Agricultural Agro-Ecosystem Assessment for the Proposed 100MW Vrede PV Solar Energy Facility, Battery Energy Storage System (BESS) and Associated Infrastructure

Submitted by TerraAfrica Consult cc

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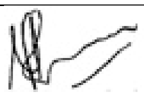
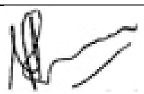
Second Draft	Mariné Pienaar	Report Author		22/04/2021
Final	Mariné Pienaar	Report Author		24/04/2021

Details and Declaration of the Specialist

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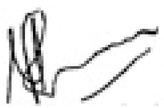
Declaration of Independence

I, Mariné Pienaar, hereby declare that TerraAfrica Consult, an independent consulting firm, has no interest or personal gains in this project whatsoever, except receiving fair payment for rendering an independent professional service.

I further declare that I was responsible for collecting data and compiling this report. All assumptions, assessments and recommendations are made in good faith and are considered to be correct to the best of my knowledge and the information available at this stage.



TerraAfrica Consult cc represented by M Pienaar
20 April 2021

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1. Introduction

Terra-Africa Consult cc was appointed by Savannah Environmental (Pty) Ltd to conduct the Agricultural Agro-Ecosystem Assessment for a renewable energy project. The proposed project will consist of the construction and operation of the 100MW Vrede Photovoltaic (PV) Solar Energy Facility (hereafter known as the 'Vrede Solar PV Facility'), Battery Energy Storage System (BESS) and associated infrastructure. The solar facility will have a contracted capacity of up to 100MWAC and will be connected to a separately authorised grid connection (a 132kV distribution line). The project applicant is South Africa Mainstream Renewable Power Developments (Pty) Ltd.

The proposed Vrede Solar PV Facility is to be developed on the Remaining extent of the farm Vrede No. 1152 and Portion 1 of the farm Uitval No. 1104, located approximately 13km south-west of the town of Kroonstad in the Free State Province (see Figure **1**). The project site falls in Ward 7 of the Moqhaka Local Municipality, within the greater Fezile Dabi District Municipality. For the baseline assessment of the soil and agricultural properties, the entire development area of 276.8ha is considered. For the impact assessment and determination of the maximum allowable limits for renewable energy development, only the development footprint is considered.

2. Project description

The overarching objective for the Vrede Solar PV Facility is to maximise electricity production through exposure to the available solar resource, while minimising infrastructure, operational and maintenance costs as well as potential social and environmental impacts (Savannah, January 2021). Following this report, the Kroonstad area is considered favourable for the development of a commercial solar energy facility as a result of the climatic conditions, relief, aspect, the extent of the affected property and the availability of the nearby grid connection together with the availability of land for such a development.

Apart from electricity production, the project will create employment opportunities for individuals with different skills levels. According to the project applicant, more than 230 individuals will be employed during the Construction Phase (a period of 18 to 24 months). During this phase, the majority of the labour force will be recruited within the District Municipality. During the Operational Phase, the project will employ more than 17 individuals.

The total capital expenditure during the Construction Phase could be approximately R1.1 billion and during Operational Phase, R32 million per year. It is expected that a significant portion of the total expenditure, will be spent in South Africa.

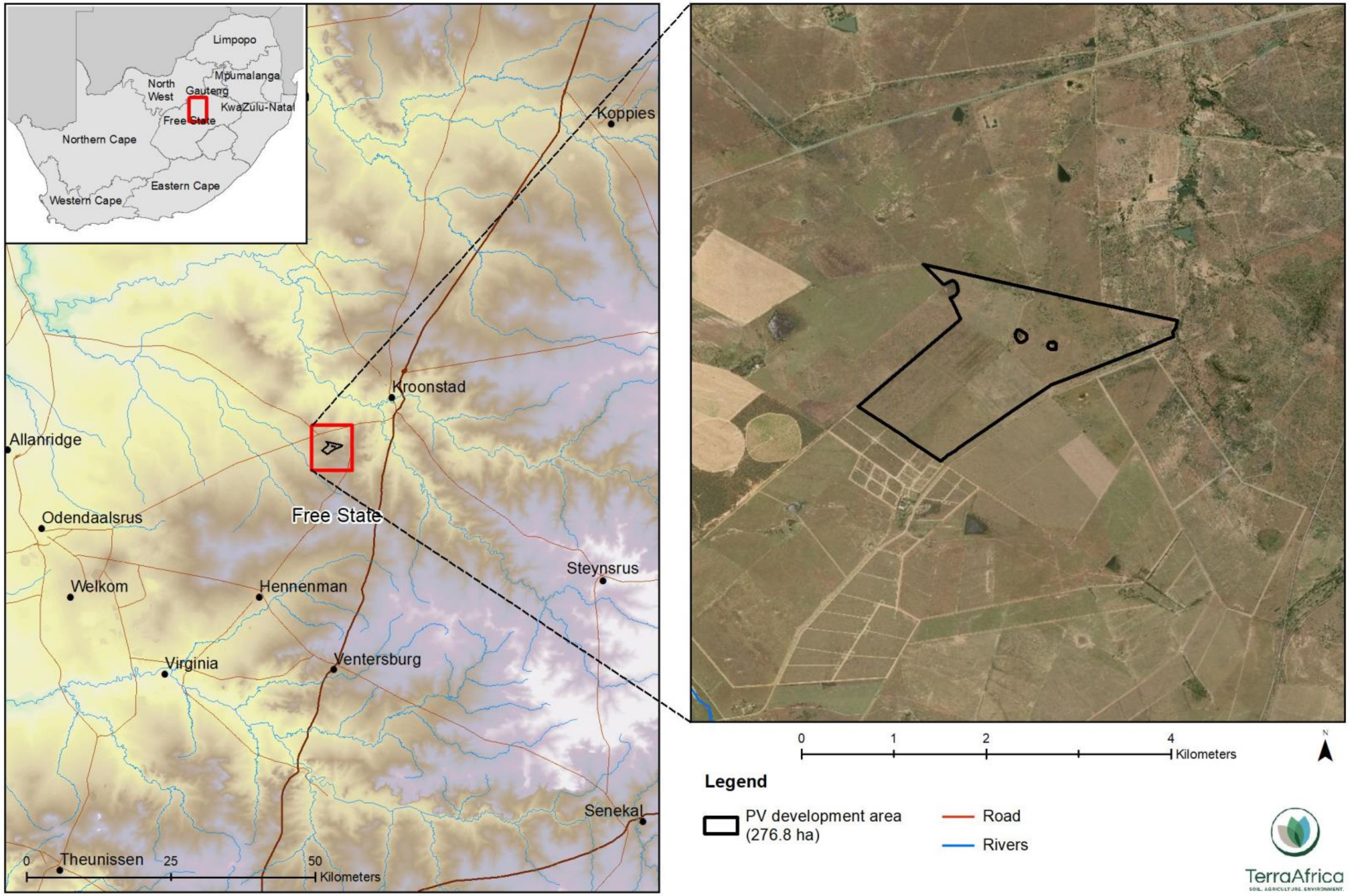


Figure 1: Locality map of the proposed Vrede Solar PV Facility development area

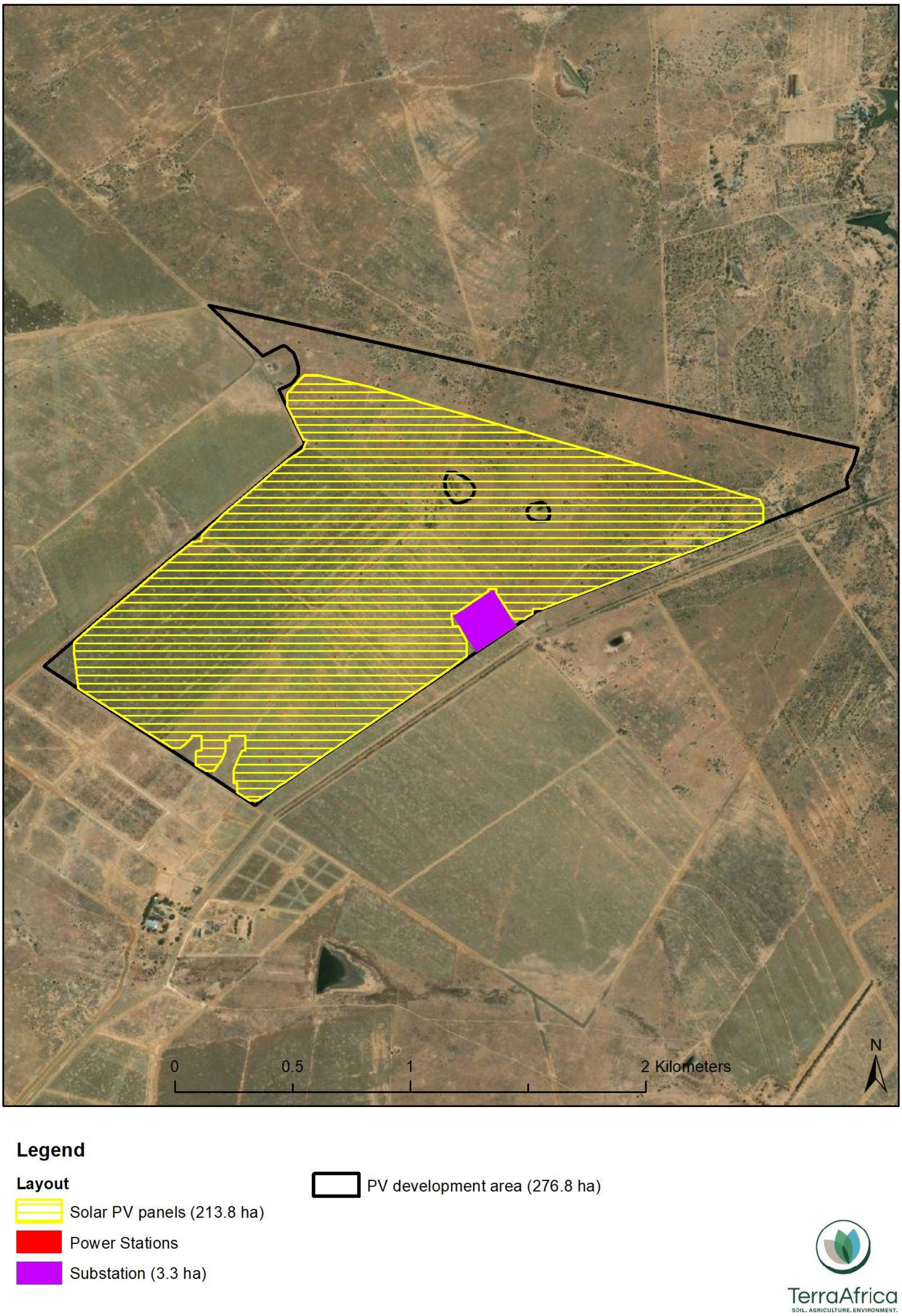


Figure 2 Layout map of the project infrastructure of the proposed Vrede solar PV facility

3. Purpose and objectives of the assessment

The overarching purpose of the Agricultural Agro-Ecosystem Specialist Assessment (from here onwards also referred to as the Agricultural Assessment) that will be included in the Environmental Impact Assessment Report, is to ensure that the sensitivity of the site to the proposed land use change (from agriculture to renewable energy generation) is sufficiently considered. Also, that the information provided in this report, enables the Competent Authority to come to a sound conclusion on the impact of the proposed project on the food production potential of the site.

To meet this objective, site sensitivity verification must be conducted of which the results must meet the following objectives:

- It must confirm or dispute the current land use and the environmental sensitivity as was indicated by the National Environmental Screening Tool.
- It must contain proof of the current land use and environmental sensitivity pertaining to the study field.
- All data and conclusions are submitted together with the Environmental Impact Assessment report for the proposed Vrede Solar PV Facility.

According to GN320, the Agricultural Agro-Ecosystem Assessment that is submitted must meet the following requirements:

- It must identify the extent of the impact of the proposed development on the agricultural resources.
- It has to indicate whether or not the proposed development will have an unacceptable impact on the agricultural production capability of the site, and in the event where it does, whether such a negative impact is outweighed by the positive impact of the proposed development on agricultural resources.

The following checklist is supplied as per the requirements of GNR 320, detailing where in the report the various requirements have been addressed:

GNR 320 requirements of an Agricultural Agro-Ecosystem Statement (High to Very High Sensitivity)	Reference in this report
Details and relevant experience as well as the SACNASP registration number of the soil scientist or agricultural specialist preparing the assessment including a curriculum vitae;	Page ii and Appendix 3
A signed statement of independence by the specialist;	Page ii
The duration, date and season of the site inspection and the relevance of the season to the outcome of the assessment;	Section 8.2
A description of the methodology used to undertake the on-site assessment inclusive of the equipment and models used, as relevant;	Section 8.2
A map showing the proposed development footprint (including supporting infrastructure) with a 50m buffered development envelope, overlaid on the agricultural sensitivity map generated by the screening tool;	Section 5, Figure 3

An indication of the potential losses in production and employment from the change of the agricultural use of the land as a result of the proposed development;	Section 10.5.3
An indication of possible long term benefits that will be generated by the project in relation to the benefits of the agricultural activities on the affected land;	Section 2
Additional environmental impacts expected from the proposed development based on the current status quo of the land including erosion, alien vegetation, waste, etc.;	Section 11
Information on the current agricultural activities being undertaken on adjacent land parcels;	Section 9.6.4
A motivation must be provided if there were development footprints that were identified as having a “medium” or “low” agriculture sensitivity and that were not considered appropriate;	Section 10.1
Confirmation from the soil scientist or agricultural specialist that all reasonable measures have been considered in the micro-siting of the proposed development to minimise fragmentation and disturbance of agricultural activities;	Section 10.1
A substantiated statement from the soil scientist or agricultural specialist with regards to agricultural resources on the acceptability or not of the proposed development and a recommendation on the approval or not of the proposed development;	Section 13
Any conditions to which this statement is subjected;	Section 14
Where identified, proposed impact management outcomes or any monitoring requirements for inclusion in the Environmental Management Programme (EMPr);	Section 13
A description of the assumptions made and any uncertainties or gaps in knowledge or data;	Section 7
Calculations of the physical development footprint area for each land parcel as well as the total physical development footprint area of the proposed development (including supporting infrastructure);	Table 5
Confirmation whether the development footprint is in line with the allowable development limits set in Table 1 above, including where applicable any deviation from the set development limits and motivation to support the deviation, including: a) Where relevant, reasons why the proposed development footprint is required to exceed the limit; b) Where relevant, reasons why this exceedance will be in the national interest; and c) Where relevant, reasons why there are no alternative options available including evidence of alternatives considered; and	Section 10.3, Table 6
A map showing the renewable energy facilities within a 50km radius of the proposed development.	Section 12, Figure 27

4. Legislative framework for the assessment

The report follows the protocols as stipulated for the Agricultural Assessment in Government Notice 320 of 2020 (GN320). This Notice provides the procedures and minimum criteria for reporting in terms of Sections 24(5)(a) and (h) and 44 of the National Environmental Management Act (No. 107 of 1998) (from here onwards referred to as NEMA). It replaces the previous requirements of Appendix 6 of the Environmental Impact Assessment Regulations of NEMA.

In addition to the specific requirements for this study, the following South African legislation is also considered applicable to the interpretation of the data and conclusions made with regards to environmental sensitivity:

- The Conservation of Agricultural Resources (Act 43 of 1983) states that the degradation of the agricultural potential of soil is illegal. This Act requires the protection of land against soil erosion and the prevention of water logging and salinisation of soils by means of suitable soil conservation works to be constructed and maintained. The utilisation of marshes, water sponges and watercourses are also addressed.
- Section 3 of the Subdivision of Agricultural Land Act 70 of 1970 may also relevant to the development.
- In addition to this, the National Water Act (Act 36 of 1998) deals with the protection of water resources, including wetlands. This legislation is considered for the purpose of identifying hydromorphic soils with wetland functionality within the study area.

