DESKTOP PALAEONTOLOGICAL HERITAGE IMPACT ASSESSEMENT REPORT ON THE SITE OF TWO PROPOSED SOLAR POWER STATIONS (HEUNINGSPRUIT PV 1 AND PV 2) TO BE LOCATED ON THE FARMS VOERSPOED 1508 RE AND VERDUN 1511 RE, FREE STATE PROVINCE

1 November 2013

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On Behalf of:

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Prepared By:

Dr B.D. Millsteed

EXECUTIVE SUMMARY

Sun Mechanics (Pty) Ltd, an independent power producer proposes to develop two 5 MW photovoltaic (PV) solar energy facilities. These projects are referred to as the Heuningspruit PV 1 Solar Energy Facility and Heuningspruit PV 2 Solar Energy Facility. The Heuningspruit PV 1 Solar Energy Facility is proposed to be located on the farm Voorspoed 1508 RE and Heuningspruit PV 2 Solar Energy Facility is proposed on the farm Verdun 1511 RE. The study area for each project is approximately 95 ha in extent, but consists of two separate and adjacent portions (one on both farms) intended to be utilised for each solar energy facilities. The aerial extent of the final development footprint is approximately 13 ha each for PV 1 and PV2. The locality lies approximately 27 Km north east of Kroonstad and 35 km south west of Koppies, Ngwathe Local Municipality, Kroonstad Magisterial District, Free State Province.

Sun Mechanics (Pty) Ltd has appointed Savannah Environmental (Pty) Ltd, as independent consultants, to undertake the required environmental assessments to identify and assess the potential environmental impacts associated with the proposed projects, and propose appropriate mitigation and management measures in an Environmental Management Programme. Savannah Environmental (Pty) Ltd has appointed BM Geological Services to provide a desktop Palaeontological Heritage Impact Assessment Report in respect of the proposed project that will form part of a Heritage Impact Assessment Report.

The purpose of the projects is to generate electricity which will be fed-into the national electricity grid (via the existing Heuningspruit Rural Substation). The minimum life of the project is 20–25 years.

An area of approximately 95 ha constitutes the area reported upon herein. Within this larger area are two smaller, aerially adjacent areas of 20 ha that are being considered for each facility, but the final aerial footprint will be approximately 13 ha for each of the two solar energy production facilities. Each facility would comprise of the following infrastructure:

- Arrays of photovoltaic (PV) panels with a capacity of up to 5 MW.
- Mounting structures to support the PV panels.
- Cabling between the project components, to be lain underground.
- Inverters/Transformer enclosures.
- An on-site 88 kv or lower voltage kV switching station.
- An overhead power line of approximately 250 m in length.
- Internal access roads.
- Fencing.

- Workshop area for maintenance, storage, offices and small modular water filtration or di-ionisation unit.
- Parking and water storage tanks.

The construction of these infrastructural elements is expected to result in disruption of the uppermost few meters of the land surface.

The reporting area is completely underlain by Permian sediments of the Volksrust Formation. The Volksrust Formation is fossiliferous elsewhere in the Karoo Basin, but known fossil localities are not numerous. The probability of a negative impact on the palaeontological heritage of the Volkrust Formation is accordingly low. However, the fossil assemblages known to occur within the Volkrust Formation are potentially scientifically significant.

Palaeontological sites are occasionally identified in alluvial terraces and dongas of Quaternary age within South Africa, but are uncommon. As such, the risk of a negative impact is low, but the significance of any negative impact on the fossil assemblages could potentially be high.

The probability of any significant negative impact upon the fossil assemblages contained within the Volksrust Formation and the Quaternary alluvium is local in extent as any effects will be restricted to the area beneath the planned infrastructure elements.

The project has been assessed as being socially beneficial, herein, as it would generate electricity which will be fed-into the stressed national electricity grid. The projects will also participate in the Department of Energy's Small Projects Renewable Energy Independent Power Producer Procurement Programme (REIPPPP) that has been designed to contribute towards the South African government's renewable energy target

A thorough field investigation by a palaeontologist as part of a Full Palaeontological Heritage Impact Assessment of the entire extent of the area reported upon, herein, for both the PV 1 and PV 2 solar energy facilities prior to the commencement of construction would allow a meaningful evaluation of the presence of potentially fossil-bearing strata within the target areas. This process would make it possible that scientifically and/or culturally significant fossils, present within the area may be discovered that would be otherwise damaged, destroyed or inadvertently moved and appropriate damage mitigation processes could be determined. A secondary advantage of such an investigation would be that any fossil materials located could prove to have a positive effect on the understanding of the fossil record of South Africa and positively affect the palaeontological heritage of the country. Similarly, thorough examinations should be made of all excavations as they are being performed. Should any fossil materials be identified during the construction phase, the

excavations should be halted and SAHRA informed of the discovery. A potential positive outcome of these mitigation protocols could be that fossil materials become available for scientific study that would otherwise have been hidden within or beneath the regolith. Should such new palaeontological material be located as a result of this site investigation this could prove to have a positive effect on the understanding of the fossil record of South Africa and positively affect the palaeontological heritage of the country.

In summary, this desktop study has not identified any palaeontological reason to prejudice the progression of this project, subject to adequate mitigation programs being put in place.

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Sun Mechanics (Pty) Ltd, an independent power producer proposes to develop two 5 MW photovoltaic (PV) solar energy facilities. These projects are referred to as the Heuningspruit PV 1 Solar Energy Facility and Heuningspruit PV 2 Solar Energy Facility. The Heuningspruit PV 1 Solar Energy Facility is proposed to be located on the farm Voorspoed 1508 RE and Heuningspruit PV 2 Solar Energy Facility is proposed on the farm Verdun 1511 RE. The study area for each project is approximately 95 ha in extent, but consists of two separate and adjacent portions (one on both farms) intended to be utilised for each solar energy facilities. The aerial extent of the final development footprint is approximately 13 ha each for PV 1 and PV2 (Figure 1). The locality lies approximately 27 Km north east of Kroonstad and 35 km south west of Koppies, Ngwathe Local Municipality, Kroonstad Magisterial District, Free State Province (Figure 2).

Sun Mechanics (Pty) Ltd has appointed Savannah Environmental (Pty) Ltd, as independent consultants, to undertake the required environmental assessments to identify and assess the potential environmental impacts associated with the proposed projects, and propose appropriate mitigation and management measures in an Environmental Management Programme. Savannah Environmental (Pty) Ltd has appointed BM Geological Services to provide a desktop Palaeontological Heritage Impact Assessment Report in respect of the proposed project that will form part of a Heritage Impact Assessment Report.

2 TERMS OF REFERENCE AND SCOPE OF THE STUDY

The terms of reference for this study were as follows:-

- Conduct a desktop assessment of the potential impact of the proposed project on the palaeontological heritage of the project area.
- Describe the possible impact of the proposed development on the palaeontological heritage of the site, according to a standard set of conventions.
- Quantify the possible impact of the proposed development on the palaeontological heritage of the site, according to a standard set of conventions.
- Provide an overview of the applicable legislative framework.
- Make recommendations concerning future work programs as, and if, necessary.

