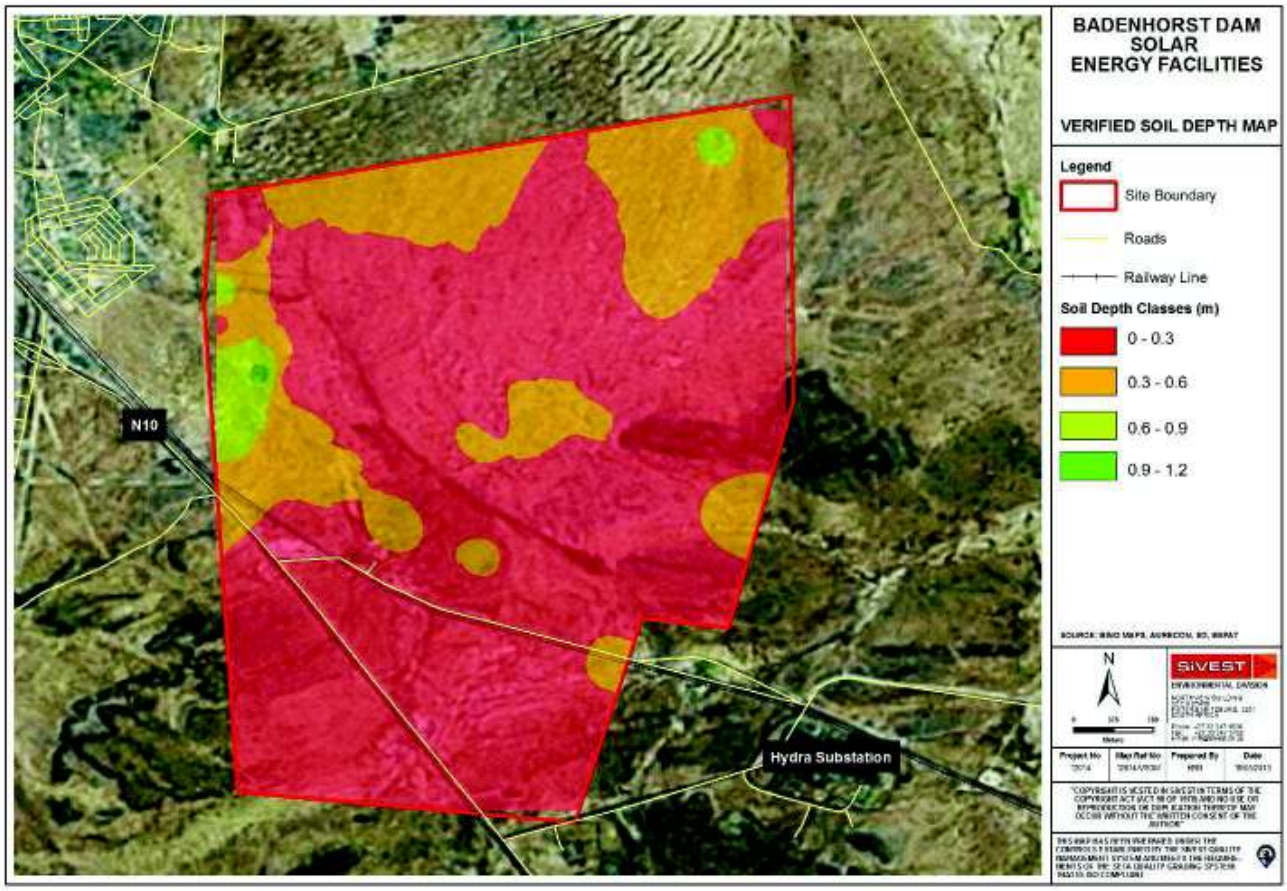

Figure 21: Verified Soil Depth Map

5. AGRICULTURAL POTENTIAL ASSESSMENT

In terms of this study, agricultural potential is described as an area's suitability and capacity to sustainably accommodate an agricultural land use with this potential being benchmarked against crop production.

5.1 Current Situation

The Badenhorst Dam Site is zoned as agricultural land, and is currently used as extensive grazing land for cattle and game production (**Figure 22)**. Stocking rates are estimated at around 1 SSM (small stock unit) per 4.5 hectares and 1 LSU (large stock unit) per 18 hectares. The site does not currently accommodate any centre pivots or irrigation schemes. Fields, near the homestead, are characterised by improved pastures. Although these fields are still characterised by low value agricultural land, they still represent actively cultivated land and thus have been precluded from the development layout. Urban expansion and the increasing rate of stock theft are increasing pressure on the productivity and sustainability of this farm unit. The evidence for this is that many of the farms in close proximity to De Aar have abandoned small stock farming in favour of beef and game production.

5.2 Verified Agricultural Potential

Overall agricultural potential of the site is based on assessing a number of inter-related factors including climate, topography, soil type, soil limitations and current land use. The overriding climate is the major limiting factor for the site. The combination of low rainfall and an extreme moisture deficit means that sustainable arable agriculture generally cannot take place without some form of irrigation. The site does not contain and is not bounded by a reliable surface water irrigation resource, and the use of borehole water for this purpose does not seem agriculturally and economically feasible. This is due to the current human pressure on borehole water, the expense of using borehole water as a source of irrigation and the brackish nature of the local groundwater resources.

The project area is dominated by flat undulating topography with an average gradient of less than 5%. The soils identified on the PDA are predominantly shallow and rocky with a low agricultural potential. Rocky soils (Mispah and Glenrosa Forms) cover 57% of the surveyed area while shallow duplex soils (Swartland) cover 38%. Most soils contained a layer that was limiting to plant growth and these layers included rock, saprolite, hard pan carbonate and strongly structured cutanic horizons.

A map indicating the agricultural potential in terms of **crop production** for the Badenhorst Dam Farm is provided in **Figure 23**. The majority of the site has been classified as having low potential for crop production due to an arid climate and highly restrictive soil characteristics. Two small areas, characterised by the Oakleaf Soil Form, have been conservatively rated as having moderate agricultural potential. The site is not classified as high potential, nor is it a unique dry land agricultural resource. The physical and chemical limitations associated with the dominant forms restrict these soils to extensive and low density grazing land. The site is considered to have a moderate to moderately low value when utilised as grazing land, which is its current use.

Figure 22: Cattle grazing on Badenhorst Dam

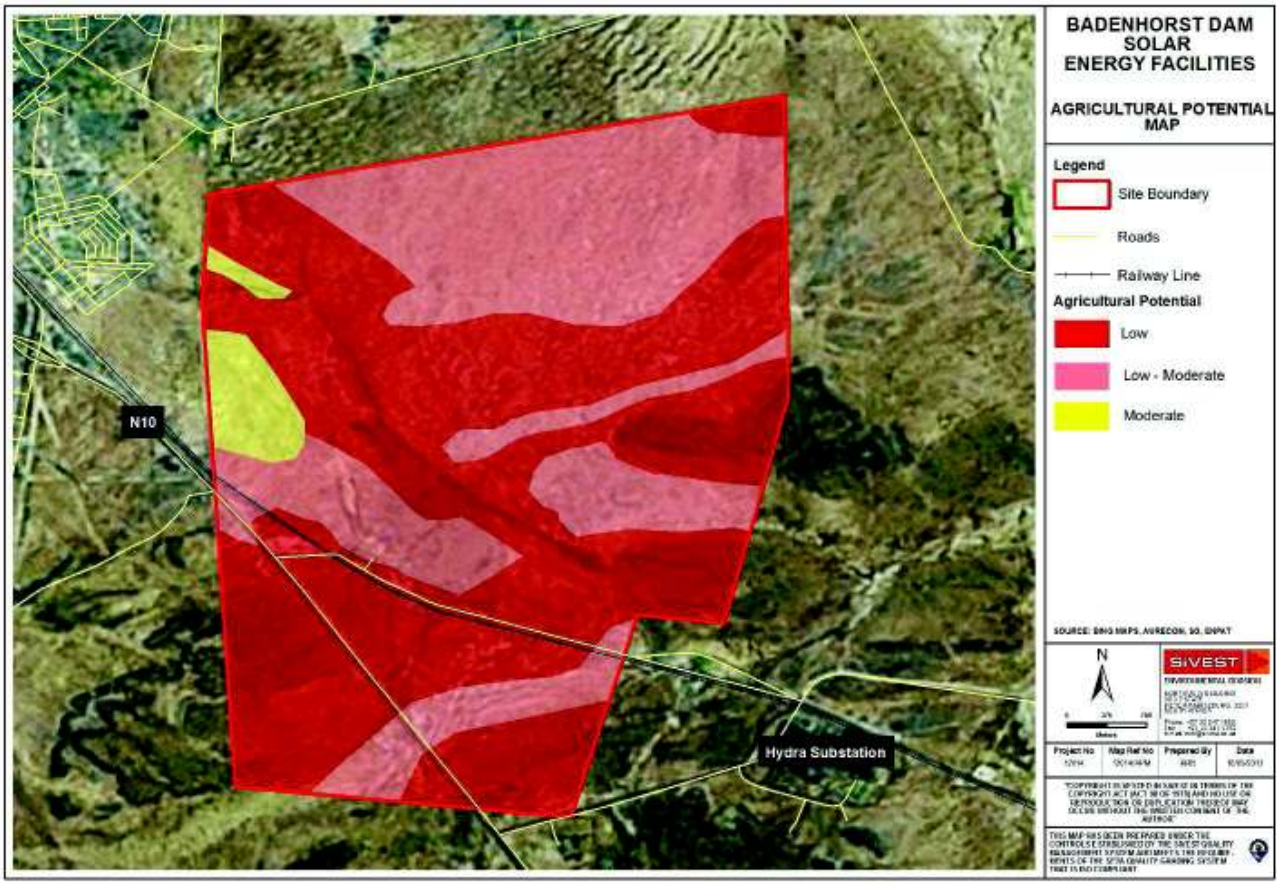

Figure 23: Agricultural Potential Map

6. AGRICULTURAL IMPACT ASSESSMENT

From an agricultural perspective the loss of high value farm land and / or food security production, as a result of the proposed activities, is the primary concern of this assessment. In South Africa there is a scarcity of high potential agricultural land, with less than 14% of the total area being suitable for dry land crop production (**Smith, 2006**). Consequently areas which can sustainably accommodate dry land production need to be protected from non-agricultural land uses. The desktop assessment, field verification and agricultural potential assessment (**Sections 3, 4 and 5**) has already shown that the study area is unsuitable for crop production and is dominated by unimproved grazing land[1].

The results of agricultural assessment indicate that the Badenhorst Dam Farm has low agricultural value and is replaceable when assessed within the context of the proposed development. Consequently, the overall impact of the Solar Energy Facility on the study area's agricultural potential and production will be low, due to the site's low inherent agricultural potential and value. The site does contain small areas of cultivation, near the homestead. These areas are simply improved pastures and represent less than 1% of the site. These fields have classified as a No-Go Zone and are precluded from development layouts and thus the overall impact on the study area's agricultural potential and production will be low, due to the remaining areas low inherent agricultural potential and/or value (**Figures 24** and **25**).

[1] Unimproved grazing land can be defined as areas of veld which are in a relatively natural condition and which have not been previously cultivated or physically/chemically improved for agricultural purposes.

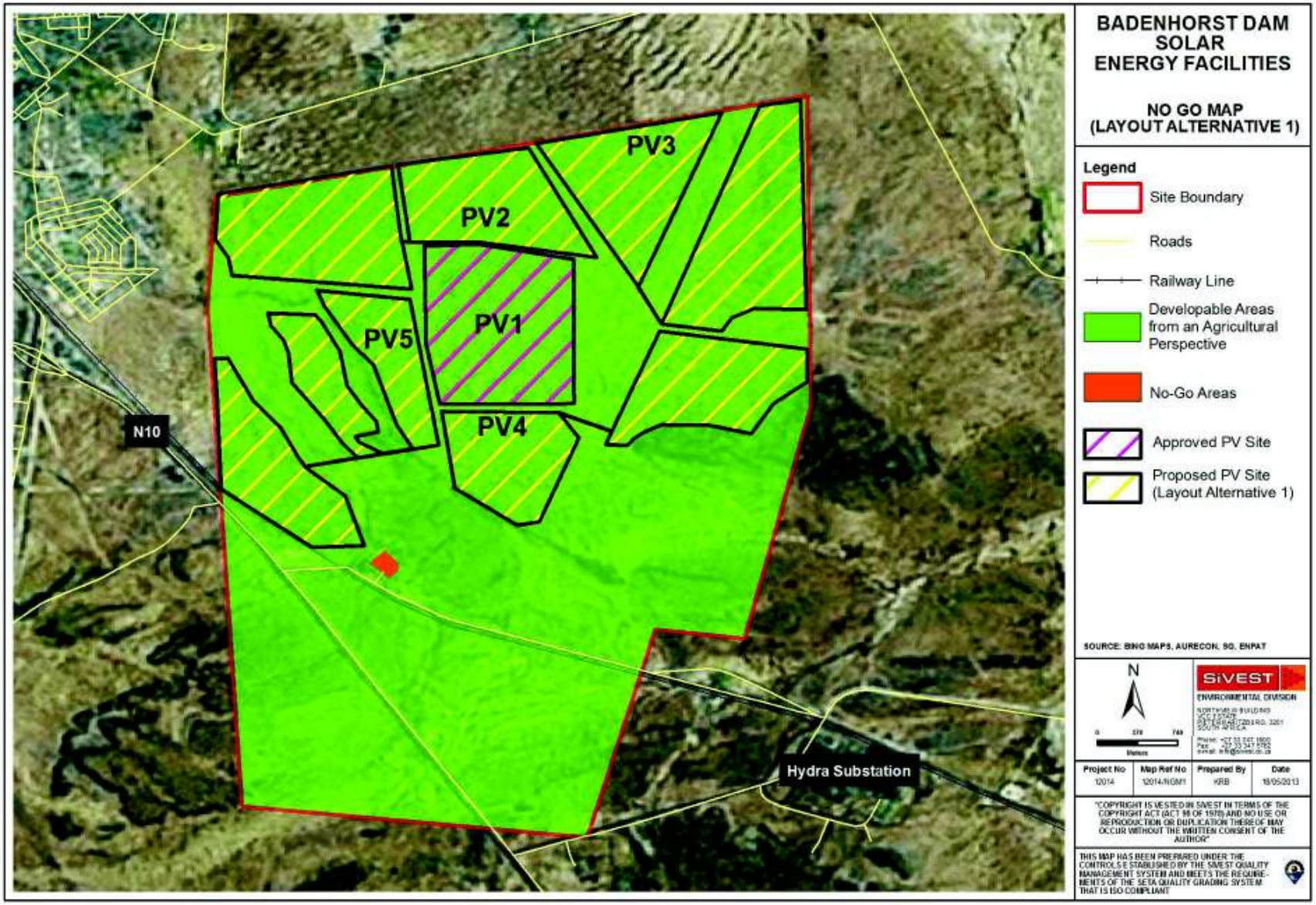

Figure 24: No Go Map (Agriculture) and Layout Alternative 1

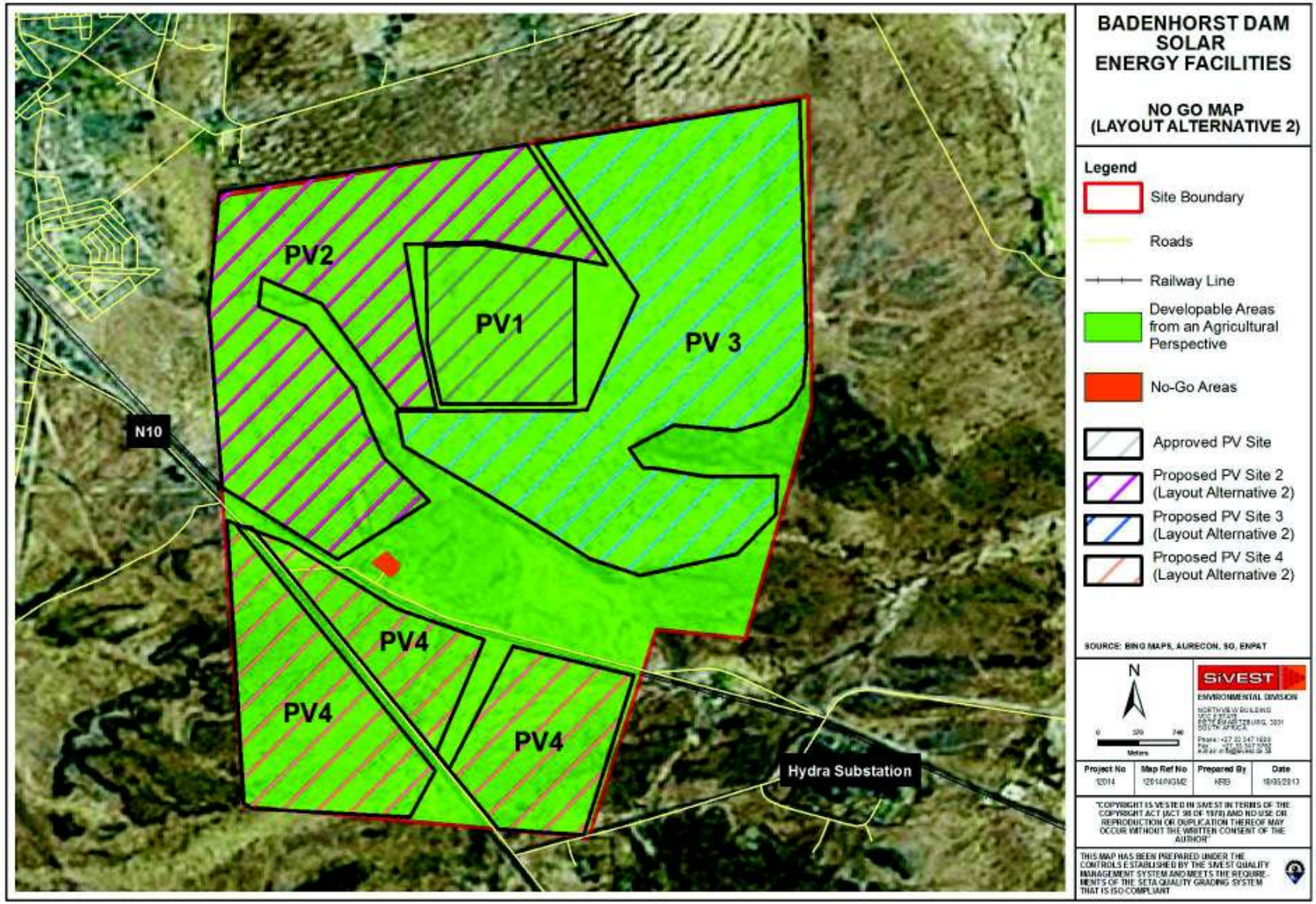

Figure 25: No Go Map (Agriculture) and Layout Alternative 2

6.1 Impact of the proposed PV solar facilities

6.1.1 Construction Phase

The proposed development's primary impact on agricultural activities includes the construction of the solar fields and associated infrastructure, which entails the clearing of vegetation and levelling of the site as indicated in Table 3. This will effectively eliminate the impacted land's agricultural potential in terms of crop production (or in this case, grazing) during the construction phase, which is estimated to last between 12 and 24 months per PV facility. The construction of the solar fields will influence a portion of the farm's total area. The remaining land will continue to function as it did, prior to the development. Furthermore, the proposed PV facilities on the farm will be phased and constructed consecutively, depending on whether the projects are approved by the DoE and DEA (**Aurecon, 2013**). Stocking rates will need to be temporarily reduced during the construction phase in order to reduce the risk of overgrazing the remaining land portions.

Table 3: Summary of the layout alternatives indicating the development and remaining footprint area (Badenhorst Dam)

Layout Alternatives	Total Footprint (ha) and Remaining land (ha)	% of land remaining undeveloped
1 (PV 2, 3, 4 and 5)	879 (1709)	66%
2 (PV 2, 3 and 4)	1816 (772)	30%

6.1.2 Operational Phase

After construction the land will need to be rehabilitated, including the re-vegetation of the solar fields. It is recommended that more palatable grass species are planted to enable faster stocking initiation. It is unlikely that typical vegetation species (Karoo shrubs) will return to the PV fields. The shading of the panels could also influence the vegetation pattern within the PV fields.

In order to further mitigate the potential impacts it is highly recommended that periodic grazing within the PV fields is allowed. This mitigation minimizes the loss of grazing land and reduces the overall impact on agricultural production. Interestingly, the farmers around De Aar have changed from sheep to beef production due to the high prevalence of stock theft. Unfortunately, cattle grazing will not be permitted within the PV fields as the animals could damage the PV panels. In order to overcome this limitation, it is recommended that the farms (within the impact areas) revert back to sheep production and use the proposed PV facilities as rotational grazing camps. The problem of small stock theft should be mitigated by the additional security and fencing associated with the PV facilities.