5. Agricultural Sensitivity

For the purpose of the assessment, the Vrede solar PV facility development area was screened for agricultural sensitivity using the National Environmental Screening Tool (www.screening.environment.gov.za). The screening report was generated by Savannah Environmental (Pty) Ltd on 21 April 2021 and presented as Figure **3**. The requirements of GN320 stipulates that a 50m buffered development envelope must be assessed with the screening tool. While the development area of 276.8ha was used for the screening, the surrounding area is also visible in the map (which shows a buffered area of 3km or more around the development area boundary) (Figure **3**). The surface infrastructure of 217.6ha will only be located within the boundaries of the development area.

The results indicates that the Vrede solar PV facility development area consists of land with High and Medium agricultural sensitivity (refer to Figure **3**). The western half of the area consists mainly of land with High sensitivity with a smaller block of land with Medium sensitivity present along the south-western corner of the site boundary. The eastern part of the site consists largely of land with Medium agricultural sensitivity. Land bordering on the development area's boundary consist of land with High and Medium agricultural sensitivity. Two centre pivot irrigation fields are visible around 2km west of the western boundary. The farm portions north, north-east and east of the development area consists mainly of land with Medium agricultural sensitivity.

In addition to the relative agricultural sensitivity of the area presented in Figure 3, the spatial data of the newly declared High Potential Agricultural Areas (HPAA) of the Free State Province were evaluated (refer to Figure 4). According to this data, the entire development area falls within a High Potential Agricultural Area with a Category B priority rating (with Class A being the highest priority).

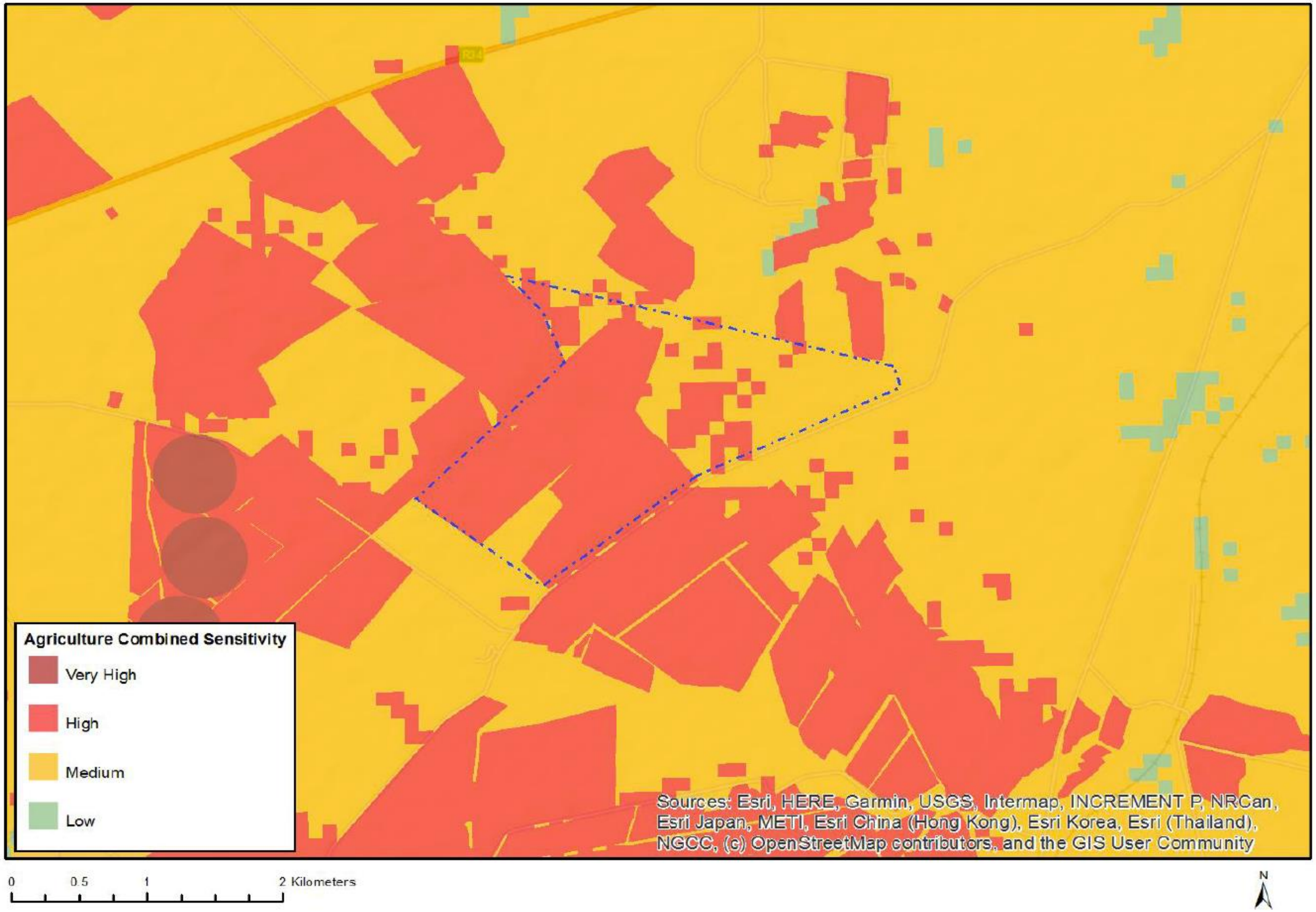


Figure 3 Agricultural Combined Sensitivity of the Vrede solar PV development area (generated by Savannah Environmental, 21 April 2021)

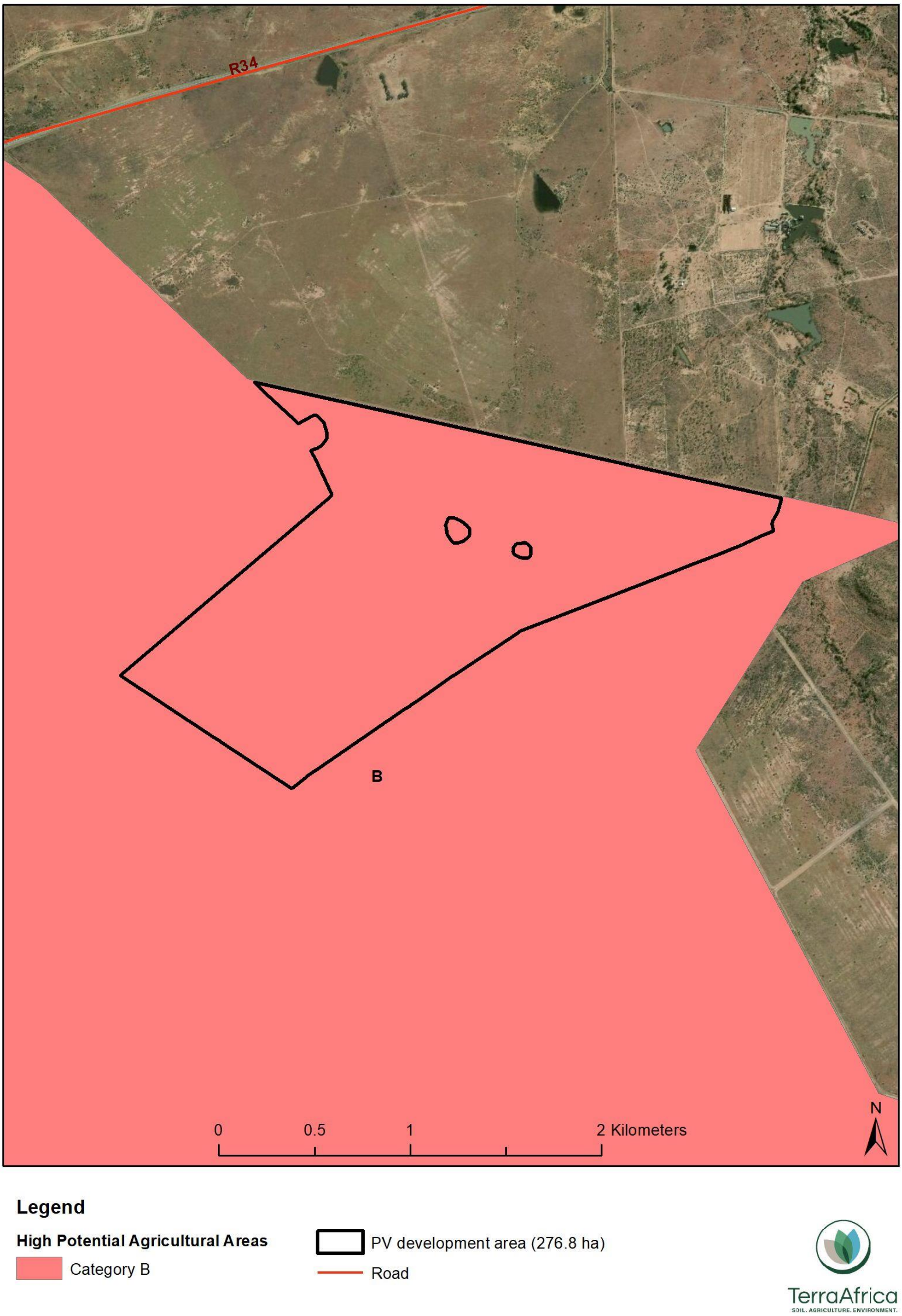


Figure 4 Position of High Agricultural Areas within and around the Vrede solar PV facility area (data source: Department of Agriculture, Land Reform and Rural Development, 2020)

6. Definition of study boundaries

During the development of the study plan, the applicant requested that the entire development area considered for the proposed Vrede solar PV facility, be assessed in detail as part of the field survey. This has enabled the applicant to consider different project layouts, based on sensitivities of the different specialist assessments.

7. Assumptions, uncertainties and information gaps

- It is also assumed that the development footprint will remain within the property boundaries of the development area.
- The only uncertainty is with regards to the position of infrastructure within the development footprint. While it will definitely within the development area, the organisation of the infrastructure may change.

No other information gaps or uncertainties were identified.

8. Methodology

8.1 Desktop analysis of satellite imagery and other spatial data

The most recent aerial photography of the area available from Google Earth was obtained. The satellite imagery was analysed prior to the site visit to determine any areas of existing impacts and land uses within the Vrede solar PV facility area as well as the surrounding areas. It was also scanned for any areas where crop production and farming infrastructure may be present.

To get a comprehensive overview of the natural resources that contribute to the agro-ecosystems of the Vrede solar PV facility development area, the following spatial data was analysed:

- The National Land Capability Evaluation Raster Data Layer was obtained from the DAFF to determine the land capability classes of the project area according to this system. The data was developed using a spatial evaluation modelling approach (DAFF, 2017).
- The long-term grazing capacity for South Africa 2018 was analysed for the area and surrounding area of the project assessment zone. This data set includes incorporation of the RSA grazing capacity map of 1993, the Vegetation type of SA 2006 (as published by Mucina L. & Rutherford M.C.), the Land Types of South Africa data set as well as the KZN Bioresource classification data. The values indicated for the different areas represent long term grazing capacity with the understanding that the veld is in a relatively good condition.
- The Free State Field Crop Boundaries (November 2019) was analysed to determine whether the proposed project assessment zone falls within the boundaries of any crop

production areas. The crop production areas may include rainfed annual crops, non-pivot and pivot irrigated annual crops, horticulture, viticulture, old fields, small holdings and subsistence farming.

- Land type data for the project assessment zone was obtained from the Institute for Soil Climate and Water (ISCW) of the Agricultural Research Council (ARC) (Land Type Survey Staff, 1972 – 2006). The land type data is presented at a scale of 1:250 000 and entails the division of land into land types, typical terrain cross sections for the land type and the presentation of dominant soil types for each of the identified terrain units.

8.2 Site assessment

The development area was visited on 5 March 2021 (autumn) for a site assessment that included a soil classification survey as well as for the collection of photographic evidence. The season has no effect on the outcome of the assessment. The soil profiles were examined to a maximum depth of 1.5m or the point of refusal using a hand-held soil auger. Observations were made regarding soil texture, structure, colour and soil depth at each survey point. A cold 10% hydrochloric acid solution was used on site to test for the presence of carbonates in the soil. Ten soil samples were collected from five different survey points (topsoil and subsoil sample at each point). The topsoil were collected between 0 and 0,3m deep and the subsoil between 0,45 and 0,6m deep. The soil of each sample was stored and sealed in a clean sampling bag and submitted to Eco-Analytica Laboratory that is part of North West University.

The soils are described using the S.A. Soil Classification: A Natural and Anthropogenic System for South Africa (Soil Classification Working Group, 2018). For soil mapping of the areas assessed in detail, the soils were grouped into classes with relatively similar soil characteristics. The locality of each of the survey points, are indicated in Figure **5** below.

8.3 Laboratory analysis of samples

The ten soil samples submitted to Eco-Analytica were analysed for the following parameters:

- pH (using potassium chloride);
- Major cationic plant nutrients (calcium, magnesium, potassium, sodium) using ammonium acetate;
- Plant-available phosphorus (using Bray 1 extract); and
- Texture (using the three-sieve technique to determine the particle size distribution).

The results of the analysis were received on 15 March 2021 and is attached as Appendix 1.

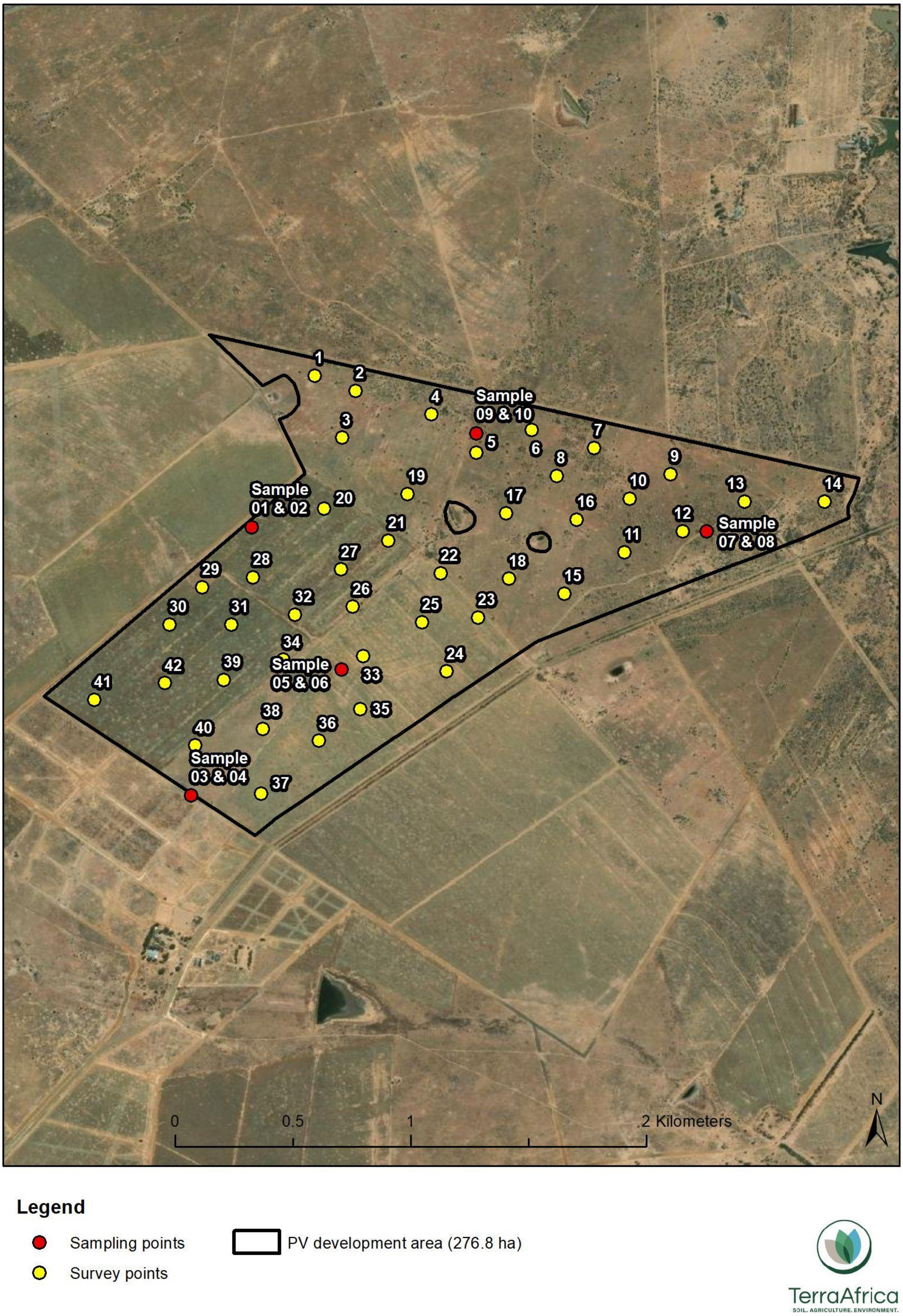


Figure 5 Survey and sampling points map of the Vrede solar PV facility development area

8.4. Verification of land capability

Once the soil classification survey was completed, the different soil form units were grouped together as the different land capability classes that are present on site. The same land capability classification criteria was used that is described in the metadata sheet that accompanies the land capability raster data layer (DAFF, 2017).

