# DESKTOP PALAEONTOLOGICAL HERITAGE IMPACT ASSESSEMENT REPORT ON THE SITE OF A PROPOSED 75 MW SOLAR ENERGY FACILITY TO BE LOCATED ON A SITE NEAR ODENDAALSRUS, FREE STATE PROVINCE

Prepared for:

Heritage Contracts and Archaeological Consulting CC

On Behalf of:

FRV Energy South Africa (Pty) Ltd

Prepared By:

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## EXECUTIVE SUMMARY

FRV Energy South Africa (Pty) Ltd proposes to construct a 75 MW export capacity photovoltaic solar energy facility on a site located approximately 11 Km to the north-east of Odendaalsrus and 9 Km to the south-east of Allanridge, within the Magisterial District of Odendaalsrus in the Free State Province of South Africa. The site occupies an area of approximately 452 ha and is located wholly within the farm Hilton 30 Portion 1.

FRV Energy South Africa (Pty) Ltd has appointed Savannah Environmental (Pty) Ltd, as independent consultants, to undertake a Scoping and Environmental Impact Assessment to identify and assess all potential environmental impacts associated with the proposed project for the area as identified, and propose appropriate mitigation measures in an Environmental Management Programme ("EMP"). Savannah Environmental (Pty) Ltd appointed Heritage Contracts and Archaeological Consulting CC to conduct the Heritage Impact Assessment component of the Scoping Study. Heritage Contracts and Archaeological Consulting CC has retained BM Geological Services to provide a desktop Palaeontological Heritage Impact Assessment Report in respect of the proposed project that will form part of the final Heritage Impact assessment Report.

The project is anticipated to consist of the following technology and infrastructural elements:

- Mounting structures for the solar panels to be either rammed steel piles or piles with pre-manufactured concrete footings to support the PV panels.
- Cabling between the project components, to be lain underground where practical.
- A new on-site substation to evacuate the power from the facility into the Eskom grid (loop in loop out connection to the 132kv line on the farm and this connects to the Grootkop 132/44/11 kV substation)
- Internal access roads and fencing.
- Workshop area for maintenance, storage, and offices.

The final location and extent of the project is unknown at the time of compilation of this report.

Two stratigraphic units are identified as underlying the project site, these being (in descending stratigraphic order):-

1. Cainozoic regolith
2. Volkrust Formation

The Cainozoic regolith and the Volksrust Formation are both potentially fossiliferous and their stratigraphic equivalents are known to contain fossils elsewhere in South Africa. Accordingly, it may be reasonably expected that scientifically and culturally significant fossils may be present within the project area. The significance of any fossil material that may be present within the rocks underlying the project area is further heightened by the general lack of knowledge of the palaeontology of the Volkrust Formation in general and the Cainozoic strata of the region. Any disruption to those fossils by the proposed construction process would potentially result in permanent and irreversible damage or destruction of the fossil heritage of the area.

The project has been assessed as being beneficial herein. Other aspects in favour of the continuation of the project are that fossils are generally rare and sporadic in their occurrence and the chances of a fossil being negatively impacted upon in any particular area are small so there is a reduced probability of a negative impact. Similarly, the area that should be impacted by the proposed development is characterised as local and the zone of permanent disruption is vertically restricted to the maximum depth of any excavations associated with the proposed constructions. The entire extent of the project area appears to be covered by a regolith cover that has been extensively cultivated (ploughed). Thus, the historical farming processes have probably destroyed any fossil materials that may have been present at surface. Similarly, the pervasive cover of the project area by the regolith would hide any fossils contained within the Volksrust Formation from discovery. Thus, despite the possibility of the present of culturally significant fossils within the rocks of the project area the potential for a negative impact on those fossils can be quantified in the following manner. Thus, any fossil materials that may have been present at/or near the surface will have been historically destroyed and the likelihood of any negative impact is categorised as negligible. The possibility of a negative impact on the depth interval between the maximum depth of ploughing and the maximum depth of excavations is categorised as low (due to the general rarity of fossils in general). Below the maximum depth of excavation any potential negative impact on the palaeontological heritage is restricted to the loss of opportunity for scientific study of any fossils for the life of the project.

The possibility of any negative impact on the palaeontological heritage of the project area could be minimised by an examination of any excavations by a palaeontologist while they are occurring. Should any fossil materials be identified during the excavation phase appropriate damage mitigation procedures could be put into action. Indeed, this course of action could result in fossil materials being made 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

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## 1. INTRODUCTION

FRV Energy South Africa (Pty) Ltd proposes to construct a 75 MW export capacity photovoltaic solar energy facility on a site located approximately 11 Km to the north-west of Odendaalsrus and 9 Km to the south-east of Allanridge, within the Magisterial District of Odendaalsrus in the Free State Province of South Africa. The site occupies an area of approximately 450 ha and is located wholly within the farm Hilton 30 Portion 1 (Figure 1).

