PALAEONTOLOGICAL IMPACT ASSESSMENT OF THE PROPOSED WOODHOUSE SOLAR 1 PV FACILITY AND ASSOCIATED INFRASTRUCTURE ON THE REMAINING EXTENT OF FARM WOODHOUSE 729, NEAR VRYBURG, NORTH WEST PROVINCE

Prepared for:
Savannah Environmental (Pty) Ltd
PO Box 148
Sunninghill
Johannesburg
2157

10April 2016

Prepared by:
Elize Butler
Karoo Palaeontology Department
National Museum
P. O. Box 266
Bloemfontein
9300

Tel: 051-447-9609
Fax: 051-447-6273
E-mail: elize.butler@nasmus.co.za

EXECUTIVE SUMMARY

Genesis Woodhouse Solar 1 (Pty) Ltd propose the development of a commercial photovoltaic (PV) solar energy facility as well as associated infrastructure on the Remaining Extent of Farm Woodhouse 729 (Fig. 1), located south east of Vryburg, and within the Naledi Local Municipality and the greater Dr Ruth Segomotsi Mompati District Municipality, North West Province. According to the National Heritage Resources Act (Act No 25 of 1999, section 38), a palaeontological impact assessment is required to detect the presence of fossil material within the proposed development footprint and to assess the impact of the construction and operation of the Woodhouse Solar 1 PV Facility on the palaeontological resources.

The development footprint (located in the northern portion of the affected property) is underlain by the Vryburg Formation of the Ghaap Group, and the Dwyka Group of the Karoo Supergroup. The geologically older Vryburg Formation (2.6 billion year-old) consists of fluvial and shallow marine quartzites, mudrocks and conglomerates, while the Dwyka Group [317 Million years] consists of Permo-carboniferous glacial sediments. The Dwyka Group (Karoo Supergroup) is represented by small outcrops in the north of the development footprint. Although trace fossils and plants could be present in the Dwyka Group the likelihood of significant fossil heritage in the Vryburg area is considered to be low. The southern portion of the development footprint consists of the Vryburg Formation, which is considered as unfossiliferous in this area. Therefore, there are no areas located within the development footprint considered as sensitive.

The scarcity of fossil heritage and a lack of exposure at the proposed development footprint indicate that the impact of the Woodhouse Solar 1 PV Facility located on the Remaining Extent of the farm Woodhouse 729 will be of a low significance in palaeontological terms. **It is therefore considered that the construction and operation of the PV facility within the proposed development site is deemed appropriate and feasible and will not lead to detrimental impacts on the palaeontological resources of the area.**

Thus, it is the opinion of the specialist that the construction and operation of the PV facility be authorised as the whole extent of the development footprint is not considered as sensitive in terms of palaeontological resources.

It is thus recommended that no further palaeontological heritage studies, ground truthing and/or specialist mitigation are required for the commencement of this development, pending the discovery or exposure of any fossil remains during the construction phase.

Contents

1. INTRODUCTION

Savannah Environmental (Pty) Ltd has been appointed as the independent Environmental Assessment Practitioners (EAP) by Genesis Eco-energy Developments for the undertaking of the Environmental Impact Assessment process for the proposed Woodhouse Solar1 PV Facility. The construction and operation of the Woodhouse Solar 1 commercial photovoltaic (PV) solar energy facility, as well as associated infrastructure on the Remaining Extent of the farm Woodhouse 729, located south east of Vryburg and within the Dr Ruth Segomotsi Mompati District Municipality is thus proposed (Fig. 1).

Two PV facilities are to be developed as stand-alone projects (known as the Woodhouse Solar 1 and Woodhouse Solar 2 PV facilities) by Genesis Eco-energy Developments under two separate Special Purpose Vehicles, namely Genesis Woodhouse Solar 1 (Pty) Ltd and Genesis Woodhouse Solar 2 (Pty) Ltd (Fig. 2). Both facilities will be located within the Remaining Extent of the farm Woodhouse 729. This Palaeontological Impact Assessment focuses on the Woodhouse Solar 1 PV Facility. The development of the Woodhouse Solar 2 PV Facility is being assessed in a separate EIA process.

The development footprint for the Woodhouse Solar 1 PV Facility is expected to be approximately 300 hectares in extent. The PV facility is proposed to include several arrays of photovoltaic solar panels with a contracted capacity of up to 100MW.