The new system has fifteen land capability classes as opposed to the initial eight classes that was described by Schoeman et al. (2002). In the new system, Classes 1 to 7 are considered to be of very low land capability making it only suitable for wilderness and grazing with a variety of management measures. The remaining classes (Class 8 to 15) are considered to have arable land capability with the potential for high yields increasing with the land capability class number.

8.5. Agricultural income and employment

The development area, is used for extensive livestock farming only and has been used for this purpose at least the last ten years, as was evident by the analysis of historical aerial imagery. Therefore, the spatial data layer of the long-term grazing capacity of the area (DAFF, 2018), was used for the calculations of the potential agricultural gross income of the land as well as the agricultural employment opportunities that it provides.

8.6 Impact assessment methodology

Following the methodology prescribed by Savannah Environmental (Pty) Ltd., the direct, indirect and cumulative impacts associated with the project have been assessed in terms of the following criteria:

- The **nature**, which shall include a description of what causes the effect, what will be affected and how it will be affected.
- The **extent**, wherein it will be indicated whether the impact will be local (limited to the immediate area or site of development) or regional, and a value between 1 and 5 will be assigned as appropriate (with 1 being low and 5 being high):
- The **duration**, wherein it will be indicated whether:
    - the lifetime of the impact will be of a very short duration (0–1 years) – assigned a score of 1;
    - the lifetime of the impact will be of a short duration (2-5 years) - assigned a score of 2;
    - medium-term (5–15 years) – assigned a score of 3;
    - long term (> 15 years) - assigned a score of 4; or
    - permanent - assigned a score of 5;
- The **magnitude**, quantified on a scale from 0-10, where 0 is small and will have no effect on the environment, 2 is minor and will not result in an impact on processes, 4 is low and will cause a slight impact on processes, 6 is moderate and will result in processes continuing but in a modified way, 8 is high (processes are altered to the

extent that they temporarily cease), and 10 is very high and results in complete destruction of patterns and permanent cessation of processes.

- The **probability** *of occurrence*, which shall describe the likelihood of the impact actually occurring. Probability will be estimated on a scale of 1–5, where 1 is very improbable (probably will not happen), 2 is improbable (some possibility, but low likelihood), 3 is probable (distinct possibility), 4 is highly probable (most likely) and 5 is definite (impact will occur regardless of any prevention measures).
- the **significance**, which shall be determined through a synthesis of the characteristics described above and can be assessed as low, medium or high; and
- the **status**, which will be described as either positive, negative or neutral.
- the degree to which the impact can be reversed.
- the degree to which the impact may cause irreplaceable loss of resources.
- the *degree* to which the impact can be *mitigated.*

The **significance** is calculated by combining the criteria in the following formula:

S=(E+D+M)P

S = Significance weighting
E = Extent
D = Duration
M = Magnitude
P = Probability

The **significance weightings** for each potential impact are as follows:

- < 30 points: Low (i.e. where this impact would not have a direct influence on the decision to develop in the area),
- 30-60 points: Medium (i.e. where the impact could influence the decision to develop in the area unless it is effectively mitigated),
- 60 points: High (i.e. where the impact must have an influence on the decision process to develop in the area).

9. Baseline description of the agro-ecosystem

9.1 Climate

The Department of Agriculture, Forestry and Fisheries (2017) compiled an updated description of the agricultural suitability of South African climatic conditions, accompanied by a raster data layer of the entire country. The description of climate capability refers to a definition by Strydom (2014) that defines it as the “capability of a geographic area to grow an agricultural crop under existing climatic conditions” (DAFF, 2017). The climate capability includes three parameters i.e. moisture supply capacity, physiological capacity and climatic constraints. The climate capability classes range from 1 (the lowest or worst) to 9 (the highest or best climate for agricultural production).

According to the climate capability raster data, the entire development area has Low-Moderate (Class 04) climate capability (refer to **Error! Reference source not found.**). This indicates that the climate of the area is marginally suitable for rainfed crop production and climate limitations include periods of drought during the summer months, frost during winter months and the possibility of hail that presents hazards to rainfed crop production.

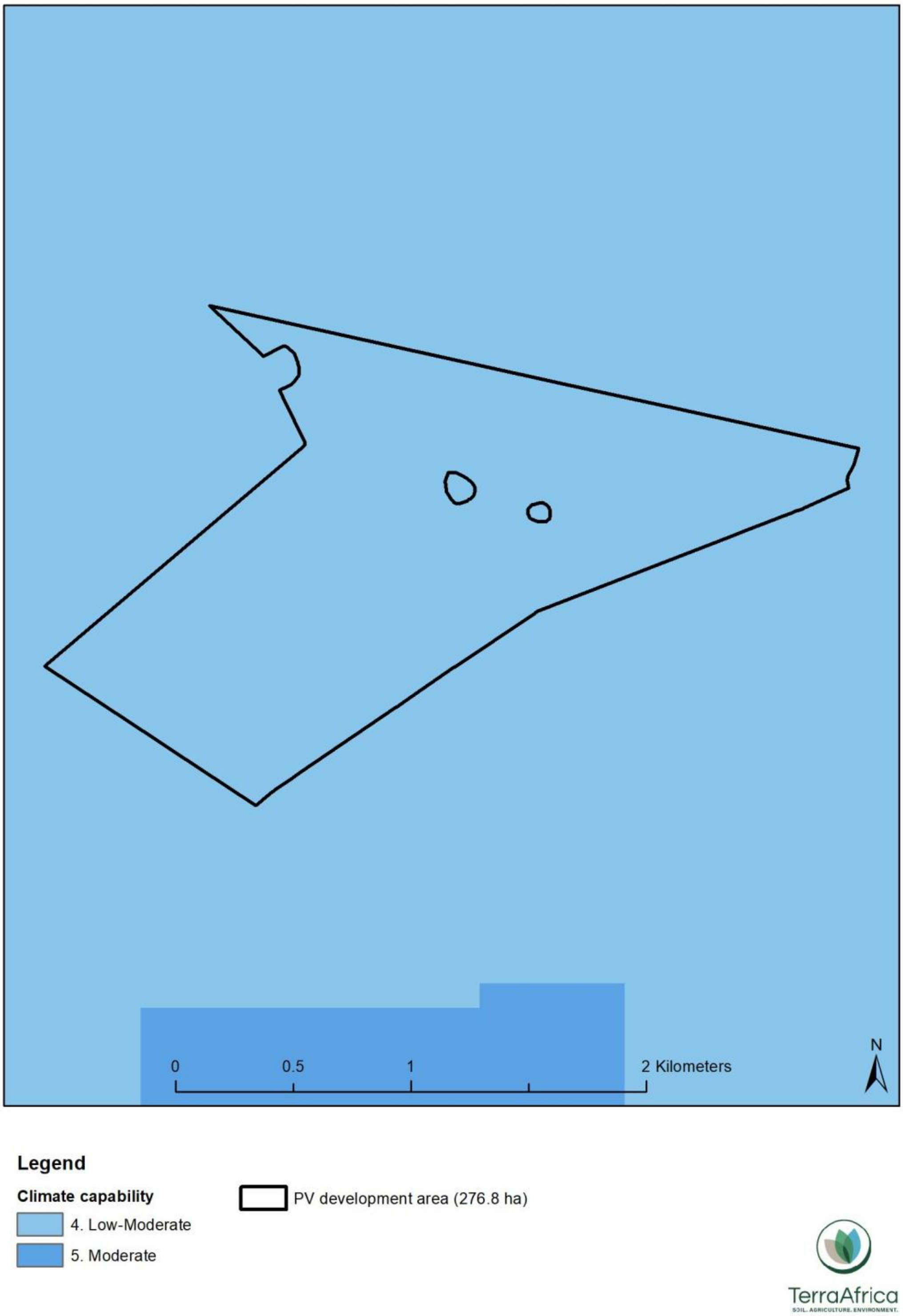


Figure 6 Climate capability rating of the Vrede solar PV facility development area (source: DAFF, 2017)

9.2 Terrain

The development consists of flat areas in the western parts of the development area where the elevation is 1402m above sea level. It becomes slightly more undulating towards the eastern site boundary where the elevation is 1419m above sea level. The terrain units of the western part of the site can be described as toe-slopes with slope ranging between 2 and 5%, changing into mid-slope positions towards the eastern part of the site (see Figure 7). The north-eastern corner can again be described as a toe-slope area that borders on a landscape depression or valley bottom.

Figure 7 Mid-slope area along the eastern part of the development area

9.3 Land type classification

The largest part of the development area consists of Land Type Bd21. The remaining small section in the north-eastern corner, consists of Land Type Dc10. The position of the land types are depicted in Figure **8**. The characteristics of each land type are described below and their typical terrain form units illustrated in Figure 9 and Figure 10. The complete land type sheet of each land type is attached as Appendix 2.

Figure 8 Land types of the Vrede solar PV facility development area

9.3.1 Land Type Bd21

Land Type Bd21 consists of four terrain units and the landscape can be described as slightly undulating with slopes ranging between 1 and 3% (refer to Figure 9). The soil formed from sandstone, mudstone and shale. The crest (Terrain unit 1) is dominated by deep Clovelly and Hutton soil forms (0.9 – 1.2m) and shallower Westleigh soil form (0.4 – 0.6m). The texture of soil in this terrain unit is dominated by sand-clay-loam with the clay fraction estimated as 10 - 20%. Terrain unit 3 (mid-slope) forms 50% of land type Bd21.

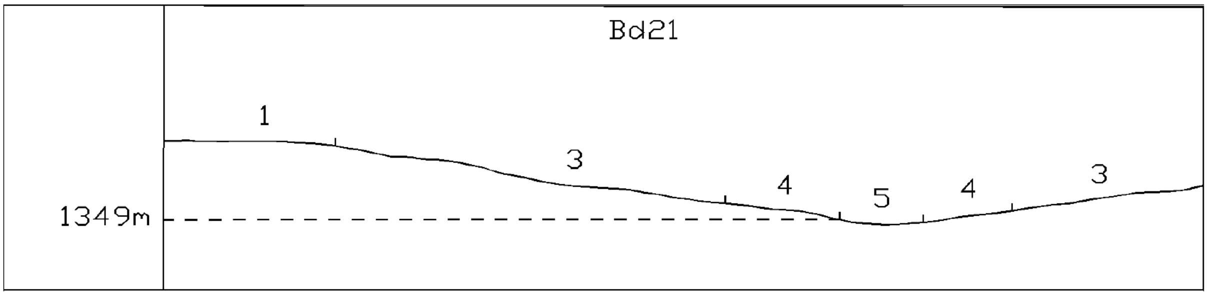


Figure 9 Terrain form sketch of Land Type Bd21

The mid-slopes consist of deep Hutton and Clovelly soil forms (0.9 – 1.2m), Westleigh soil form (0.4 – 0.6m) Valsrivier soil form (0.25 – 0.35m). The toe-slopes (Terrain unit 4) is dominated by the shallow Valsrivier soil form. Sterkspruit, Bonheim and Kroonstad soil forms are also present in the toe slope. Terrain unit 5 (Valley bottom) consists of Dundee, Bonheim, Valsrivier and Sterkspruit soil forms. The soil depth ranges from 0.25m (Valsrivier) to 1.2m (Dundee).The clay content ranges from 20 – 45% and the texture ranges from sand-clay-loam to sand-clay.

9.3.2 Land Type Dc10

Land Type Dc10 comprise of five terrain units where Terrain Units 1, 3 and 4 which dominate the landscape (93%) represent an undulating landscape (see Figure 10). Terrain Unit 5 are the areas of slight depression at the valley bottoms with a slope of 1 – 2%. Terrain unit 2 (upper slope) has steep slopes of >100% but represent only 1% of the Land Type. Terrain unit 3 (lower slope) has a slope of 4 – 12%while the slopes of the other terrain units (crest and toe slope) range between 1 and 5%. The soil originated on the crests and scarps (upper slopes) from dolerite or sandstone and the mid slopes and toe slopes mainly from mudstone and shale.

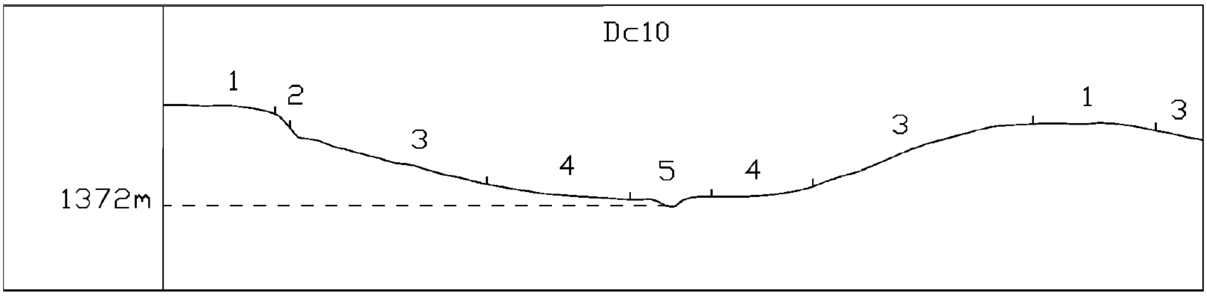


Figure 10 Depiction of the terrain forms of Land Type Dc10

The texture of soil in this land type is dominated by sandy clay and clay on the mid slope and toe slope with the clay ranging between 15 and 30%. Terrain units 3 and 4 that represent 71%

of this land type mainly consists of rock, shallow soil profiles (0.1 – 0.3m) of the Swartland and Mispah forms with an estimated 7 - 12% of areas in these terrain units consisting of deeper soil profiles (0.3 – 0.58m) of the Bonheim form. The valley bottoms are dominated by deep soil profiles (>1.2m) of the Dundee and Inhoek soil forms.

9.4 Soil properties

9.4.1 Soil forms

Nine different soil forms have been identified within the development area. The majority of the soil forms are typical of a plinthic catena while smaller areas with more structured soil forms that are calcareous are found along the south-western boundary as well as the northern boundary. The location of the soil forms within the study area is illustrated in Figure 12. The approximate size of the areas as well as the horizon organisation of each soil form, is presented in Table **1**. Photographic examples of the soil properties of the soils within the development area, are presented as Figure **11**, Figure **13** and Figure **14**.