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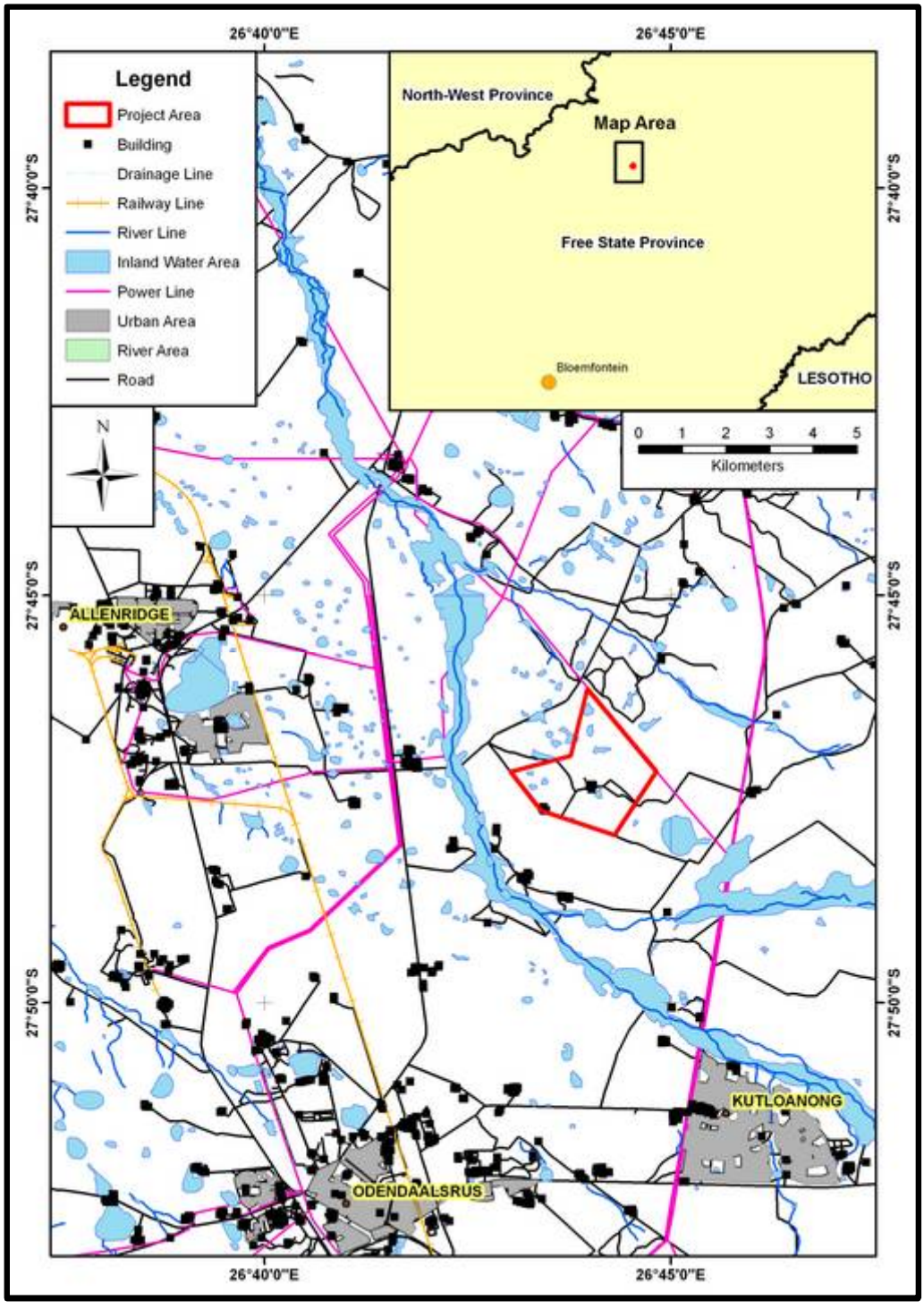
## 2. TERMS OF REFERENCE AND SCOPE OF THE STUDY

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

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

## 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).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Legend
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Building
Drainage Line
Railway Line
River Line
Inland Water Area
Power Line
Urban Area
River Area
Road
North-West Province
Map Area
Free State Province
Bloemfontein
LESOTHO
N
0 1 2 3 4 5
Kilometers
ALLENRIDGE
KUTLOANONG
ODENDAALSRUS

**Figure 1**: Location map showing the position of the proposed FRV Energy South Africa (Pty) Ltd solar energy generation facility.