A simplified and generic phased construction approach and related mitigations are illustrated in **Figure 26**, where

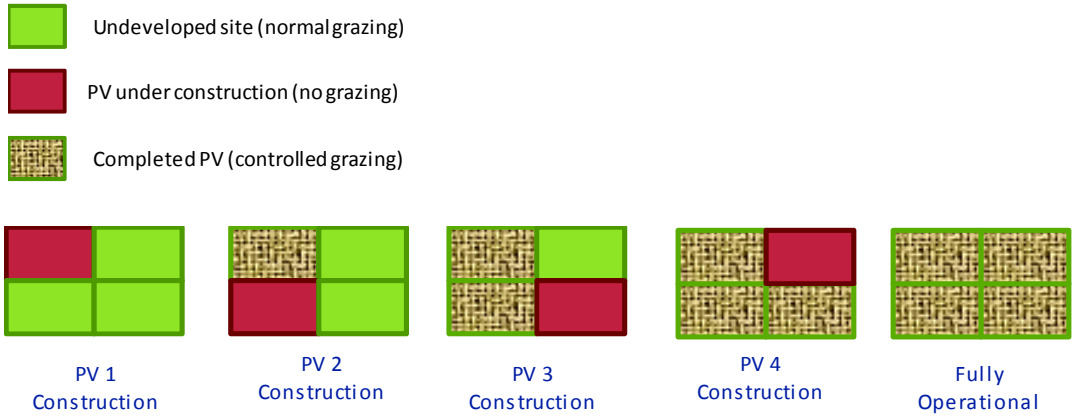

Figure 26: The proposed phased construction approach and grazing schedule (This simplified example is based on the construction of 4 PV facilities but can be adapted to any number of proposed PV facilities)

6.1.3 Cumulative Impacts

A number of solar and renewable energy projects have been proposed in the De Aar area, and thus, the cumulative impact of these developments on surrounding farms could become detrimental to local agricultural resources if the loss of usable grazing land is not taken into account when determining optimum herd size. A phased approach in combination with erosion control and land rehabilitation, within each farm, will reduce this impact. The inherently low agricultural potential of the region also reduces the overall cumulative impact.

6.2 Impact of the Transmission Line and Associated Infrastructure

Three new 132 kV transmission line will be constructed in order to connect the new solar PV facilities to the Eskom grid. A corridor approach has been adopted to assess this impact. According to spatial Land Use data and in-field verification, these routes are dominated by vacant land and unimproved grazing land. Owing to this, the crossing of this land by these power lines will have a very limited impact on agricultural production. Where the lines do cross farm land, normal grazing can still take place under the power lines. The only loss of agricultural land will be directly below the tower's footprint. In terms of line routing, there is no significant variance between agricultural characteristics within the assessment corridor and as such, from an agricultural perspective, the lines may be routed anywhere within this corridor.

The remaining supporting infrastructure, *inter alia* road and water pipe line construction, is envisioned to have a negligible impact on agricultural resources and production.

6.3 Determination of Impact Significance: Methodology

Significance is determined through a synthesis of impact characteristics which include the context and the intensity of an impact. Context refers to the geographical scale (i.e. site, local, national or global) whereas Intensity is defined by the severity of the impact (e.g. the magnitude of deviation from background or baseline conditions, the size of the area affected, the duration of the impact and the overall probability of occurrence). Significance 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. The rating system used in this assessment is based on **Aurecon's Methodology** and is summarised below:

For each impact, the EXTENT (spatial scale), MAGNITUDE and DURATION (time scale) would be described. These criteria would be used to ascertain the SIGNIFICANCE of the impact, firstly in the case of no mitigation and then with the most effective mitigation measure(s) in place.

The tables below indicate the scale used to assess these variables, and defines each of the rating categories.

Table 4: Assessment criteria for the evaluation of impacts

CRITERIA	CATEGORY	DESCRIPTION
Extent or spatial influence of impact	**Regional**	Beyond a 10 km radius of the candidate site.
	Local	Within a 10 km radius of the candidate site.
	Site specific	On site or within 100 m of the candidate site.
Magnitude of impact (at the indicated spatial scale)	**High**	Natural and/ or social functions and/ or processes are *severely* altered
	Medium	Natural and/ or social functions and/ or processes are *notably* altered
	Low	Natural and/ or social functions and/ or processes are *slightly* altered
	Very Low	Natural and/ or social functions and/ or processes are *negligibly* altered
	Zero	Natural and/ or social functions and/ or processes remain *unaltered*

CRITERIA	CATEGORY	DESCRIPTION
Duration of impact	**Construction period**	Up to 4 years if PV facilities is constructed consecutively
	Short Term	Up to 5 years after construction
	Medium Term	5-15 years after construction
	Long Term	More than 15 years after construction

The SIGNIFICANCE of an impact is derived by taking into account the temporal and spatial scales and magnitude. The means of arriving at the different significance ratings is explained in **Table 5**.

Table 5: Definition of significance ratings

SIGNIFICANCE RATINGS	LEVEL OF CRITERIA REQUIRED
High	• High magnitude with a regional extent and long term duration • High magnitude with either a regional extent and medium term duration or a local extent and long term duration • Medium magnitude with a regional extent and long term duration
Medium	• High magnitude with a local extent and medium term duration • High magnitude with a regional extent and construction period or a site specific extent and long term duration • High magnitude with either a local extent and construction period duration or a site specific extent and medium term duration • Medium magnitude with any combination of extent and duration except site specific and construction period or regional and long term • Low magnitude with a regional extent and long term duration
Low	• High magnitude with a site specific extent and construction period duration • Medium magnitude with a site specific extent and construction period duration • Low magnitude with any combination of extent and duration except site specific and construction period or regional and long term • Very low magnitude with a regional extent and long term duration
Very low	• Low magnitude with a site specific extent and construction period duration • Very low magnitude with any combination of extent and duration except regional and long term
Neutral	• Zero magnitude with any combination of extent and duration

Once the significance of an impact has been determined, the PROBABILITY of this impact occurring as well as the CONFIDENCE in the assessment of the impact, would be determined using the rating systems outlined in **Table 6** and **Table 7** respectively. It is important to note that the significance of an impact should always be considered in concert with the probability of that impact occurring. Lastly, the REVERSIBILITY of the impact is estimated using the rating system outlined in **Table 8**.

Table 6: Definition of probability ratings

PROBABILITY RATINGS	CRITERIA
Definite	Estimated greater than 95 % chance of the impact occurring.
Probable	Estimated 5 to 95 % chance of the impact occurring.
Unlikely	Estimated less than 5 % chance of the impact occurring.

Table 7: Definition of confidence ratings

CONFIDENCE RATINGS	CRITERIA
Certain	Wealth of information on and sound understanding of the environmental factors potentially influencing the impact.

Sure	Reasonable amount of useful information on and relatively sound understanding of the environmental factors potentially influencing the impact.
Unsure	Limited useful information on and understanding of the environmental factors potentially influencing this impact.

Table 8: Definition of reversibility ratings

REVERSIBILITY RATINGS	CRITERIA
Irreversible	The activity will lead to an impact that is in all practical terms permanent.
Reversible	The impact is reversible within 2 years after the cause or stress is removed.

6.4 Impact Summaries: Solar Energy Facilities

This impact summary investigates the construction, operational and decommissioning phases of the two Layout Alternatives tabled for Badenhorst Dam Farm as well as the predicted cumulative impacts.

Table 9: Impact rating table for the loss of agricultural land and degradation of soil resources during the construction phase (**Solar Energy Facility: Layout Alternative 1: PV 2, 3, 4 and 5**)

Layout Alternative 1: Construction Phase		
	Pre-mitigation impact rating	Post mitigation impact rating
Extent	**Site specific**	**Site specific**
Magnitude	**Med**	**Low**
Duration	**Construction**	**Construction**
Significance rating	**Low**	**Low**
Probability	**Definite**	**Definite**
Confidence	**Sure**	**Sure**
Reversibility	**Irreversible**	**Reversible**
Mitigation measures	▪ A planned phased approach must be adopted. ▪ Allow normal agricultural activities to continue in unaffected areas. ▪ Stocking rates will need to be temporarily reduced during the construction phase in order to reduce the risk of overgrazing the remaining land portions. ▪ Initiate land rehabilitation and re-vegetation as soon as possible. ▪ Due to the overarching site characteristics, and the nature of the proposed development, the remaining viable mitigation measures are limited and will most likely revolve around erosion control: ➢ The soil erosion plan and associated recommendations should	

	be employed. ➢ Clearing activities should be kept to a minimum. ➢ In the unlikely event that heavy rains are expected, activities should be put on hold to reduce the risk of erosion. ➢ If additional earthworks are required, any steep or large embankments that are expected to be exposed during the 'rainy' months should be armoured with fascine like structures (a fascine structure usually consists of a natural wood material and is used for the strengthening of earthen structures or embankments). ➢ If earth works are required then storm water control and wind screening should be undertaken to prevent soil erosion.

Table 10: Impact rating table for the loss of agricultural land and degradation of soil resources during the construction phase (**Solar Energy Facility: Layout Alternative 2: PV 2, 3 and 4)**

Layout Alternative 2: Construction Phase		
	Pre-mitigation impact rating	Post mitigation impact rating
Extent	**Site specific**	**Site specific**
Magnitude	**Med**	**Med**
Duration	**Construction**	**Construction**
Significance rating	**Low**	**Low**
Probability	**Definite**	**Definite**
Confidence	**Sure**	**Sure**
Reversibility	**Irreversible**	**Reversible**
Mitigation measures	▪ Allow normal agricultural activities to continue in unaffected areas. ▪ Stocking rates will need to be temporarily reduced during the construction phase in order to reduce the risk of overgrazing the remaining land portions. ▪ Initiate land rehabilitation and re-vegetation as soon as possible. ▪ Due to the overarching site characteristics, and the nature of the proposed development, the remaining viable mitigation measures are limited and will most likely revolve around erosion control: ➢ The soil erosion plan and associated recommendations should be employed. ➢ Clearing activities should be kept to a minimum. ➢ In the unlikely event that heavy rains are expected, activities should be put on hold to reduce the risk of erosion. ➢ If additional earthworks are required, any steep or large embankments that are expected to be exposed during the	

	'rainy' months should be armoured with fascine like structures ➢ If earth works are required then storm water control and wind screening should be undertaken to prevent soil erosion.

Table 11: Impact rating table for the loss of agricultural land and degradation of soil resources during the operational phase (**Solar Energy Facility: Layout Alternative 1: PV 2, 3, 4 and 5**)

Layout Alternative 1: Operational Phase		
	Pre-mitigation impact rating	Post mitigation impact rating
Extent	**Site specific**	**Site specific**
Magnitude	**Medium**	**Very Low**
Duration	**Long Term**	**Long Term**
Significance rating	**Medium**	**Very Low**
Probability	**Definite**	**Definite**
Confidence	**Sure**	**Sure**
Reversibility	**Irreversible**	**Reversible**
Mitigation measures	▪ Initiate land rehabilitation and re-vegetation as soon as possible and continue to visually monitor land for early detection of degradation. ▪ It is recommended that more palatable species form part of the re-vegetation plan to enable faster stocking initiation. ▪ Allow normal agricultural activities to continue in unaffected areas. ▪ Allow periodic grazing within the PV fields (sheep and wildlife). This mitigation will minimise the loss of grazing land and reduce the impact on agricultural production. ▪ Unfortunately cattle grazing (large stock unit) will not be permitted within the PV fields as the animals could damage the PV panels. In order to overcome this limitation it is recommended that the impacted areas revert back to sheep production (small stock unit) and use the proposed PV facilities as rotational grazing camps.	

Table 12: Impact rating table for the loss of agricultural land / production and degradation of soil resources during the operational phase (**Solar Energy Facility: Layout Alternative 2: PV 2, 3 and 4)**

Layout Alternative 2: Operational Phase		
	Pre-mitigation impact rating	Post mitigation impact rating
Extent	**Site specific**	**Site specific**
Magnitude	**Medium**	**Very Low**
Duration	**Long Term**	**Long Term**
Significance rating	**Medium**	**Very Low**
Probability	**Definite**	**Definite**
Confidence	**Sure**	**Sure**
Reversibility	**Irreversible**	**Reversible**
Mitigation measures	▪ Initiate land rehabilitation and re-vegetation as soon as possible and continue to monitor land degradation. ▪ It is recommended that more palatable species form part of the re-vegetation plan to enable faster stocking initiation. ▪ Allow normal agricultural activities to continue in unaffected areas. ▪ Allow periodic grazing within the PV fields (sheep and wildlife). This mitigation will minimise the loss of grazing land and reduce the impact on agricultural production. ▪ Unfortunately cattle grazing will not be permitted within the PV fields as the animals could damage the PV panels. In order to overcome this limitation it is recommended that the impacted areas revert back to sheep production and use the proposed PV facilities as rotational grazing camps.	

Table 13: Impact rating table for soil disturbance and temporary disturbance to grazing regime during the decommissioning phase (**Solar Energy Facility: Layout Alternative 1: PV 2, 3, 4 and 5**)

Layout Alternative 1: Decommissioning Phase		
	Pre-mitigation impact rating	Post mitigation impact rating
Extent	**Site specific**	**Site specific**
Magnitude	**Very Low**	**Very Low**
Duration	**Construction**	**Construction**
Significance rating	**Very Low**	**Very Low**
Probability	**Definite**	**Definite**
Confidence	**Sure**	**Sure**
Reversibility	**Reversible**	**Reversible**
Mitigation measures	▪ A planned phased approach must be adopted. ▪ Allow normal agricultural activities to continue in unaffected areas. ▪ Initiate land rehabilitation as soon as possible. ▪ Due to the overarching site characteristics, and the nature of the proposed activities, the remaining viable mitigation measures are limited and will most likely revolve around erosion control: ➢ The soil erosion plan and associated recommendations should be employed. ➢ Clearing activities should be kept to a minimum. ➢ In the unlikely event that heavy rains are expected, activities should be put on hold to reduce the risk of erosion.	

Table 14: Impact rating table for soil disturbance and temporary disturbance to grazing regime during the decommissioning phase (**Solar Energy Facility: Layout Alternative 2: PV 2, 3 and 4)**

Layout Alternative 2: Decommissioning Phase		
	Pre-mitigation impact rating	Post mitigation impact rating
Extent	**Site specific**	**Site specific**
Magnitude	**Medium**	**Very Low**
Duration	**Long Term**	**Long Term**
Significance rating	**Medium**	**Very Low**
Probability	**Definite**	**Definite**
Confidence	**Sure**	**Sure**

Reversibility	**Irreversible**	**Reversible**
Mitigation measures	▪ A planned phased approach must be adopted. ▪ Allow normal agricultural activities to continue in unaffected areas. ▪ Initiate land rehabilitation as soon as possible. ▪ Due to the overarching site characteristics, and the nature of the proposed activities, the remaining viable mitigation measures are limited and will most likely revolve around erosion control: ➢ The soil erosion plan and associated recommendations should be employed. ➢ Clearing activities should be kept to a minimum. ▪ In the unlikely event that heavy rains are expected, activities should be put on hold to reduce the risk of erosion.	

Table 15: Impact rating table for the predicted cumulative loss of agricultural land and degradation of soil resources

Cumulative Impacts		
	Pre-mitigation impact rating	Post mitigation impact rating
Extent	**Regional**	**Regional**
Magnitude	**Low**	**Very Low**
Duration	**Long Term**	**Long Term**
Significance rating	**Medium**	**Low**
Probability	**Probable**	**Probable**
Confidence	**Unsure**	**Unsure**
Reversibility	**Reversible**	**Reversible**
Mitigation measures	▪ A planned phased approach must be adopted. ▪ Allow normal agricultural activities to continue in unaffected areas. ▪ Initiate land rehabilitation and re-vegetation as soon as possible and continue to monitor land for early signs of degradation and erosion.	

6.5 Impact Assessment: Construction and Operational Phases: 132 kV Transmission Lines

Due to the nature of the development, the construction and operational phases have been combined for this particular activity.

Table 16: Impact rating table for construction and operation of a 132 kV Transmission Lines within the corridor

	Pre-mitigation impact rating	Post mitigation impact rating
Extent	**Site**	**Site**
Magnitude	**Very Low**	**Very Low**
Duration	**Long Term**	**Long Term**
Significance rating	**Very Low**	**Very Low**
Probability	**Definite**	**Definite**
Confidence	**Certain**	**Certain**
Reversibility	**Reversible**	**Reversible**
Mitigation measures	▪ Due to the overarching route characteristics, and the nature of the proposed development, viable mitigation measures are limited and will most likely revolve around erosion control: ➢ Clearing activities should be kept to a minimum. ➢ In the unlikely event that heavy rains are expected, activities should be put on hold to reduce the risk of erosion. ➢ If additional earthworks are required, any steep or large embankments that are expected to be exposed during the 'rainy' months should be armoured with fascine like structures ▪ If earth works are required then storm water control and wind screening should be undertaken to prevent soil erosion. ▪ Interact with landowners during the routing process.	

6.7 Preferred Alternatives

It is evident that if the proposed mitigation measures are implemented, then the proposed activities will have a low impact on current agricultural production and soil resources.

From an agricultural perspective the post-mitigation impact scores are similar for the preferred and alternative layouts. However, the **Layout Alternative 1** is more desirable. This layout affects around 34% of the total farm area, compared to the 70% coverage of the alternative layout. The preferred layout will also allow normal agricultural activities to continue for longer and on greater portions of the remaining farm. The proposed phased approach will also reduce cumulative impacts and should also allow for easier site management, rehabilitation and grazing scheduling. The preferred layout also precludes the major drainage lines, which are associated with the highest grazing potential.

In terms of line routing, there is no significant variance in agricultural characteristics within the assessment corridor and as such, from an agricultural perspective, the entire corridor is suitable to accommodate the proposed transmission line.

7. EROSION MANAGEMENT PLAN

Soil is a natural resource, is non-renewable in the short term and is expensive either to reclaim or improve following degradation (**van Lynden & Oldeman, 1997**). Even though the areas directly affected by the proposed developments have low agricultural value and capability, the activities still have the potential to negatively impact the immediate and surrounding soil and land resources. The ***International Soil Reference and Information Centre*** **(ISRIC)**, the producers of the World Map of Human-Induced Soil Degradation, recognises two categories of human-induced soil degradation processes.

The **first category** deals with soil degradation by displacement of soil material mainly through water and wind erosion. Soil erosion causes land degradation through a reduction in agricultural potential in many parts of South Africa. The major issues surrounding soil erosion are the loss of the top soil layer required for plant growth, reduction of soil nutrients, siltation of aquatic systems, as well as the general land and ecosystem degradation.

The **second category** of soil degradation deals with in-situ soil physical, chemical and biological deterioration. In-situ soil degradation due to anthropogenic activities can be divided into various classes and subclasses:

- **Physical Degradation** (waterlogging, compaction, crusting, pore modification, etc.)
- **Chemical Degradation** (eutrophication, acidification, salinisation, heavy metal pollution, etc.)
- **Biological Degradation** (pathogen introduction, modification of microbial activity etc.)

A single or combination of the aforementioned degradations leads to a decrease in soil quality/health, which in turn influences land capability ratings (**ISRIC, 1990**). Due to the proposed activities this management plan focuses primarily on soil erosion however generic soil contamination mitigations are provided in **Section 7.3**.

7.1 Soil Erosion Monitoring

Due to the size of the site and without rigorous scientific methods and equipment, soil erosion will need to be monitored visually by the appointed Environmental Control Officer (ECO)[2]. Soil erosion is a natural process, whose rate and intensity can be anthropogenically increased. Excessive erosion can lead to land degradation and the reduction of the area's carrying capacity. It is recommended that areas around roads, stockpiles and PV panels are visually monitored during audits. A photographic record of the on-site conditions will also aid in the identification of erosion problems A quarterly (3 month) photographic frequency is recommended. However, photographs should also be taken immediately after significant rainfall events, as these events are associated with the highest rate of erosion. Signs of rill and gully erosion should be remediated as soon as possible. Typical remediation techniques are provided in **Section 7.2**, below.

7.2 Proposed Soil Erosion Mitigatory Measures

Clearing activities should be kept to a minimum and must only be undertaken during agreed working times, as well as permitted weather conditions. If heavy rains are expected clearing activities should be put on hold. In this regard, the contractor must be aware of weather forecasts. The further unnecessary removal of groundcover vegetation from slopes must be prevented, especially on steep slopes. Following the clearing of an area, the surfaces of all exposed slopes must be roughened to retain water and increase infiltration (especially important during the wet season). Any steep or large embankments that are expected to be exposed during the 'rainy' months should either be armoured with fascine[3] like structures or vegetated. If a cleared area is not going to be built on immediately, the top layer (nominally 150 mm) of soil should be removed and stockpiled in a designated area approved by the ECO. Vegetation shall be stripped in a sequential manner as the work proceeds so as to reduce the time that stripped areas are exposed to the elements. Top-soiling and re-vegetation shall start immediately after the completion of an activity and at an agreed distance behind any particular work front. It is highly recommended that existing farm roads are used as much as possible, while the additional creation of access roads should be kept to a minimum.

Storm water control and wind screening should be undertaken to prevent soil loss from the site. All embankments shall be protected by a cut off drain to prevent water from running down the face of the embankment, resulting in soil erosion. Typical erosion control measures such as the installation of silt fences, hay bales, EcoLogs™ and Bio Jute™ are recommended if erosion problems are noted during construction and operation phases (**Figure 27**).

[2] The person appointed will provide direction to the Contractor concerning the activities within the Construction Zone, and who will be responsible for conducting the Environmental Audit of the project during the construction and operational phases of the project.

[3] A fascine structure usually consists of natural wood material and is used for the strengthening earthen structures or embankments.