Table 1 Summary of soil classification results of the Vrede solar PV facility development area

Soil form	Area (ha)	Horizon organisation (topsoil/subsoil/nature of underlying material)	Soil depth range (m)
Avalon	8.90	Orthic / Yellow-Brown Apedal / Soft Plinthic	0.55 – 0.70
Bainsvlei	9.20	Orthic / Red Apedal / Soft Plinthic	0.95 – 1.20
Bloemdal	26.2	Orthic / Red Apedal / Gleyic	0.80 – 1.00
Gamoep	27.0	Orthic / Neocutanic / Hard carbonate	0.55 – 0.80
Glencoe	20.1	Orthic / Yellow-brown apedal / Hard plinthite	0.55 – 0.70
Palmiet	12.6	Orthic / Yellow-brown apedal / Neocutanic	0.70 – 1.10
Pinedene	27.2	Orthic / Yellow-brown apedal / Gleyic	1.20 – 1.40
Rustenburg	11.3	Vertic / Hard rock	0.65 – 0.90
Tukulu	134.1	Orthic / Yellow-brown apedal / Gleyic	0.65 – 1.3

Figure **11** Example of the orthic topsoil and yellow-brown subsoil of the Pinedene soil formTable **1** Summary of soil classification results of the Vrede solar PV facility development area

Figure 11 Example of the orthic topsoil and yellow-brown subsoil of the Pinedene soil form

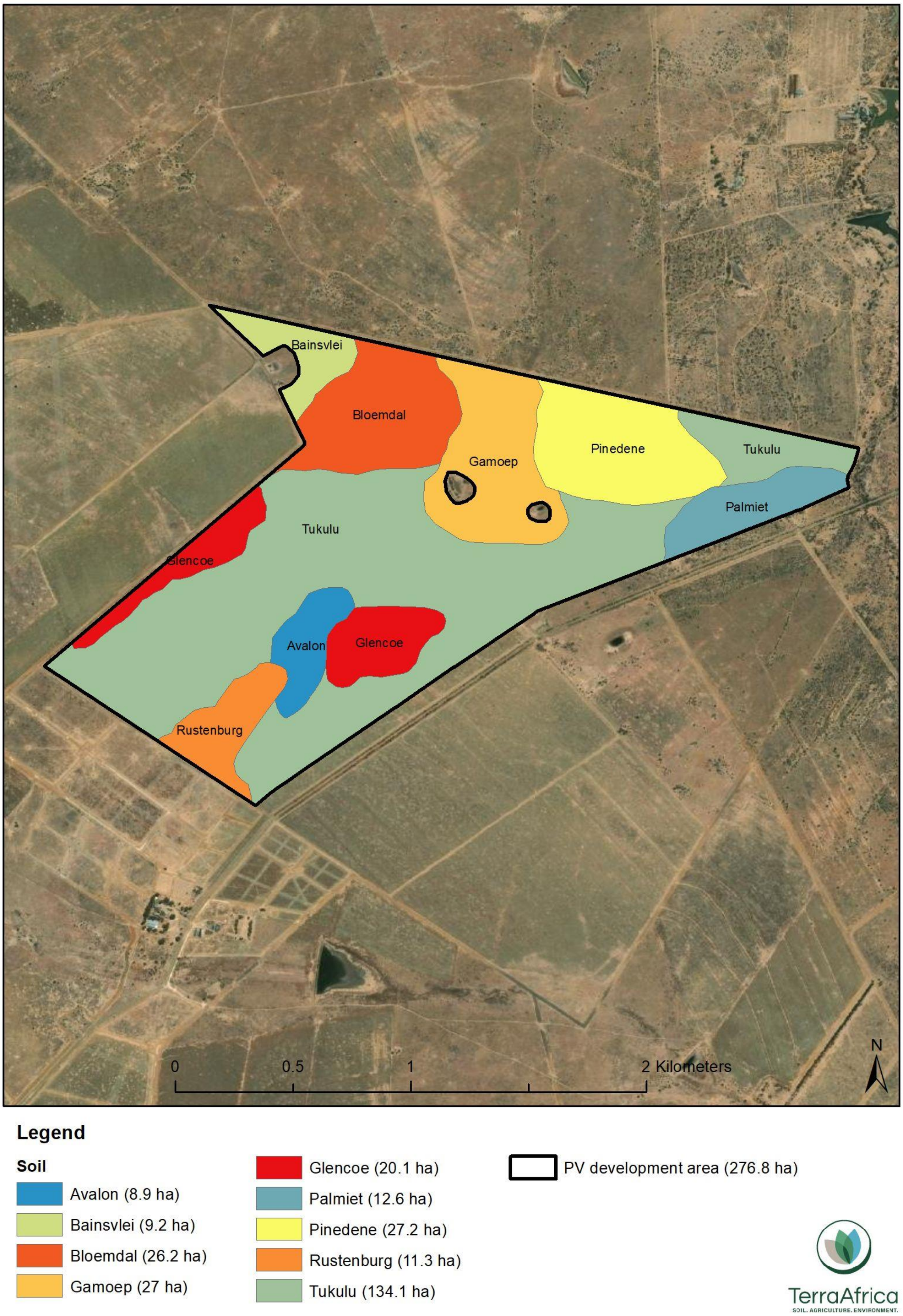


Figure 12 Soil classification map of the Vrede solar PV development area

Figure 13 Example of the soft plinthic material of the Avalon soil form

Figure 14 Example of the vertic topsoil of the Rustenburg form

9.4.2 Soil texture

The soil texture of the soil forms present within the proposed development area, was calculated by using the results of the particle size analysis for the soil texture triangle formulas as provided on the website of the United States Department of Agriculture's under Natural Resource Conservation Services (Soil) (www.nrcs.usda.gov). The results of the particle size analysis of the soil samples as well as the soil texture class into which results translate, are presented in Table **2** below. Following the results, the soil texture of soils within the development area range between Sand and Clay with Sandy Clay Loam being the dominant texture class.

Table 2 Summary of particle size distribution and soil texture classes of the soil samples analysed

Sample no:	Particle size distribution (%)			Texture class
	Sand	Silt	Clay	
1	89.9	3.4	6.7	Sand
2	86.8	1.1	12.2	Loamy Sand
3	71.4	13.9	14.7	Sandy Loam
4	68.4	6.2	25.5	Sandy Clay Loam
5	81.0	8.0	11.0	Sandy Loam
6	71.8	6.6	21.6	Sandy Clay Loam
7	74.5	11.1	14.4	Sandy Loam
8	72.2	5.9	21.9	Sandy Loam
9	78.2	8.1	13.7	Sandy Loam
10	39.0	7.1	53.9	Clay

9.4.3 Soil fertility parameters

The soil pH(KCl) values range between strongly acidic value (pH 4.25 and 4.34 for Sample 7 and 8 respectively) to moderately acidic (pH 5.36 and 5.43 for Sample 4 and Sample 10, respectively). For the purpose of crop production, pH values above 4.5 is recommended to prevent aluminium toxicities, prevent phosphate fixation and allow for optimal nutrient uptake by crop roots. However, the areas from which the samples were collected have not been used for crop production at least ten years and the soil pH analysis results are not considered problematic for livestock production.

The calcium levels range between 285.5mg/kg in Sample 1 and 2 031.1mg/kg in Sample 4. The magnesium levels are the lowest in Samples 1 and 2 (72.7mg/kg and 62.6mg/kg) and the highest value was measured in Sample 10 at 805.0 mg/kg. The potassium levels range between a low of 124.1mg/kg in Sample 4 and 1563.1mg/kg in Sample 10.

The plant-available phosphorus levels are low in all samples analysed except two (Sample 1 and Sample 5). The higher levels of Sample 1 and Sample 5 may be as a result of more recent fertilizer application in some of the fields where planted pasture was established.

Although sodium is not considered an essential plant nutrient and can cause soil sodicity when present in very high concentrations, a number of C4 plants use sodium for the concentration of carbon dioxide, thereby aiding in maximum biomass yield in these plants (Subbarao et al., 2003). A wide range of sodium concentrations are present in soil on site, ranging from very low at 2.6mg/kg to much higher concentrations of 180.4mg/kg.

9.5 Land capability

The land capability classification is used as one of the main criteria for the determination of the Agricultural combined sensitivity of a specific development area and the raster data is incorporated into the Environmental Screening Tool of the Department of Environmental Affairs. Land capability classification is also used in the criteria set out for the calculation of the allowable development limits for renewable energy generation developments for the generation of electricity of 20MW or more.

Prior to the site visit, the development area boundary was overlaid on the DAFF land capability raster data (DAFF, 2017), with the result depicted in Figure **15**. Following the raster data, the Vrede solar PV facility development area includes five different land capability classes according to the land capability data (DAFF, 2017). **Error! Reference source not found.** indicates the position of the different classes within the farm portions that form the proposed development area. The entire development area largely consists of land with Moderate (Class 8) to Moderate High (Class 9) land capability. Smaller patches in the centre and south-west consist of land with Low- Moderate (Classes 06 and 07) land capability. Classes 08 and 09 have potential for the production of specific crops under rainfed conditions while classes 06 and 07 are likely to be very marginal arable land that is more suitable for livestock grazing.

Once the soil classification map was developed, the area was classified into different land capability classes based on the suitability of the soil properties – under the climate of the study area, to be used for rainfed crop production. The Vrede solar PV facility development area have been assigned four different land capability classes. These classes are Low (Class 05), Low-Moderate (Class 06), Moderate (Class 08) and Moderate-High (Class 09). The position of the different land capabilities are depicted in Figure **16** and the results of the land capability classification are present in Table **3**.

Table 3 Summary of land capability classification results of the Vrede solar PV facility development area

Land capability class	Class no.	Horizon organisation (topsoil/subsoil/nature of underlying material)	Area (ha)
Moderate-High	09	Bainsvlei, Bloemdal, Pinedene	11.3
Moderate	08	Tukulu, Palmiet	56.1
Low-Moderate	06	Glencoe, Avalon, Gamoep	146.8
Low	05	Rustenburg	62.7

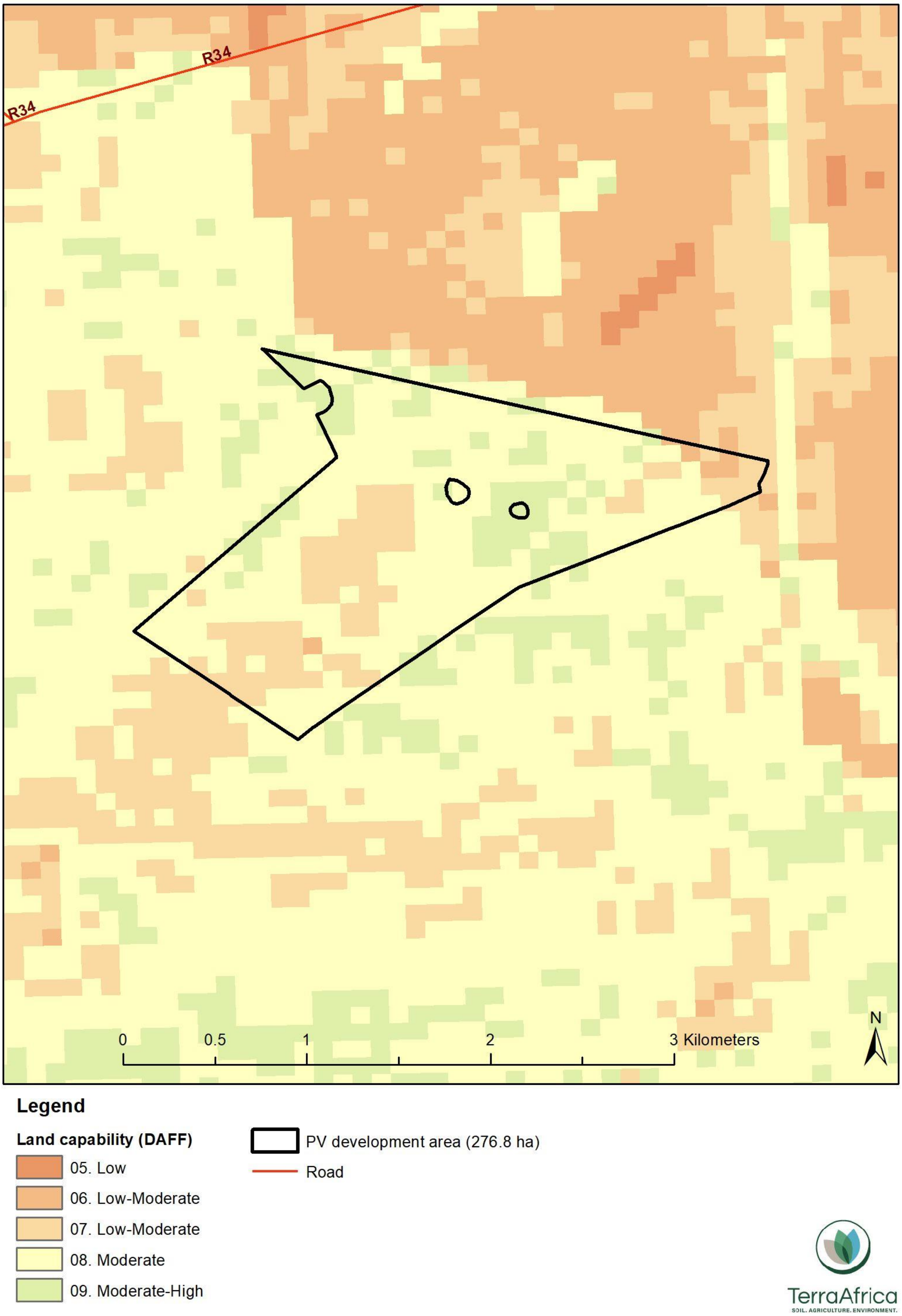


Figure 15 Land capability map of the Vrede solar PV project area (data source: DAFF, 2017)

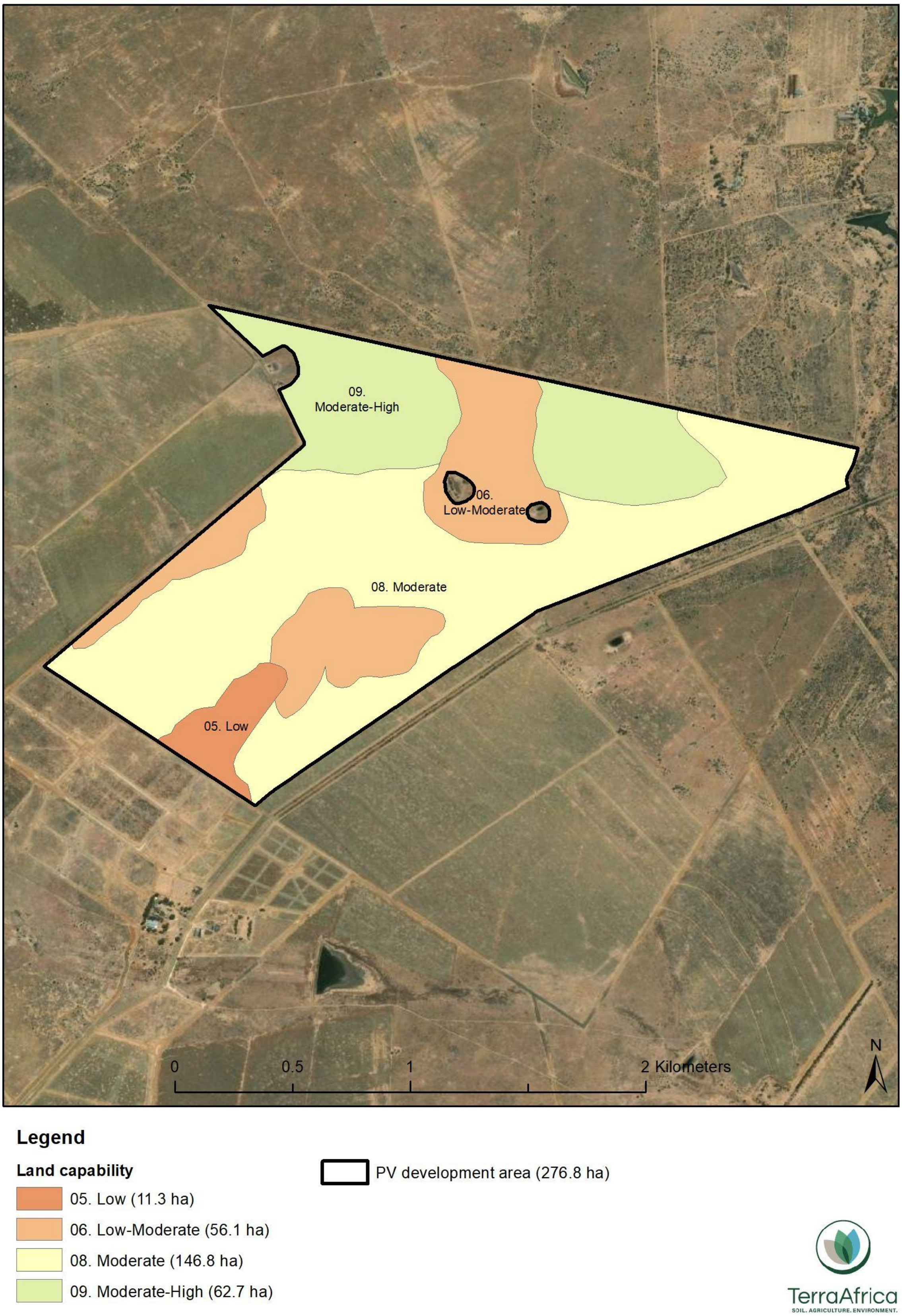


Figure 16 Land capability classification of the Vrede solar PV facility development area, based on soil classification and on-site verification of terrain suitability

9.6 Agricultural production

9.6.1 Field crop boundaries

In preparation for the site visit, the Vrede solar PV facility development area, has been scanned for field crop boundaries. The results showed that the area consist of a large section of either rainfed annual crops or planted pastures (see Figure **17**). Several pivot irrigation fields are located outside the development area, mostly south-west and south of it. Large fields with rainfed crops and/or planted pastures are located to the west and south of the development area with old fields to the north.