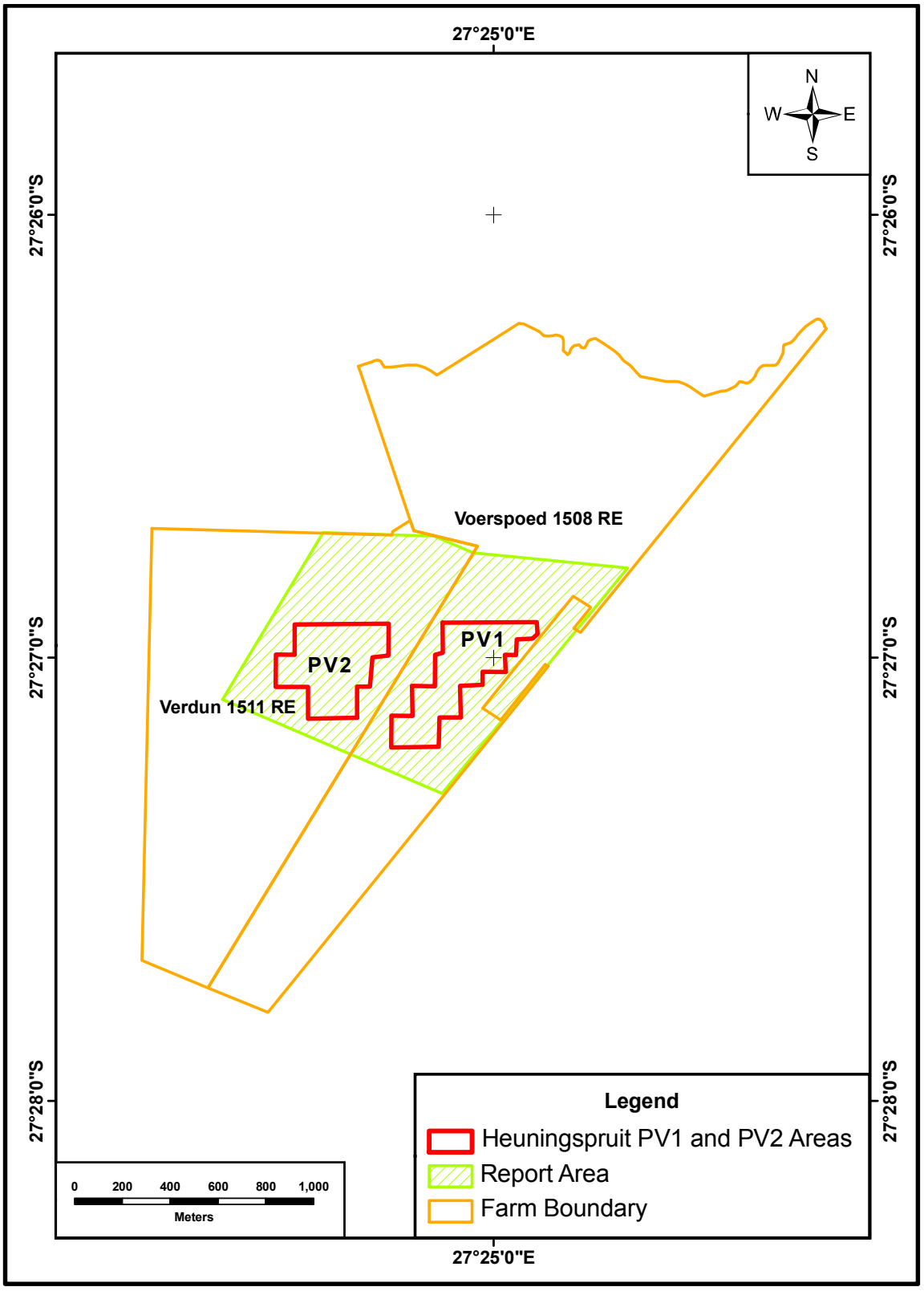

Figure 1: Location of the study area and the preferred location of PV 1 and PV2 within the farms Verdun 1511 RE and Verspoed 1508 RE.

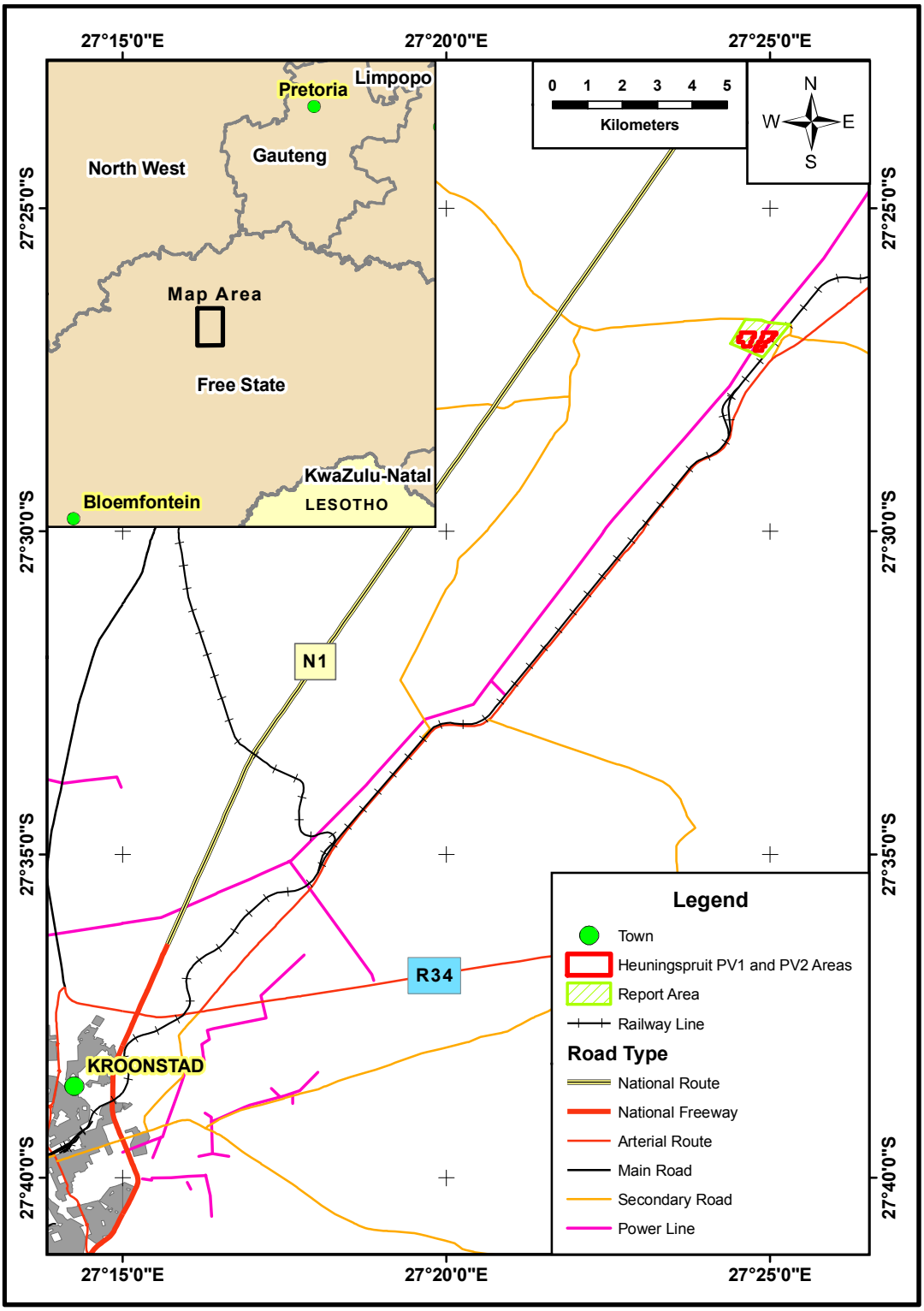

Figure 2: Location map of the study area.

3 LEGISLATIVE REQUIREMENTS

South Africa's cultural resources are primarily dealt with in two Acts. These are the National Heritage Resources Act (Act 25 of 1999) and the National Environmental Management Act (Act 107 of 1998)[as amended].

3.1 The National Heritage Resources Act

The following are protected as cultural heritage resources by the National Heritage Resources Act:

- Archaeological artefacts, structures and sites older than 100 years,
- Ethnographic art objects (e.g. prehistoric rock art) and ethnography,
- Objects of decorative and visual arts,
- Military objects, structures and sites older than 75 years,
- Historical objects, structures and sites older than 60 years,
- Proclaimed heritage sites,
- Grave yards and graves older than 60 years,
- Meteorites and fossils,
- Objects, structures and sites of scientific or technological value.

The Act also states that those heritage resources of South Africa which are of cultural significance or other special value for the present community and for future generations must be considered part of the national estate and fall within the sphere of operations of heritage resources authorities. The national estate includes the following:

- Places, buildings, structures and equipment of cultural significance,
- Places to which oral traditions are attached or which are associated with living heritage,
- Historical settlements and townscapes,
- Landscapes and features of cultural significance,
- Geological sites of scientific or cultural importance,
- Sites of Archaeological and palaeontological importance,
- Graves and burial grounds,
- Sites of significance relating to the history of slavery,
- Movable objects (e.g. archaeological, palaeontological, meteorites, geological specimens, military, ethnographic, books etc.).

3.2 Need for Impact Assessment Reports

Section 38 of the Act stipulates that any person who intends to undertake an activity that falls within the following:

- The construction of a linear development (road, wall, power line, canal etc.) exceeding 300m in length,
- The construction of a bridge or similar structure exceeding 50 m in length,
- Any development or other activity that will change the character of a site and exceed 5 000 m^2 or involve three or more existing erven or subdivisions thereof,
- Re-zoning of a site exceeding 10 000 m^2,
- Any other category provided for in the regulations of SAHRA or a provincial heritage authority.

must at the very earliest stages of initiating such a development, notify the responsible heritage resources authority and furnish it with details regarding the location, nature and extent of the proposed development. If there is reason to believe that heritage resources will be affected by such development, the developer may be notified to submit an impact assessment report. A Palaeontological Impact Assessment (PIA) only looks at the potential impact of the development on palaeontological resources of the proposed area to be affected.