## 3.1 The National Heritage Resources Act

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

- Archaeological artifacts, 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 or 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 50m 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 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

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 is 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 of 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 remuneration for these professional services. Neither Dr Millsteed nor BM Geological Services has any financial interest in either FRV Energy South Africa (Pty) Ltd or the proposed power generation facility.

## 6. GEOLOGY AND FOSSIL POTENTIAL

The project area is completely underlain by Permian sedimentary rocks of the Volksrust Formation (Figure 2). This stratigraphic unit crops out along and forms a part of the basin fill sequence of the Main Karoo Basin along its north-eastern margin (Figure 3). Located approximately 6.5 Km to the west of the project area is a thin, north-west to south-east oriented inlier of the Late Achaean Ventersdorp Supergroup (consisting of the older Bothaville Formation and a younger Allanridge Formation) which forms basement for the Karoo Basin succession. Located approximately 12.5 Km to the south of the

project area are exposures of the sediments of the Late Permian Adelaide Subgroup, Karoo Supergroup. The Adelaide Subgroup is stratigraphically younger than the Volksrust Formation and forms the basal portion of the Beaufort Group. Figure 4 shows that there is a significant cover of Cainozoic regolith covering the entire region and, thus, also the Volksrust Formation bedrock.

A brief description of the Volksrust Formation and the Cainozoic regolith and their potential palaeontological contents is provided below.