Figure 27: Typical soil erosion mitigatory measure: BioJute Installtion (**top left**); a silt fence protecting a stockpile (**top right**) and pegged hay bale wall used to reduce runoff velocities (**bottom**)

7.3 Proposed Groundwater and Soil Contamination Mitigatory Measures

Every precaution must be taken to ensure that chemicals and hazardous substances do not contaminate the soil or groundwater on site.

For this purpose the Contractor must:

- Ensure that the mixing /decanting of all chemicals and hazardous materials should take place on a tray or impermeable surface.
- Dispose of any generated waste at a registered landfill site.
- Ensure all storage tanks are designed and managed in order to prevent pollution of drains, groundwater and soils.
- Construct separate storm water collection areas and interceptors at storage tanks, and other associated potential pollution activities.
- Ensure the control of fuels and chemicals in order to prevent spillage potential ground leaching. Adequate spillage containment measures shall be implemented, such as cut off drains, etc. Fuel and chemical storage containers shall be set on a concrete plinth. The containment capacity shall be equal to the full amount of material stored, plus 10%.
- Appoint appropriate contractors to remove any residue from spillages from site. Handling, storage and disposal of excess or containers of potentially hazardous materials shall be in accordance with the requirements of the above-mentioned Regulations and Acts.
- Ensure that used oils/lubricants are not disposed of on/near the site, and that contractors purchasing these materials understand the liability under which they must operate. The ECO will be responsible for reporting the storage/use of any other potentially harmful materials to the relevant authority.

- Ensure that potentially harmful materials are properly stored in a dry, secure environment, with concrete or sealed flooring. The ECO will ensure that materials storage facilities are cleaned/maintained on a regular basis, and that leaking containers are disposed of in a manner that allows no spillage onto the bare soil or surface water. The management of such storage facilities and means of securing them shall be agreed upon.
- Site staff shall not be permitted to use any stream, river, other open water body or natural water source adjacent to or within the designated site for the purposes of bathing, washing of clothing or for any other construction or related activities. Municipal water or another source approved by the ECO should rather be used for all activities such as washing of equipment, dust suppression, concrete mixing and compacting.

7.4 Stockpile Management

General requirements for stockpiles include that they should be situated in an area that should not obstruct the natural water pathways on site. Topsoil stockpiles will be kept separate from other stockpiles, shall not be compacted, and shall not exceed 2m in height. If exposed to windy conditions or heavy rain, stockpiles should be protected by re-vegetation using an indigenous grass seed mix or cloth, depending on the duration of the project. The construction of a berm consisting of sand bags, or a low brick wall, can be placed around the base of the stockpile for retention purposes. Stockpiles should be weeded regularly; to ensure they are kept free of alien vegetation and shall be kept free of any contaminants whatsoever, including paints, building rubble, cement, chemicals, oil, etc.

Subsoil and topsoil stockpiles will be moved to areas of final utilisation as soon as possible to avoid unnecessary erosion. Stockpiles not utilized within three months of the initial stripping process (or prior to the onset of seasonal rains) will be seeded with appropriate grass seed mixes, including indigenous grasses to further avoid possible erosion.

7.5 Land Rehabilitation

All rubble is to be removed from the site to an approved landfill site as per the construction phase requirements. No remaining rubble is to be buried on site. The site is to be free of litter, and surfaces are to be checked and cleared of waste products resulting from activities such as concreting or asphalting.

After construction the land will need to be rehabilitated, which includes a re-vegetation plan. It is recommended that more palatable species are planted to enable faster stocking initiation.

8. SUMMARY AND RECOMMENDATIONS

Aurecon on behalf of Mulilo Renewable Energy requested a baseline assessment of the soil, land use and agricultural characteristics for the areas affected by the proposed construction of four separate solar energy facilities, on Badenhorst Dam Farm (Portion 1 of Farm 180), near De Aar in the Northern Cape.

A detailed soil and agricultural report was undertaken for Badenhorst Dam Farm in January 2012, as part of an Environmental Impact Assessment for a 100 MW Photovoltaic (PV) solar energy facility, known as Badenhorst PV1. Environmental Authorisation for this project was granted for this project in July 2012. Mulilo now plans to construct four additional PV facilities on Badenhorst Dam Farm as an attempt to maximise the generation capacity of the farm.

The farm consists mainly of flat grassy plains with limited kopjes and rolling hills. Due to small stock theft the farm is currently used as grazing land for cattle and Springbok. Access to the site is obtained via the N10 and private farm roads. The access and internal roads are in good condition. Water is the major limiting factor to local agricultural enterprises and the assessed area does not border a perennial river. The surrounding land is comparable to the study area and is dominated by agricultural grazing land.

The study area has a semi-arid to arid continental climate with a summer rainfall regime i.e. most of the rainfall is confined to summer and early autumn. MAP is approximately 300 mm per year. The low rainfall and moisture availability is reflected in the lack of dry land crop production within the study area. The climate for the study area is severely restrictive to arable agriculture, primarily due to the lack of rainfall and severe moisture availability restrictions. The study area is dominated by flat and gently sloping topography with an average gradient of less than 5% making the this area ideal for intensive agriculture with high potential for large scale mechanisation. The site does, however contain a number of small rocky outcrops and ridges, which are limiting to arable agriculture. From a developmental perspective the flat areas, which dominate the site, will also allow for minimal earthworks and site preparation.

The soils identified on the Badenhorst Dam Site are predominantly shallow and rocky with a low agricultural potential. Rocky soils (Mispah and Glenrosa Forms) cover 57% of the surveyed area while shallow duplex soils (Swartland) cover 38%. Most soils contained a layer that was limiting to plant growth and these layers included rock, saprolite, hard pan carbonate and strongly structured cutanic horizons Soils with an effective depth of greater than 50 cm were rarely observed during the soil survey. The physical and chemical limitations associated with the dominate forms, will in most instances, restrict these soils to extensive grazing.

The majority of the site has been classified as having low potential for crop production due to an arid climate and highly restrictive soil characteristics. Two small areas, characterised by the Oakleaf Soil Form has been conservatively rated as having moderate agricultural potential. The site is not classified as high potential, nor is it a unique dry land agricultural resource. The site is considered to have a moderate to moderately low value when utilised as grazing land, its current use.

The site does not currently accommodate any centre pivots or irrigation schemes. Active fields, near the homestead, are characterised by improved pastures (less than 1% of the site). Although these fields are still characterised by low value agricultural land, they still represent actively cultivated land. These fields are precluded from development layouts and thus the overall impact on the study area's agricultural potential and production will be low, due to the remaining areas low inherent agricultural potential and/or value.

The proposed development's primary impact on agricultural activities will involve the construction of the solar fields and associated infrastructure. This will entail the clearing of vegetation and levelling of the site. This will effectively eliminate the impacted land's agricultural potential in terms of crop production, or in this case grazing, during the construction phase, which is estimated to last between 12 and 24 months. The construction of the solar fields will influence a portion of the farms total area. The remaining land will continue to function as it did prior to the development. Furthermore, facilities on the farm will be phased and constructed consecutively depending on whether the projects are approved by the DoE and DEA. Stocking rates will need to be temporarily reduced during the construction phase in order to reduce the risk of overgrazing on the remaining land portions.

After construction the land will need to be rehabilitated, including the re-vegetation of the solar fields. It is recommended that more palatable species are planted to enable faster stocking initiation.

In order to further mitigate the potential impacts it is highly recommended that periodic grazing within the PV fields is allowed. This mitigation will minimise the loss of grazing land and reduce the overall impact on agricultural production. Interestingly the farmers around the De Aar have changed from sheep to beef production due to the high prevalence of stock theft. Unfortunately cattle grazing will not be permitted within the PV fields as the animals could damage the PV panels. In order to overcome this limitation it is recommended that the farms revert back to sheep production (in the impacted areas) and use the proposed PV facilities as rotational grazing camps. The problem of small stock theft should be mitigated by the additional security and fencing associated with the PV facilities.

A number of solar and renewable energy projects have been proposed in the De Aar area and thus, the cumulative impact of these developments on surrounding farms could become detrimental to local agricultural resources, if the loss of usable grazing land is not taken into account when determining optimum herd size. A phased approach for each farm in combination with erosion control and land rehabilitation within each farm will reduce this impact. The inherently low agricultural potential of the region also reduces the overall cumulative impact.

From an agricultural perspective the post-mitigation impact scores are similar for the preferred and alternative layouts. However, the **Layout Alternative 1** is more desirable. This layout influences around 34% of the total farm area, compared to the 70% coverage of the alternative layout. The preferred layout will also allow normal agricultural activities to continue for longer and on greater portions of the remaining farm. The proposed phased approach will also reduce cumulative impacts and should also allow for easier site management, rehabilitation and grazing scheduling. The preferred layout also precludes the major drainage lines, which are associated with the highest grazing potential.

In terms of the transmission, there is no significant variance in agricultural characteristics within the assessment corridor and as such, from an agricultural perspective, the entire corridor is suitable to accommodate the proposed transmission line.

If the suggested mitigation measures and erosion management plan are correctly implemented there is no reason why the proposed solar energy facilities and supporting infrastructure cannot be accommodated on the Badenhorst Dam Site.

9. REFERENCES

AGIS Database. (2013). Source: *http://www.agis.agric.za/agisweb/agis.html*

Aurecon South Africa. (2013). Draft Scoping Reports for the Proposed Photovoltaic (solar) Energy Facilities on Badenhorst Dam Farm near De Aar, Northern Cape.

Brady, N.C., and Weil, R.R. (2004). Elements of The Nature and Properties of Soils, 2nd edn. Upper Saddle, NJ: Prentice-Hall.

Department of Environmental Affairs and Tourism. (2001). *Environmental Potential Atlas for South Africa.* Source: www.environment.gov.za/enviro-info/enpat.htm.

FAO. (2007) Mapping biophysical factors that influence agricultural production and rural vulnerability. Source: www.fao.org/docrep/010/a1075e/a1075e00.HTM.

Fey, M. (2010). Soils of South Africa. Cambridge University Press.

Mucina, L. and Rutherford, M.C.(eds). 2006. The Vegetation of South Africa, Lesotho and Swaziland. Strelitzia 19. South African National Biodiversity Institute, Pretoria.

SAWS. (2010). Climate Information for De Aar. Source: http://www.weathersa.co.za/Climat/Climstats/DeAarStats.jsp

SiVEST (2012). Proposed Solar Energy Facilities Near De Aar: Final Soil and Agricultural Assessment Report.

Smith, B. (2006). The Farming Handbook. University of KwaZulu-Natal Press.

Soil Classification Working Group. (1991). Soil Classification: a taxonomic system for South Africa. ARC-Institute for Soil, Climate and Water, Pretoria.

Van Lyden, **G.W.J.** and **Oldeman**, **L.R.(1997)** The Assessment of the Status of Human-Induced Soil Degradation in South and Southeast Asia. International Soil Reference and Information Centre.

10. APPENDIX A: SOIL PROPERTIES

Auger Number	Soil Form	Soil Family	Effective Depth (m)	Limiting Layer	X	Y
1	Ms	1200	0.1	Rock	24.054990	-30.691140
2	Sw	1122	0.5	Saprolite	24.058380	-30.687700
3	Ms	1200	0.1	Rock	24.059120	-30.686680
4	Gs	1112	0.3	Rock	24.062350	-30.683160
5	Ms	1200	0.1	Rock	24.064080	-30.679300
6	Sw	1122	0.2	Saprolite	24.069310	-30.677670
7	Ms	1200	0.2	Rock	24.078540	-30.678900
8	Sw	1122	0.3	Saprolite	24.084970	-30.679720
9	Ms	1200	0.2	Rock	24.084930	-30.673140
10	Ms	1200	0.2	Rock	24.084840	-30.670050
11	Sw	1122	0.5	Saprolite	24.084720	-30.667910
12	Sw	1122	0.3	Saprolite	24.084680	-30.663250
13	Ms	1200	0.1	Rock	24.084440	-30.658980
14	Sw	1122	0.7	Saprolite	24.078780	-30.663340
15	Sw	1122	0.4	Saprolite	24.076930	-30.667280
16	Sw	1122	0.4	Saprolite	24.075010	-30.671460
17	Sw	1122	0.4	Saprolite	24.073540	-30.674630
18	Ms	1200	0.2	Rock	24.070130	-30.682010
19	Ms	1200	0.2	Rock	24.069230	-30.684000
20	Sw	1122	0.4	Saprolite	24.068210	-30.686030
21	Ms	1200	0.2	Rock	24.066660	-30.689360
22	Ms	1200	0.1	Rock	24.063830	-30.693530
23	Ms	1200	0.1	Rock	24.062790	-30.696150
24	Ms	1200	0.1	Rock	24.058370	-30.694580
25	Sw	1122	0.5	Saprolite	24.063510	-30.686370
26	Ms	1200	0.1	Rock	24.053780	-30.684720
27	Ms	1200	0.1	Rock	24.053250	-30.680540
28	Sw	1122	0.3	Saprolite	24.051670	-30.676930
29	Ms	1200	0.2	Rock	24.051000	-30.675440
30	Ms	1200	0.2	Rock	24.045680	-30.674780
31	Oa	1220	0.8	Rock	24.035110	-30.673790
32	Ms	1200	0.2	Rock	24.035090	-30.676720
33	Oa	1220	0.7	Rock	24.036010	-30.679780
34	Oa	1220	1	Rock	24.039870	-30.682430
35	Ms	1200	0.1	Rock	24.042710	-30.682860
36	Ms	1200	0.1	Rock	24.048590	-30.683560
37	Gs	1112	0.3	Rock	24.046160	-30.683040
38	Ms	1200	0.1	Rock	24.046010	-30.679370
39	Ms	1200	0.1	Rock	24.044240	-30.676470
40	Gs	1112	0.2	Rock	24.035540	-30.670340
41	Gs	1112	0.2	Rock	24.035950	-30.666890
42	Sw	1122	0.4	Saprolite	24.042300	-30.665830
43	Sw	1122	0.3	Saprolite	24.047310	-30.665040
44	Sw	1122	0.5	Saprolite	24.050710	-30.666220
45	Sw	1122	0.3	Saprolite	24.057130	-30.663460
46	Sw	1122	0.3	Saprolite	24.066910	-30.661850
47	Sw	1122	0.3	Saprolite	24.064800	-30.667350
48	Sw	1122	0.2	Saprolite	24.067690	-30.671710
49	Cg	2000	0.1	HPC	24.045940	30.698100
50	Gs	1211	0.2	Rock	24.042390	30.695900
51	Sw	1111	0.5	Saprolite	24.036860	30.692600
52	Cg	2000	0.1	HPC	24.052500	30.701800
53	Ms	1200	0.1	Rock	24.062850	30.704900
54	Sw	1121	0.4	Saprolite	24.070520	30.706800
55	Ms	1100	0.1	Rock	24.05610	30.703200
56	Gs	1211	0.1	Rock	24.046330	30.704900
57	Sw	1111	0.3	Saprolite	24.052870	30.713500
58	Ms	1100	0.1	Rock	24.056830	30.718000
59	Gs	1211	0.2	Saprolite	24.068090	30.719800

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FRESHWATER ASSESSMENT FOR THE PROPOSED PHOTOVOLTAIC (SOLAR) ENERGY FACILITIES ON BADENHORST DAM FARM NEAR DE AAR, NORTHERN CAPE

May 2013

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Executive Summary

Mulilo Renewable Energy (Pty) Ltd (Mulilo) proposes that four PV facilities be constructed at Badenhorst Dam Farm (Portion 1 of Farm 180). A previous EIA was undertaken at the same location and information is available and environmental sensitive areas were taken into consideration in the preliminary designs. It is therefore proposed to further develop a site which is already well studied, found suitable for the proposed development, is located close to existing and proposed Eskom infrastructure, and where no fatal flaws have been identified.

The freshwater features on the farm Badenhorst Dam consist largely of ephemeral tributaries of the Brak River. These tributaries are considered to be in a moderately modified ecological state, with a low ecological importance and sensitivity. The expected impacts of the proposed activities are likely to be as follows:

- *Solar energy facility (brown polygons):* Proposed site is outside of all identified freshwater features/drainage lines on the site therefore potential impact on freshwater features is very low for this component.
- *Laydown areas (yellow polygons):* The proposed areas are outside of any identified freshwater features/drainage lines therefore the potential impact on freshwater features is very low for this component. Of the three areas proposed as laydown areas, Laydown Area 1 is preferred from a freshwater perspective.
- *Overhead transmission lines/corridors (white polygons with yellow lines):* The preferred transmission lines/corridors do not appear to cross any freshwater features/drainage lines therefore the potential impact on freshwater features is very low for this component.
- *Substations (black rectangles).* None of the substations are placed in or near any freshwater features/drainage lines therefore the potential impact on freshwater features is very low for this component.
- *Access routes (red lines) and water pipeline (blue line):* The proposed access route and water pipeline crosses the lower reach of the Sandsloot tributary, however it is below the larger instream dam and just upstream of the Nonzwakazi township where there is no discernible river/drainage channel. The potential impact on freshwater features for this component is expected to be low to very low.

The significance of the proposed alternative layout for the project (Alternative 2) is likely to be more significant as a number of the identified freshwater features/drainage lines on the site will be modified by the proposed activities. Alternative 1 is thus the preferred alternative from a freshwater perspective.

Provided that the following recommended mitigation measures are implemented the overall significance of the potential impact of the preferred option is expected to be very low:

- A buffer of 30m should be maintained adjacent to the identified streams for the proposed PV footprint area as well as the substations. This is currently the case for the preferred development layout.
- Construction activities for the proposed infrastructure that will need to take place within the river channels and riparian zone (i.e. linear development components – roads, transmission lines and water pipeline) should transect the streams at right angles and be limited as far as possible to ensure minimum disturbance of this area. Disturbed areas within the riparian zones and stream beds should be rehabilitated as soon as possible after construction has been completed and revegetated with suitable indigenous vegetation. Where possible previously disturbed areas such as existing roads or transmission line routes should be utilised.
- Construction should preferably take place during the low flow months (May to October) to minimize the risk of erosion and contaminated runoff from construction sites into adjacent freshwater features.
- All rubble, sand and waste material resulting from the construction activities should be removed from any stream and drainage channels to ensure that flow in these channels are not impeded.
- Invasive alien plants should be removed from the disturbed areas within the drainage channels.
- Contaminated runoff from the construction sites should be prevented from entering the streams.
- All materials on the construction sites should be properly stored and contained.
- Disposal of waste from the sites should also be properly managed.
- Construction workers should be given ablution facilities at the construction sites that are located at least 100m away from the river systems/freshwater features and regularly serviced.

A water use authorization application may need to be submitted to the Department of Water Affairs Northern Cape Regional Office for approval of the water use aspects of the proposed activities, in particular a water use authorisation will be required for any development activities relating to the stream crossings.

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1. BACKGROUND

Mulilo Renewable Energy (Pty) Ltd (Mulilo) proposes to construct four separate solar energy facilities, on Badenhorst Dam Farm (Portion 1 of Farm 180), near De Aar in the Northern Cape. Each of the four proposed facilities would have a maximum generation capacity of 75MW Alternating Current (AC) through photovoltaic (PV) technology.

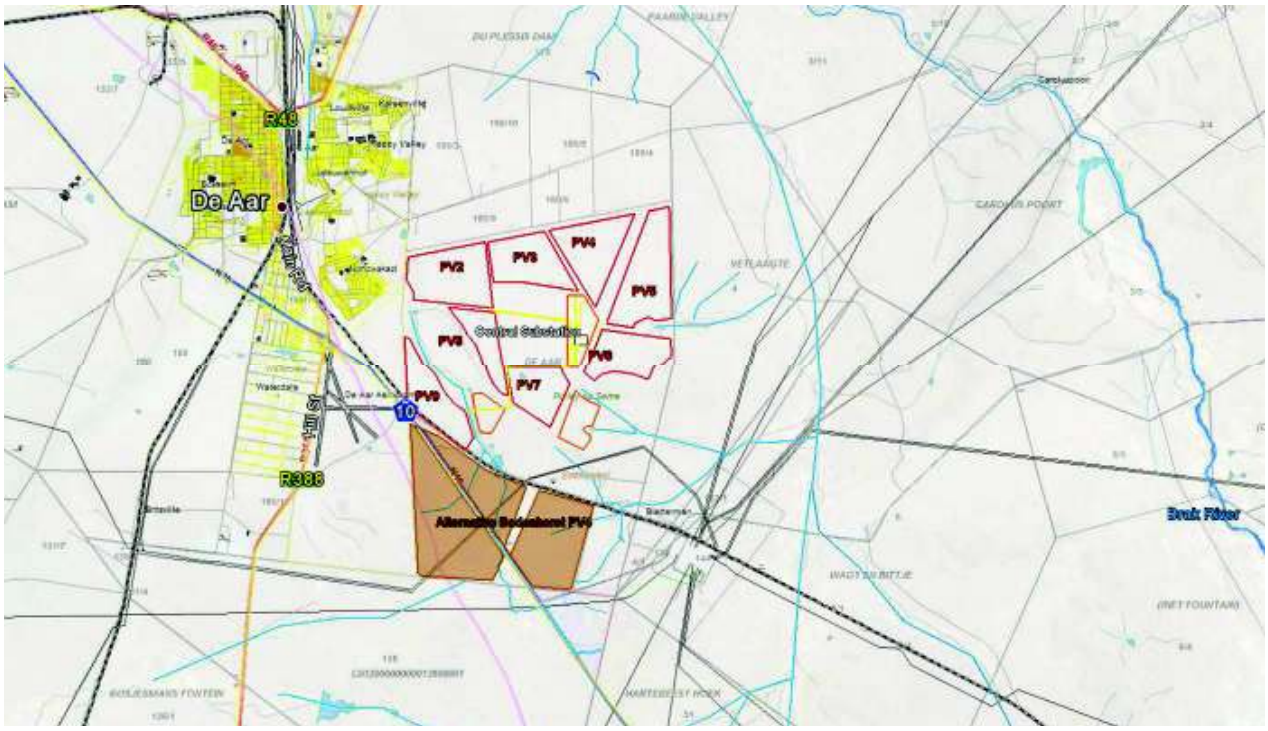


Figure 1. Locality map of the proposed photovoltaic energy facilities

The proposed project would consist of:

- **Technology:** A photovoltaic component comprising of numerous arrays of PV panels to generate up to 75MW per facility, through the photovoltaic effect.
- Transmission lines and substations.
- **Boundary fencing:** Each 75MW facility will be fenced for health, safety and security reasons.
- **Roads:** one access road and internal access roads for servicing and maintenance.
- Water supply infrastructure.
- **Storm water infrastructure:** Including drainage channels, berms, detention areas and kinetic energy dissipaters.
- **Buildings:** Buildings would likely include onsite substations, a connection building, control building, guard cabin, an electrical substation and solar resource measuring substation.