3.3 Legislation Specifically Pertinent to Palaeontology*

*****Note: Section 2 of the Act defines "palaeontological" material as "any fossilised remains or fossil trace of animals or plants which lived in the geological past, other than fossil fuels or fossiliferous rock intended for industrial use, and any site which contains such fossilised remains".

Section 35(4) of this Act specifically deals with archaeology, palaeontology and meteorites. The Act states that no person may, without a permit issued by the responsible heritage resources authority (national or provincial):

- Destroy, damage, excavate, alter, deface or otherwise disturb any archaeological or palaeontological site or any meteorite,
- Destroy, damage, excavate, remove from its original position, collect or own any archaeological or palaeontological material or object or any meteorite,
- Trade in, sell for private gain, export or attempt to export from the Republic any category of archaeological or palaeontological material or object, or any meteorite; or

- Bring onto or use at an archaeological or palaeontological site any excavation equipment or any equipment that assists in the detection or recovery of metals or archaeological and palaeontological material or objects, or use such equipment for the recovery of meteorites,
- Alter or demolish any structure or part of a structure which is older than 60 years as protected.

The above mentioned palaeontological objects may only be disturbed or moved by a palaeontologist, after receiving a permit from the South African Heritage Resources Agency (SAHRA). In order to demolish such a site or structure, a destruction permit from SAHRA will also be needed.

Further to the above point, Section 35(3) of this Act indicates that "any person who discovers archaeological or palaeontological objects or material or a meteorite in the course of development or agricultural activity must immediately report the find to the responsible heritage resources authority, or to the nearest local authority offices or museum, which must immediately notify such heritage resources authority.". Thus, regardless of the granting of any official clearance to proceed with any development based on an earlier assessment of its impact on the Palaeontological Heritage of an area, the development should be halted and the relevant authorities informed should fossil objects be uncovered during the progress of the development.

3.4 The National Environmental Management Act [as amended]

This Act does not provide the detailed protections and administrative procedures for the protection and management of the nation's Palaeontological Heritage as are detailed in the National Heritage Resources Act, but is more general in its application. In particular Section 2(2) of the Act states that environmental management must place people and their needs at the forefront of its concerns and, amongst other issues, serve their cultural interests equitably. Further to this point section 2(4)(a)(iii) states that disturbances of sites that constitute the nation's cultural heritage should be avoided, and where it cannot be avoided should be minimised and remedied.

Section 23(1) indicates that a general objective of integrated environmental management is to identify, predict and evaluate the actual and potential impact of activities upon the cultural heritage. This section also highlights the need to identify options for mitigating negative effects of activities with a view to minimising negative impacts.

In order to give effect to the general objectives of integrated environmental management outlined in the Act the potential impact on cultural heritage of activities that require authorisation or permission by law must be investigated and assessed prior to their implementation and reported to the relevant organ of state. Thus, a survey and

evaluation of cultural resources must be done in areas where development projects that will potentially negatively affect the cultural heritage will be performed. During this process the impact on the cultural heritage will be determined and proposals for the mitigation of the negative effects made.

4 RELEVENT EXPERIENCE

Dr Millsteed holds a PhD in palaeontology and has previously been employed as a professional palaeontologist with the Council for Geoscience in South Africa. He is currently the principle of BM Geological Services and has sufficient knowledge of palaeontology and the relevant legislation required to produce this Palaeontological Impact Assessment Report. Dr Millsteed is registered with the South African Council for Natural Scientific Professions (SACNASP), and is a member of the Palaeontological Society of South African and the Geological Society of South Africa.

5 INDEPENDENCE

Dr Millsteed was contracted as an independent consultant to conduct this Palaeontological Heritage Impact assessment study and shall receive fair remuneration for these professional services. Neither Dr Millsteed nor BM Geological Services has any financial interest in Sun Mechanics (Pty) Ltd or the proposed power station.

6 GEOLOGY AND FOSSIL POTENTIAL

The project area is completely underlain by Early Permian strata of the Volksrust Formation (Figure 3). Geological Sheet 2726 Kroonstad (Council for Geoscience, 19980) shows the presence of significant extents of Quaternary alluvium associated with the Heuningspruit drainage system within the northern portions of the reporting area (Figure 4). It is evident from Figure 4 that the alluvium is only present from immediately north of the northern boundary of the two photovoltaic facility areas (PV1 and PV2). A summary of the characteristics of both the Volksrust Formation and Quaternary alluvium and their fossiliferous potentials follows.

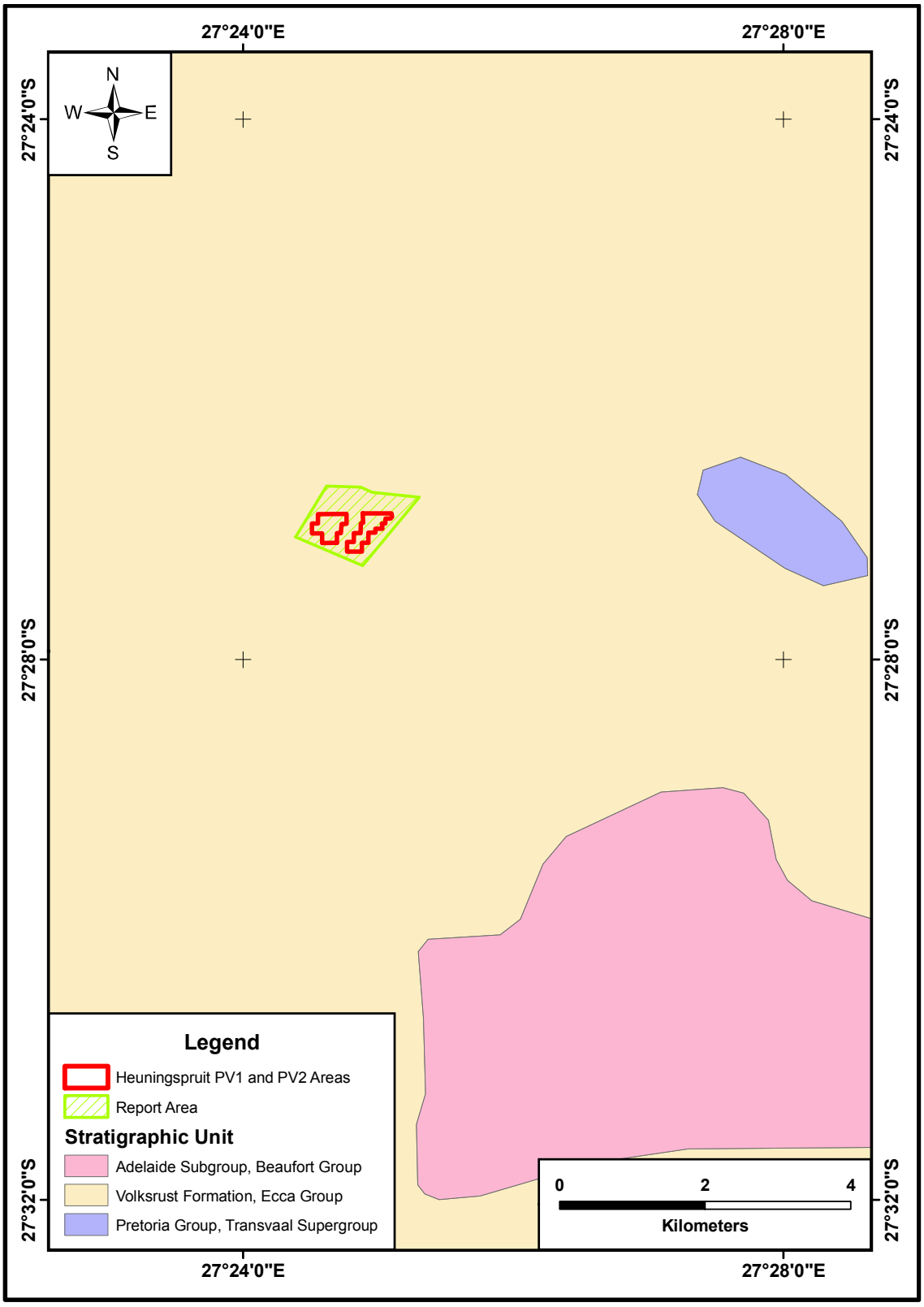

Figure 3: Map of the bedrock geology underlying the project area and its immediate environs.