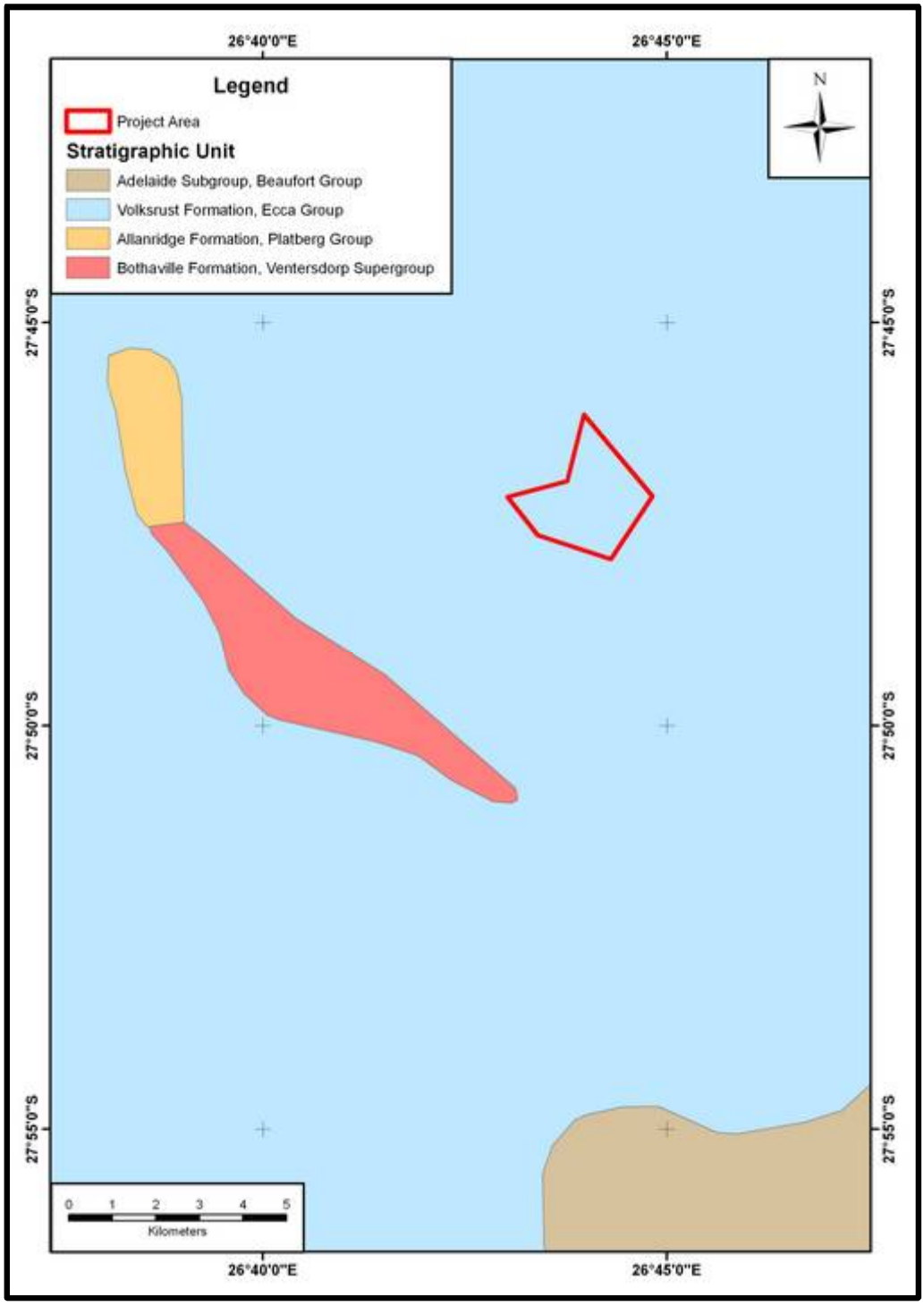


**Figure 2:** Map of the bed rock geology of the project area and its environs.

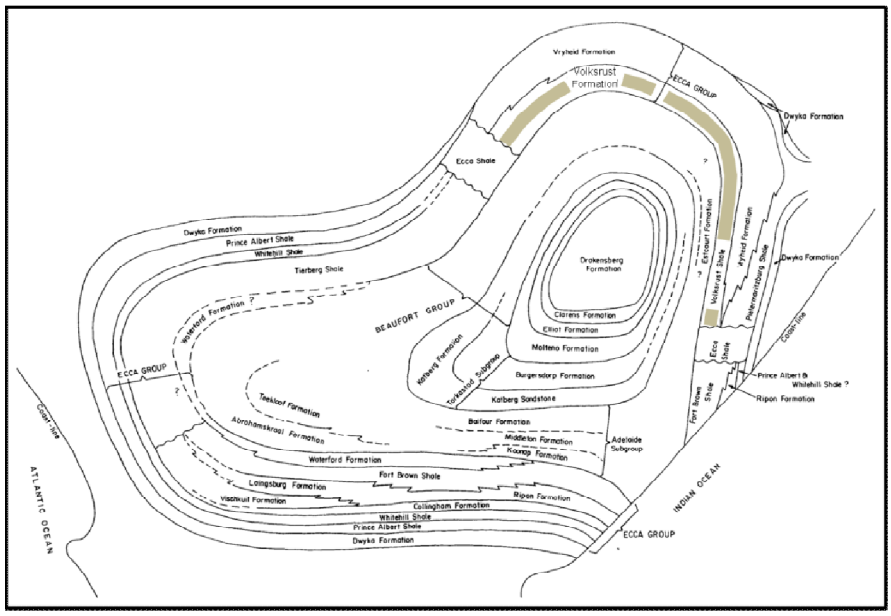


**Figure 3:** Schematic map of the Main Karoo Basin showing the aerial distribution of the outcrop patterns of its various stratigraphic units. The location of the area of outcrop of the Volksrust Formation is highlighted with the khaki line.

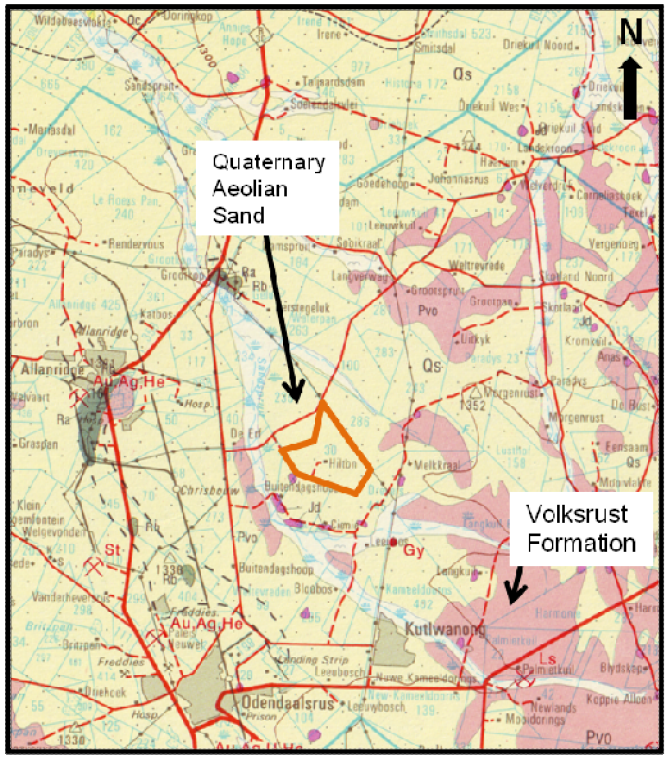


**Figure 4:** Map of the surface geology of the project area and its environs. It is evident that the entire extent of the project area is covered by Cainozoic aeolian sands (modified from Geological Survey of South Africa 1: 250 000 geological map series 2726 Kroonstad).