2. TERMS OF REFERENCE

The proposed Terms of Reference for the aquatic specialist studies are as follows:

- Summary of available information pertaining to surface water (streams, dams and wetlands) in close vicinity to the sites;
- Undertake water quality and biotic assessments sampling for stream, wetland and dam condition assessments;
- Describe and determine importance, functionality and trophic state of the water resources;
- Assess the potential impact of the change in site hydrology (quantity) and water chemistry (quality) on any streams, dams and wetlands during the construction and operational phases;
- Assessment of cumulative impacts;
- Evaluate (a) magnitude, frequency of occurrence, duration and probability of impacts, (b) the local, regional, and national significance of predicted impacts, (c) the level of confidence in findings relating to potential impacts, (d) the degree to which the impact can be reversed, and (e) cumulative impacts that may occur as a result of the activities;
- Recommend mitigation measures aimed at minimising the potential negative impacts and enhancing potential positive impacts while retaining reasonable operational efficiencies;
- List additional or required permitting and/or licensing requirements; and
- Take cognisance of the Wetland Delineation Guideline Document of the Department of Water, and if applicable the DEA&DP draft guideline: “Guideline for involving biodiversity specialists in EIA processes.

3. APPROACH TO THE STUDY AND STUDY LIMITATIONS AND ASSUMPTIONS

Input into this report was informed by a combination of desktop assessments of existing freshwater ecosystem information for the study area and catchment, as well as by a more detailed assessment of the freshwater features at the various proposed sites. Aquatic Ecosystem Health assessments were carried out to provide information on the ecological condition and ecological importance and sensitivity of the river and wetland systems to be impacted. The river health and wetland health assessments were carried out using South African Department of Water Affairs developed methodologies.

The site was visited in January 2012 during the first EIA process and again in May 2013 for this assessment. During the field visit, the characterisation, mapping and integrity assessments of the freshwater features were undertaken. This information/data was used to inform the potential impact of the proposed activities as well as the recommended mitigation measures.

Limitations and uncertainties often exist within the various techniques adopted to assess the condition of ecosystems. Analysis of the freshwater ecosystems was undertaken according to nationally developed

methodologies and was undertaken at a rapid level which was considered a suitable level of evaluation for this freshwater impact assessment.

4. USE OF THIS REPORT

This report reflects the professional judgment of its author. The full and unedited content of this should be presented to the client. Any summary of these findings should only be produced in consultation with the author.

5. OVERVIEW OF THE PROPOSAL

5.1. Overview of the Study Area

The study area is situated in the Northern Cape Province, within the boundaries of the Emthanjeni Local Municipality as well as the greater Pixley ka Seme District Municipality near De Aar. The broader landscape consists of predominantly flat lowlands along with few flat-topped hills.

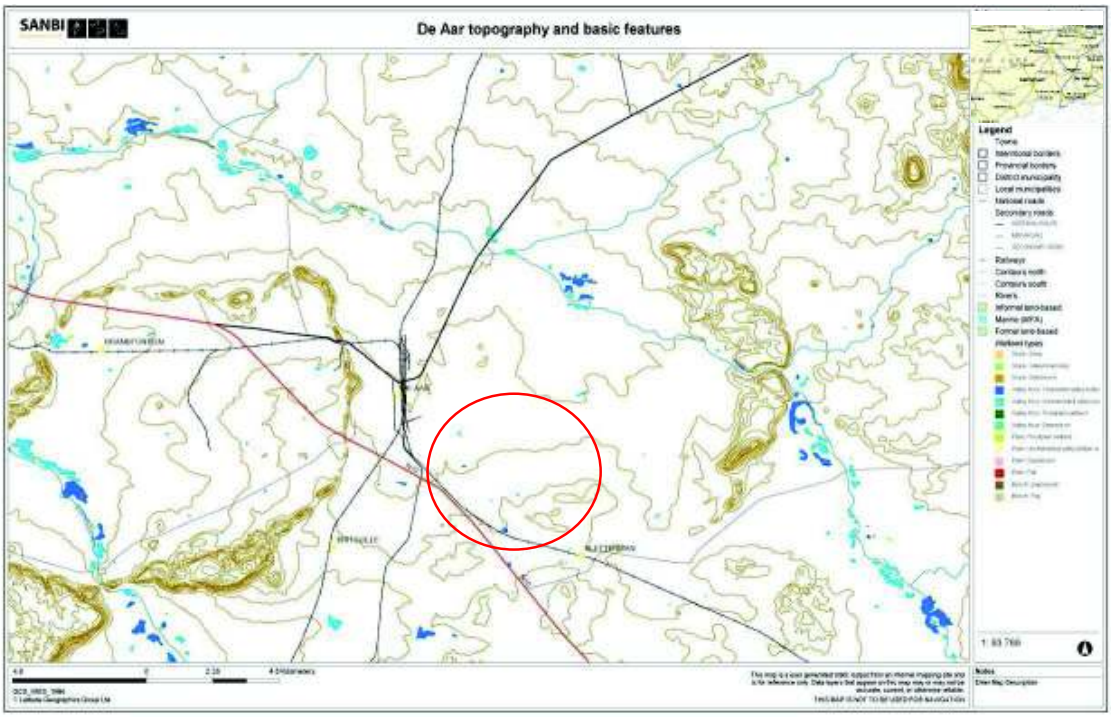


Figure 2. Locality map for the study area

The main water feature in the area is the Brak River, a tributary within the Orange River System. Most of the land surrounding De Aar is undeveloped and only utilised for grazing of sheep, cattle, goats, ostriches or game such as springbok.

5.2. Activity Description

It is proposed that four PV facilities be constructed at Badenhorst Dam Farm (Portion 1 of Farm 180). A previous EIA was undertaken at the same location (Aurecon, 2013) and information is available and environmental sensitive areas were taken into consideration in the preliminary designs. It is therefore proposed to further develop a site which is already well studied, found suitable for the proposed development, is located close to existing and proposed Eskom infrastructure, and where no fatal flaws have been identified. It is also more economically feasible to group developments to promote infrastructure sharing. Mulilo has already received an Environmental Authorisation for one PV facility on this farm.

Layout Alternative 1: This alternative consists of the four proposed 75MW PV facilities and associated infrastructure referred to as PV2, PV3, PV4 and PV5 (Figure 3). These layouts take cognisance of the 75MW Department of Energy's (DoE) capacity limit for solar facilities and the environmentally sensitive areas as identified by Aurecon (2012).

Layout Alternative 2: This alternative consists of three 150MW PV facilities. The layout for these was developed by extending and combining some of the proposed 75MW facilities. This alternative is thus not limited to the DOE's 75MW cap per project.

The layout of Alternative 2 more or less overlaps with the Alternative 1 layout, with the exception of PV4. Extended PV2 is approximately the same extent as PV2 and PV5 combined and extended PV3 is similar to the combined layout of PV3 and PV4. The proposed layout for extended PV4 is located at the southern boundary of the farm.

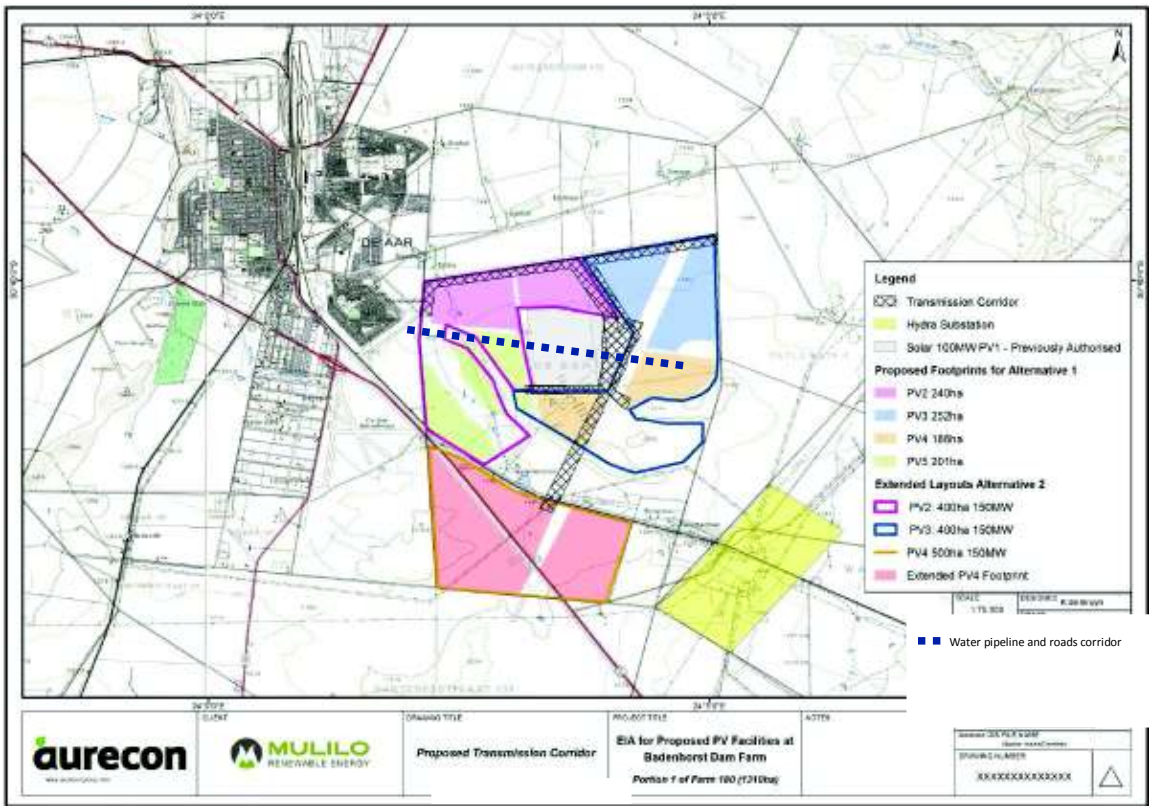


Figure 3. Diagram of the proposed localities of the Photovoltaic power generation facilities

Routing infrastructure: One routing alternative for access roads and water pipeline is being considered

Technology alternatives: The proposed technology is a photovoltaic single axis tracking system with concrete pile mounting

Transmission line routing: One transmission corridor is being considered

Laydown Areas: Three laydown areas are being considered.

5.3. Legal Requirements

The following Acts, regulations and ordinances are applicable to the development:

The National Environmental Management Act (Act No. 107 of 1998) (NEMA)

Chapter Seven of the NEMA states that:

"Every person who causes, has caused or may cause significant pollution or degradation of the environment must take reasonable measures to prevent such pollution or degradation from occurring, continuing or recurring, or, in so far as such harm to the environment is authorised by law or cannot reasonably be avoided or stopped, to minimise and rectify such pollution or degradation of the environment".

The Act also clearly states that the landowner, or the person using or controlling the land, is responsible for taking measures to control and rectify any degradation. These may include measures to:

"(a) investigate, assess and evaluate the impact on the environment;

(b) inform and educate employees about the environmental risks of their work and the manner in which their tasks must be performed in order to avoid causing significant pollution or degradation of the environment:

(c) cease, modify or control any act, activity or process causing the pollution or degradation:

(d) contain or prevent the movement of pollutants or degradation: or

(e) eliminate any source of pollution or degradation: or

(f) remedy the effects of the pollution or degradation."

- NEMA Basic Assessment Regulations, GN R543 of 2010

Activities listed in terms of Chapter 5 of NEMA in Government Notice No. R. 544, 5 and 6 trigger a mandatory Basic Assessment, or even a full scoping EIA process, prior to development.

The National Environmental Management Second Amendment Act (Act No.8 of 2004) provided for formal procedures for offenders in terms of Section 24G to apply for rectification of the unlawful commencement of listed activities.

National Water Act, 1998 (Act No. 36 of 1998)

The purpose of the National Water Act (Act 36 of 1998) (NWA) is to provide a framework for the equitable allocation and sustainable management of water resources. Both surface and groundwater sources are redefined by the NWA as national resources which cannot be owned by any individual, and rights to which are not automatically coupled to land rights, but for which prospective users must apply for authorisation and register as users. The NWA also provides for measures to prevent, control and remedy the pollution of surface and groundwater sources.

- Regulations Requiring that a Water User be Registered, GN R.1352 (1999)

Regulations requiring the registration of water users were promulgated by the Minister of the Department of Water Affairs (DWA) in terms of provision made in section 26(1)(c), read together with section 69 of the NWA. Section 26(1)(c) of the NWA allows for registration of all water uses including existing lawful water use in terms of section 34(2). Section 29(1)(b)(vi) also states that in the case of a general authorisation, the responsible authority may attach a condition requiring the registration of such water use. The Regulations (Art. 3) oblige any water user as defined under section 21 of the Act to register such use with the responsible authority and effectively to apply for a Registration Certificate as contemplated under Art.7(1) of the Regulations.

- General Authorisation in terms of s. 39 of the National Water Act, GN R 1199 of 2009

Government Notice R1199 was issued as a revision of the General Authorisations (No. 1191 of 1999) for Section 21 (c) and (i) water uses as defined under the NWA (Act 36 of 1998). The revision was published and came into effect on 2009/12/18. According to the preamble to Part 6 of the National Water Act, "This Part establishes a procedure to enable a responsible authority, after public consultation, to permit the use *of water by publishing general authorisations in the Gazette...*"

"*The use of water under a general authorisation does not require a licence until the general authorisation is revoked, in which case licensing will be necessary*…"

The authorisation of water use activities for Sections 21 (a) - abstraction, 21 (c) - change to the bed, banks and characteristics of a water course and 21 (i)- impeding and diverting the flow, will need to be applied for at the Northern Cape Regional Office of the Department of Water Affairs. As such, the regional office will need to be notified of the proposed activities and will need to give comments as to whether the activities require a licence process or not in a-non binding letter.

6. AQUATIC SYSTEMS IN THE STUDY AREA

6.1. Description of the Study Area

a. Physical Characteristics

The locality of the proposed project is just southeast of the town of De Aar, in the Northern Cape Province. De Aar was established in 1903 and derives its name refers from the water-bearing arteries that occur underground. The surrounding area is characterised by wide open plains and low hills, with sparse settlements and predominately wide open spaces.

Figure 4. A view of the De Aar area

b. Climate

De Aar normally receives on average about 196mm of rain per year, mostly during autumn. The lowest rainfall (1mm) usually occurs in August and the highest (45mm) in March (Figure 5). The average midday temperatures for De Aar range from 16°C in June to 30.3°C in January. The region is the coldest during July when the mercury drops to 0.3°C on average during the night.

Figure 5. Average monthly rainfall for the area (SA Explorer, 2008)

c. Geology and Soil

The geology of the study area can be described as being underlain by flat-lying sedimentary rocks of the Karoo Supergroup, which have been intruded by innumerable sills and dykes of dolerite.

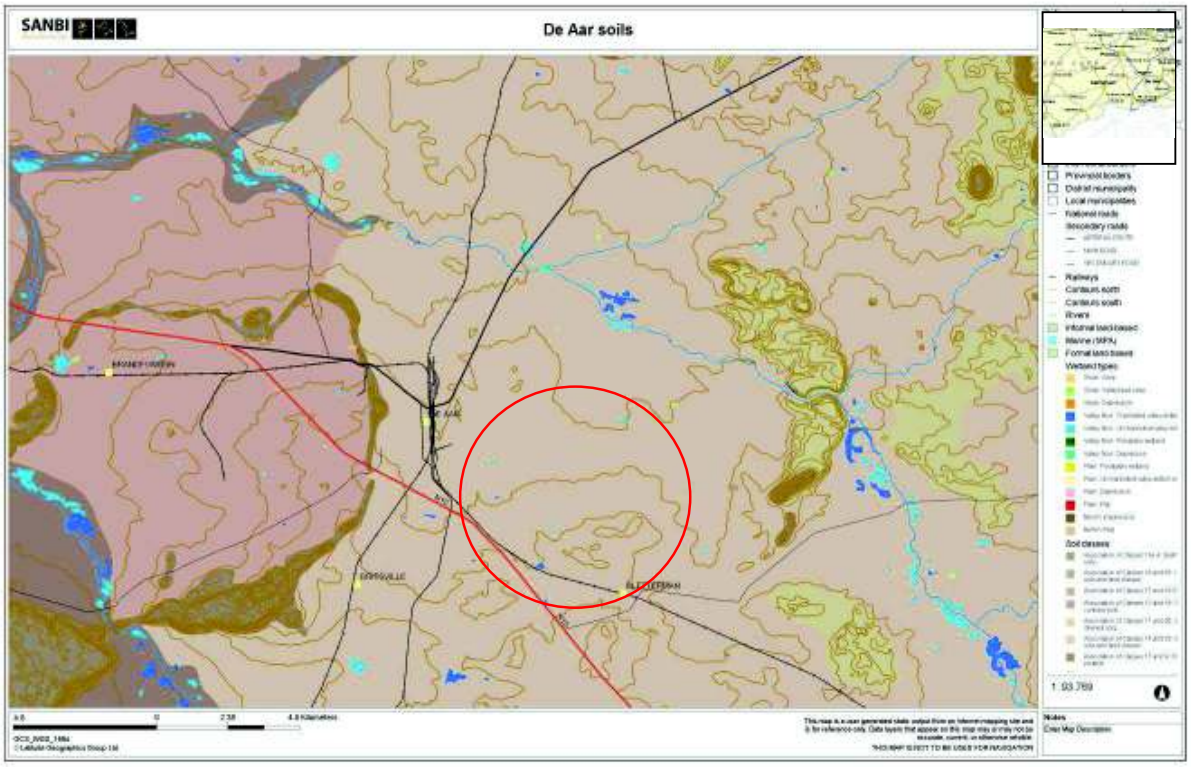


Figure 6. Soil map for the area (Biodiversity GIS, 2009)

The overlying soils are variable from shallow to deep, red-yellow apedal, freely draining soils to very shallow Glenrosa and Mispah forms (Figure 6). The soils in the study site are primarily red soils of a restricted soil depth, excessive drainage, high erodibility and low fertility. Calcrete soils are also prevalent as a result of the climatic conditions and underlying parent material.

d. Flora

The study area lies near the eastern edge of the Nama Karoo biome, and is mapped according to the national vegetation types (2006) as being of the vegetation type Northern Upper Karoo (Figure 7) which is considered to be least threatened. The vegetation cover is generally dominated by sparse dwarf karroid scrub and tufted grass with bare patches of sand in between. Portions of the area are in a disturbed condition, most likely as a result of livestock grazing.

Along the Brak River and the Sandsloot tributary the common reed *Phragmites australis* occurs with very little discernible riparian vegetation. The ephemeral streams have no visible aquatic vegetation.