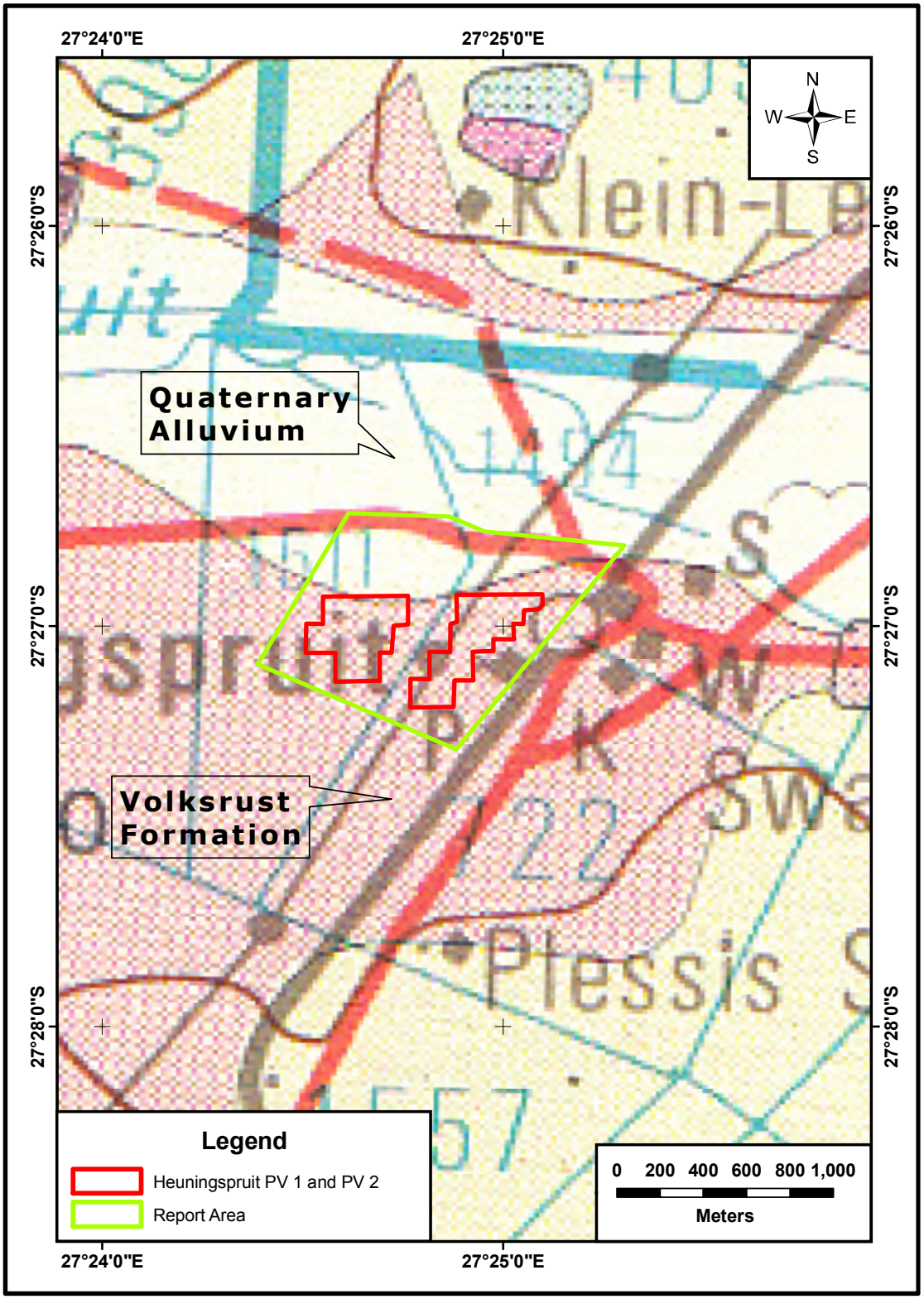

Figure 4: 1: 250 000 Geological Sheet 2726 Kroonstad (Council for Geoscience, 1998) showing the extent of the area comprising this report, as well as the preferred locations for PV 1 and PV2. Quaternary alluvium is only present in those portions of the reporting area that lie north of the proposed sites of PV 1 and PV 2.

6.1 Vryheid Formation

6.1.1 Geology

The Main Karoo Basin consists of a retro-arc foreland basin filled with a lithological succession ranging in age from the Late Carboniferous to the Middle Jurassic (Johnson *et al*., 2006). The basin-fill sequence wedges out northwards over the adjacent Kaapvaal Craton.

In the Main Karoo Basin of South Africa the Volksrust Formation is a predominantly argillaceous unit that interfingers (i.e., is transitional with and partially time equivalent to) the overlying Beaufort Group and the underlying Vryheid Formation (Figure 5). The formation consists of grey to black silty shale with thin, usually bioturbated, siltstone or sandstone lenses, particularly toward its upper and lower boundaries with the more sandstone-rich Adelaide Subgroup and Vryheid Formation respectively (Johnson *et al*., 2006). To the south and south-east the Volksrust Formation grades laterally into undifferentiated, deep-water argillites of the Ecca Group (Figure 5). The substantial thickness of predominantly argillaceous rocks and great lateral extent of the Volksrust Formation suggest that this unit represents a transgressive, open "shelf" sequence consisting predominantly of mud deposited from suspension (Johnson *et al*., 2006). The increased grain size in the upper and lower portions of the formation indicates, in part,

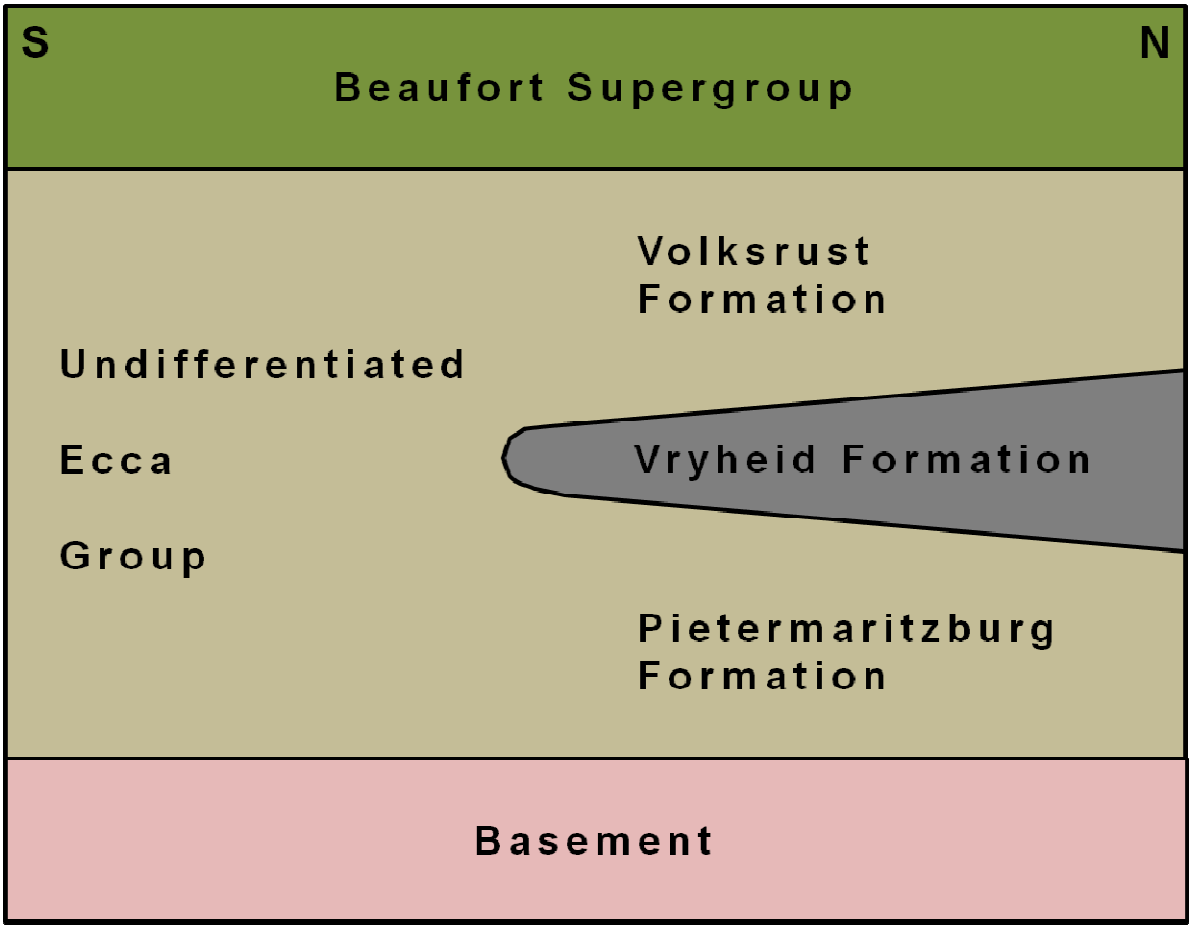

Figure 5: Schematic north-south oriented stratigraphic section of the Ecca Group in the north-east corner of the Karoo Basin. The Volksrust and Pietermaritzburg Formations can only be recognised when the Vryheid Formation forms part of the vertical sequence. In the north and north-western portions of the basin the Pietermaritzburg Formation was not deposited and the coal-bearing strata of the Vryheid Formation rest directly upon the basement.