## 6.1 Cainozoic regolith

Figure 4 indicates that there is an aerially extensive cover of Cainozoic age regolith of unknown thickness over the entire project area. The legend of Geological Survey of South Africa 1: 250 000 geological map series 2726 Kroonstad indicates that these sands were deposited by aeolian processes. Cainozoic age palaeontological sites are occasionally identified in alluvial terraces and dongas throughout South Africa. It may be expected that large mammal bones, dentition, horn cores, micromammal bones and fresh water molluscs may be identified within strata of this age.

### *6.1.1 Palaeontological potential*

If the aeolian sands are primary sediments there is a reduced palaeontological potential for the sequence. However, the author has person experience from elsewhere that some similar sequences represent fluvially reworked aeolian sands. If this is the case the palaeontological potential would be higher. Unfortunately, there is no information available to elucidate this question. No palaeontological materials are known to occur within these strata in the project area.

## 6.2 Volksrust Formation

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 mud deposited from suspension (Johnson *et al*., 2006). The increased grain size in the upper and lower portions of the formation indicates, in part,

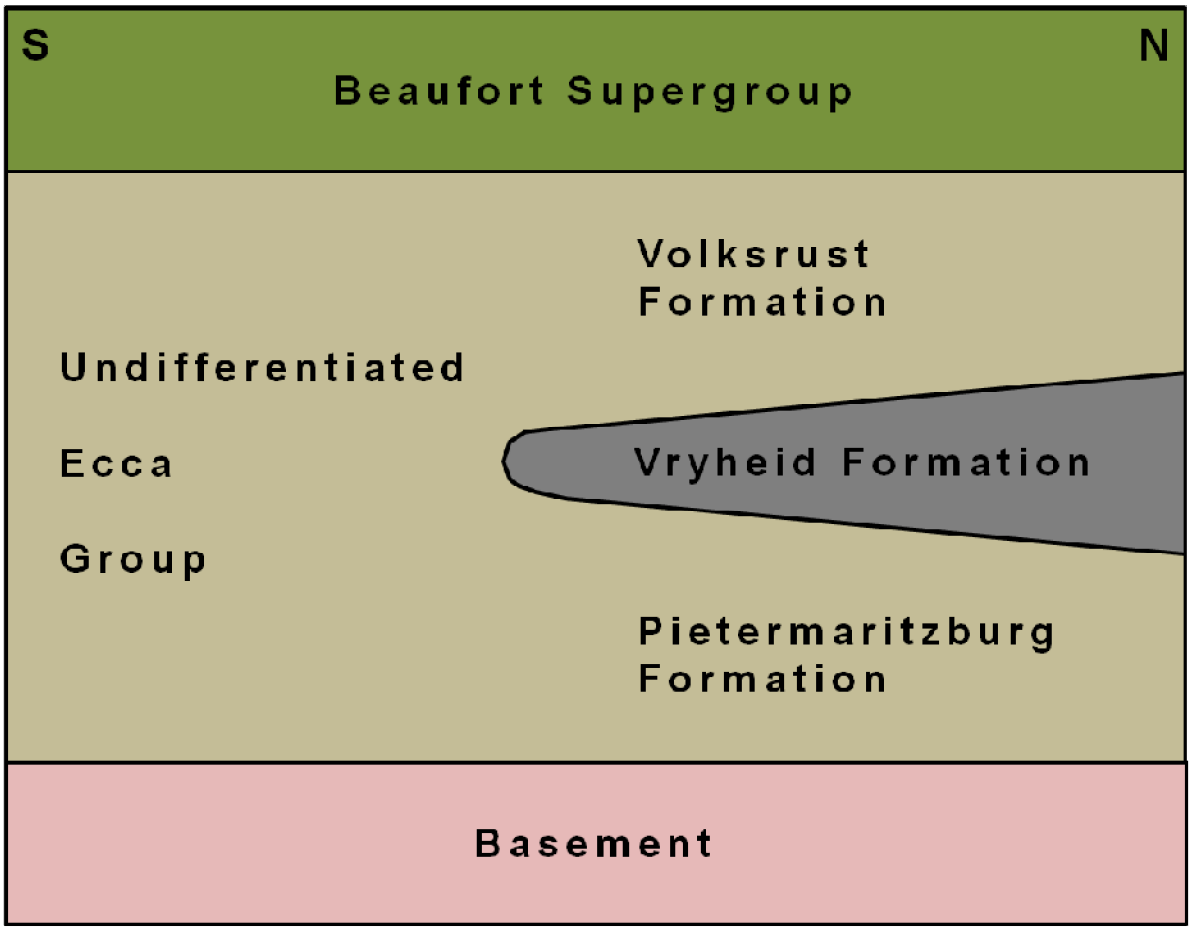


**Figure 5:** Schematic north-south oriented stratigraphic section of the Ecca Group in the north-east corner of the Karoo Basin. The Volksrust and Pietermaritburg Formations can only be recognised when the Vryheid Formation forms part of the vertical sequence. In the north and north-western portions of the basin the Pietermaritzburg Formation was not deposited and the coal-bearing strata of the Vryheid Formation rest directly upon the basement (see Figure 3).

that these portions may well have been deposited in lacustrine to possibly lagoonal and shallow coastal embayments (Tavener-Smith et al., 1998).