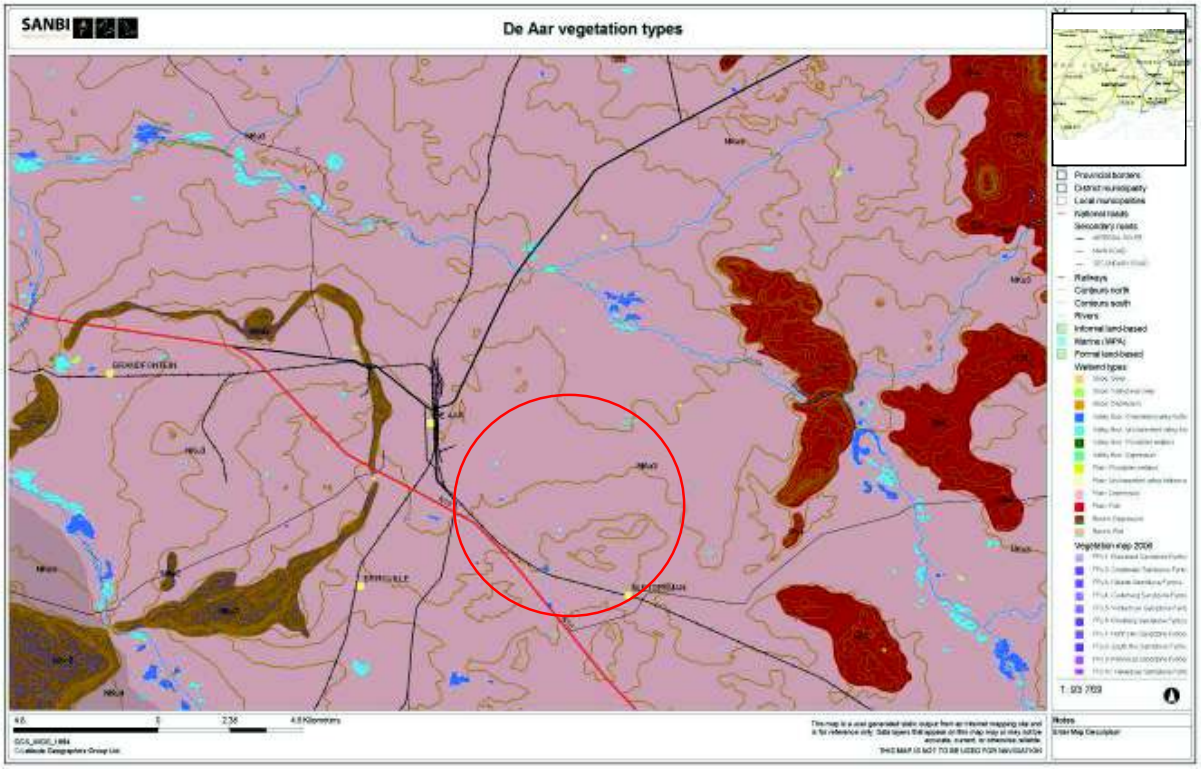


Figure 7. Vegetation map for the area (SANBI Biodiversity GIS)

e. Aquatic features and fauna

The main aquatic feature within the study area is the Brak River (Figure 8), a seasonal tributary within the Orange River System. The river flows along the northern boundary of the study area with a number of its tributaries crossing the site as they flow in a northerly direction. The most notable of the tributaries is the Sandsloot River (Figure 9) which originates near the Badenhorst Dam Farm, flows though the town of De Aar. Most of the other, smaller tributaries within the study area are ephemeral and are discernible only as slightly shallow depressions with no clear associated vegetation and slightly clayey soils (Figure 10). Small, shallow instream dams have been constructed within the drainage channel which flows through the site.

Figure 8. The Brak River north of De Aar

Figure 9. The Sandsloot tributary on Badenhorst Dam Farm with a small instream dam

These freshwater features are discussed in more detail in the following section.

f. Land use

Much of the study area is undeveloped, with some homesteads and the veld being used for grazing of sheep, cattle as well as goats, ostriches and game such as springbok. The closest urban area is De Aar, with the township of Nonzwakazi located adjacent to the western boundary of the farm, Badenhorst Dam. Smaller towns of Britstown, Philipstown, Hanover and Richmond occur within a 65km radius of De Aar.

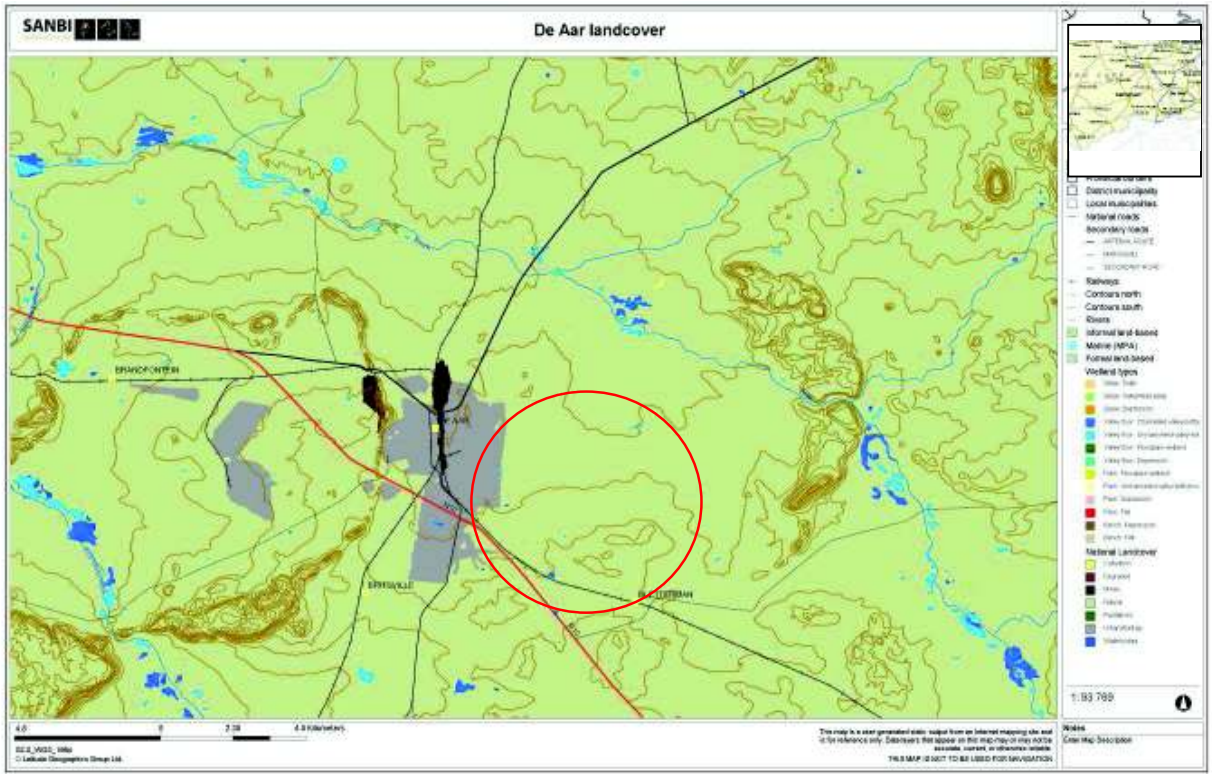


Figure 10. Land cover map for the area (SANBI Biodiversity GIS, 2011)

g. Freshwater Biodiversity and Conservation

In the study area, the Brak River has been identified as having conservation importance. Figure 11 is the Freshwater Ecosystem Protected Areas (FEPA) map for the area. FEPAs are strategic spatial priorities for conserving freshwater ecosystems and associated biodiversity. FEPAs were determined through a process of systematic biodiversity planning and were identified using a range of criteria for serving ecosystems and associated biodiversity of rivers, wetlands and estuaries.

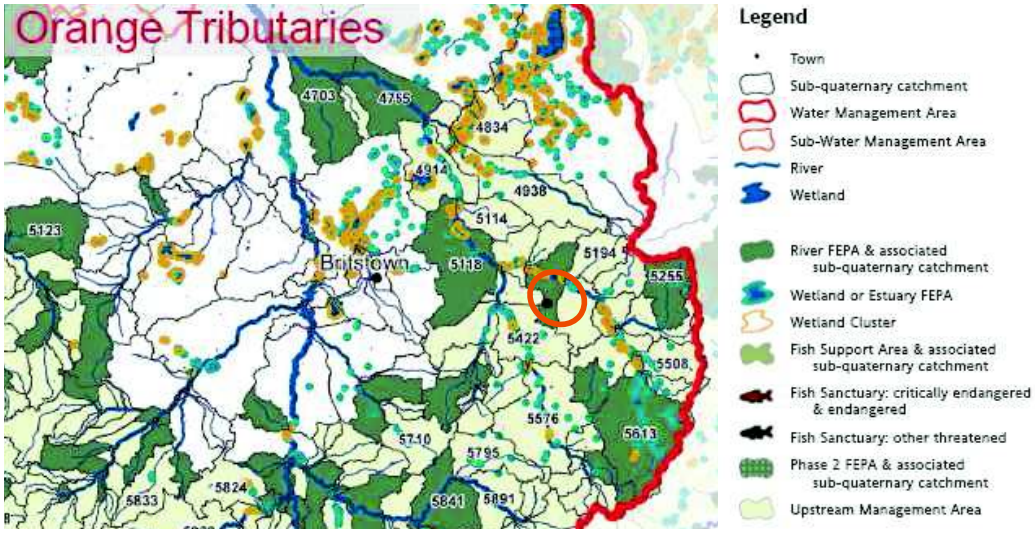


Figure 11. Freshwater Ecosystem Priority Areas for the study area (orange oval)

6.2. Freshwater Assessment of the Study Area

The Index for Habitat Integrity (IHI) and a Site Characterisation were used to provide information on the ecological condition of the Brak River tributaries within the study area.

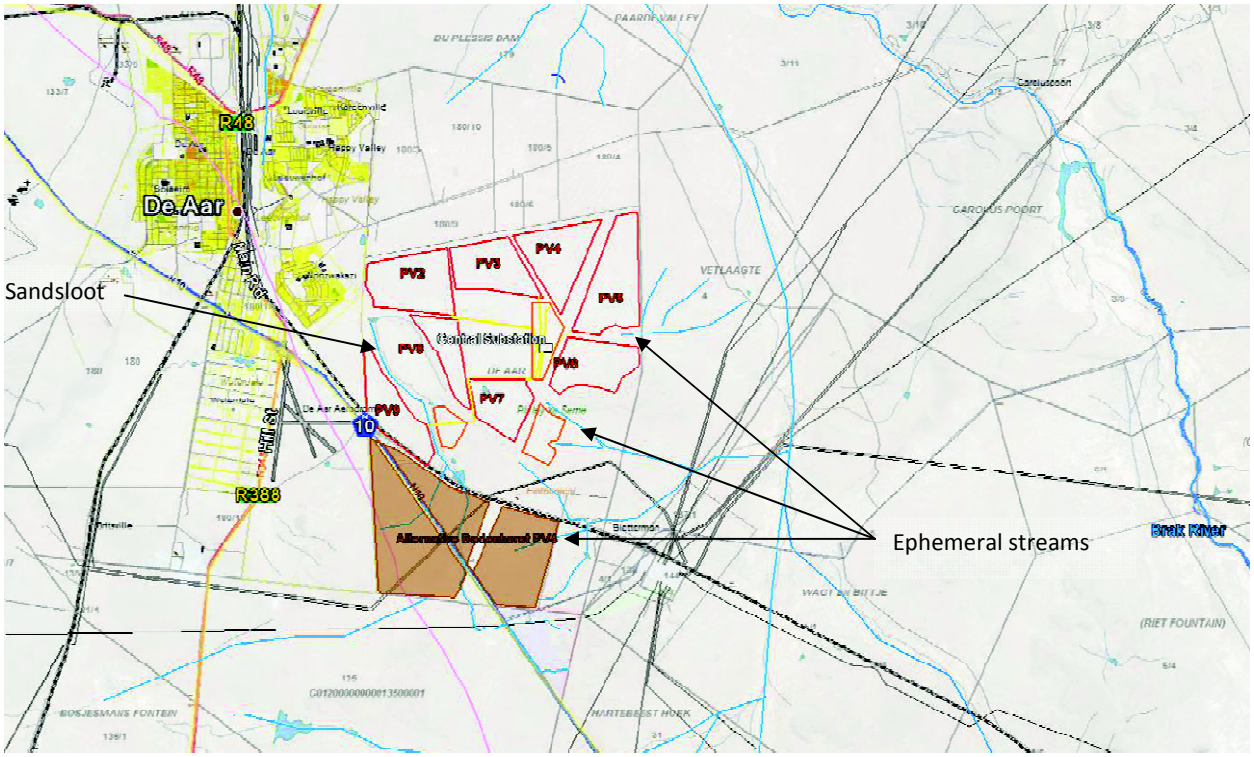


Figure 12. Water features in the study area

River classification

In order to assess the condition and ecological importance and sensitivity of the rivers in the study area, it is necessary to understand how the rivers might have appeared under unimpacted conditions. This is achieved through classifying rivers according to their ecological characteristics, in order that it can be compared to ecologically similar rivers.

River typing or classification involves the hierarchical grouping of rivers into ecologically similar units so that inter- and intra-river variation in factors that influence water chemistry, channel type, substratum composition and hydrology are best accounted for. Any comparative assessment of river condition should only be done between rivers that share similar physical and biological characteristics under natural conditions. Thus, the classification of rivers provides the basis for assessing river condition to allow comparison between similar river types. The primary classification of rivers is a division into Ecoregions. Rivers within an ecoregion are further divided into sub-regions.

Ecoregions are groups of rivers within South Africa, which share similar physiography, climate, geology, soils and potential natural vegetation. For the purposes of this study, the ecoregional classification presented in Department of Water Affairs and Forestry in 1999, which divides the country's rivers into

ecoregions, was used. The river assessed lies within the Nama Karoo Ecoregion, with the characteristics as described in Table 1.

Sub-regions (or geomorphological zones) are groups of rivers, or segments of rivers, within an ecoregion, which share similar geomorphological features, of which gradient is the most important. The use of geomorphological features is based on the assumption that these are a major factor in the determination of the distribution of the biota. Table 2 provides the geomorphological features of the streams assessed.

Table 1. Characteristics of the Nama Karoo Ecoregion (Dominant Types In Bold)

Main Attributes	Description
Terrain Morphology: Broad division	Plains; Low Relief; Plains **Moderate Relief; Lowlands; Hills and Mountains; Moderate and High Relief**; Open Hills, Lowlands; Mountains; Moderate to High Relief; Closed Hills; Mountains; Moderate and High Relief
Vegetation types	Eastern Mixed Nama Karoo; Upper Nama Karoo; **Bushmanland Nama Karoo**; Orange River Nama Karoo
Altitude (m a.m.s.l)	300-1700
MAP (mm)	0 to 500
Rainfall seasonality	Late to very late summer to Winter
Mean annual temp. (°C)	12 to 20
Median annual simulated runoff (mm) for quaternary catchment	<5 to 60

River/Site Characterisation

The Brak River drains shrubland vegetation in an area with a very low rainfall. As a result, the water within the river system is saline and turbid and seasonally flowing. At the time of the field visits in January 2012 and May 2013, the river consisted of isolated pools and was not suited to an assessment of water quality or aquatic biota present. From the Site Characterisation assessments, the geomorphological and physical characteristics of the Brak River tributaries can be classified as shown in Table 2.

Table 2. Geomorphological and Physical features of the Brak River tributaries

River	Ephemeral tributaries of the Brak River
Geomorphological Zone	Foothill rivers in the Upper Karoo Geomorphic Province
Lateral mobility	Unconfined
Channel form	Complex
Channel pattern	Multiple thread: low sinuosity
Channel type	Silt/clayey with pebbles
Channel modification	Moderate modification (trampling and grazing within river channel, instream impoundments)
Hydrological type	ephemeral
Ecoregion	Nama Karoo
DWA catchment	D62D
Vegetation type	Northern Upper Karoo shrubland
Rainfall region	Autumn

c. Index of Habitat Integrity

The evaluation of Index of Habitat Integrity (IHI) provides a measure of the degree to which a river has been modified from its natural state. This assessment was undertaken for the Brak River tributaries (Table 3). The methodology (DWAF, 1999) involves a qualitative assessment of the number and severity of anthropogenic perturbations on a river and the damage they potentially inflict upon the system. These disturbances include both abiotic and biotic factors, which are regarded as the primary causes of degradation of a river. The severity of each impact is ranked using a six-point scale with 0 (no impact), 1 to 5 (small impact), 6 to 10 (moderate impact), 11 to 15 (large impact), 16 to 20 (serious impact) and 21 to 25 (critical impact).

The IHI assessment is based on an evaluation of the impacts of two components of the rivers, the riparian zone and the instream habitat. Assessments are made separately for both components, but data for the riparian zone are interpreted primarily in terms of the potential impact on the instream component.

The estimated impact of each criterion is calculated as follows:

Rating for the criterion/maximum value (25) x weight (percent)

The estimated impacts of all criteria calculated in this way are summed, expressed as a percentage and subtracted from 100 to arrive at an assessment of habitat integrity for the instream and riparian components respectively. The total scores for the instream and riparian zone components are then used to place the habitat integrity of both in a specific habitat category (Table 3).

Table 3: Habitat Integrity categories (From DWAF, 1999)

Category	Description	Score (% of Total)
A	Unmodified, natural.	90-100
B	Largely natural with few modifications. A small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged.	80-90
C	Moderately modified. A loss and change of natural habitat and biota have occurred but the basic ecosystem functions are still predominantly unchanged.	60-79
D	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred.	40-59
E	The loss of natural habitat, biota and basic ecosystem functions is extensive.	20-39
F	Modifications have reached a critical level and the lotic system has been modified completely with an almost complete loss of natural habitat and biota. In worst instances, basic ecosystem functions have been destroyed and changes are irreversible.	0

The ephemeral streams at Badenhorst Dam (Figure 13 and 16) are moderately modified with the modification of the habitat occurring as a result of the surrounding farming activities (livestock grazing). The results from the habitat integrity assessment are shown in Table 4.

Table 4. Index of Habitat Integrity Assessment results and criteria assessed of ephemeral tributaries

Instream Criteria	Weight	Score	Riparian Zone Criteria	Weight	Score
Water abstraction	14	8	Water abstraction	13	8
Flow modification	13	12	Inundations	11	8
Bed modification	13	10	Flow modification	12	12
Channel modification	13	8	Water quality	13	4
Water quality	14	4	Indigenous vegetation removal	13	9
Inundation	10	8	Exotic vegetation encroachment	12	3
Exotic macrophytes	9	0	Bank erosion	14	4
Exotic fauna	8	0	Channel modification	12	8
Solid waste disposal	6	1			
Category		C	Category		C

Figure 13. The ephemeral stream at Badenhorst Dam – past veld fires and livestock grazing have resulted in reduced vegetation cover

d. Ecological Importance and Sensitivity (EIS)

EIS (Table 5) considers a number of biotic and habitat determinants surmised to indicate either importance or sensitivity. The determinants are rated according to a four-point scale (Table 6). The median of the resultant score is calculated to derive the EIS category (Table 7).

Table 5. Ecological importance and sensitivity categories (DWAF, 1999)

EISC	General description	Range of median
Very high	Quaternaries/delineations that are considered to be unique on a national and international level based on unique biodiversity (habitat diversity, species diversity, unique species, rare and endangered species). These rivers (in terms of biota and habitat) are usually very sensitive to flow modifications and have no or only a small capacity for use.	>3-4
High	Quaternaries/delineations that are considered to be unique on a national scale based on their biodiversity (habitat diversity, species diversity, unique species, rare and endangered species). These rivers (in terms of biota and habitat) may be sensitive to flow modifications but in some cases may have substantial capacity for use.	>2-≤3

Moderate	Quaternaries/delineations that are considered to be unique on a provincial or local scale due to biodiversity (habitat diversity, species diversity, unique species, rare and endangered species). These rivers (in terms of biota and habitat) are not usually very sensitive to flow modifications and often have substantial capacity for use.	>1-≤2
Low/ marginal	Quaternaries/delineations that are not unique on any scale. These rivers (in terms of biota and habitat) are generally not very sensitive to flow modifications and usually have substantial capacity for use.	≤1

Table 6. Definition of the four-point scale used to assess biotic and habitat determinants presumed to indicate either importance or sensitivity

Scale	Definition
1	One species/taxon judged as rare or endangered at a local scale.
2	More than one species/taxon judged to be rare or endangered on a local scale.
3	One or more species/taxon judged to be rare or endangered on a Provincial/regional scale.
4	One or more species/taxon judged as rare or endangered on a National scale (i.e. SA Red Data Books)

Table 7. Results of the EIS assessment for the Brak River tributaries

Biotic Determinants	Ephemeral tributaries
Rare and endangered biota	0
Unique biota	0
Intolerant biota	0
Species/taxon richness	1
Aquatic Habitat Determinants	
Diversity of aquatic habitat types or features	1
Refuge value of habitat type	0
Sensitivity of habitat to flow changes	1
Sensitivity of flow related water quality changes	1
Migration route/corridor for instream and riparian biota	1
National parks, wilderness areas, Nature Reserves, Natural Heritage sites, Natural areas, PNEs	0
RATINGS	0.5
EIS CATEGORY	Low

The rivers are all considered to be of a low Ecological Importance and Sensitivity.

7. ASSESSMENT OF IMPACTS

7.1. Description and assessment of Impacts of proposed activities

This section provides an assessment of the overall potential impacts to freshwater ecosystems that are likely to be associated with the proposed activities. The impact assessment and recommended mitigation measures are grouped according to the various proposed activities, that is, the proposed solar energy facilities; the overhead transmission lines, the access routes and the supporting infrastructure. More detailed impacts for specific aspects of the project for each activity and its alternatives are dealt with in more detail in the next section.

Impact of proposed Solar Energy Facilities:

Construction Phase

Nature of Impact: Due to the intensive nature of the construction activities for the solar energy facilities, they could be expected to have a moderate impact on any freshwater features within the proposed development area. For the preferred development layout the PV sites have been selected are outside of any of the identified freshwater features identified in the previous freshwater assessment for the area. Thus there is likely to be a limited impact on the ecological condition of these features as a result of a change of land cover of the surrounding landscape. The proposed alternative is likely to have a more significant impact as freshwater features are included within the proposed PV sites (see following section for more detail).

Clearing of the land of its covering vegetation could result in eroded areas which could extend into the freshwater features near the proposed construction areas. The disturbance of the site compaction of the soils will also impact on the surface and subsurface water flow on the site. In addition, the disturbance of habitat during and after the construction activities provides an opportunity for invasive alien plants to proliferate into the disturbed areas. Impairment of the surface water quality and an increase in turbidity could potentially occur, namely sedimentation during the construction phase, if activities are to take place during the wet season.