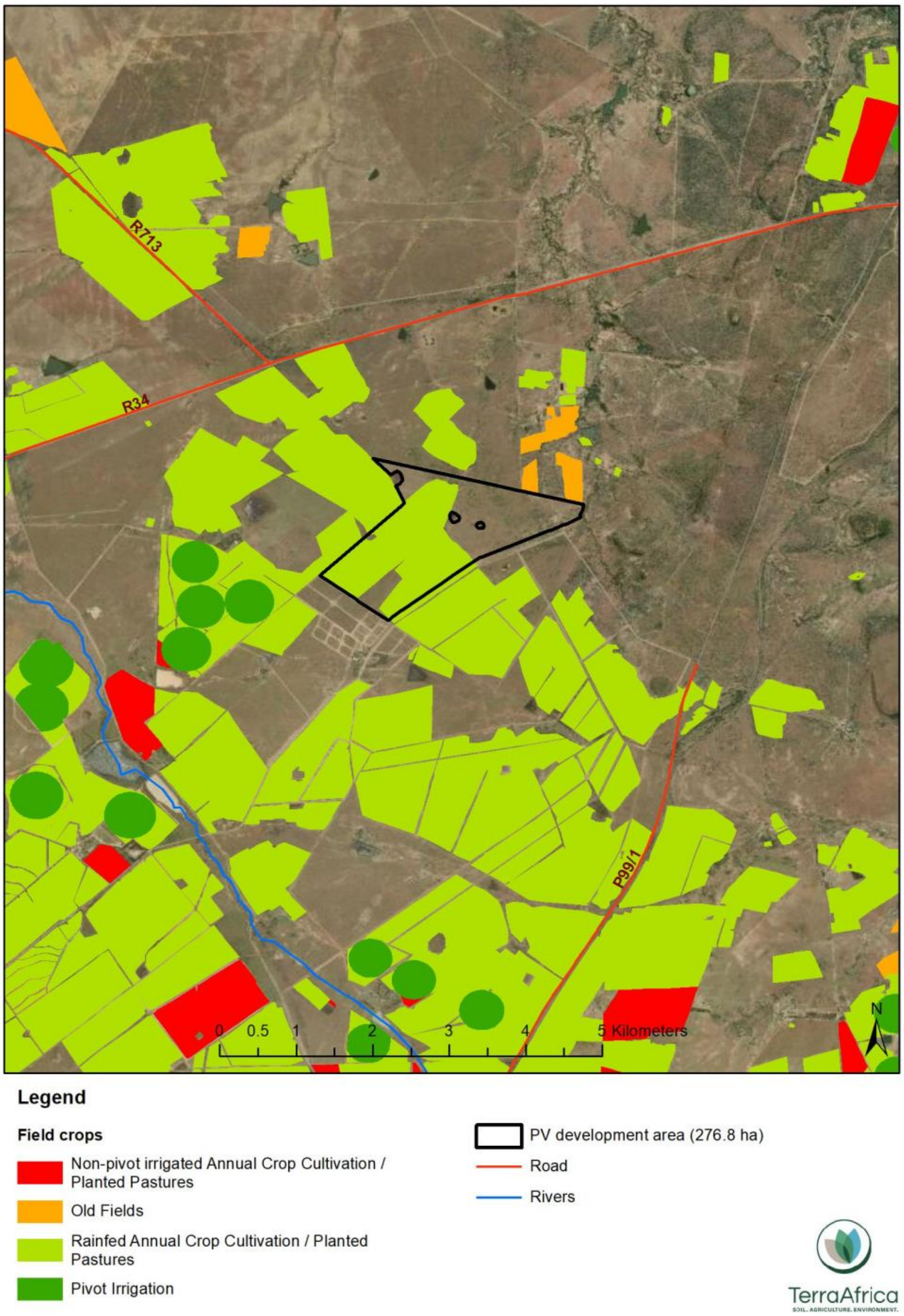


Figure 17 Position of field crop boundaries within and around the Vrede solar PV facility development area

During the site visit it was established that the entire development now consist of grazing land with planted pastures in the area where rainfed crops were historically produced. The dominant species of the planted pasture is Smutsfinger (*Digitaria eriantha*) (see Figure 18). In the areas never used for grain crop production on the eastern side of the development area, the vegetation include a mixture of grass species such as red grass (*Themeda triandra*) and trees such as the *Vachellia spp.* (see Figure 19).

Figure 18 Photographic evidence of planted pasture (Digitaria eriantha) in areas where grain crops were produced prior to 2005

Figure 19 Example of the eastern part of the site with a mixture of indigenous grass and tree species

The landowner has indicated that the conversion of fields from rainfed annual crop cultivation was completed in 2005 already and stated that crop cultivation was economically non-viable. Although good quality aerial imagery of the land use of the development area prior to 2011 could not be obtained from Google Earth, the aerial imagery of the area between 2011 and 2020 clearly shows no cultivation took place in the period between 2011 and 2020 (refer to Figure 20, Figure 21 and Figure 22). It also shows that between 2013 and 2020, two crop fields bordering on the development area (directly west and north-west) have been converted from rainfed annual crops to pasture.

Figure 20 Land uses within and around the development area in 2011 (source: Google Earth)

Figure 21 Land uses within and around the development area in 2011 (source: Google Earth)

Figure 22 Land uses within and around the development area in 2011 (source: Google Earth)

9.6.2 Livestock farming

The farmer has indicated that he farms with Bonsmara cattle and the operation is focussed on commercial production for livestock auctions. The herd of cattle was observed grazing within the development area within the development area.

Figure 23 Photographic evidence of the Bonsmara cattle grazing within the development area

The ideal grazing capacity of a specified area is an indication of the long-term production potential of the vegetation layer growing there to maintain an animal with an average weight of 450 kg (defined as 1 Large Stock Unit [LSU]) with an average feed intake of 10 kg dry mass per day over the period of approximately a year. This definition includes the condition that this feed consumption should also prevent the degradation of the soil and the vegetation. The grazing capacity is therefore expressed in a number of hectares per LSU (ha/LSU) (South Africa, 2018). Following the metadata layer obtained from DAFF, the grazing capacity of the largest section of the development area, is 6 ha/LSU (see Figure **24**). A small area in the north-eastern corner of the development area, has grazing capacity of 5 ha/LSU.

Figure 24 Long-term grazing capacity of the Vrede solar PV facility development area

9.6.3 Agricultural income and employment within the development footprint

The potential gross income that can be generated from the land annually, was calculated by using the long-term average grazing capacity of the area that will be affected by the proposed project. The following assumptions have been made in the calculations:

- The construction of the Vrede solar PV facility infrastructure will including fencing off the development footprint. This will exclude any cattle farming activities from the fenced-off area. The area considered a loss to production from the onset of the construction period is:
    - Proposed development (276.8 ha) minus the area that will remain available for livestock farming (64.6 ha) = area where cattle forage will no longer be available (212 ha)
- At a long-term average grazing capacity of 6 hectare per Large Stock Unit (/ha/LSU) (DAFF, 2018), the area of 212 ha, provide forage to 35 head of cattle.
- The herd is considered to have a 80% weaning rate which is considered an optimistic figure and does not take any potential losses from stock theft into consideration. This allows for the sale of around 28 weaners per annum.
- The average weight of a Bonsmara weaner is estimated at 220 kg and the average auction price for live weight (or "hoof weight") the past year, was R36/kg.

The total gross income that could possibly be generated by livestock farming in the area the past year, is therefore estimated to be R221 760.00.

Following the requirements of GN320, the potential gross income loss from agricultural activities in the area for the next five years, must also be considered. For this estimation, it was assumed that there will be a price increase of 6% per annum for live weight of cattle. The estimates for four years as well as the total gross income lost from agricultural production, is presented in the table below.

Table 4 Gross livestock income forecast for the proposed development footprint

Year	**Price of live weight (R/kg)**	**Gross annual income (R)**
2020/2021	36.00	R221 760.00
2021/2022	38.16	R235 065.60
2022/2023	40.44	R249 110.40
2023/2024	42.87	R264 079.20
2024/2025	45.44	R279 910.40
Estimated total gross income from livestock production between 2021 and 2025		**R1 249 925.60**

The labour requirement of the livestock farming within the development area requires one to two people to assist with animal herding, disease management and general farm maintenance. For the calculation of the employment expenditure, a salary of R6 000 per month was used (more than the minimum wage for farm workers in South Africa). Assuming the monthly salary, the annual expenditure for labour will range between R72 000.00 and R144 000.00.

9.6.4 Agricultural activities on adjacent land parcels

The land parcel located directly west of the south-western boundary of the development area, is used for farming with lions. The land parcels west of the development area, include mixed farming activities such as rainfed and irrigated crop production as well as livestock farming. Land parcels located north and east of the development area consist of natural veld and/or planted pasture for livestock and game grazing.

10. Agricultural sensitivity of the site

10.1 Sensitivity rating of current development footprint layout

Following the consideration of all the baseline and desktop data discussed in the sections above, the proposed Vrede solar PV facility development area can be categorised into areas with one of three sensitivities i.e. High, Medium and Low. The location of the different areas are reflected in Figure 25. To illustrate the extent of the proposed land use change from agriculture to renewable energy, the development footprint (as received from the applicant), was superimposed on the agricultural sensitivity map and the areas measured that will be affected (see Figure 26).

Table 5 Summary of the impact of the development footprint on the agricultural sensitivity of the site

Sensitivity class	Land capability classes	Area within development area (ha)	Area that will be affected by development footprint (ha)
High	Moderate-High (09), Moderate (08)	209.4	155.3
Medium	Low-Moderate (06)	56.1	47.8
Low	Low (05)	11.3	9.1

10.2 Consideration of alternative infrastructure layouts and micro-siting

The applicant considered a number of different project layout options but none of these options would have minimised the areas with High agricultural sensitivity. The different project layout options were focussed on keeping the layout as compact as possible in order to avoid fragmentation of agricultural land. Therefore the proposed substation area is embedded within the layout of the solar PV panel area.