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.

### *6.2.1 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 be present 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 macroplant fossils *Buthelezia*, *Sphenophyllum*, *Rangia*, *Phyllotheca*, *Schizoneura*, *Sphenopteris*, *Noeggerathiopsis*, *Taeniopteris*, *Pagiophyllum* and *Benlightfootia* and the wood tax *Australoxylon* and *Prototaxoxylon*. To these records can be added those of Tavener-Smith *et al*., (1988) who recorded the presence of *Glossopteris* and *Vertebraria* to 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 the Senge coal-fields of Zimbabwe elsewhere. 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 prescence 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.

## 7. ENVIRONMENT OF THE PROPOSED PROJECT SITE

The project area is approximately 450 ha in extent. Examination of Google Earth imagery of the project area suggests that the land surface is essentially flat, featureless and appears to be used for agriculture and has been extensively cultivated (Figure 6).


**Figure 6:** Google Earth image of the project area and its environs. It is evident from the image that the area has been extensively cultivated (ploughed) for agricultural use.

## 8. OVERVIEW OF SCOPE OF THE PROJECT AND POTENTIAL NEGATIVE EFFECT

### 8.1 Project overview

The proposed facility will have an export capacity of approximately 75 MW. The main infrastructure includes the following technology and infrastructural elements:

» Mounting structures for the solar panels to be either rammed steel piles or piles with pre-manufactured concrete footings to support the PV panels.
» Cabling between the project components, to be lain underground where practical.
» A new on-site substation to evacuate the power from the facility into the Eskom grid (loop in loop out connection to the 132kv line on the farm and this connects to the Grootkop 132/44/11 kV substation)
» Internal access roads and fencing.
» Workshop area for maintenance, storage, and offices.

The extent of the vertical disturbance of the regolith and/or bedrock profile that can be anticipated by this project has not been specified. However, comparison to other similar solar power generation facilities suggests that the disruption would be shallow (i.e., restricted to approximately the top 1-2 meters of the land surface). The following impact assessment is made in the light of this assumption.

## 9. IMPACT ASSESSMENT

The potential impact of FRV Energy South Africa (Pty) Ltd's solar power generation facility 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 significantly reduce or completely destroy any scientific significance for the fossils.

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 affect of the proposed project on the palaeontological heritage of South Africa is restricted to the damage, destruction or relocation of fossil material caused by the construction of the necessary infrastructure elements forming part of 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 **long term**. This is 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 structures and infrastructural elements that will constitute the power generation facility will be unavailable for scientific study for the life of the existence of those features.

### 9.4 Probability of impact

The geology and palaeontology of the Volksrust Formation is not well documented and has 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.

The entire surface area of the project area, and the underlying rocks of the Volksrust Formation, appear to be covered by a layer of regolith of aeolian sands. This regolith is potentially fossiliferous, but its aeolian origin suggests that this fossiliferous potential is low. It is impossible to determine from this desktop study if the regolith covers 100 percent of the surface area of the project area, but the extensively cultivated appearance of the land surface (Figure 6) suggests that this appears to be the case. The implication of the extensive cover of the heavily cultivated regolith horizon is two-fold.

Firstly, that any fossils that may have existed within the surface of the regolith will have been destroyed damaged as a result of the historical farming operations. Secondly, any fossil materials contained within the Volksrust Formation will be hidden beneath the regolith and, as such, will be hidden from discovery. Depending on the depth of the regolith cover it is also possible that if the regolith is sufficiently thick, any disruption caused by excavations required for the project will be confined to the regolith layer and that any fossils contained in the underlying Volksrust Formation may not be directly moved, damaged or destroyed. If the regolith layer is thin, then only the upper-most and presumably weathered (due to presence of a marked erosional unconformity between that unit and the regolith) portion of the Volksrust Formation will be affected. If the thickness of the regolith layer is determined and the maximum depth of disturbance of the land surface to be expected due to the project be determined these possibilities can be better quantified.

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 in 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 of the area occurring at any particular point is improbable** (low likelihood).

## 9.5 Severity / Benefit scale

The proposed project is categorised, herein, as being potentially **beneficial**. This classification is based on the intention that the project will provide a long term benefit to the community in terms of the provision of electricity to an increasingly stressed national power grid. This positive benefit will continue throughout the life of the project. The probability of a negative impact on the palaeontological heritage of the project area has been categorised as low. The palaeontological heritage of the Volksrust Formation is not well documented and any palaeontological data that can be obtained from the area would be of significant cultural and scientific significance. This situation would also be true of any fossil materials that occur within the regolith horizon below the depth of disturbance due to historical ploughing. Thus, although the likely hood of any disturbance of palaeontological materials is low, the severity of any impact could be high.