Significance of impacts without mitigation: A localized shorter term impact (up to four years) of moderate to high intensity (depending on the distance between the construction activities and the freshwater features) that is expected to have a moderate to low overall significance in terms of its impact on the identified aquatic ecosystems in the area (this is dependent on the selection of the preferred verses the alternative layout plan is mentioned above and provided in more detail in the following section).

Proposed mitigation: Construction activities should as far as possible be limited to the delineated site for the proposed development and the identified access routes. A buffer of 30m should be maintained adjacent to the identified freshwater features. It is important that any of the cleared areas that are not hardened surfaces are rehabilitated after construction is completed by revegetating the areas disturbed by the construction activities with suitable indigenous plants. Invasive alien plants that currently exist within the immediate area of the construction activities should also be removed and the sites monitored and managed for invasive alien regrowth during the operational phase.

Run-off over the exposed areas should be mitigated to reduce the rate and volume of run-off and prevent erosion occurring on the site and within the freshwater features and drainage lines. Contaminated runoff from the construction site(s) should be prevented from entering the rivers. All materials on the construction sites should be properly stored and contained. Disposal of waste from the sites should also be properly managed. Construction workers should be given ablution facilities at the construction sites that are located at least 100m away from the river system and regularly serviced. These measures should be addressed, implemented and monitored in terms of the Environmental Management Programme for the construction phase.

Significance of impacts after mitigation: A localized, short-term impact will still occur during the construction phase; however, the overall significance of the impact on the aquatic ecosystems is expected to be low.

Operation Phase

Nature of Impact: During the operation phase regular access will be required to the site for maintenance and cleaning of solar panels.

Significance of impacts without mitigation: A localized longer term impact (more than 15 years) impact of low intensity (depending on the distance between the PV facilities and the freshwater features) that is expected to have a low to negligible overall significance in terms of its impact on the identified aquatic ecosystems in the area.

Proposed mitigation: Operational activities should as far as possible be limited to the delineated site for the proposed development and the identified access routes. Invasive alien plant growth should be monitored on an ongoing basis to ensure that these disturbed areas do not become infested with invasive alien plants.

Storm water run-off infrastructure must be maintained to mitigate both the flow and water quality impacts of any storm water leaving the PV facilities site.

Significance of impacts after mitigation: A localized, short-term impact will still occur during the construction phase; however, the overall significance of the impact on the aquatic ecosystems is expected to be low.

Impact of the Overhead Transmission lines:

Construction and Operation Phase

Nature of Impact: An impact of very limited significance is expected on the drainage characteristics of minor tributaries of the Brak River during and after the construction phase. This is due to the fact that the overhead transmission lines in general follow routes where overhead transmission lines are already in existence.

Significance of impacts without mitigation: A localized shorter term impact of moderate to low intensity that is expected to have a low to very low overall significance in terms of its impact on the identified aquatic ecosystems in the area.

Proposed mitigation: Where transmission lines need to be constructed over/through the drainage channel, disturbance of the channel should be limited and any structures placed at least 30m outside of the identified freshwater features. All crossings over drainage channels or stream beds after the construction phase should be rehabilitated such that the flow within the drainage channel is not impeded.

Significance of impacts after mitigation: A localized, short-term impact will still occur during the construction phase; however, the overall significance of the impact on the aquatic ecosystems is expected to be a very low impact.

Impact of the Access Routes:

Construction and Operation Phase

Nature of Impact: An impact of limited significance is expected at the access route river crossings of ephemeral streams during and after the construction phase.

Significance of impacts without mitigation: A localized shorter term impact of moderate to low intensity that is expected to have a low to very low overall significance in terms of its impact on the identified aquatic ecosystems in the area.

Proposed mitigation: Access routes should preferably be located along existing farm/Eskom roads wherever possible. Where access routes need to be constructed through ephemeral streams, disturbance of the channel should be limited. All crossings over drainage channels or stream beds should be such that the flow within the drainage channel is not impeded. Any disturbed areas should be rehabilitated and monitored to ensure that these areas do not become subject to erosion or invasive alien plant growth. Where roads are located along steep gradients, erosion control measures should be put in place to reduce the potential for erosion to take place.

Significance of impacts after mitigation: A localized, short-term impact will occur during the construction phase; however, the overall significance of the impact on the aquatic ecosystems is expected to be a very low impact.

Cumulative impact of the overall project activities on freshwater ecosystems:

Should all the proposed renewable energy projects in and around De Aar be approved, there is likely for some impact of a low significance on the aquatic features to occur. This is due to the fact that there will be an increased hardening of surfaces, change of land cover and an increase in the activities taking place within the Brak River catchment which can be expected to alter the flow, water quality and habitat of the streams within the river system. In general of the activities relating to the renewable energy projects are outside of the identified freshwater features and provided the construction and operation activities of the various projects remain contained within the allocated areas and any disturbed areas within the freshwater features rehabilitated, as is usually stipulated through the environmental authorisation process, the overall impact should be limited and of a low significance.

7.2. Summary of assessment of potential impacts of the proposed activities:

Construction Phase:

Potential impact on freshwater features	Proposed PV Facilities and substations
Nature of impact:	Limited disturbance of freshwater related habitats at the construction sites and some loss of drainage channel habitat
Extent and duration of impact:	Localised short term impacts
Intensity of Impact	Moderate to high
Probability of occurrence:	Probable as a result of construction activities in close proximity to stream beds / drainage channels
Degree to which impact can be reversed:	Medium to high
Irreplaceability of resources:	Medium to low
Impact prior to mitigation:	Low
Significance of impact pre-mitigation	Low
Degree of mitigation possible:	Very low
Proposed mitigation:	• A buffer of 30m should be maintained adjacent to the identified streams for the proposed PV footprint area as well as the substations. • There should be minimal use of machinery within the drainage channels and disturbance within this area should be kept to a minimum. • Disturbed areas within the riparian zones and stream beds should be rehabilitated according to an approved rehabilitation plan as soon as possible after construction has been completed and revegetated with suitable indigenous vegetation. • Invasive alien plant growth within the disturbed areas should be visually monitored every 3 months and any regrowth of invasive alien plants removed. • Run-off over the exposed areas should be mitigated according to an approved storm water management plan to reduce the rate and volume of run-off and prevent erosion occurring on the site and within the freshwater features and drainage lines.
Impact post mitigation:	Very Low
Significance after mitigation	Very Low

Potential impact on freshwater features	Proposed transmission lines, access roads and water pipeline
Nature of impact:	Disturbance of habitat and possibly impedance/diversion of flow at river crossings
Extent and duration of impact:	Localised short term impacts
Intensity of Impact	Low
Probability of occurrence:	Probable depending on the extent of construction activities within stream bed
Degree to which impact can be reversed:	High
Irreplaceability of resources:	Medium to Low
Impact prior to mitigation:	Low
Significance of impact pre-mitigation	Very low
Degree of mitigation possible:	Very low
Proposed mitigation:	• Construction activities for the proposed infrastructure that will need to take place within the river channels and riparian zone (i.e. linear development components – roads, transmission lines and water pipeline)

	should transect the streams at right angles and be limited as far as possible to ensure minimum disturbance of this area. • Minimise duration and extent of construction activities in the river – construction should also preferably take place in the low flow months (May to October). • Clearing of debris, sediment and hard rubble associated with the construction activities should be undertaken post construction to ensure that flow within the drainage channels are not impeded or diverted. • Rehabilitate disturbed stream bed and banks and revegetate with suitable indigenous vegetation according to the approved rehabilitation plan. • All crossings over drainage channels or stream beds should be such that the flow within the drainage channel is not impeded. • Any disturbed areas should be rehabilitated and visually monitored every 3 months to ensure that these areas do not become subject to erosion or invasive alien plant growth.
Impact post mitigation:	Very Low to negligible impact
Significance after mitigation	Very Low

Potential impact on freshwater features	Proposed Laydown Areas
Nature of impact:	Disturbance of habitat and possibly impedance/diversion of flow at river crossings
Extent and duration of impact:	Localised short term impacts
Intensity of Impact	Moderate to Low
Probability of occurrence:	Probable
Degree to which impact can be reversed:	High
Irreplaceability of resources:	Medium to Low
Impact prior to mitigation:	Low
Significance of impact pre-mitigation	Low
Degree of mitigation possible:	Very low
Proposed mitigation:	• Contaminated runoff from the construction site(s) should be prevented from entering the rivers. All materials on the construction sites should be properly stored and contained. Disposal of waste from the sites should also be properly managed. Construction workers should be given ablution facilities at the construction sites that are located at least 100m away from the river systems/freshwater features and regularly serviced. These measures should be addressed, implemented and monitored in terms of the EMP for the construction phase. • The laydown area should be cleaned and rehabilitated after construction is complete according to the approved rehabilitation plan.
Impact post mitigation:	Very Low
Significance after mitigation	Very Low

Operation Phase:

Potential impact on freshwater features	Maintenance of PV facilities and associated infrastructure
Nature of impact:	Limited ***disturbance of freshwater related habitats*** at the stream crossings for transmission lines and access roads as well as along the length of the site adjacent to any streams
Extent and duration of impact:	Localised longer term impacts

Intensity of Impact	Low
Probability of occurrence:	Probable as a result of construction activities in stream beds/riparian zones
Degree to which impact can be reversed:	Medium to high
Irreplaceability of resources:	Medium to Low
Impact prior to mitigation:	Very low due to the existing disturbances within these streams
Significance of impact pre-mitigation	Very low
Degree of mitigation possible:	Very low
Proposed mitigation:	• Disturbed areas should be visually monitored at least every 3 months and kept free of invasive alien plant growth. • There should be an approved storm water management plan in place for the operation phase of the project. • Storm water runoff from the constructed areas should be monitored to ensure eroded areas do not develop, particularly in drainage channels.
Impact post mitigation:	Very Low
Significance after mitigation	Very Low

Decommission Phase:

Potential impact on freshwater features	Existence of PV facilities and associated infrastructure post operation phase
Nature of impact:	Longer term ***loss of freshwater related habitats*** for streams within PV sites as a result on unmitigated erosion and invasive alien vegetation growth once the operation phase for the project has ceased.
Extent and duration of impact:	Localised long term impacts
Intensity of Impact	Low
Probability of occurrence:	Probable as a result of past activities within stream beds and riparian zones
Degree to which impact can be reversed:	Medium to high
Irreplaceability of resources:	Medium to Low
Impact prior to mitigation:	Very low due to the existing disturbances within these streams
Significance of impact pre-mitigation	Very low
Degree of mitigation possible:	Very low
Proposed mitigation:	• A decommission plan should be drawn up and approved for the site that addresses the removal of the PV facilities and infrastructure post operation phase. The decommission plan should address aspects such as monitoring and management of invasive alien plants and erosion of the site after the activities on the site are complete.
Impact post mitigation:	Very Low
Significance after mitigation	Very Low to insignificant

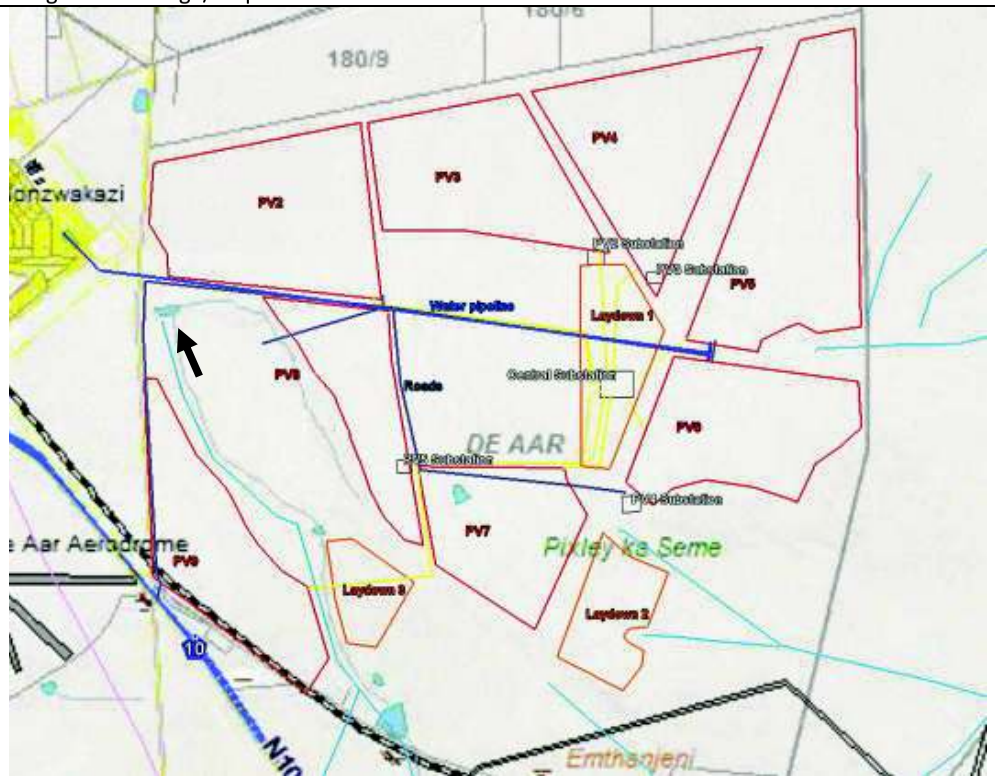
Cumulative Impacts:

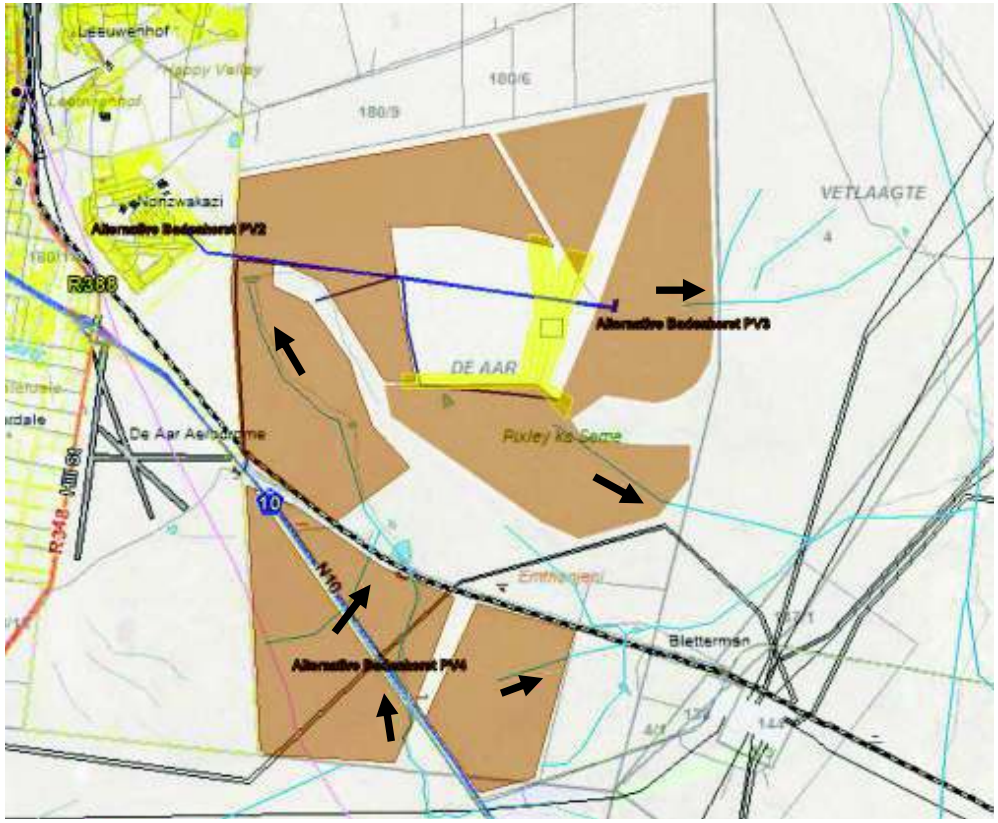
Key impacts	Extent	Magnitude	Duration	SIGNIFICANCE (Without Mitigation)	Probability	Confidence	Reversibility
Impact to surface water ecosystem No mitigation	Regional	Medium/Low	Longer term	Low	Probable	Medium	Reversible
Impact to surface water ecosystem with mitigation	Regional	Low	Longer term	Very Low	Improbable	Medium	Reversible

7.3. Assessment of Proposed Activities and Alternatives at Sites

The proposed activities and alternatives for Badenhorst Dam Farm are discussed in the following table:

Table 7. Assessment of Proposed Activities at Site: Preferred and Alternative Layout Plans (white arrows indicate potential impact areas on freshwater features)

Site No.	Google Earth image/map	Comment
Alternative 1		*Solar energy facility (brown polygons):* Proposed site is outside of all identified freshwater features/drainage lines on the site. *Laydown areas (yellow polygons):* The proposed areas are outside of any identified freshwater features/drainage lines. Of the three areas proposed laydown Area 1 is preferred from a freshwater perspective. *Overhead transmission lines/corridors (white polygons with yellow lines):* The preferred transmission lines/corridors do not appear to cross any freshwater features/drainage lines. *Substations (black rectangles).* None of the substations are placed in or near any freshwater features/drainage lines. *Access routes (red lines) and water pipeline (blue line):* The proposed access route and water pipeline crosses the lower reach of the Sandsloot tributary, however it is below the larger instream dam and just upstream of the Nonzwakazi township where there is no discernible river/drainage channel. *Laydown Camps:* All three proposed camps are situated outside of any identified freshwater/drainage features. *Summary of Impacts to freshwater features:* Access road/water pipeline crosses freshwater features/drainage line where the freshwater feature has been significantly modified – purple circle. ***The likely significance of the proposed preferred layout is very low***

Alternative 2		*Solar energy facility (brown polygons):* The alternative proposed layout will result in modification of a number of the identified freshwater features/drainage lines on the site. *Overhead transmission lines/corridors (white polygons with yellow lines):* The preferred transmission lines/corridors do not appear to cross any freshwater features/drainage lines. *Substations (black rectangles):* None of the substations are placed in or near any freshwater features/drainage lines. *Access routes (red lines) and water pipeline (blue line):* The proposed access route and water pipeline crosses the lower reach of the Sandsloot tributary, however it is below the larger instream dam and just upstream of the Nonzwakazi township where there is no discernible river/drainage channel. *Summary of Impacts to freshwater features:* A number of the identified freshwater features/drainage lines on the site (see black arrows) will be modified within the footprint of the proposed PV sites. Access road/water pipeline crosses freshwater features/drainage line where the freshwater feature has been significantly modified. ***The likely significance of the proposed alternative layout is moderate***

8. CONCLUSIONS AND RECOMMENDATIONS

The Brak River tributaries within the study area are considered to be in a moderately modified ecological state, with a low ecological importance and sensitivity. The expected impacts of the proposed activities are likely to be as follows:

- *Solar energy facility (brown polygons):* Proposed site is outside of all identified freshwater features/drainage lines on the site therefore potential impact on freshwater features is very low for this component.
- *Laydown areas (yellow polygons):* The proposed areas are outside of any identified freshwater features/drainage lines therefore the potential impact on freshwater features is very low for this component. Of the three areas proposed as laydown areas, Laydown Area 1 is preferred from a freshwater perspective.
- *Overhead transmission lines/corridors (white polygons with yellow lines):* The preferred transmission lines/corridors do not appear to cross any freshwater features/drainage lines therefore the potential impact on freshwater features is very low for this component.
- *Substations (black rectangles).* None of the substations are placed in or near any freshwater features/drainage lines therefore the potential impact on freshwater features is very low for this component.
- *Access routes (red lines) and water pipeline (blue line):* The proposed access route and water pipeline crosses the lower reach of the Sandsloot tributary, however it is below the larger instream dam and just upstream of the Nonzwakazi township where there is no discernible river/drainage channel. The potential impact on freshwater features for this component is expected to be low to very low.

The significance of the proposed alternative layout for the project (Alternative 2) is likely to be more significant as a number of the identified freshwater features/drainage lines on the site will be modified by the proposed activities. Alternative 1 is thus the preferred alternative from a freshwater perspective.

Provided that the following recommended mitigation measures are implemented the overall significance of the potential impact of the preferred option is expected to be very low:

- A buffer of 30m should be maintained adjacent to the identified streams for the proposed PV footprint area as well as the substations. This is currently the case for the preferred development layout.
- Construction activities for the proposed infrastructure that will need to take place within the river channels and riparian zone (i.e. linear development components – roads, transmission lines and water pipeline) should transect the streams at right angles and be limited as far as possible to ensure minimum disturbance of this area. Disturbed areas within the riparian zones and stream beds should be rehabilitated as soon as possible after construction has been completed and revegetated with suitable indigenous vegetation according to the approved rehabilitation plan.

Where possible previously disturbed areas such as existing roads or transmission line routes should be utilised. Disturbed areas should be visually monitored every 3 months and kept free of invasive alien plant growth.