that these portions may well have been deposited in lacustrine to possibly lagoonal and shallow coastal embayments (Tavener-Smith *et al*., 1988).

The Volksust Formation is one of sixteen (16) recognised stratigraphic units that constitute the Permian Ecca Group. During the deposition of the Ecca Group the basin was dominated by a large sea (the salinity levels of this water body remain unresolved). The exception to this model was the deposition of the coal-bearing strata of the Vryheid

Formation along the northern margin during an episode of deltaic progradation into the basin.

Genetically the Volksrust Formation represents a time of deep-water deposition of muds along the northern margin of the Main Karoo Basin following a rise in relative water level and the resultant inundation and drowning of the coal swamps and fluvial-lacustrine environments that deposited the underlying Vryheid Formation. Deposition of the Volksrust Formation was terminated by a progressive infilling of the basin and the resultant, widespread deposition of the terrestrially deposited, fluvio-lacustrine strata of the Beaufort Group.

6.1.2 Palaeontological potential

The most conspicuous and common components of the palaeontological record of the Ecca Group in general are the plant macrofossils of the *Glossopteris* flora. Two large and conspicuous leaf form taxa dominate the *Glossopteris* flora; these being *Glossopteris* and *Gangamopteris*. Within the upper Ecca (containing the Volksrust Formation) *Gangamopteris* has ceased to occur with only *Glossopteris* present (Anderson and McLauchlan, 1976). The palaeobotanical record of the Ecca Group is diverse and the literature describing it is voluminous (numerous papers having been published by E. Plumstead, H. Anderson, J. Anderson, E. Kovaks-Endrődy and M. Bamford amongst many others). A comprehensive review of the flora in the Karoo Basin literature is, accordingly, beyond the scope of this study, but a thorough review of the palaeobotanical content of the Ecca Group in general and the Volksrust Formation in particular is presented in Bamford (2004). In that summary it is indicated that the Volksrust Formation can be expected to contain the plant macrofossils *Buthelezia*, *Sphenophyllum*, *Rangia*, *Phyllotheca*, *Schizoneura*, *Sphenopteris*, *Noeggerathiopsis*, *Taeniopteris*, *Pagiophyllum* and *Benlightfootia* and the wood tax *Australoxylon* and *Prototaxoxylon*. In addition to the above records can be added the observations of Tavener-Smith *et al*., (1988) who recorded the presence of both *Glossopteris* and *Vertebraria* within the palaeontological record of the formation.

In portions of the formation that are typified by low thermal alteration abundant assemblages of palynomorph plant microfossils (including acritarchs) can be expected (Anderson, 1977).

Animal body fossils are rare within the Ecca Group in general (excepting the faunas of the Whitehill Formation). Within the Volksrust Formation the large pelycopod bivalve *Megadesmus* has been recorded near the boundary with the Beaufort Group (Cairncross *et al*., 2005). A locality containing beetles (Coleoptera) have been recorded from the formation in Kwazulu-Natal (Ponomarenko & Mostovski, 2005).

Jubb and Gardiner (1975) report the presence of fragmentary fish fossils within the Ecca sequence of southern Africa; these being *Coelacanthus dendrites* from the Somkele coal-field of northern Natal and *Namaicthys digitata* from correlative strata in the Senge Coal-fields of Zimbabwe. While fish faunas are obviously rare and none have been reported from the Volksrust Formation the possibility remains that they may be present. No reptile fossils have been identified within this formation.

Tavener-Smith *et a*l., (1988) document the presence of trace fossils they ascribed to *Planolites* type, *Skolithus*, *Scolicia*-like trails, burrows similar to *Teichichnus* and *Palaeophycus* burrows present in the formation in Zululand. Hobday and Tavener-Smith (1975) reviewed trace fossil assemblages identified within the underlying Vryheid Formation. Within that fossil assemblage they identified two forms (*Helminthiopsis* and *Taphrelminthopsis* within horizontally laminated siltstones and mudstones that represent part of the deep water *Nerites* community. While these taxa were not found within the Volksrust Formation that stratigraphic unit that stratigraphic unit was also deposited within deep water and, as such, similar deep water trace fossil forms may also be expected to be present within the unit.

6.2 Quaternary Alluvium

6.2.1 Geology

Within the region alluvium exists mainly along the Vaal-, Vet-, Vals- and Renoster-Rivers, as well as along some of their tributaries. Where fluvial floodplains are located upon the shales of the Volkrust Formation and alluvium is present, the aerial extent of the alluvium is much wider than normal because the easily eroded nature of the shales (Schutte, 1993). The thickness and lithological characteristics of the alluvium are unknown to the author.

6.2.2 Palaeontological potential

Palaeontological sites are occasionally identified in alluvial terraces and dongas of Quaternary age within South Africa. However, the author is unaware of any known Quaternary fossil sites within the project area. Should fossil material be present it may expected that large mammal bones, dentition, horn cores, micromammal bones and fresh water molluscs may be identified within this part of the stratigraphic sequence.

7 ENVIRONMENT OF THE PROPOSED PROJECT SITE

The aerial extent of the study area for both PV 1 and PV 2 is approximately 95 ha, but it is anticipated that only approximately 13 ha will be finally utilised for each photovoltaic facility. Examination of Google Earth imagery of the study area (Figure 6) suggests that

the land surface of the project area consists of grassland. A farm dam is present in the north-western corner of the project area. The land surface of the northern half of PV2 appears to have been extensively disturbed, but the cause is uncertain. The land surface of both areas is utilised for sheep and cattle grazing.

Examination of the spacing between topographic contour intervals (Figure 7) indicates that the project area consists of generally flat, featureless landscape. Heuningspruit is located close to the northern boundaries of the study area, but no fluvial drainage lines are located within either of the two sites. Mucina and Rutherford (2006) indicate that the vegetation cover of the project area consists of Central Free State Grassland (Figure 8). The conservation status of this vegetation unit is classified as vulnerable.