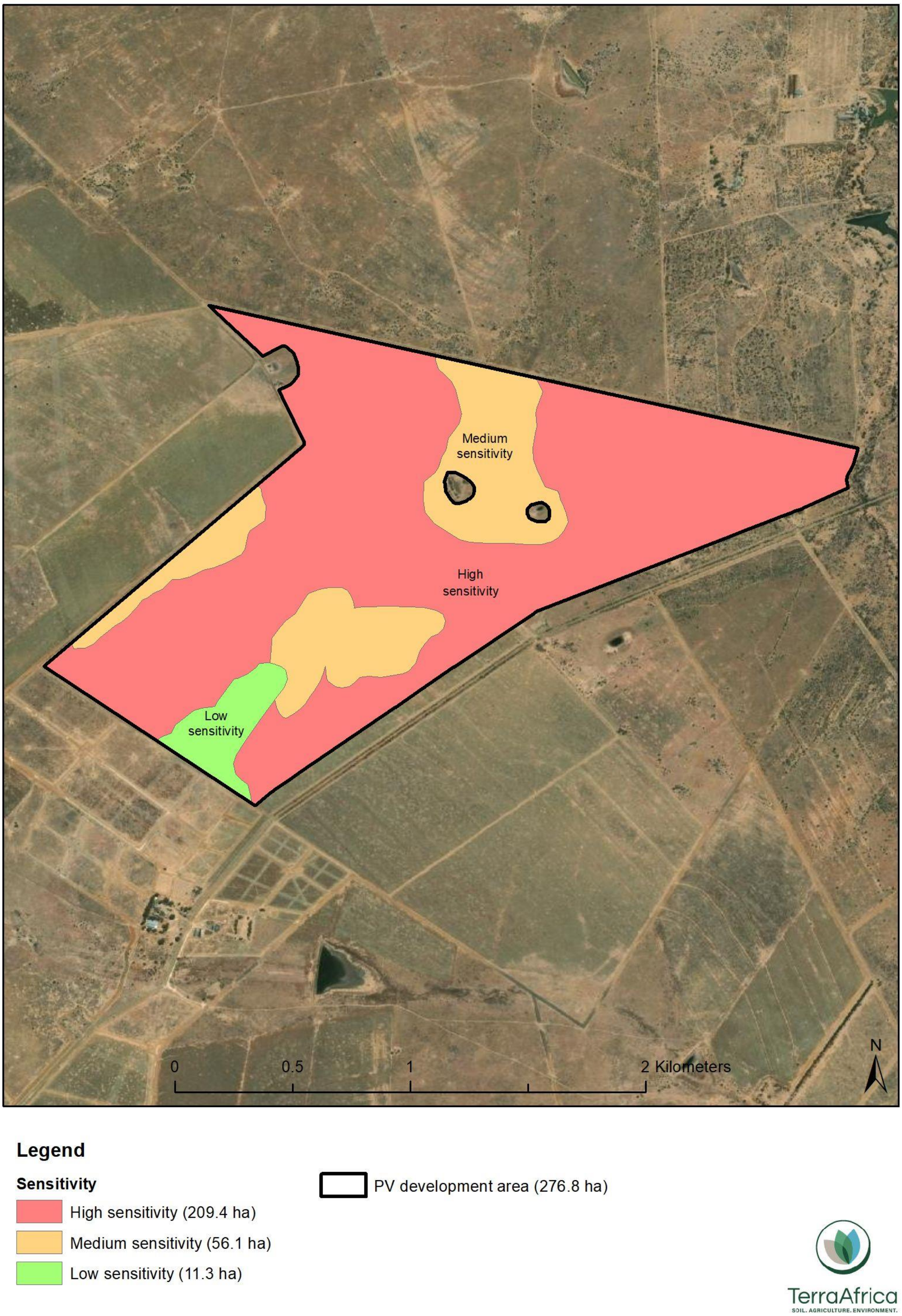


Figure 25 Sensitivity rating of the Vrede solar PV facility development area

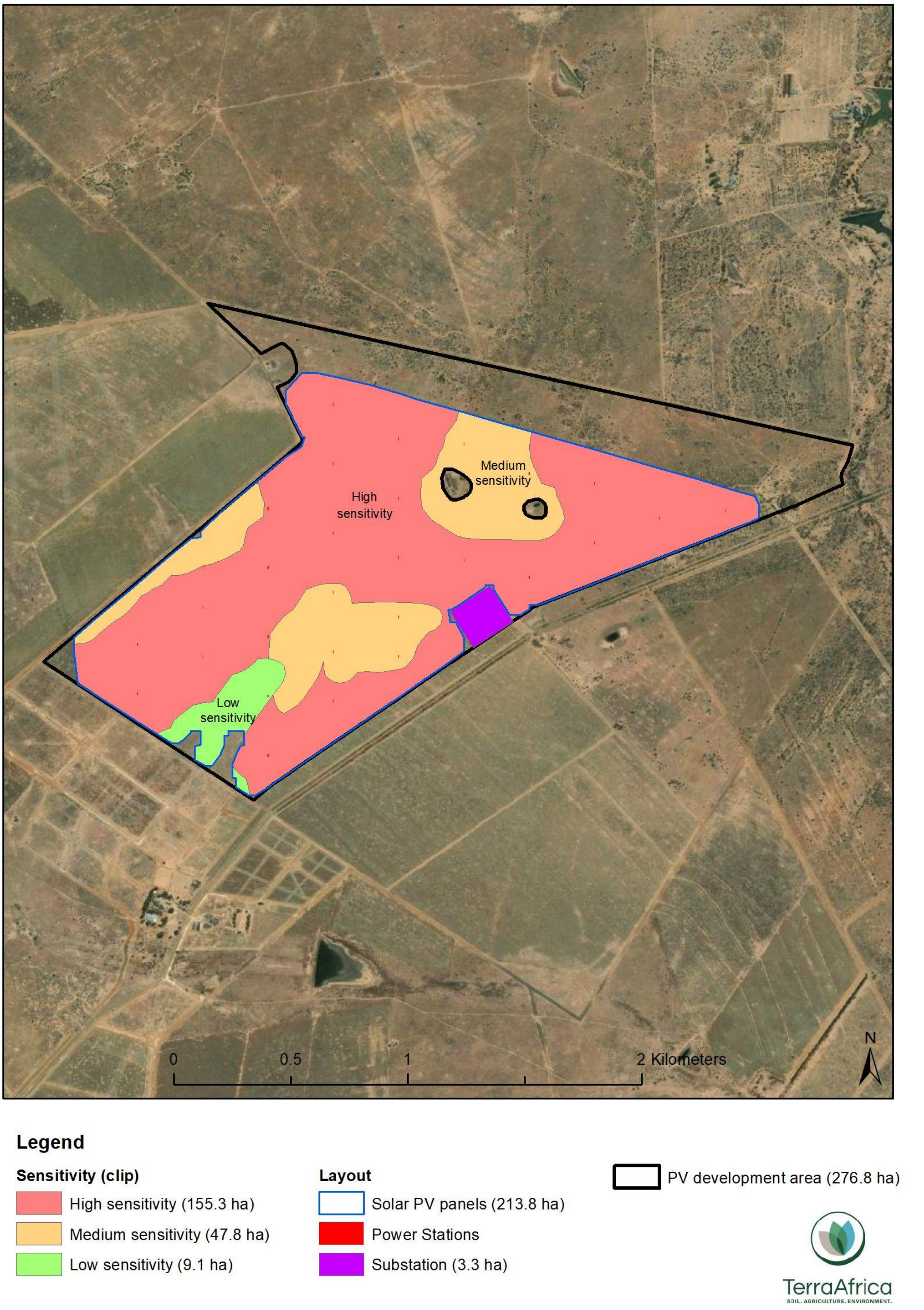


Figure 26 The Vrede solar PV facility development footprint superimposed on the agricultural sensitivity of the site

10.3 Allowable development limits

GN320 provides Allowable Development Limits for renewable energy generation developments of 20MW or more in Table 1 of Section 2 (page 31). The limits are based on the identification of the agricultural sensitivity of the proposed development footprint. The limits take land capability, the presence of irrigated agriculture and priority rating of high value agricultural areas into consideration. Although the field crop boundary data layer indicates that there are crop fields in the area, these crop fields have already been converted to pasture since 2005. The allowable development limit for areas outside of crop fields will therefore be used for the calculations. The results of the calculations are provided in Table **6** below.

Table 6 Summary of the impact of the development footprint on the agricultural sensitivity of the site

Sensitivity class	Land capability classes	Area that will be affected by development footprint (ha)	Allowable limit (ha/MW)	Area allowed for a 100MW development (ha)	Area that exceeds allowable limit (ha)
High	Moderate-High (09), Moderate (08)	155.3	0.35	35	120.3
Medium	Low-Moderate (06)	47.8	2.50	250	0
Low	Low (05)	9.1	2.50	250	0

Following the calculations above, the development footprint exceeds the allowable limit with 120.3 ha of land with high agricultural sensitivity. The Medium and Low sensitivity areas that will be affected by the development footprint, falls within the allowable development limit.

Although the area exceeds the allowable development limit, it is recommended that the application for Environmental Authorisation not be rejected on this base. The reasons for the recommendation is as follows:

- The landowner indicated during the discussion session that rainfed crop production was not a economically viable land use and that the remaining crop fields were converted to grazing land after he purchased the land parcels in 2002. Since 2005, no annual or other crops were produced in these areas.
- The landowner also indicated that he has no intention of ever returning the old crop fields to rainfed crop production. Therefore, as long as he remains the landowner, the land parcels will not contribute to the volume of crops produced in the region.
- The land parcels considered for the Vrede solar PV facility, are the only ones available in the area for such a development as the energy generation potential, the close

proximity to a substation and the willingness of the land owner to allow such a project on his land, contribute to the viability of the project.

- No other land parcels in close proximity to the proposed development area, are available for consideration.

11. Impact assessment of additional environmental impacts

11.1 Project description

The Vrede solar PV facility will consist of the following infrastructure:

- Solar PV array comprising PV modules and mounting structures.
- Inverters and transformers.
- Cabling between the project components.
- On-site facility substation to facilitate the connection between the solar PV facility and the Eskom electricity grid.
- Battery Energy Storage System (BESS).
- Site offices and maintenance buildings, including workshop areas for maintenance and storage.
- Laydown areas.
- Access roads, internal distribution roads and fencing around the development area.
- Telecommunication infrastructure.
- Stormwater channels
- and water pipelines.

The power generated will connect to an authorised substation via an overhead 132kV power line (separately authorised). However, the power line is not part of this Environmental Authorisation process and impacts of the activities associated with power line construction is excluded from the discussion below.

11.2 Impact significance rating

The most significant impacts of the proposed Vrede solar PV facility project on soil and agricultural productivity, will occur during the construction phase when the vegetation is removed and the soil surface is prepared for infrastructure commissioning. During the operational phase, the risk remains that soil will be polluted by the waste generated during the operational phase or in the case of a spill incident. During the decommissioning phase, soil will be prone to erosion when the infrastructure is removed from the soil surface. Below follows a rating of the significance of each of the impacts.

11.2.1 Construction phase

Impact: Change in land use from livestock farming to energy generation

Nature: Prior to construction of the thermal generation plant, the area will be fenced off and livestock farming will be excluded from 212.2ha of land. The area where infrastructure will be constructed will be stripped of vegetation and will no longer be suitable for livestock grazing.

	Without mitigation	With mitigation
Extent	Local (1)	Local (1)
Duration	Medium duration (3)	Medium duration (3)
Magnitude	Low (4)	Low (4)
Probability	Definite (4)	Definite (4)
Significance	**Medium (32)**	**Medium (28)**
Status (positive or negative)	Negative	Negative
Reversibility	Moderate	Moderate
Irreplaceable loss of resources?	Yes	Yes
Can impacts be mitigated?	No	N/A

Mitigation:

- Vegetation clearance must be restricted to areas where infrastructure is constructed.
- No materials removed from development area must be allowed to be dumped in nearby livestock farming areas.
- Prior arrangements must be made with the landowners to ensure that livestock and game animals are moved to areas where they cannot be injured by vehicles traversing the area.
- No boundary fence must be opened without the landowners' permission.
- All left-over construction material must be removed from site once construction on a land portion is completed.
- No open fires made by the construction teams are allowable during the construction phase.

Residual Impacts:
The residual impact from the construction and operation of the Vrede solar PV facility is considered medium.

Cumulative Impacts:
Any additional infrastructure development in support of the Vrede solar PV facility, will result in additional areas where grazing veld will be disturbed.

Impact: Soil erosion

Nature: All areas where vegetation is removed from the soil surface in preparation for the infrastructure construction, will result in exposed soil surfaces that will be prone to erosion. Both wind and water erosion are a risk and even though the project area is in the arid climate, the intensity of single rainstorm may result in soil particles being transported away.

	Without mitigation	With mitigation
Extent	Local (1)	Local (1)
Duration	Medium-term (3)	Medium-term (3)
Magnitude	Moderate (6)	Low (4)
Probability	Probable (3)	Improbable (2)
Significance	**Medium (30)**	**Low (16)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Low
Irreplaceable loss of resources?	Yes	No
Can impacts be mitigated?	Yes	N/A

Mitigation:

- Land clearance must only be undertaken immediately prior to construction activities and only within the development footprint;
- Unnecessary land clearance must be avoided;
- Level any remaining soil removed from excavation pits that remained on the surface instead of allowing small stockpiles of soil to remain on the surface.
- Where possible, conduct the construction activities outside of the rainy season.

Residual Impacts:
The residual impact from the construction and operation of the proposed Vrede solar PV facility Thermal Facility on the susceptibility to erosion is considered low.

Cumulative Impacts: Any additional infrastructure development in support of the Vrede solar PV facility Thermal Facility, will result in additional areas where exposed to soil erosion through wind and water movement.

Impact: Soil compaction

Nature: The clearing and levelling of land for both the thermal plant infrastructure as well as the access road, will result in soil compaction. In the area where access roads will be constructed, topsoil will be removed and the remaining soil material will be deliberately compacted to ensure a stable road surface.		
	Without mitigation	**With mitigation**
Extent	Local (1)	Local (1)
Duration	Medium-term (3)	Medium-term (3)
Magnitude	Moderate (6)	Low (4)
Probability	Probable (3)	Improbable (2)
Significance	**Medium (30)**	**Low (16)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Low
Irreplaceable loss of resources?	Yes	No
Can impacts be mitigated?	Yes	N/A
Mitigation: • Vehicles and equipment must travel within demarcated areas and not outside of the construction footprint; • Unnecessary land clearance must be avoided; • Where possible, conduct the construction activities outside of the rainy season; and • Vehicles and equipment must park in designated parking areas.		
Residual Impacts: The residual impact from the construction and operation of the proposed Vrede solar PV facility on soil compaction is considered low.		
Cumulative Impacts: Any additional infrastructure development in support of the Vrede solar PV facility, will result in additional areas exposed to soil compaction.		

Impact: Soil pollution

During the construction phase, construction workers will access the land for the preparation of the terrain and the construction of the thermal plant and access road. Both potential spills and leaks from construction vehicles and equipment as well as waste generation on site, can result in soil pollution.

Nature: The following construction activities can result in the chemical pollution of the soil: 1. Petroleum hydrocarbon (present in oil and diesel) spills by machinery and vehicles during earthworks and the removal of vegetation as part of site preparation. 2. Spills from vehicles transporting workers, equipment, and construction material to and from the construction site. 3. The accidental spills from temporary chemical toilets used by construction workers. 4. The generation of domestic waste by construction workers. 5. Spills from fuel storage tanks during construction. 6. Pollution from concrete mixing. 7. Pollution from road-building materials. 8. Any construction material remaining within the construction area once construction is completed. 9. Containment breaches related to the battery units and any inadvertent chemical exposure therefrom.		
	Without mitigation	**With mitigation**

Extent	Local (1)	Local (1)
Duration	Short-term (2)	Short-term (2)
Magnitude	Moderate (6)	Low (4)
Probability	Low (4)	Improbable (2)
Significance	**Medium (36)**	**Low (14)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Low
Irreplaceable loss of resources?	Yes	No
Can impacts be mitigated?	Yes	N/A
Mitigation: • Maintenance must be undertaken regularly on all vehicles and construction/maintenance machinery to prevent hydrocarbon spills; • Any waste generated during construction, must be stored into designated containers and removed from the site by the construction teams. • Any left-over construction materials must be removed from site. • Ensure battery transport and installation by accredited staff / contractors. • Compile (and adhere to) a procedure for the safe handling of battery cells during transport and installation.		
Residual Impacts: The residual impact from the construction and operation of the proposed project will be low to negligible.		
Cumulative Impacts: Any additional infrastructure that will be constructed to strengthen and support the operation of the Vrede solar PV facility and where waste is not removed to designated waste sites, will increase the cumulative impacts associated with soil pollution in the area.		

11.2.2 Operational phase

Impact: Soil erosion

During the operational phase, staff and maintenance personnel will access the Vrede solar PV facility daily. This phase will have no additional impact on the livestock farming potential of the area. The following impacts on soil is expected for this phase:

Nature: The areas where vegetation was cleared, will remain at risk of soil erosion, especially during a rainfall event when runoff from the cleared surfaces will increase the risk of soil erosion in the areas directly surrounding the Vrede solar PV facility.		
	Without mitigation	**With mitigation**
Extent	Local (1)	Local (1)
Duration	Medium-term (3)	Medium-term (3)
Magnitude	Moderate (6)	Low (4)
Probability	Probable (3)	Improbable (2)
Significance	**Medium (30)**	**Low (16)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Low
Irreplaceable loss of resources?	Yes	No
Can impacts be mitigated?	Yes	N/A
Mitigation: • The area around the development footprint must regularly be monitored to detect early signs of soil erosion on-set. • If soil erosion is detected, the area must be stabilised by the use of geo-textiles and facilitated re-vegetation.		

Residual Impacts: The residual impact from the operation of the proposed Vrede solar PV facility on the susceptibility to erosion is considered low.		
Cumulative Impacts: Any additional infrastructure that will be constructed to strengthen and support the operation of the Vrede solar PV facility, will result in additional areas where exposed to soil erosion through wind and water movement.		

Impact: Soil pollution

Nature: During the operational phase, potential spills and leaks from maintenance vehicles and equipment as well as waste generation on site, can result in soil pollution. Also, any failure of the fuel storage containers or equipment can be a source of soil pollution.		
	Without mitigation	**With mitigation**
Extent	Local (1)	Local (1)
Duration	Short-term (2)	Short-term (2)
Magnitude	Moderate (6)	Low (4)
Probability	Low (4)	Improbable (2)
Significance	**Medium (36)**	**Low (14)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Low
Irreplaceable loss of resources?	Yes	No
Can impacts be mitigated?	Yes	N/A
Mitigation: • Maintenance must be undertaken regularly on all vehicles and maintenance machinery to prevent hydrocarbon spills; • No domestic and other waste must be left at the site and must be transported with the maintenance vehicles to an authorised waste dumping area. •		
Residual Impacts: The residual impact from the operation of the proposed project will be low to negligible.		
Cumulative Impacts: The operation of any additional infrastructure to strengthen and support the operation of the Vrede solar PV facility and where waste is not removed to designated waste sites, will increase the cumulative impacts associated with soil pollution in the area.		

11.2.3 Decommissioning phase

The decommissioning phase will have the same impacts as the construction phase i.e. soil erosion, soil compaction and soil pollution. It is anticipated that especially the risk of soil erosion will remain until the vegetation growth has re-established in the area where the Vrede solar PV facility will be decommissioned.