Infrastructure associated with the PV facility includes:

- Arrays of PV panels with a capacity of up to 100MW.
- Mounting structures to support the PV panels.
- On-site inverters to convert the power from a direct current to an alternating current and a substation to facilitate the connection between the solar energy facility and the Eskom electricity grid
- A new 132kV power line between the on-site substation and the Eskom grid connection point.
- Cabling between the project components, to be laid underground where practical
- Offices and workshop areas for maintenance and storage
- Temporary laydown areas
- Internal access roads and fencing around the development area

Four alternatives are being considered for the grid connection:

- Alternative 1: a direct connection to the authorised Eskom Bophirima Substation to be constructed within the northern portion of the affected property;
- Alternative 2: a direct connection to the existing Woodhouse 88/22kV Substation located north of the boundary of the affected property;
- Alternative 3: a turn-in turn-out connection to the existing Delareyville Munic / Vryburg 1 88kV Feeder located along the northern boundary of the affected property; and

- Alternative 4: A turn-in turn-out connection to the authorised 132kV Eskom Bophirima–Mookodi power line to be constructed by Eskom.

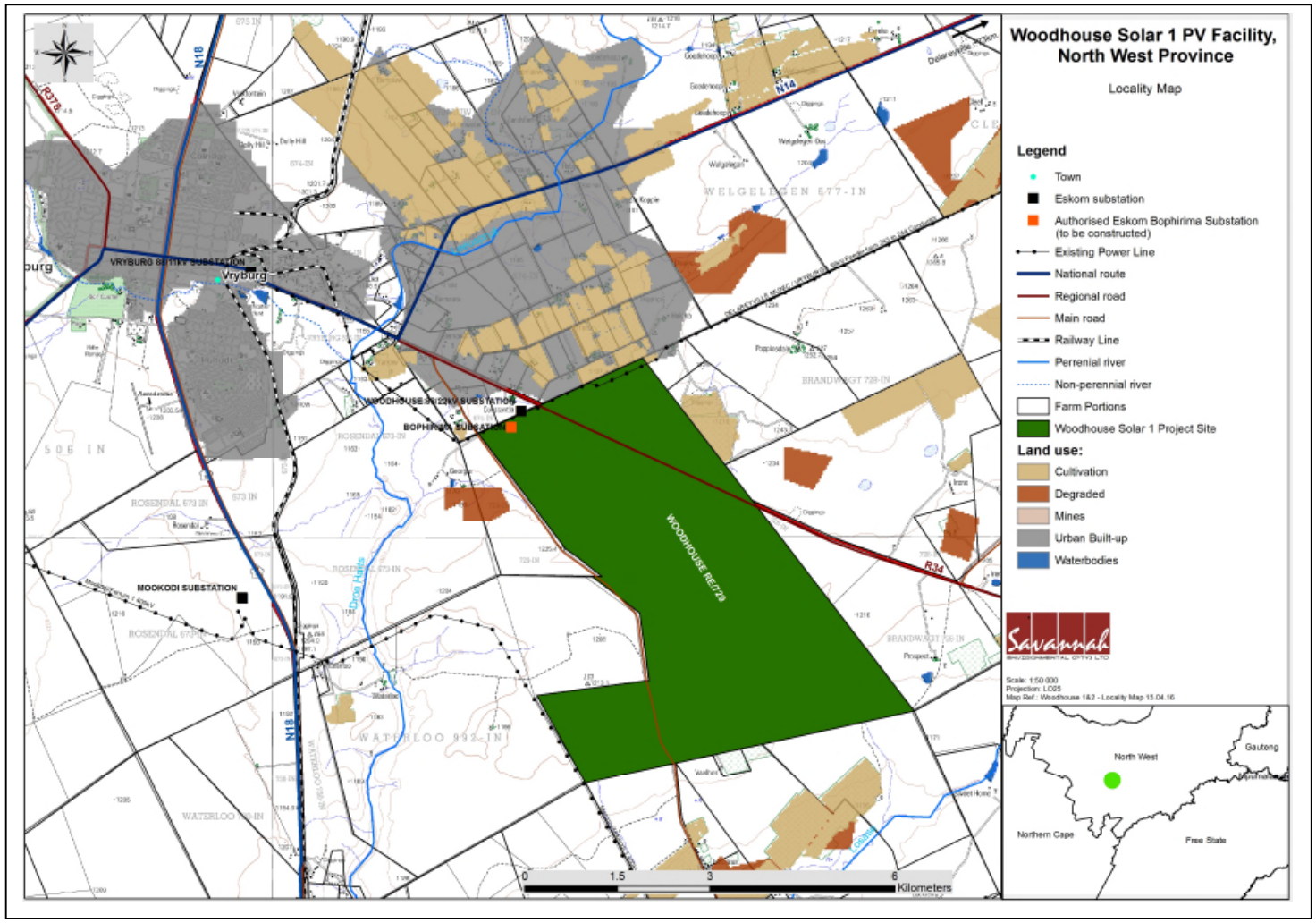

Figure 1. The location of the Remaining Extent of the farm Woodhouse 729, near Vryburg, located within the Dr Ruth Segomotsi Mompati District Municipality, North West Province (Map provided by Savannah Environmental).