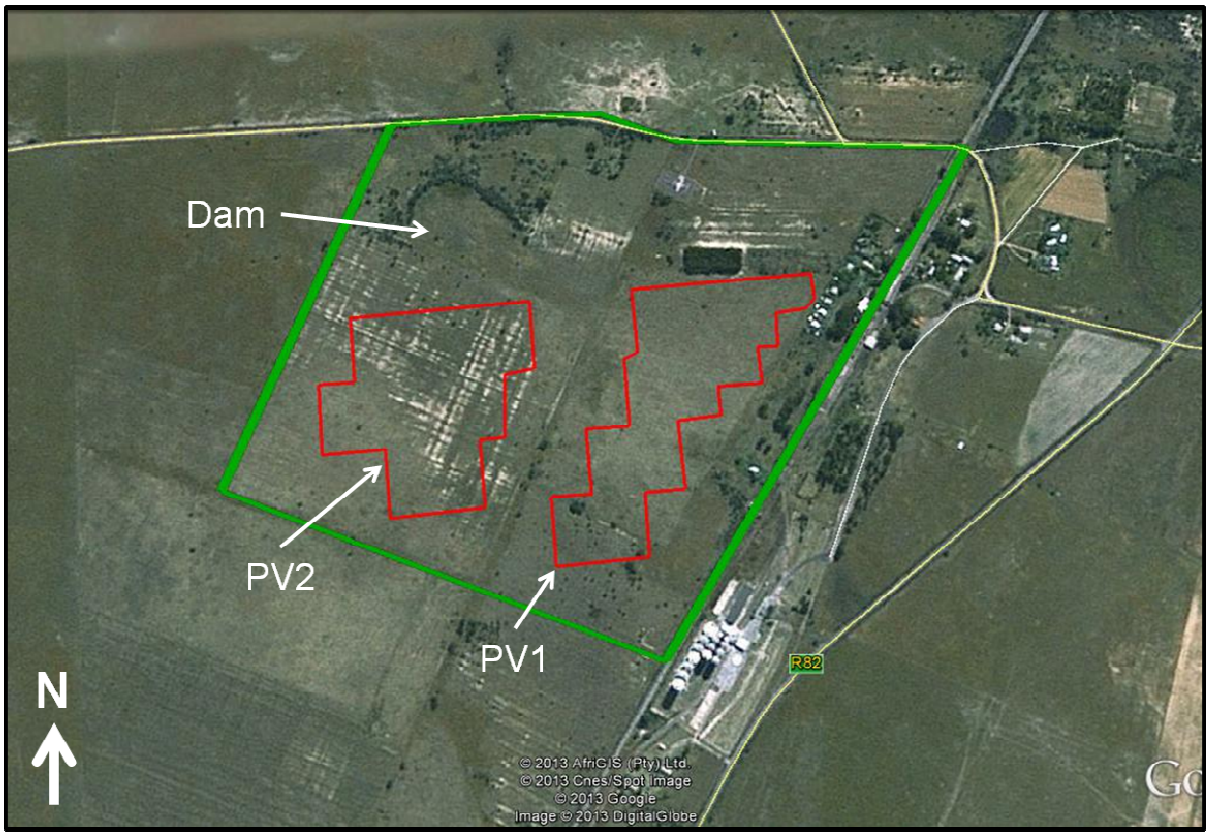

Figure 6: Google Earth image of the reporting area (green polygon) and the two preferred sites for PV 1 and PV 2 (red polygons). It is evident from the image that the area is extensively vegetated with grassland, although much of the land surface of PV2 appears to have been disturbed. The topography is very flat and featureless.

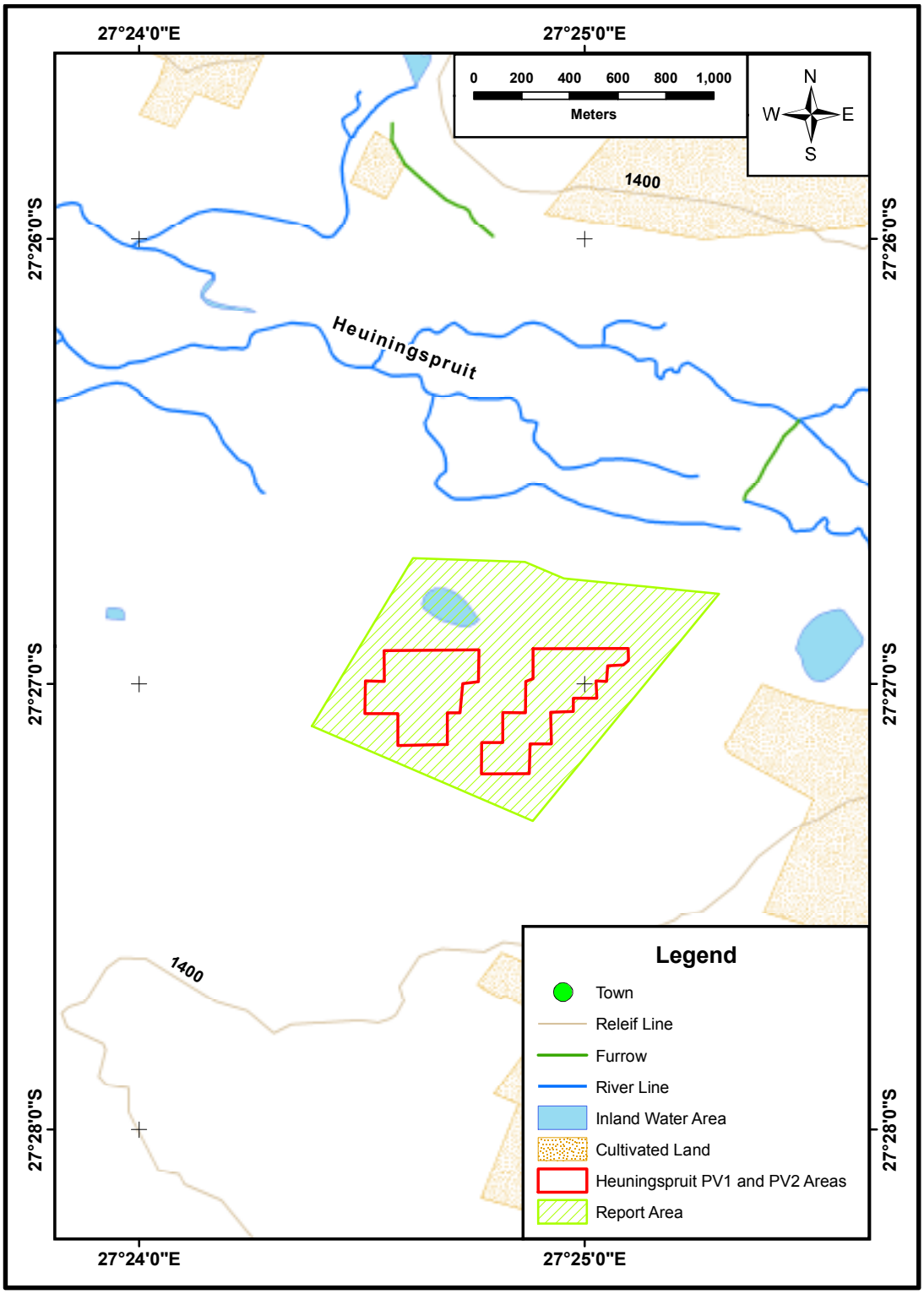

Figure 7: Map of the project area and its immediate environs. The topographic contour interval is 20 m and, as such, it is clear that the region is very flat and featureless. Heuningspruit lies close to the northern margin of the study area, but no fluvial drainage lines traverse the area.