- Construction should preferably take place during the low flow period to minimize the risk of erosion and contaminated runoff from construction sites into adjacent freshwater features.
- All rubble, sand and waste material resulting from the construction activities should be removed from any stream and drainage channels to ensure that flow in these channels are not impeded.
- Invasive alien plants should be removed from the disturbed areas within the drainage channels.
- Contaminated runoff from the construction sites should be prevented from entering the streams.
- All materials on the construction sites should be properly stored and contained.
- Disposal of waste from the sites should also be properly managed.
- Construction workers should be given ablution facilities at the construction sites that are located at least 100m away from the river systems/freshwater features and regularly serviced.
- The laydown area(s) should be cleaned and rehabilitated after construction is complete according to the approved rehabilitation plan.
- There should be an approved storm water management plan in place for the operation phase of the project. Storm water runoff from the constructed areas should also be visually monitored after large rainfall events to ensure that eroded areas do not develop, particularly within the drainage channels.
- A decommission plan should be drawn up and approved for the site that addresses the removal of the PV facilities and infrastructure post operation phase. The decommission plan should address aspects such as monitoring and management of invasive alien plants and erosion of the site after the activities on the site are complete.

A water use authorization application may need to be submitted to the Department of Water Affairs Northern Cape Regional Office for approval of the water use aspects of the proposed activities, in particular a water use authorisation will be required for any development activities relating to the stream crossings.

9. REFERENCES

Aurecon. 2012. Proposed Photovoltaic (Solar) Energy Facility De Aar, Northern Cape Report 1:100 Year Recurrence Interval Floodline Determination.

Aurecon. 2013. Proposed Photovoltaic (Solar) Energy Facility on Badenhorst Dam Farm near De Aar, Northern Cape: Draft Scoping Report No 7565.

Belcher, T. 2012. Freshwater Assessment for the Proposed Photovoltaic Energy Facilities near De Aar. Report Prepared for Mulilo Renewable Energy (Pty) Ltd.

Department of Water Affairs and Forestry. (1999). *Resource Directed Measures for Protection of Water Resources. Volume 3: River Ecosystems Version 1.0*. Resource Directed Measures for Protection of Water Resources, Pretoria, South Africa.

Department of Water Affairs and Forestry. (2005). *River Ecoclassification: Manual for Ecostatus Determination (Version 1)*. Water Research Commission Report Number KV 168/05. Pretoria.

Driver, Nel, Snaddon, Murray, Roux, Hill. (2011). Implementation Manual for Freshwater Ecosystem Priority Areas. Draft Report for the Water Research Commission.

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ENVIRONMENTAL IMPACT ASSESSMENT PROCESS: PROPOSED PHOTOVOLTAIC (SOLAR) ENERGY FACILITIES ON BADENHORST DAM FARM NEAR DE AAR, NORTHERN CAPE

Conceptual Stormwater Management Plan - Badenhorst Dam Farm

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1. Background

Mulilo Renewable Energy (Pty) Ltd (Mulilo) proposes to construct four separate solar energy facilities, on Badenhorst Dam Farm (Portion 1 of Farm 180), near De Aar in the Northern Cape. Each of the four proposed facilities would have a maximum generation capacity of 75 MW. The location of the farm and its extent is presented in Figure 1. Mulilo is proposing a similar project for the nearby Du Plessis Dam Farm, which is located north-east of De Aar. As both of these projects are located within the same project area, they are both shown in Figure 1. Aurecon South Africa (Pty) Ltd was requested to produce separate Conceptual Stormwater Management Reports for both Badenhorst Dam Farm and Du Plessis Dam Farm. This report focuses on Badenhorst Dam Farm. The proposed development includes, but is not limited to gravel access lanes, grading of the site and foundations and equipment for numerous solar panels, water supply infrastructure and on-site buildings.

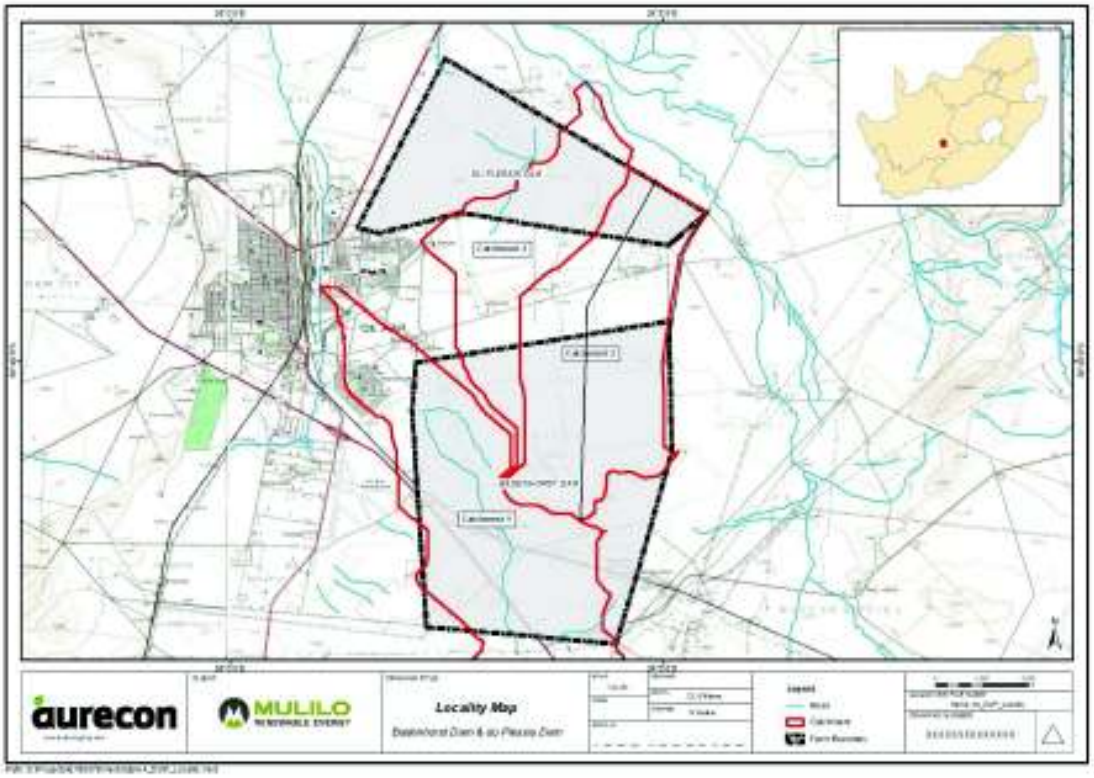

Figure 1: Location of the Badenhorst Dam Farm (Portion 1 of Farm 180), near De Aar in the Northern Cape

2. Terms of Reference

The development of a Conceptual Stormwater Management Report for the planned photo-voltaic (PV) facility at Badenhorst Dam Farm is necessary to mitigate any adverse effects of the proposed development in relation to local stormwater runoff. To this end, pre- and post-development stormwater runoff from the sites will be assessed and recommendations made to mitigate and / or accommodate

increased and concentrated runoff for a range of storm Recurrence Intervals (RI), typically 1:5 year and 1:20 year. The 1:20 year RI is considered adequate for rural stormwater assessment.

3. Approach to the Study

Two alternatives for the development of the site are proposed. The layout of these alternatives overlaps 3 different catchments. Therefore the effect on stormwater runoff needs to consider the increase in runoff of each alternative as it impacts on each catchment.

A comparison of layout Alternatives 1 and 2 in regard to the impact on the runoff was conducted for the 1:5 and 1:20 year flood. The pre- and post-development flood peaks were determined for Catchments 1, 2 and 3 (Figure 1). The layout Alternatives are described in Section **Error! Reference source not found.** with the envisaged land alterations described in Section 5. The 1:20 year flood peak was ascertained using the Rational Method (Section 6). For Catchment 1 where the flow of runoff moves from a rural to a more built up environment (where it flows through De Aar) the SCS method was used to check the flood peak.

As mentioned in Section 1, there is a proposed solar energy facility on the nearby Du Plessis Dam Farm. Part of the scope of this investigation is to consider the impact of proposed development on the Badenhorst Dam Farm facility on the Du Plessis Dam Farm and also the cumulative effects of the two facilities. The cumulative effect is described in more detail in the Du Plessis Dam Farm Conceptual Stormwater Management Plan as it lies downstream of the Badenhorst Dam Farm.

The pre- and post-development runoff was determined for each of the PV blocks. Only 20m contours are currently available for the site so a “typical” drainage layout with the direction of flow for each PV is presented in Section 7 with erosion control measures discussed in Section 8.

This information has been based on the limited information available (e.g. SRTM 90m Digital Elevation Model). A detailed drainage layout will need be developed when a detailed topographic survey for the site is available.

4. Description of Layout Alternatives and site characteristics

4.1 Layout Alternatives

The DEA&DP 2013 guidelines state that "every EIA process must identify and investigate alternatives, with feasible and reasonable alternatives to be comparatively assessed." The alternatives for Badenhorst Dam Farm are termed Alternative 1 and 2 are described in Sections 4.1.1 and 0. The layouts for the alternatives at both Badenhorst Dam Farm and Du Plessis Dam farm are shown in **Figure 2** and **Figure 4**. A previous EIA, similar to this study, was undertaken at the same location (Aurecon, 2012a). After completion of the EIA (DEA Reference Number: 12/12/20/2499), the DEA authorised a PV facility with 100MW capacity (Environmental Authorisation (EA) dated 9 July 2012).

4.1.1 Layout Alternative 1

This alternative consists of the four proposed 75MW PV facilities and associated infrastructure referred to as PV2, PV3, PV4 and PV5. These layouts take cognisance of the 75MW Department of Environment's cap and the environmentally sensitive areas as identified by Aurecon (2012a). The layout for Alternative 1 is shown in Figure 2 and the area each PV block is given in Table 1.

Table 1: Area of Badenhorst Dam Farm PV blocks for Alternative 1

Name	Area (ha)
PV2	240
PV3	252
PV4	188
PV5	201

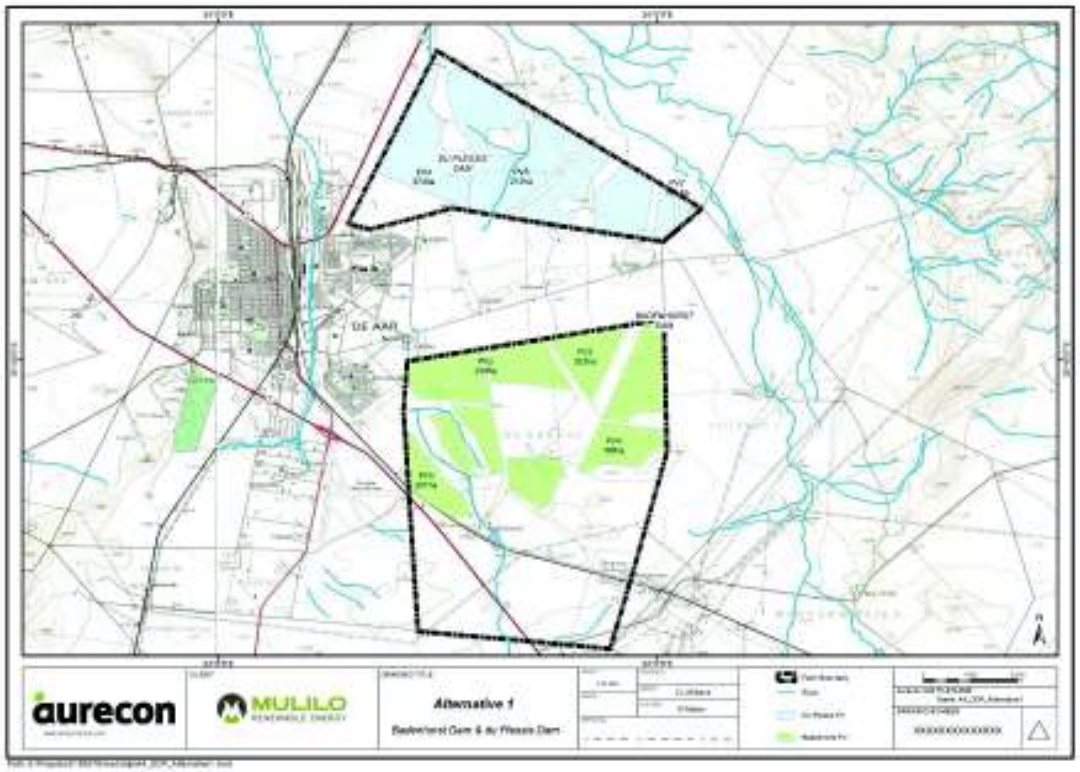

Figure 2: Layout of Alternative 1 for both Badenhorst Dam Farm and Du Plessis Dam Farm

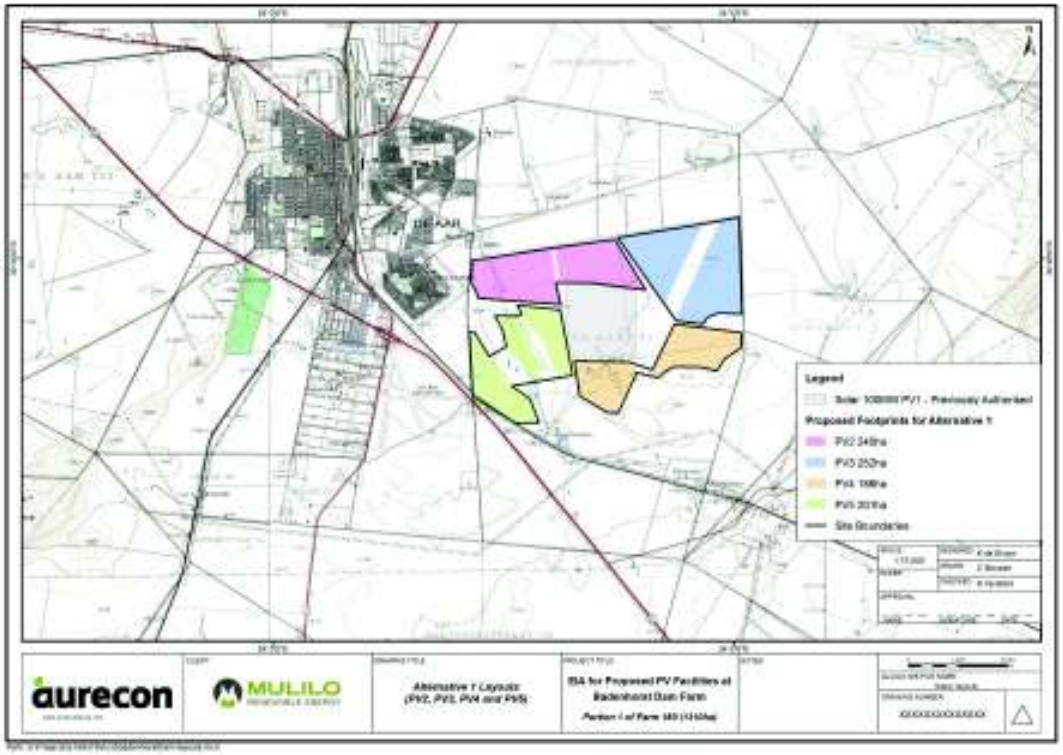

Figure 3: Layout of Alternative 1 for Badenhorst Dam Farm also showing PV1 area previously approved for 100MW capacity

4.1.2 Layout Alternative 2

This alternative consists of three 150MW PV facilities (**Figure 4**). The area of each PV block is given in Table 2. The layout for these was developed by extending and combining some of the proposed 75MW facilities. This alternative is not restricted to the Department of Environment's 75MW cap per project. The layout of Alternative 2 more or less overlaps with the Alternative 1 layout, with the exception of PV4. The extended PV2 in Alternative 2 is approximately the same extent as PV2 and PV5 combined from Alternative 1 and extended PV3 in Alternative 2 is similar to the combined layout of PV3 and PV4 from Alternative 1. The proposed layout for extended PV4 (Alternative 2) is located at the southern boundary of the farm. Runoff from PV4 would cross both an existing road (the N10) and existing railway line.

Table 2: Area of Badenhorst Dam Farm PV blocks for Alternative 2

Name	Area (ha)
PV2	400
PV3	400
PV4	500

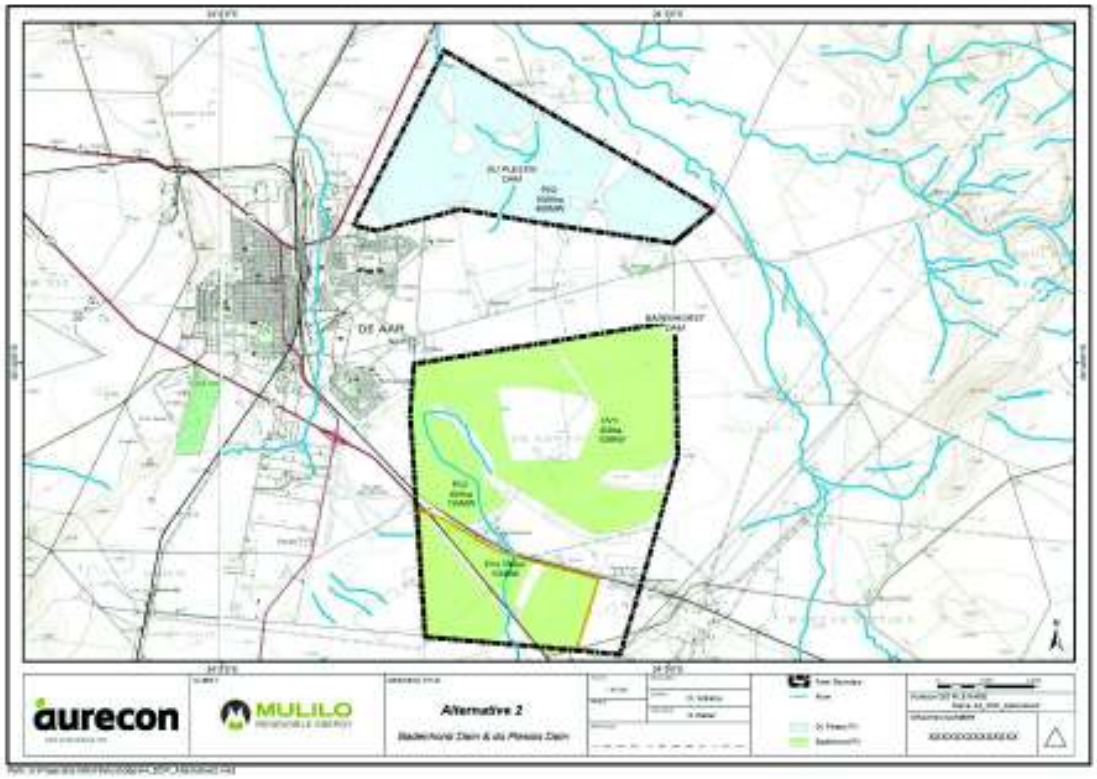

Figure 4: Layout of Alternative 2 for both Badenhorst Dam Farm and Du Plessis Dam Farm

4.2 Climate and Land Use

The study area has a Mean Annual Precipitation (MAP) of around 300 mm. Figure 5 shows the annual precipitation for a gauge in De Aar (1921-1999). The study area has a semi-arid climate with a rainfall regime confined to summer and early autumn (Figure 6).

The site has an average catchment slope in the region of 2% (Aurecon, 2012b). The current use of the land is grazing (Figure 7) and the soils are not suitable for arable agriculture (SiVest, 2012).