A potential benefit of the project would be that the excavations resulting from the progress of the project would certainly expose deeper portions of the regolith horizon

that are unaffected by the historical cultivation practises and possibly even the rocks of the Volksrust Formation. If these excavations are inspected by a palaeontologist, with a view to identifying any possible palaeontological materials exposed, the possibility would be generated to be able to study and excavate fossil materials that would otherwise be hidden to scientific study.

### 9.6 Significance

Should the project progress without due care to the possibility of fossils being present within either the bedrock or regolith 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 either the Volkrust Formation in general or the Cainozoic history of the project area. Thus, any fossil materials occurring within the project area are potentially extremely significant. However, if adequate mitigation processes are put into place then the potential for damage to any fossil material can be minimised.

The potential impact of the proposed project is restricted to the project area. The project area, as discussed herein, is relatively small (approximately 450 Ha) and it is anticipated that the aerial extent of the final power generation facility would be significantly smaller. Any negative impacts on the palaeontological heritage of the area will be restricted to those locations where construction activities occur and as such are strictly local in effect. Accordingly, **the significance of the proposed project on the palaeontological heritage is categorised as low if appropriate mitigation procedures are put into place**.

### 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. As the proposed project would supply electricity to the stressed South African national power grid 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 of the site by a palaeontologist of the site identified for final construction of the solar power generation facility prior to the commencement of construction would allow a meaningful evaluation of the affects of any cultivation practices upon the fossil-bearing potential of the regolith. Such an investigation would allow the recognition of the presence of any outcrops of Volkrust Formation within the area as well as their potential to be fossiliferous and, if fossiliferous, the identification of any fossil materials that should be protected completely or could have damage mitigation procedures emplaced to minimise negative impacts.

A second significant potential benefit 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 made available for scientific study.

Should scientifically or culturally significant fossil material exist within the project area any negative impact could be mitigated by its excavation (under permit from SAHRA) by a palaeontologist and the resultant material being 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.

### 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 or destroyed the **damage is irreversible**. By their nature fossils are usually rare and sporadic in their occurrence and the chances of negatively

impacting on a fossil in any particular area are low. However, any fossil material may be of the greatest scientific importance. This is particularly true of vertebrate fossils in which many taxa are known from only one fossil. Thus, the potential always exists during construction and excavation of 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 necessary significant culturally of scientifically significant. However, 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. In particular, the discussion of the geological units present within the project area (and as such the basis of understanding the fossiliferous potential of the area) was derived from the published 1:250 000 geological map of the area). The accuracy of 1:250 000 geological maps is often variable; some areas being compiled from air photo interpretation or remote sensing procedures. The possibility of the presence of additional geological units being present within the project area cannot be disregarded.

Cainozoic age palaeontological sites are occasionally identified in alluvial terraces and dongas throughout South Africa. It may be expected that large mammal bones, dentition, horn cores, micromammal bones and fresh water molluscs may be identified within Cainozoic strata. Examination of the available data for project site indicates that there are no significant fluvial features present in the project area and the presence of fluvial terraces in the area is not probable. There are, however, significant exposures of potentially fossiliferous Cainozoic strata evident across the area on the geological map of the area (Geological Survey of South Africa 1: 250 000 geological map series 2726 Kroonstad). The thickness of the regolith is unknown and, therefore, it is uncertain if there would be any regolith that would be unaffected by the historical faming activities by as a result of lying below the maximum extent of those activities. Similarly, there may be locations within the project area where the Volksrust Formation crops out at surface.

## 12. ENVIRONMENTAL IMPACT STATEMENT

A desktop study has been conducted on the site of the construction of a 75 MW solar power generation facility. This desktop study forms part of a Heritage Impact Assessment Report that is a component of a larger Scoping and Environmental Impact Assessment to identify and assess all potential environmental impacts associated with the proposed project for the area as identified, and propose appropriate mitigation measures in an Environmental Management Programme.

The project site discussed, herein, is relatively small (240 haHa) in size and it is probable that the area that will be affected by the proposed project is considerably smaller, but this is yet to be finalised. Any negative effects emanating from the project will be restricted to the local environment of the final development area. It is anticipated, herein, that most infrastructural elements will only directly affect the surface of the site to a relatively shallow depth, although the maximum depth of the constructions is unknown at the time of compilation of this report.