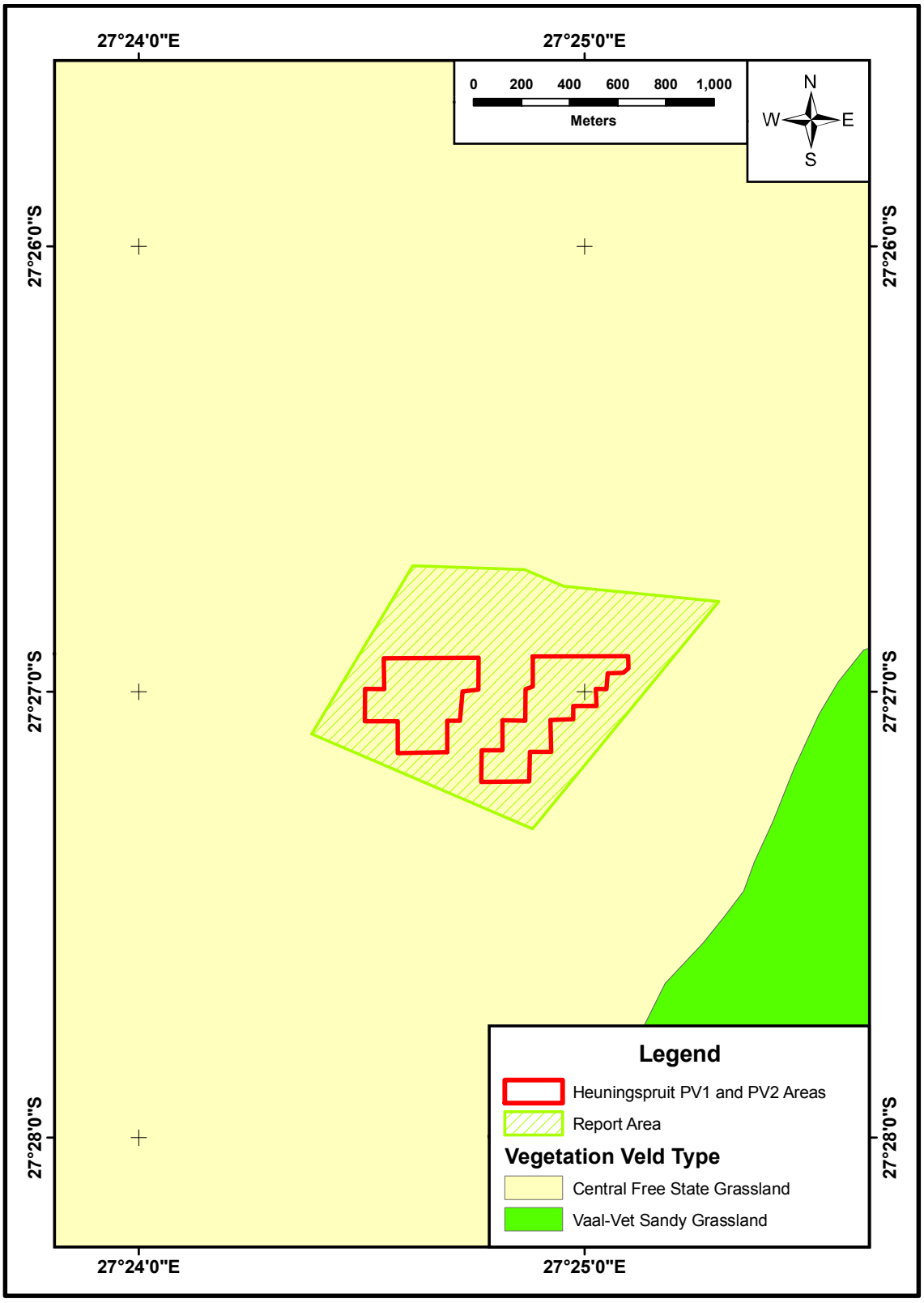

Figure 8: Map of the distribution of the vegetation veld types located within the project area and its immediate environs (after Mucina and Rutherford, 2006).

8 OVERVIEW OF SCOPE OF THE PROJECT

The purpose of the projects PV 1 and PV 2 is to generate electricity which will be fed-into the national electricity grid (via the existing Heuningspruit Rural Substation). The two projects will participate in the Department of Energy's Small Projects Renewable Energy Independent Power Producer Procurement Programme (REIPPPP). The REIPP Programme has been designed to contribute towards the South African government's renewable energy target and to stimulate the renewable energy industry in South Africa.

Sun Mechanics (Pty) Ltd will be required to apply for a generation license from the National Energy Regulator of South Africa (NERSA), as well as a power purchase agreement from Eskom (i.e. typically for a period of 20-25 years). The minimum life of the project is, accordingly, 20–25 years.

8.1 Power Station Infrastructure

An area of approximately 20 ha is being considered for each facility, one within the broaders of each of the two farm portions identified. Both 20 ha areas are contained within the all encompassing approximately 95 ha area that forms the basis of this report. A final aerial footprint of approximately 13 ha will necessary for each of the two solar energy production facilities. Each facility would comprise of the following infrastructure:

- Arrays of photovoltaic (PV) panels with a capacity of up to 5 MW.
- Mounting structures to be either rammed steel piles or piles with pre-manufactured concrete footing to support the PV panels.
- Cabling between the project components, to be lain underground.
- Inverters/Transformer enclosures.
- An on-site 88 kv or lower voltage kV switching station.
- An overhead power line of approximately 250 m in length to tie into the existing power line (Heuningspruit Rural-Syferfontien Traction 88 kV Eskom power line) on site. An application to Eskom has been made to connect into Eskom's existing Heuningspruit Rural Substation which is located adjacent (north western boundary) to the development site. Eskom will confirm voltage of connection power line and connection point. Eskom may request adjustment or possible expansion or inclusion of additional transformers or bays or switching gear associated with the existing substation and 88 kva overhead transmission line.
- Internal access roads.
- Fencing.
- Workshop area for maintenance, storage, offices and small modular water filtration or di-ionisation unit.
- Parking and water storage tanks.

8.2 Anticipated Effects of the Project Infrastructure

It is assumed, herein, that that any impacts on the palaeontological heritage of the area directly affected by the construction of the infrastructure elements described above will be limited to the immediate land surface and shallow subsurface where foundations are required for the buildings (i.e., the upper few metres in general. Any negative impact associated with the development of these infrastructural elements will be restricted to the areas underlain by each infrastructure element. The potential effects on the Volkrust Formation of any construction that may occur on the exposures of alluvium present in the north of the project area (i.e., north of the areas identified as the preferred locations for PV 1 and PV 2) cannot be determined until the thickness of the alluvium is ascertained.

9 IMPACT ASSESSMENT

The potential impact of the proposed mining area is categorised below according to the following criteria:-

9.1 Nature of Impact

The potential negative impacts of the proposed project on the palaeontological heritage of the area are:

- Damage or destruction of fossil materials during the construction of project infrastructural elements to a maximum depth of those excavations. Many fossil taxa (particularly vertebrate taxa) are known from only a single fossil and, thus, any fossil material is potentially highly significant. Accordingly, the loss or damage to any single fossil can be potentially significant to the understanding of the fossil heritage of South Africa and to the understanding of the evolution of life on Earth in general. Where fossil material is present and will be directly affected by the building or construction of the projects infrastructural elements the result will potentially be the irreversible damage or destruction of the fossil(s).
- Movement of fossil materials during the construction phase, such that they are no longer *in situ* when discovered. The fact that the fossils are not *in situ* would either significantly reduce or completely destroy their scientific significance.
- The loss of access for scientific study to any fossil materials present beneath infrastructural elements for the life span of the existence of those constructions and facilities.

9.2 Extent of Impact

The possible extent of the permanent impact of the proposed project on the palaeontological heritage of South Africa is restricted to the damage, destruction or accidental relocation of fossil material caused by the excavations and construction of the necessary infrastructure elements forming part of the project. The possible source of a less permanent negative impact on the palaeontological heritage is the loss of access for scientific research to any fossil materials that become covered by the various infrastructural elements that comprise the project. The **extent of the area of potential impact is, accordingly, categorised as local** (i.e., restricted to the project site).

9.3 Duration of Impact

The anticipated duration of the identified impact is assessed as potentially **permanent to long term**. This assessment is based on the fact that, in the absence of mitigation procedures (should fossil material be present within the area to be affected) the damage or destruction of any palaeontological materials will be permanent. Similarly, any fossil materials that exist below the planned built structures and infrastructural elements that will constitute the project and which are not directly impacted, will be unavailable for scientific study for the life of the existence of those features (minimum 20–25 years).

9.4 Probability of Impact

The geology and palaeontology of the Volksrust Formation are not well documented and have not been studied in great detail, but the formation has been proven to contain important fossil plant and trace fossil horizons (Tavener-Smith *et al*., 1988). Thus, despite the relative paucity of palaeontological data in the literature it is possible that there are fossil materials located within the Volksrust Formation underlying the project area. Fossil assemblages are not common within South Africa's Quaternary alluvial deposits, but they do occur and, as such a chance exists that fossils may be present within the alluvial deposits.

In general it is pertinent to realise that fossils are generally rare and sporadic in their occurrence and as such the probability of a development affecting a fossil at any particular point on the land surface is normally relatively low. Significantly, the author is unaware of any fossil localities that are known from within the project area. In accordance with the above discussion points the probability of any negative impact on the palaeontological heritage contained within both the Volksrust Formation and the Quaternary alluvium is assessed as being **low.**

9.5 Significance of Impact

Should the project progress without due care to the possibility of fossils being present within either the Volkrust Formation or Quaternary alluvium the resultant damage, destruction or inadvertent relocation any affected fossils will be permanent and irreversible. This potential for negative impact is accentuated by the fact that little information currently exists on the palaeontological heritage of the Volkrust Formation. Any fossil materials that may be present within the quaternary alluvium could potentially provide valuable palaeoclimatic and palaebiogeographic data for understanding the Quaternary environment of South Africa. Thus, any fossil materials occurring within the project area are potentially extremely scientifically and culturally significant and any negative impact on them would be of **high significance**.

The scientific and cultural significance of fossil materials is underscored by the fact that many fossil taxa are known from only a single fossil and, thus, any fossil material is potentially highly significant. Accordingly, the loss or damage to any single fossil can be potentially significant to the understanding of the fossil heritage of South Africa and to the understanding of the evolution of life on Earth in general. Where fossil material is present and will be directly affected by the building or construction of project infrastructural elements the result will potentially be the irreversible damage or destruction of the fossil(s).