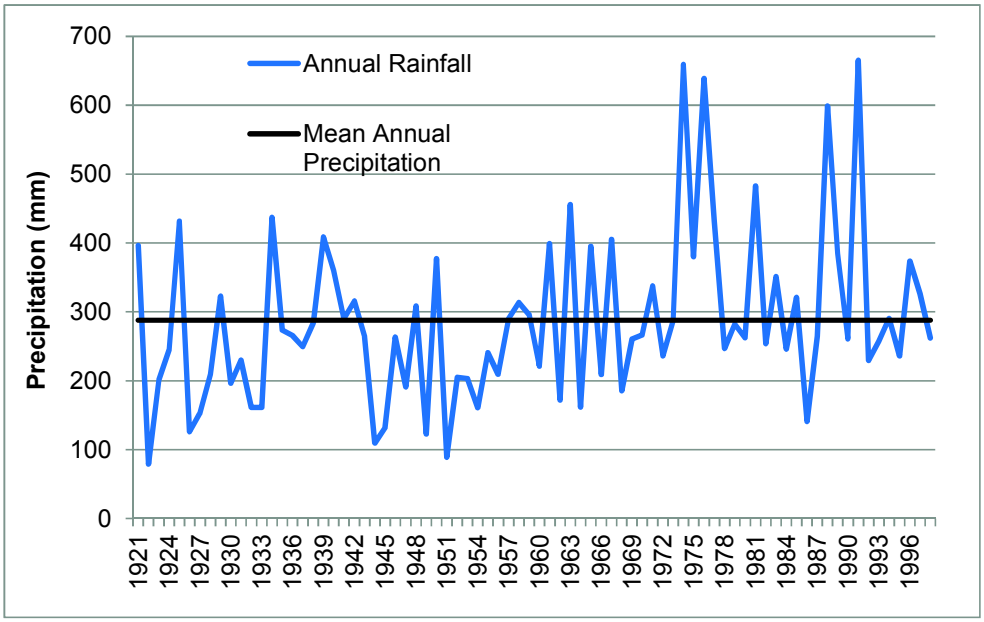

Figure 5: Annual precipitation for De Aar (rainfall station 0170009 A)

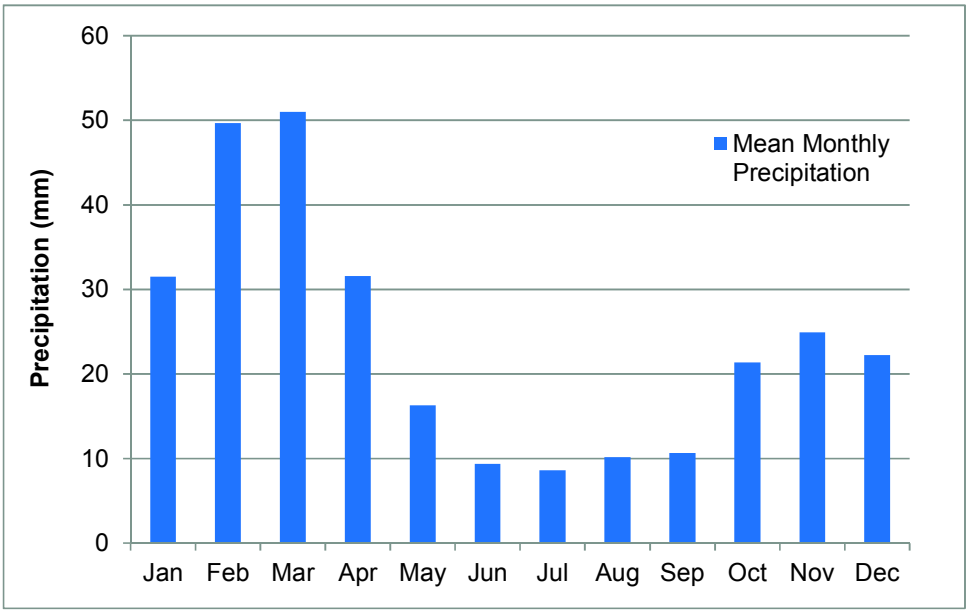

Figure 6: Mean monthly precipitation for De Aar (rainfall station 0170009 A)

4.3 Drainage Characteristics

Drainage of the existing undeveloped site is primarily via overland sheet flow. There is an ephemeral watercourse that crosses the R32 and runs through Badenhorst Dam Farm in a south to north direction (Figure 8) and exits approximately 400m from the south-west corner of the farm. An indicative 1:100 year floodline was determined previously for this watercourse (Aurecon 2012b). This showed that the PV areas were outside if the 1:100 year floodline. It is recommended that after the site has been surveyed the 1:100 year floodline should be re-determined before the PV areas are finalised. There is also a drainage line that starts in the south of the farm and exits in the south-east of the farm at Bletterman. This is a very minor drainage channel which will be evaluated as part of the detailed design.

Figure 7: Grazing land at Badenhorst Dam Farm

Figure 8: Ephemeral watercourse on Badenhorst Dam Farm

5. Proposed Physical Land Alterations

It is anticipated that the existing plants at the site will be removed. The proposed development will include the following:

- construction of gravel access lanes
- possible grading of the site
- foundations and tracking equipment for numerous solar panels,
- site boundary fence
- local drainage channels and possibly stormwater attenuation facilities.

The proposed PV panels are approximately 2m wide and 1m long. These panels are arranged into modules that are durable and can last up to 25 years due to the sturdiness of the structure and few moving parts. The PV modules (which will include a number of PV panels) will be physically mounted to a galvanized steel rotation tube, single axis tracking system to ensure ground connection from the module frames to the structure. The PV modules, fixed to the tracking system, are arranged into tracker blocks as indicated in Figure 8. These tracker blocks will be uniformly aligned to facilitate efficient sun-tracking.The dimensions of a tracker block range between 88m and 113m in an east to west direction and 35m to 38m in a north-south direction (Mulilo, 2013).

Figure 9: Single axis tracking system (image courtesy of Mulilo)

The supports of the frame will be fixed on top of steel piles. Since there is existence of rock at shallow depths, it is likely that the steel piles would be embedded into concrete piles. However, the final design of the foundations will depend on the geotechnical conditions of the site which will be determined at a later stage.

With the solar panels being impervious, rainwater will land on the panels and run off directly onto the ground below the individual panels. Some erosion may occur beneath each solar panel as well as downstream of panels as runoff is incremented and concentrated due to the site layout and topography. V-drains should be provided to intercept and convey the runoff.

6. Methods for Flood Peak Estimation

The potential flood risks have been assessed by analysing storm runoff generated by storms of 5-year and 20-year recurrence interval. The 5-year runoff has been used to assess storm drainage requirements on the PV site while the 20-year runoff has been used to assess the risks associated with external drainage paths and stormwater control measures. The analyses for the internal drainage (1:5 year) and external drainage (1:20 year) were undertaken using the Rational Method. For Catchment 1 where the flow of runoff moves from rural to a more built-up environment (where it flows through De Aar) the SCS method was used to check the flood peak.

Parameters for Catchments 1, 2 and 3 are summarised in Table 3.

Table 3: Catchment Parameters for Catchments 1, 2 and 3

Catchment Parameter	Catchment 1	Catchment 2	Catchment 3
Catchment Area (km^2)	20.27	10.65	16.16
Longest Water Course (km)	12.91	10.83	7.50
Centroid of Catchment (km)	6.83	4.54	3.97
Average Catchment Slope (%)	1.65	1.13	1.12
Slope Watercourse 10:85 Method (m/m)	0.007	0.005	0.005
1 day point rainfall (mm) 20 year RI	73	73	73
1 day point rainfall (mm) 5 year RI	61	61	61

6.1 Design Rainfall

For a deterministic design flood approach (i.e. the Rational Method and SCS) a crucial input is the design rainfall. The design rainfall is associated with a particular recurrence interval and critical storm duration. For the Rational Method, the critical design storm duration is usually set equal to the "Time of Concentration" (T_c). The SCS method is designed for a critical design storm duration of 24 hours.

The design point rainfall for the 1:5 and 1:20 year RI (Table 3) was obtained from the Smithers and Schulze (2002) database. The design point rainfall depths were converted to 24-hour point rainfall using Adamson's (1981) conversion factor of 1.11. The 24-hour design point rainfall depths were then converted into their respective duration rainfall depths by applying the Adamson (1981) sub-daily ratios for the summer rainfall region (R1). To convert the 24-hour point rainfall values to areal rainfall for each catchment, an Areal Reduction Factor (ARF) was applied based on the curves developed by Alexander (1990).

6.2 Runoff Determination

The ESRI GIS-tool, Arc Hydro 1.4, was used to automate the generation of the river networks and delineation of the associated catchment boundaries from the SRTM 90m Digital Elevation Model. Catchment parameters used in the flood estimation are presented in Table 3. The Rational Method and the SCS approach were originally developed for small catchments and are widely used internationally. Both approaches have been extensively enhanced by research conducted in South Africa.

6.2.1 Rational Method

The Rational Method is represented by the following relationship:

$$Q = \frac{CIA}{3.6}$$

Q = design flood peak (m^3/s)

C= runoff coefficient (dimensionless)

I = average rainfall intensity over catchment (mm/hour)

A = effective area of catchment (km^2)

3.6 = conversion factor

The Rational Method yields a design flood peak only (i.e. no hydrograph). The flood response of the catchment is expressed by two quasi-physical parameters: runoff Coefficient (C), which is a function of average catchment slope, permeability, land-use, MAP, RI and Time of Concentration (T_c), which is a function of the length of the longest watercourse and the average slope of that watercourse. This investigation utilised the C-value guide derived by the Department of Water Affairs (Alexander, 1990). For the 1:20 year RI the C-value was adjusted by 0.75 (Table 4) and for the 1:5 year RI the C-value was adjusted by 0.65 (Table 5). The C-value or runoff coefficient can change if the land use changes. There is a difference in the C-value for two alternatives (post-development) as the percentage of impervious surface in Catchments 1, 2 and 3 is different for the 2 alternatives. The C-values given in Table 5 are for the PV facilities only and not the wider catchment, as the percentage of impervious surface is the same implying that the C-values remain the same.

Table 4: C-Values for the 1:20 year RI for Catchments 1, 2 and 3

C-value	Catchment 1	Catchment 2	Catchment 3
C-Value pre-development	0.16	0.16	0.16
C-Value Alternative 1	0.19	0.22	0.24
C-Value Alternative 1 and Du Plessis Dam farm section	n/a	0.28	0.29
C-Value Alternative 2	0.26	0.27	0.24
C-Value Alternative 2 and Du Plessis Dam farm section	n/a	0.32	0.33
Time of concentration pre-development (hrs)	2.10 (defined watercourse)	3.61 (overland flow)	3.04 (overland flow)
Time of concentration post-development (hrs)	2.10 (defined watercourse)	3.19 (defined watercourse)	2.41 (defined watercourse)

Table 5: C-Value for the 1:5 year RI for the different PV facilities

Alternative	C-Value pre-development	C-Value post-development
1	0.14	0.22
2	0.14	0.22

6.2.2 SCS Method

The SCS was used as a conceptually different alternative to the Rational Method. The SCS approach yields a full design flood hydrograph. The flood response of the catchment is represented by two quasi-physical parameters: Curve Number (CN), which is a function of soil group, land-use, vegetation cover, and antecedent soil moisture conditions; and Lag Time, which is a function of average catchment slope, length of the longest watercourse and CN. Soil groups are classified according to Binomial Classification System for Southern Africa (Soil Group A – D), which has a strong texture and depth basis (Schmidt and Schulze, 1987b).

A soil survey of each of the sites found the dominating soils to be a combination of rocky soils, such as Mispah and Glenrosa Forms, and shallow duplex soils such as Swartland (SiVEST, 2012 and 2013). These soils are categorised as Soil Group C in the Bionomial Classification system. For the purposes of the EIA investigation an assumption was made that these soils are characteristic of the catchments in which they are found. Therefore, in determining the CN for the SCS 100% soil group C was assumed.

The original SCS basin lag equation was used in this study as the original equation has been shown in verification studies to be applicable to catchments in more arid areas, limited vegetation and shallow soils (Schmidt and Schulze, 1987a). The parameters used in the SCS method are presented in Table 6.

Table 6: SCS parameters

Parameter	Catchment 1
SCS curve number pre-development	78
SCS curve number Alternative 1	79
SCS curve number Alternative 2	81
Basin lag pre-development (mins)	208
Basin lag Alternative 1 (mins)	201
Basin lag Alternative 2 (mins)	183

The SCS approach requires a rainfall hyetograph as input. For this Study the 24-hour rainfall hyetograph based on the South African-derived “Storm Type II Distribution” was employed (Schmidt and Schulze, 1987b).

7. Stormwater Assessment

7.1 Flood Peaks Estimates

The direction of flow through the different PV facilities is presented in Figure 10. The ephemeral watercourse situated in Catchment 1 takes the flow in the direction De Aar and flows near to Nonzwakazi area of De Aar. Catchments 2 and 3 do not have a defined watercourse but the flow direction is towards the Du Plessis Dam Farm.

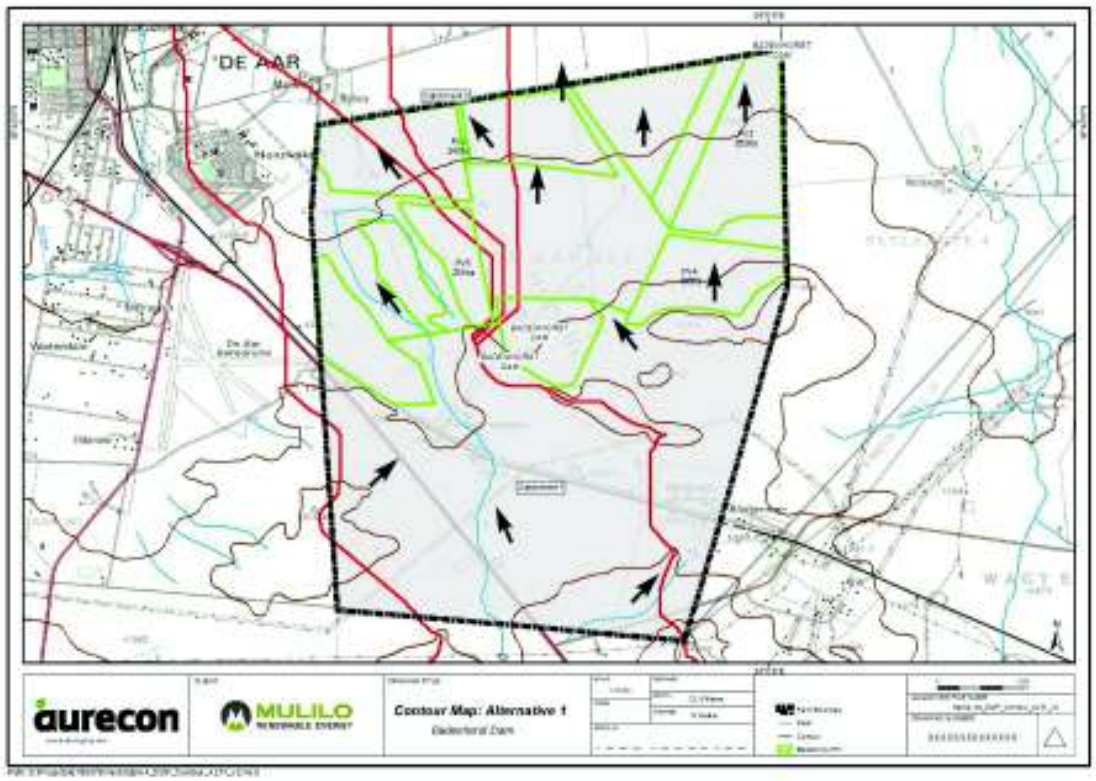

Figure 10: Direction of flow (pre-development through Badenhorst Dam Farm

The flood peaks for Catchment 1 for the different development conditions are summarised in Table 7. Alternative 1 increased the 1:20 year peak flow of Catchment 1 by 16% while Alternative 2 increased the peak by 60%. The increase in runoff is of particular concern as this watercourse joins the Sandsloot River in De Aar. Flooding has occurred in the past in De Aar and the detailed design phase must ensure that the risk of flooding in the existing downstream system is not exacerbated by the proposed development. Mitigation for both Alternatives would be required to reduce the flood peak to pre-development levels. At this stage it appears likely that attenuation ponds will be required.

The flood peaks for Catchment 2 and 3 are presented in Table 8. The development, for both Alternative 1 and 2, in Catchments 2 and 3 causes the hydrology of site to change from predominately overland flow in the upper reaches to channelled flow. The 1:20 year peak flow is also increased. Mitigation measures are discussed in Section 7.2. Catchment 1 has a defined watercourse and the PV

facilities will be placed outside of this. The major concern with the developments in terms of stormwater is the increased likelihood erosion locally around the panels as well in the wider catchment. Erosion control measures are discussed in Section 7.2 and Section 8. The expected 1:5 year runoff from the individual PV site of Alternative 1 and 2 are summarised in Tables 9 and 10 respectively.

Table 7: 1:20 year Flood Peak Estimates for Catchment 1

Condition	Catchment 1 Rational Method	Catchment 1 SCS
Pre-development flood peak (m^3/s)	17.5	19.6
Alternative 1 flood peak (m^3/s)	20.3	21.4
Alternative 2 flood peak (m^3/s)	28.2	27.6

Table 8: 1:20 year Flood Peak Estimates for Catchments 2 and 3

Condition	Catchment 2	Catchment 3
Pre-development flood peak (m^3/s)	7.3	12.8
Alternative 1 flood peak (m^3/s)	11.1	22.4
Alternative 1 and Du Plessis section flood peak (m^3/s)	13.9	26.8
Alternative 2 flood peak (m^3/s)	13.2	22.2
Alternative 2 and Du Plessis section flood peak (m^3/s)	16.0	31.3

Table 9: 1:5 year peak flows for the PV sites for Alternative 1

Catchment	1: 5 year peak pre-development (m^3/s)	1: 5 year peak post-development (m^3/s)
PV2	6.1	12.6
PV3	4.8	9.8
PV4	4.7	9.6
PV5	5.2	10.7

Table 10: 1:5 year peak flows for the PV sites for Alternative 2

Catchment	1: 5 year peak pre-development (m^3/s)	1: 5 year peak post-development (m^3/s)
PV2	6	9.9
PV3	5.4	8.8
PV4	9.6	15.8

7.2 Discussion and proposed measures to alleviate drainage problems

Of particular concern is the increase runoff post-development for Catchment 1 as this joins the Sandsloot River in De Aar. To reduce the peak flow to pre-development levels attenuation ponds and energy dissipaters should be used. Alternative 1 is preferable in this catchment as it has less of an impact on runoff (an increase of 16% compared 60% for Alternative 2). However, a possible mitigation measure could be to rehabilitate the Badenhorst Farm Dam and use it as an attenuation pond (Figure 9). Runoff from Alternative 2 (PV4) also increases runoff to road and rail culverts so once a detailed survey is available the impact on the road and rail culverts needs to be investigated.

The expected 1:5 year runoff from the PV facilities of Alternative 1 are summarised in Table 7. It is not recommended that the internal drainage system concentrate the flow from a large area (200ha+) to one outlet. This will cause erosion and change the hydrology of the area from overland flow to channelled flow. Instead the area should be sub-divided into smaller sub-catchments (which will distribute the runoff) and have multiple outlets from the site. A schematic of this is shown in Figure 11. Concrete aprons with rip-rap no less than 12m long should be used at the multiple outlets. This will prevent erosion, assist in moving the runoff from channelled flow back to overland flow and will dissipate energy. A summary of the mitigation measures for each Alternative are presented in Table 11.

Figure 11: Badenhorst Farm Dam with a damaged embankment

Table 11: Summary of mitigation measure for the increased runoff

Condition	Impact	Mitigation
Catchment 1 Alternative 1	Increase in peak 1.8 m^3/s	Use of multiple apron outlets at the exit of the PV site and attenuation ponds.
Catchment 1 Alternative 2	Increase in peak by 10.7 m^3/s	Use of multiple apron outlets at the exit of the PV site and attenuation ponds. In addition to this, possible rehabilitation of Badenhorst Farm Dam for use as an attenuation pond.
Catchment 2 Alternatives 1 and 2	Change in hydrology from overland flow to channel flow	Use of multiple apron outlets at the exit of the PV site and possibly an attenuation pond.
Catchment 3 Alternatives 1 and 2	Change in hydrology from overland flow to channel flow	Use of multiple apron outlets at the exit of the PV sites and possibly attenuation ponds.

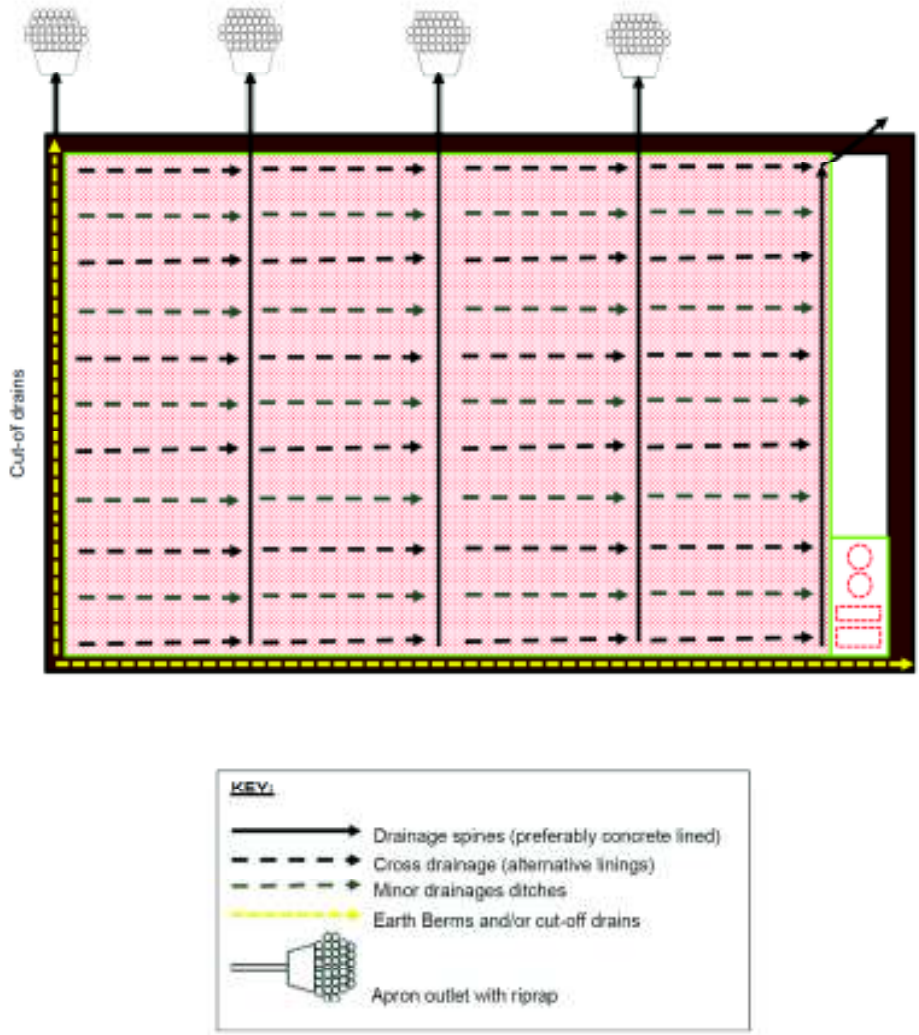

Figure 12: A typical drainage scheme