12 Cumulative Impacts

"Cumulative Impact", in relation to an activity, means the past, current and reasonably foreseeable future impact of an activity, considered together with the impact of activities associated with that activity that in itself may not be significant, but may become significant when added to existing and reasonably foreseeable impacts eventuating from similar or diverse activities[1].

The role of the cumulative assessment is to test if such impacts are relevant to the proposed project in the proposed location (i.e. whether the addition of the proposed project in the area will increase the impact). This section should address whether the construction of the proposed development will result in:

- Unacceptable risk
- Unacceptable loss
- Complete or whole-scale changes to the environment or sense of place
- Unacceptable increase in impact

For the determination of cumulative impacts, all other renewable energy projects within a 50km radius from the Vrede solar PV facility development area, were considered. The only project within 12.5km of the development area, is the proposed Rondavel solar PV facility. Other solar PV projects, in different phases of the environmental authorisation process, are 30km or futher away. The position of these project areas are depicted in Figure **27**.

The cumulative impacts of the proposed project have been discussed in Section 10 above.

Table 7 Assessment of cumulative impact of decrease in areas available for livestock farming

Nature: Decrease in areas with suitable land capability for cattle farming.		
	Overall impact of the proposed project considered in isolation	**Cumulative impact of the project and other projects in the area**
Extent	Local (1)	Regional (2)
Duration	Short duration - 2-5 years (2)	Long-term (4)
Magnitude	Low (4)	Low (4)
Probability	Highly likely (4)	Highly likely (4)
Significance	**Low (28)**	Medium (40)
Status (positive/negative)	Negative	Negative
Reversibility	High	Low
Loss of resources?	Yes	Yes
Can impacts be mitigated?	Yes	No
Confidence in findings: High.		
Mitigation: The only mitigation measure for this impact is to keep the footprints of all renewable energy facilities as small as possible and to manage the soil quality by avoiding far-reaching soil degradation such as erosion.		

[1] Unless otherwise stated, all definitions are from the EIA Regulations 2014 (GNR 326).

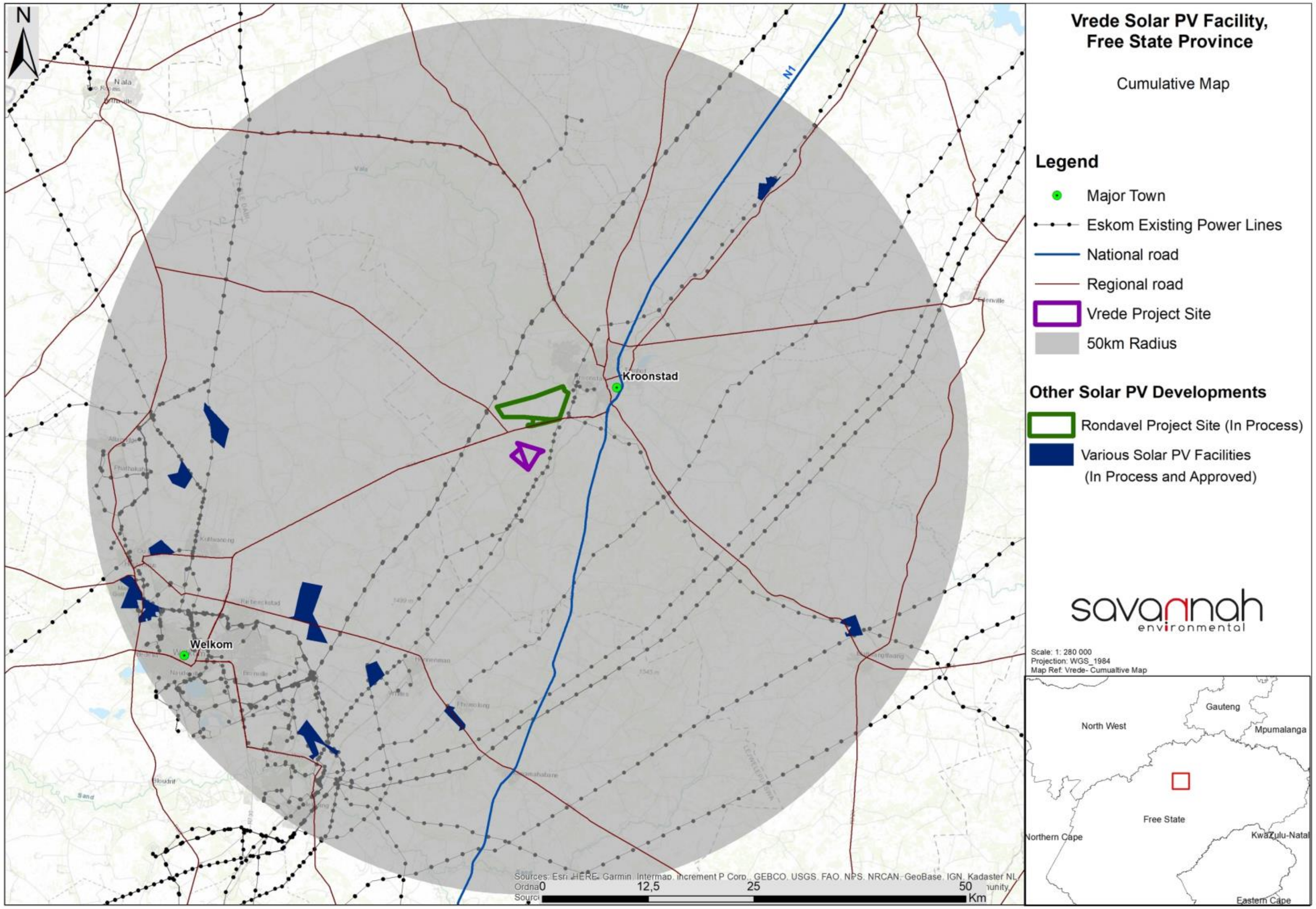


Figure 27 Other renewable energy projects within a 50km radius of the Vrede solar PV facility development area (source: Savannah Environmental)

Table 8 Assessment of cumulative impact of areas susceptible to soil erosion

Nature: Increase in areas susceptible to soil erosion		
	Overall impact of the proposed project considered in isolation	**Cumulative impact of the project and other projects in the area**
Extent	Local (1)	Regional (2)
Duration	Medium-term (3)	Medium-term (3)
Magnitude	Moderate (6)	Moderate (6)
Probability	Probable (3)	Probable (3)
Significance	**Medium (30)**	**Medium (33)**
Status (positive/negative)	Negative	Negative
Reversibility	Low	Low
Loss of resources?	Yes	Yes
Can impacts be mitigated?	Yes	No
Confidence in findings: High.		
Mitigation: Each of the projects should adhere to the highest standards for soil erosion prevention and management as defined in Section 10.2.2 above.		

Table 9 Assessment of cumulative impact of increased risk of soil pollution

Nature: Increase in areas susceptible to soil pollution		
	Overall impact of the proposed project considered in isolation	**Cumulative impact of the project and other projects in the area**
Extent	Local (1)	Regional (2)
Duration	Short-term (2)	Short-term (2)
Magnitude	Moderate (6)	Moderate (6)
Probability	Probable (3)	Probable (3)
Significance	**Low (27)**	**Medium (30)**
Status (positive/negative)	Negative	Negative
Reversibility	Low	Low
Loss of resources?	Yes	Yes
Can impacts be mitigated?	Yes	No
Confidence in findings: High.		
Mitigation: Each of the projects should adhere to the highest standards for soil pollution prevention and management as defined in Section 10.2.3 above.		

13 Mitigation and management measures

The objective of the mitigation and management measures presented below are to reduce the risk of soil degradation that will in turn result in affect the ability of soils in within the project site to support the natural vegetation and provide ecosystem services.

Prevention and management of soil erosion:

Project component/s	• Construction of infrastructure • Construction of the access road
Potential Impact	Soil particles can be removed from the area through wind and water erosion
Activity/risk source	The removal of vegetation in areas where infrastructure will be constructed
Mitigation: Target/Objective	To avoid the onset of soil erosion that can spread into other areas

Mitigation: Action/control	Responsibility	Timeframe
• Limit vegetation clearance to only the areas where the surface infrastructure will be constructed. • Avoid parking of vehicles and equipment outside of designated parking areas. • Plan vegetation clearance activities for dry seasons (late autumn, winter and early spring). • Design and implement a Stormwater Management System where run-off from surfaced areas are expected. • Re-establish vegetation along the access road to reduce the impact of run-off from the road surface.	Environmental Control Officer / SHEQ division	During the entire construction, operational and decommissioning phases

Performance Indicator	No visible signs of soil erosion around the project infrastructure
Monitoring	• Regular inspections around the constructed infrastructure to detect early signs of soil erosion developing. • When signs of erosion is detected, the areas must be rehabilitated using a combination of geo-textiles and re-vegetation to prevent the eroded area(s) from expanding.

Prevention and management of soil pollution:

Project component/s	• Construction of infrastructure • Daily activities and maintenance during the operational phase
Potential Impact	Potential fuel and oil spills from vehicles as well as the generation of waste can cause soil pollution.
Activity/risk source	• Petroleum hydrocarbon (present in oil and diesel) spills by machinery and vehicles during earthworks and the removal of vegetation as part of site preparation. • Spills from vehicles transporting workers, equipment, and construction material to and from the construction site. • The accidental spills from temporary chemical toilets used by construction workers. • The generation of domestic waste by construction workers.

	• Spills from fuel storage tanks during construction. • Pollution from concrete mixing. • Pollution from road-building materials. • Any construction material remaining within the construction area once construction is completed. • Containment breaches related to the battery units and any inadvertent chemical exposure therefrom.
Mitigation: Target/Objective	To avoid soil pollution that can harm the surrounding environment and human health.

Mitigation: Action/control	Responsibility	Timeframe
• Maintenance must be undertaken regularly on all vehicles and construction/maintenance machinery to prevent hydrocarbon spills; • Any waste generated during construction, must be stored into designated containers and removed from the site by the construction teams. • Any left-over construction materials must be removed from site. • Ensure battery transport and installation by accredited staff / contractors. • Compile (and adhere to) a procedure for the safe handling of battery cells during transport and installation.	Environmental Control Officer / SHEQ division	During the entire construction, operational and decommissioning phases

Performance Indicator	• No visible signs of waste and spills within the project site. • No accumulation of contaminants in the soils of the project site.
Monitoring	• Regular inspections of vehicles and equipment that enter the project site. • Analysis of soil samples around high-risk areas to determine whether soil contaminants are present. • In the case that soil pollution is detected, immediate remediation must be done.

14 Acceptability statement

The soil and agricultural properties and sensitivities of the proposed Vrede solar PV facility development was the subject of the Agricultural Agro-Ecosystem Assessment conducted. The study found that the area consists of nine different natural soil forms, ranging from 0.55m to 1.5m in effective soil depth. The soil forms identified are Avalon, Bainsvlei, Bloemdal, Gamoep, Glencoe, Palmiet, Pinedene, Rustenburg and Tukulu. The development area is therefore a combination of plinthic catena soils as well as slighty to moderately structure soils. The soil chemical analysis indicate pH levels between severely acidic and moderately acidic and the plant nutrient concentrations provide an indication that fertilizer may have previously been applied in a few areas.

The largest portion of the development area has land with Moderate (Class 08) land capability that is suitable for dryland crop production. A section along the northern boundary of the site has land with Moderate-High (Class 09) land capability. The remaining areas consist of land with Low-Moderate (Class 06) and Low (Class 05) land capability. The sensitivity rating of the site was also based on land capability classification of the site. Approximately 155.3ha has High agricultural sensitivity, 47.8ha has Medium sensitivity and 9.1ha has Low sensitivity. The development footprint includes areas of all three sensitivity categories. While the development footprint for the Medium and Low sensitivity areas fall within the allowable development limits, the proposed project footprint exceed the limit with 120.3ha for the areas with High sensitivity.

It is anticipated that the construction and operation of the Vrede solar PV facility will have impacts that range from medium to low. Through the consistent implementation of the recommendation mitigation measures, most of impacts can all be reduced to low. Since the area around the development footprint will be fenced off, it is not anticipated that the impact on livestock farming can be mitigated as this area will now be excluded from livestock farming.

Considering that the infrastructure components, including the proposed substation, will be placed in close proximity to each other, I confirm that as far as I know, all reasonable measures have been taken to avoid or minimize fragmentation and disturbance of agricultural activities, provided that the mitigation measures provided in this report are implemented.

It is my professional opinion that even though the development footprint include areas with High agricultural sensitivity that exceeds the allowable development limits, this application be considered favourably. The area has not been used for crop production since 2005 (according to the land owner) and aerial imagery has confirmed that the area has not been used for annual crops at least the past ten years. The landowner also indicated that crop farming is not a viable option and that he will not return the fields to crop fields again. The farm is currently used for commercial cattle production of 35 head of cattle and can at most provide employment for two farmworkers.

In contrast to that, the proposed Vrede solar PV project will contribute a significant amount of expenditure to the area and employ more than 230 workers during the construction phase and more than 17 workers during the operational phase. In the light of the high number of employment opportunities that will be created per hectare of land, the proposed Vrede solar PV facility is considered an acceptable land use change.

However, the project is considered acceptable permitting that the mitigation measures stipulated in this report are followed to prevent soil erosion and soil pollution and to minimise impacts on the veld quality of the farm portions that will be affected. The project infrastructure should also remain within the proposed footprint boundaries that will be fenced off and the construction corridor around the access road must be as narrow as possible.