The certainty of the exact *in situ* location of fossils and their precise location within the stratigraphic sequence is essential to the scientific value of fossils. The movement of any fossil material during the construction of the facility that results in the exact original location of the fossil becoming unknown will either greatly diminish or destroy the scientific value of the fossil.

9.6 Severity / Benefit Scale

The proposed project is categorised, herein, as being potentially **beneficial**. The projects PV 1 and PV 2 will participate in the Department of Energy's Small Projects Renewable Energy Independent Power Producer Procurement Programme (REIPPPP). The REIPP Programme has been designed to contribute towards the South African government's renewable energy target and to stimulate the renewable energy industry in South Africa. The projects will thus, assist the government attain its renewable energy target, but will also provide energy to a stressed national power grid.

The Volksrust Formation and Quaternary alluvial both contain scientifically important and unique fossils elsewhere in the South Africa. It is, therefore, possible that there are fossils of the highest scientific and cultural significance present within the sediments underlying the project area. Many fossil taxa are known from only a single fossil and the

loss or damage to any single fossil or fossil locality can, accordingly, be potentially significant to the understanding of the fossil heritage of South Africa. Thus, any fossil material that may be present within the regolith unit is potentially of high cultural and scientific significance.

The possibility of any negative impact on the palaeontological heritage of the area can, however, be minimised by the implementation of adequate damage mitigation procedures. If appropriate damage mitigation is properly undertaken the benefit/severity scale for the project will lie within the beneficial category.

A potential secondary benefit of the project would be that the excavations resulting from the progress of the project may uncover fossils materials that were hidden beneath the surface exposures and, as such, would have remained unknown to science. If the planned excavations are inspected, while they are occurring, with a view to identifying any possible palaeontological materials present the possibility would be generated of being able to study and excavate fossil materials that would otherwise be hidden to scientific study.

9.7 Status

Given the combination of factors discussed above, it is anticipated that as long as adequate mitigation processes are emplaced prior to commencement of the construction phase little to no negative effect on the palaeontological heritage of the area is anticipated. The proposed project would supply energy to a stressed national power grid and assist the government to attain its renewable energy target; the project is determined as having a **positive status** herein.

10 DAMAGE MITIGATION, REVERSAL AND POTENTIAL IRREVERSABLE LOSS

The degree to which the possible negative effects of the proposed project can be mitigated, reversed or will result in irreversible loss of the palaeontological heritage can be determined as discussed below.

10.1 Mitigation

A thorough field investigation by a palaeontologist as part of a Full Palaeontological Heritage Impact Assessment of the entire extent of the study would allow a meaningful evaluation of the presence of potentially fossil-bearing strata. A report should be compiled and submitted to SAHRA for consideration. If fossil materials prove to be present the process would allow the determination of the significance of any such fossils. Should scientifically or culturally significant fossil materials exist within the project area any negative impact upon the palaeontological heritage could be mitigated by the

excavation of the fossils (under permit from SAHRA) by a palaeontologist. The resultant fossils should then be lodged with an appropriately permitted institution. In the event that an excavation is impossible or inappropriate the fossil or fossil locality could be protected and the site of any planned construction moved to an alternative location.

It is also recommended that a close examination of all excavations be made during the construction phases of the project while they are occurring. Should any fossil materials be identified, the excavations should be halted and SAHRA informed of the discovery. A significant potential benefit of the examination of the excavations associated with the construction of the project is that currently unobservable fossils may be uncovered. As long as the construction process is closely monitored it is possible that potentially significant fossil material may be discovered and be available for scientific study.

10.2 Reversal of Damage

Any damage to, or the destruction of, palaeontological materials or reduction of scientific value due to a loss of the original location is **irreversible**.

10.3 Degree of Irreversible Loss

Once a fossil is damaged, destroyed or moved from its original position without its geographical position and stratigraphic location being recorded the **damage is irreversible**.

The chances of negatively impacting on a fossil in any particular area have been assessed herein as **low**. However, any fossil material that may be contained within the strata underlying the project area is potentially of the **high scientific and cultural importance**. Thus, the potential always exists during construction and excavation within potentially fossiliferous rocks for the permanent and irreversible loss of extremely significant or irreplaceable fossil material. This said, many fossils are incomplete in their state of preservation or are examples of relatively common taxa. As such, just because a fossil is present it is not necessarily of great scientific value. Accordingly, not all fossils are necessarily culturally of scientifically significant and the potential degree of irreversible loss will vary from case to case. The judgement on the significance of the fossil must be made by an experienced palaeontologist.

11 ASSUMPTIONS, UNCERTAINTIES AND GAPS IN KNOWLEDGE

The information provided within this report was derived from a desktop study of available maps and scientific literature; no direct observation was made of the area as result of a site visit.

Examination of 1:250 000 Geological Sheet 2726 Kroonstad (Council for Geoscience, 1998) indicates that potentially fossiliferous Quaternary alluvium associated with the Heuningspruit drainage system occur across the top of the project area and terminate immediately adjacent to the northern boundaries of both the PV 1 and PV preferred location areas. Given the inherent inaccuracies in most geological maps of this scale it remains possible that alluvium may be present within the two areas identified as the preferred sites of PV 1 and PV 2.

12 ENVIRONMENTAL IMPACT STATEMENT

The project area reported on herein is large (approximately 95 ha), but comprised two separate, but adjacent geographic areas that have been identified for the construction of the PV 1 and PV 2 facilities; one is located on each farm. The final development footprint of the each project is large (i.e., approximately 13 ha). However, as the potential heritage impacts are wholly restricted to the immediate area of the power plant and the related infrastructure elements the extent of any impact is characterised as **local**.

The effects of the construction of the power generation facilities will be restricted to the Volkrust Formation and Quaternary alluvium cover (present to the north of the preferred sites of PV 1 and PV 2). It is interpreted herein that the effects of the construction of the project will in general be restricted to the immediate land surface and the upper few metres of the geological substrate. Any fossil materials that remain undiscovered beneath infrastructure elements after the construction of the project will only be negatively affected in so far as they will be unavailable for scientific study for the life expectancy of the infrastructural elements that comprise the project (e.g., a minimum of 20-25 years).

The Volkrust Formation contains both plant macrofossils of the *Glossopteris* Flora, insect faunas, the bivalve *Megadesmus* and trace fossil assemblages that are potentially highly significant to the cultural and scientific heritage of South Africa. However, the number of fossil sites reported from the formation is not numerous, as such, the risk of a negative impact is **low**, but the significance of any negative impact on the fossil assemblages could potentially be **high**.

Palaeontological sites are occasionally identified in alluvial terraces and dongas of Quaternary age within South Africa, but are uncommon. Should palaeontological materials be present they may be expected to include large mammal bones, dentition, horn cores, micromammal bones and fresh water molluscs. However, as the number of fossil sites reported from the unit is not numerous the risk of a negative impact is

assessed as **low**, but the significance of any negative impact on the fossil assemblages could potentially be **high**.

Any damage that occurs to such fossil material during the excavation and construction phase of the project would be permanent and irreversible. The potential negative impact to the palaeontological heritage of the area can be minimised by the implementation of appropriate mitigation processes.

A thorough field investigation by a palaeontologist as part of a Full Palaeontological Heritage Impact Assessment of the entire extent of the area reported upon, herein, for both the PV 1 and PV 2 solar energy facilities prior to the commencement of construction would allow a meaningful evaluation of the presence of potentially fossil-bearing strata within the target areas. This process would make it possible that scientifically and/or culturally significant fossils, present within the area may be discovered that would be otherwise damaged, destroyed or inadvertently moved and appropriate damage mitigation processes could be determined. A secondary advantage of such an investigation would be that any fossil materials located could prove to have a positive effect on the understanding of the fossil record of South Africa and positively affect the palaeontological heritage of the country. Similarly, thorough examinations should be made of all excavations as they are being performed. Should any fossil materials be identified during the construction phase, the excavations should be halted and SAHRA informed of the discovery. A potential positive outcome of these mitigation protocols could be that fossil materials become available for scientific study that would otherwise have been hidden within or beneath the regolith. Should such new palaeontological material be located as a result of this site investigation this could prove to have a positive effect on the understanding of the fossil record of South Africa and positively affect the palaeontological heritage of the country.

The social benefits of the project have been classified as beneficial, herein, as the project aims to provide employment opportunities within the power station. As such **this desktop study has not identified any palaeontological reason to prejudice the progression of this project, subject to adequate mitigation programs being put in place**.

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