This study has identified that there are two geological units that underlie the project area. These geological units, in order of decreasing stratigraphic age, are a regolith composed of Cainozoic aeolian sands and the underlying Volksrust Formation; both of which are potentially fossiliferous. The fossils that may be anticipated to be present within these units are potentially significant to the cultural and scientific heritage of South Africa. The potential value of any fossils that are potentially present is further accentuated by the fact that the palaeontological heritage of the area of the Volksrust Formation in general and the regolith of the area are not well known and, thus, any fossil material present could significantly add to the knowledge of the area. However, it appears that the entire extent of the project area is covered by the regolith layer and that the regolith has been extensively disturbed by ploughing. Thus, any fossil materials that may have been present at/or near the surface will have been historically destroyed. The regolith cover would also ensure that the presence any fossil materials within the Volksrust Formation will be difficult to verify prior to commencement of the project. Thus, the likelihood of a negative impact on the palaeontological heritage on the immediate land surface can be described extremely low to negligible. The possibility of a negative impact on the depth interval between the maximum depth of ploughing and the maximum depth of excavations is categorised as low. The possibility of destruction or damage to any fossil materials below the maximum depth of the excavations is non-existent. Below the maximum depth of excavation any potential negative impact on the palaeontological heritage is restricted to the loss of opportunity for scientific study of any fossils for the life of the project. However, the probability of this latter possibility is low and any such fossils are currently probably hidden beneath the regolith and would require extensive excavations to locate.

In general fossils are rare and sporadic in their occurrence and, as such, the chances of a fossil being disturbed by the excavations contemplated for the emplacement of the projects infrastructural elements or lost to study beneath those infrastructural elements is not high. However, despite the rare and sporadic occurrence of fossils a single fossil can have immense scientific importance (e.g., many vertebrate fossil taxa are known from a single fossil) so the potential for significant loss to the palaeontological heritage remains. Any damage to fossil material that occurs during the excavation and construction phase of the project is permanent and irreversible. However, the potential negative impact to the palaeontological heritage can be minimised by the implementation of appropriate mitigation processes.

In summary, the proposed project poses a low potential for causing a negative impact on the palaeontological heritage of the area. Indeed, should adequate examination of any excavations be performed it is possible that scientifically and/or culturally significant fossils may be discovered that would be otherwise hidden from discovery. 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 a renewable source of energy to the South Africa power grid. The power generation capacity of South Africa is presently under significant pressure.

## 13. REFERENCES

Anderson, A.M. and McLauchlan, I.R. (1976). The plant record in the Dwyka and Ecca Series (Permian) of the south-western half of the Great Karoo Basin, South Africa. *Palaeontologia Africana*, 19: 31-42.

Bamford, M.K. (2004). Diversity of woody vegetation of Gondwanan southern Africa. *Gondwana Research*, 7: 153-164.

Cairncross, B., Beukes, N.J., Coetzee, L.L. and Rehfeld, U. (2005). The bivalve *Megadesmus* from the Permian Volksrust Formation (Karoo Supergroup), northeastern Karoo Basin, South Africa: implications for Late Permian basin development. *South African Journal of Geology* 108, 547-556.

Geological Survey of South Africa (1986). 1: 250 000 geological map series 2726 Kroonstad.

Hobday, D.K. and Taverner-Smith, R. (1975). Trace fossils in the Ecca of northern Natal and their palaeoenvironmental significance. *Palaeontologia Africana*, 18: pp 47-52.

Johnson, M.R., van Vuuren, C.J., Visser, J.N.J., Cole, D.I., de V. Wickens, H., Christie, A.D.M., Roberts, D.I., and Brandl, G. (2006). *Sedimentary Rocks of the Karoo Supergroup*, in Johnson, M.R., Anhaeusser, C.R. and Thomas, R.J. (eds) *The Geology of South Africa*, Johannesburg: Council for Geoscience, Pretoria: Geological Society of South Africa, pp. 461 – 499.

Jubb, R.A. and Gardiner, B.G., (1975). A preliminary catalogue of identifiable fossil fish material from southern Africa. Annals of the South African Museum, 67 (11): 381–440.

Ponomarenko, A.G. & Mostovski, M.B. (2005). New beetles (Insecta: Coleoptera) from the Late Permian of South Africa. *African Invertebrates* 46. The Council of Natal Museum.

Republic of South Africa. (1998). National Environmental Management Act (No 107 of 1998). Pretoria: The Government Printer.

Republic of South Africa. (1999). National Heritage Resources Act (No 25 of 1999). Pretoria: the Government Printer.

Tavener-Smith, R., Cooper, J.A.G. and Rayner, R.J. (1998). Depositional environments in the Volksrust Formation (Permian) in the Mhlatuze River, Zululand. South African Journal of Geology 91, 198-206.

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