APPENDIX 1 – LABORATORY SOIL ANALYSIS RESULTS

NORTH-WEST UNIVERSITY
ECO-ANALYTICA

Eco Analytica
P.O. Box 19140
NOORDBRUG 2522
Tel: 018-285 2732/3/4

TERRA AFRICA (VREDE SOLAR PV FACILITY)

2021/03/15 **Nutrient Status**

Sample no.	Ca	Mg	K	Na	P	pH(KCl)
	(mg/kg)					
1	285,5	72,7	211,2	3,5	19,3	5,11
2	383,9	62,6	208,1	2,6	4,7	5,00
3	1188,4	303,7	340,1	12,5	4,3	5,04
4	2031,1	592,4	124,1	180,4	3,0	5,43
5	401,7	123,2	311,5	2,7	14,8	5,02
6	611,4	167,9	151,3	5,8	3,6	4,49
7	612,9	174,5	290,0	3,6	3,7	4,34
8	624,6	283,6	268,1	33,0	2,9	4,25
9	513,9	175,6	420,4	9,1	3,4	4,80
10	1637,1	805,0	1563,1	76,3	2,7	5,36

Cation Ratios

Sample	Ca:Mg	Mg:K	Ca+Mg:K	K%	Ca%	Mg%	Na%
1	2,38	1,11	3,74	20,99	55,23	23,20	0,58
2	3,72	0,97	4,55	17,93	64,38	17,31	0,38
3	2,37	2,87	9,67	9,32	63,38	26,72	0,58
4	2,08	15,33	47,18	1,97	62,90	30,26	4,87
5	1,98	1,27	3,78	20,86	52,35	26,49	0,30
6	2,21	3,56	11,42	8,01	62,96	28,52	0,52
7	2,13	1,93	6,04	14,16	58,21	27,34	0,30
8	1,34	3,40	7,93	10,94	49,61	37,16	2,28
9	1,77	1,34	3,72	21,02	50,02	28,18	0,77
10	1,23	1,65	3,69	20,95	42,69	34,63	1,73

2021/03/15 **Particle Size Distribution**

Sample no.	> 2mm (%)	Sand	Silt	Clay
		(% < 2mm)		
1	0,0	89,9	3,4	6,7
2	32,1	86,6	1,1	12,2
3	0,5	71,4	13,9	14,7
4	0,1	68,4	6,2	25,5
5	0,9	81,0	8,0	11,0
6	12,1	71,8	6,6	21,6
7	1,6	74,5	11,1	14,4
8	2,0	72,2	5,9	21,9
9	4,4	78,2	8,1	13,7
10	0,2	39,0	7,1	53,9

"HANDBOOK OF STANDARD SOIL TESTING METHODS FOR ADVISORY PURPOSES"

EXCHANGEABLE CATIONS: 1 M NH_4-asetaat pH=7

pH H_2O/KCl: 1:2,5 - Extract PHOSPHATE: Bray 1 - Extract

This laboratory participates in the following quality control schemes:
Agri-Laboratory Associatie of South Africa

APPENDIX 2 – LAND TYPE DATA SHEETS

LAND TYPE / *LANDTIPE*...................... : Bd21
CLIMATE ZONE / *KLIMAATSONE* .... : 35S
Area / *Oppervlakte* .... : 240150 ha
Estimated area unavailable for agriculture
Beraamde oppervlakte onbeskikbaar vir landbou : 6600 ha

Occurrence (maps) and areas / *Voorkoms (kaarte) en oppervlakte :*
2726 Kroonstad (226510 ha)   2826 Winburg (13640 ha)

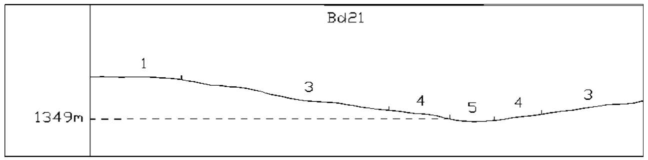
Inventory by / *Inventaris deur :*
R W Bruce

Modal Profiles / *Modale profiele :*
P190 P191 P192
1722 1723 1724

		1	3	4	5
Terrain unit / *Terreineenheid*	:	1	3	4	5
% of land type / *% van landtipe*	:	33	50	11	6
Area / *Oppervlakte (ha)*	:	79250	120075	26416	14409
Slope / *Helling (%)*	:	1 - 2	2 - 3	1 - 2	1 - 2
Slope length / *Hellingslengte (m)*	:	500 - 1000	1000 - 1500	300 - 400	150 - 250
Slope shape / *Hellingsvorm*	:	Y	Z-Y	Z-X	X
MB0, MB1 (ha)	:	76872	118874	26417	14409
MB2 - MB4 (ha)	:	2377	1201	0	0

Soil series or land classes *Grondseries of landklasse*	**Depth** *Diepte* (mm)	MB	ha	%	ha	%	ha	%	ha	%	**Total** *Totaal* ha	%	**Clay content %** *Klei-inhoud %* A	E	B21	Hor	**Texture** *Tekstuur* Class / *Klas*	**Depth limiting material** *Diepte-beperkende materiaal*
Soetmelk Av36	900-1100	0	53098	67	45628	38					98726	41.1	10-20		15-35	B	fiSaClLm	sp
Rietvlei We12, Sibasa We13	400-600	0	14265	18	45628	38					59893	24.9	10-20		30-40	B	fiSaClLm-SaCl	sp
Lindley Va41, Valsrivier Va40	250-350	0			14409	12	13208	50	2450	17	30067	12.5	10-25		30-45	B	fiSaCl-Cl	vp
Bainsvlei Bv36, Shorrocks Hu36	900-1200	0	9510	12	9606	8					19116	8.0	8-20		15-30	B	fiSaLm-SaClLm	sp,R
Chinyika Wo21, Killarney Ka20, Dundee Du10	400-1200	0							8934	62	8934	3.7	20-40			A	fiSaClLm-SaCl	gh
Sterkspruit Ss26, Stanford Ss23	200-300	0			1201	1	7132	27	432	3	8765	3.7	8-20		30-40	A	LmfiSa-SaLm	pr
Bonheim Bo41	400-500	0					2377	9	2594	18	4971	2.1	35-45		40-50	A	fiSaCl	vp
Kroonstad Kd13, Bluebank Kd16	500-700	0			1201	1	2377	9			3578	1.5	10-20	10-20	30-45	E	LmfiSa-SaLm	gc
Mispah Ms10, Williamson Gs16, Kanonkop Gs13	50-200	3	2378	3	1201	1					3578	1.5	10-20			A	LmfiSa-SaLm	R,so
Nyoka Sw41, Malakata Sw40	150-250	0			1201	1	1321	5			2522	1.1	13-20		30-45	B	fiSaCl	vp

Terrain type / *Terreintipe* : A2
Terrain form sketch / *Terreinvormskets*



For an explanation of this table consult LAND TYPE INVENTORY (table of contents)
Ter verduideliking van hierdie tabel kyk LANDTIPE - INVENTARIS (inhoudsopgawe)

Geology: Adelaide Subgroup and Ecca sandstone, mudstone and shale, with occasional dolerite sills. Ventersdorp lava may occur sporadically in the north. Aeolian and or colluvial sand overlies nearly all rocks.

Geologie: Subgroep Adelaide en Eccasandsteen, -moddersteen en -skalie met enkele dolerietplaatindringings. Ventersdorplawa mag sporadies in die noorde voorkom. Eoliese en of kolluviale sand bedek byna alle gesteentes.

LAND TYPE / *LANDTIPE*...................... : Dc10
CLIMATE ZONE / *KLIMAATSONE* .... : 35S
Area / *Oppervlakte* .... : 366057 ha
Estimated area unavailable for agriculture
Beraamde oppervlakte onbeskikbaar vir landbou : 9000 ha

Occurrence (maps) and areas / *Voorkoms (kaarte) en oppervlakte :*
2726 Kroonstad (333100 ha) 2728 Frankfort (25737 ha)
2826 Winburg (7180 ha) 2828 Harrismith (40 ha)

Inventory by / *Inventaris deur :*
R W Bruce

Modal Profiles / *Modale profiele :*
P189 P198 P199 P307
1721 1730 1731 4426

		1	2	3	4	5
Terrain unit / *Terreineenheid*	:	1	2	3	4	5
% of land type / *% van landtipe*	:	22	1	50	21	6
Area / *Oppervlakte (ha)*	:	80533	3661	183028	76872	21963
Slope / *Helling (%)*	:	1 - 5	>100	4 - 12	1 - 4	1 - 2
Slope length / *Hellingslengte (m)*	:	250 - 500	20 - 50	300 - 800	250 - 500	50 - 150
Slope shape / *Hellingsvorm*	:	Y	Z	Z-X	X	X
MB0, MB1 (ha)	:	28992	0	98835	56885	20865
MB2 - MB4 (ha)	:	51541	3661	84193	19987	1098

Soil series or land classes / ***Grondseries of landklasse***	**Depth** / ***Diepte*** **(mm)**	**MB**		**ha**	**%**	**ha**	**%**	**ha**	**%**	**ha**	**%**	**ha**	**%**	**Total** / ***Totaal*** **ha**	**%**	**Clay content %** / ***Klei-inhoud %*** **A**	**E**	**B21**	**Hor**	**Texture** / ***Tekstuur*** **Class / *Klas***	**Depth limiting material** / ***Diepte-beperkende materiaal***
Soil-rock complex			:																		
Grond-rotskompleks:			:																		
Rock/Rots		4	:	18523	23	2563	70	42096	23	1537	2			64719	17.7						
Mispah Ms10	100-150	3	:	14496	18	732	20	20133	11	10762	14			46123	12.6	15-25			A	fiSaLm-SaClLm	R
Williamson Gs16, Trevanian Gs17,			:																		
Robmore Gs18	150-200	3	:	11275	14	366	10	10982	6	3844	5			26466	7.2	15-35			A	fiSaLm-SaClLm	so,R
Lindley Va41, Arniston Va31,			:																		
Valsrivier Va40, Nyoka Sw41,			:																		
Swartland Sw31	100-300	0	:	12885	16			71381	39	23830	31	1098	5	109195	29.8	15-30		30-55	B	fiSaCl-Cl	vp
Bonheim Bo41, Weenen Bo40,			:																		
Dumasi Bo30, Glengazi Bo31	300-580	0	:	4832	6			12812	7	9225	12	1098	5	27967	7.6	20-48		25-41	A	fiSaClLm-ClLm	vp
Graythorne Mw21, Milkwood Mw11,			:																		
Dansland Mw10, Msinsini My11,			:																		
Mayo My10	200-400	3	:	7248	9			10982	6	3844	5	1098	5	23171	6.3	20-45			A	fiSaClLm-SaCl	so,R
Sterkspruit Ss26, Stanford Ss23	250-350	0	:					7321	4	6918	9			14240	3.9	12-25		30-55	A	fiSaLm-SaClLm	pr
Gelykvlakte Ar20	500-800	0	:	805	1			1830	1	8456	11	2636	12	13727	3.8	45-65			A	Cl	gh
Jozini Oa36, Limpopo Oa46,			:																		
Dundee Du10, Cromley Ik10	>1200	0	:									13178	60	13178	3.6	15-35		15-35	B	fiSaLm-SaClLm	R,so
Sibasa We13, Rietvlei We12	400-600	0	:	6443	8			3661	2					10103	2.8	15-20		30-40	B	fiSaCl-SaClLm	sp
Estcourt Es36, Enkeldoorn Es33,			:																		
Uitvlugt Es34, Avoca Kd17,			:																		
Mkambati Kd14	300-700	0	:							8456	11			8456	2.3	10-20	10-25	30-55	E	fi/meSaLm	pr,gc
Soetmelk Av36,			:																		
Bezuidenhout Av37	600-800	0	:	4027	5			1830	1					5857	1.6	15-25		25-40	B	fiSaClLm-SaCl	sp
Rensburg Rg20, Killarney Ka20,			:																		

APPENDIX 3 - CURRICULUM VITAE OF SPECIALIST

+2782-828-3587

mpienaar@terraafrica.co.za

linkedin.com/in/marinepienaar

Wolmaransstad,
South Africa

EXPERTISE

Soil Quality Assessment

Soil Policy and Guidelines

Agricultural Agro-Ecosystem Assessment

Sustainable Agriculture

Data Consolidation

Land Use Planning

Soil Pollution

Hydropedology

EDUCATION

MASTER'S DEGREE
Environmental Science
University of Witwatersrand
2010 – 2018

BACHELOR'S DEGREE
Agricultural Science
University of Pretoria
2001 – 2004

PROFESSIONAL PROFILE

I contribute specialist knowledge on agriculture and soil management to ensure long-term sustainability of projects in Africa. For the past thirteen years, it has been my calling and I have consulted on more than 200 projects. My clients include environmental and engineering companies, mining houses, and project developers. I enjoy the multi-disciplinary nature of the projects that I work on and I am fascinated by the evolving nature of my field of practice. The next section provide examples of the range of projects completed. A comprehensive project list is available on request.

PROJECT EXPERIENCE

Global Assessment on Soil Pollution

Food and Agricultural Organisation (FAO) of the United Nations (UN)

Author of the regional assessment of Soil in Sub-Saharan Africa. The report is due for release in February 2021. The different sections included:

- Analysis of soil and soil-related policies and guidelines for each of the 48 regional countries
- Description of the major sources of soil pollution in the region
- The extent of soil pollution in the region and as well as the nature and extent of soil monitoring
- Case study discussions of the impacts of soil pollution on human and environmental health in the region
- Recommendations and guidelines for policy development and capacitation to address soil pollution in Sub-Saharan Africa

Data Consolidation and Amendment

Range of projects: Mining Projects, Renewal Energy

These projects included developments where previous agricultural and soil studies are available that are not aligned with the current legal and international best practice requirements such as the IFC Principles. Other projects are expansion projects or changes in the project infrastructure layout. Tasks on such projects include the incorporation of all relevant data, site verification, updated baseline reporting and alignment of management and monitoring measures.

Project examples:

- Northam Platinum's Booysendal Mine, South Africa
- Musonoi Mine, Kolwezi District, Democratic Republic of Congo
- Polihali Reservoir and Associated Infrastructure, Lesotho
- Kaiha 2 Hydropower Project, Liberia
- Aquarius Platinum's Kroondal and Marikana Mines

PROFESSIONAL MEMBERSHIP

South African Council for Natural Scientific Professions (SACNASP)

Soil Science Society of South Africa (SSSSA)

Soil Science Society of America (SSSA)

Network for Industrially Contaminated Land in Africa (NICOLA)

LANGUAGES

English (Fluent)

Afrikaans (Native)

French (Basic)

PRESENTATIONS

There is spinach in my fish pond
TEDx Talk
Available on YouTube

♦

Soil and the Extractive Industries
Session organiser and presenter
Global Soil Week, Berlin (2015)

♦

How to dismantle an atomic bomb
Conference presentation (2014)
Environmental Law Association (SA)

PROJECT EXPERIENCE (Continued)

Agricultural Agro-Ecosystem Assessments

Range of projects: Renewable Energy, Industrial and Residential Developments, Mining, Linear Developments (railways and power lines)

The assessments were conducted as part of the Environmental and Social Impact Assessment processes. The assessment process includes the assessment of soil physical and chemical properties as well as other natural resources that contributes to the land capability of the area.

Project examples:

- Mocuba Solar PV Development, Mozambique
- Italthai Railway between Tete and Quelimane, Mozambique
- Lichtenburg PV Solar Developments, South Africa
- Manica Gold Mine Project, Mozambique
- Khunab Solar PV Developments near Upington, South Africa
- Bomi Hills and Mano River Mines, Liberia
- King City near Sekondi-Takoradi and Appolonia City near Accra, Ghana
- Limpopo-Lipadi Game Reserve, Botswana
- Namoya Gold Mine, Democratic Republic of Congo

Sustainable Agriculture

Range of projects: Policy Development for Financial Institutions, Mine Closure Planning, Agricultural Project and Business Development Planning

Each of the projects completed had a unique scope of works and the methodology was designed to answer the questions. While global indicators of sustainable agriculture are considered, the unique challenges to viable food production in Africa, especially climate change and a lack of infrastructure, in these analyses.

Project examples:

- Measurement of sustainability of agricultural practices of South African farmers – survey design and pilot testing for the LandBank of South Africa
- Analysis of the viability of avocado and mango large-scale farming developments in Angola for McKinsey & Company
- Closure options analysis for the Tshipi Borwa Mine to increase agricultural productivity in the area, consultation to SLR Consulting
- Analysis of risks and opportunities for farm feeds and supplement suppliers of the Southern African livestock and dairy farming industries
- Sustainable agricultural options development for mine closure planning of the Camutue Diamond Mine, Angola

PROFESSIONAL DEVELOPMENT

Contaminated Land Management 101 Training
Network for Industrially Contaminated Land in Africa
2020

Intensive Agriculture in Arid & Semi-Arid Environments
CINADCO/MASHAV R&D Course, Israel
2015

World Soils and their Assessment Course
ISRIC – World Soil Information Centre, Netherlands
2015

Wetland Rehabilitation Course
University of Pretoria
2010

Course in Advanced Modelling of Water Flow and Solute Transport in the Vadose Zone with Hydrus
University of Kwazulu-Natal
2010

Environmental Law for Environmental Managers
North-West University Centre for Environmental Management
2009

PROJECT EXPERIENCE (Continued)

Soil Quality Assessments

Range of projects: Rehabilitated Land Audits, Mine Closure Applications, Mineral and Ore Processing Facilities, Human Resettlement Plans

The soil quality assessments included physical and chemical analysis of soil quality parameters to determine the success of land rehabilitation towards productive landscapes. The assessments are also used to understand the suitability for areas for Human Resettlement Plans

Project examples:

- Closure Planning for Yoctolux Colliery
- Soil and vegetation monitoring at Kingston Vale Waste Facility
- Exxaro Belfast Resettlement Action Plan Soil Assessment
- Soil Quality Monitoring of Wastewater Irrigated Areas around Matimba Power Station
- Keaton Vanggatfontein Colliery Bi-Annual Soil Quality Monitoring

REFERENCES

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