1.1 LEGISLATION

Cultural Heritage in South Africa is governed by the National Heritage Resources Act (Act 25 of 1999). This Palaeontological Environmental Impact Assessment forms part of the Heritage Impact Assessment (HIA) and complies with the requirements of the above mentioned Act. In accordance with Section 38, an HIA is required to assess any potential impacts to palaeontological heritage within the development footprint.

SECTION 35 OF THE NATIONAL HERITAGE RESOURCES ACT 25 OF 1999

- The protection of archaeological and palaeontological sites and material and meteorites is the responsibility of a provincial heritage resources authority.
- All archaeological objects, palaeontological material and meteorites are the property of the State.
- 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.
- No person may, without a permit issued by the responsible heritage resources authority—
    - 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 which assist in the detection or recovery of metals or archaeological and palaeontological material or objects, or use such equipment for the recovery of meteorites.
- When the responsible heritage resources authority has reasonable cause to believe that any activity or development which will destroy, damage or alter any archaeological or palaeontological site is under way, and where no application for a permit has been submitted and no heritage resources management procedure in terms of section 38 has been followed, it may—
    - serve on the owner or occupier of the site or on the person undertaking such development an order for the development to cease immediately for such period as is specified in the order; and/or
    - carry out an investigation for the purpose of obtaining information on whether or not an archaeological or palaeontological site exists and whether mitigation is necessary.

2 Objective

According to the SAHRA APM Guidelines: Minimum Standards for the Archaeological and Palaeontological Components of Impact Assessment Reports' the aims of the palaeontological impact assessment are:

- to identify exposed and subsurface rock formations that are considered to be palaeontologically significant;
- to assess the level of palaeontological significance of these formations;
- to comment on the impact of the development on these exposed and/or potential fossil resources; and
- To make recommendations as to how the developer should conserve or mitigate damage to these resources.

The objective is thus to conduct a Palaeontological Impact Assessment, which forms of part of the Heritage Impact Assessment (HIA) and the EIA Report, to determine the impact of the development on potential palaeontological material at the site.

When a palaeontological desktop/scoping study is conducted, the potentially fossiliferous rocks (i.e. groups, formations, members, etc.) represented within the study area are determined from geological maps. The known fossil heritage within each rock unit is collected from published scientific literature; fossil sensitivity map; consultations with professional colleagues, previous palaeontological impact studies in the same region and the databases of various institutions may be consulted. This data is then used to assess the palaeontological sensitivity of each rock unit of the study area on a desktop level. The likely impact of the proposed development on local fossil heritage is subsequently established on the basis of the palaeontological sensitivity of the rocks and the nature and scale of the development itself (extent of new bedrock excavated).

If rocks of moderate to high palaeontological sensitivity are present within the study area, a Phase 1 field-based assessment by a professional palaeontologist is necessary. Generally, damaging impacts on palaeontological heritage occur during the construction phase. These excavations will modify the existing topography and may disturb damage, destroy or permanently seal-in fossils at or below the ground surface that are then no longer available for scientific study.

When specialist palaeontological mitigation is suggested, it may take place prior to construction or, even more successfully, during the construction phase when new, potentially fossiliferous bedrock is still exposed and available for study. Mitigation usually involves the careful sampling, collection and recording of fossils as well as relevant data concerning the surrounding sedimentary matrix. Excavation of the fossil heritage will require a permit from SAHRA and the material must be housed in a permitted institution. With appropriate mitigation, many developments involving bedrock excavation will have a *positive* impact on our understanding of local palaeontological heritage.

3 BACKGROUND TO THE GEOLOGICAL AND PALAEONTOLOGICALHISTORY

The development footprint, located near Vryburg, is underlain by the Ghaap Group, Vryburg Formation and the Dwyka Group of the Karoo Supergroup. The geologically older Vryburg Formation (2.6 billion year-old) consists of fluvial and shallow marine quartzites, mudrocks and conglomerates, while the Dwyka Group [317 Million years (Ma)] consists of Permo-carboniferous glacial sediments (Fig. 3).

The **Dwyka Group**, present in the northern portion of the proposed development footprint represents the lowermost unit of the Karoo Supergroup. It consists almost throughout of gravelly sediments with subordinate vorved shale and mudstone containing scraped and facetted pebbles. These sediments are supposed to be of glacial origin and in places these materials have been deposited on typical glacier floors. In the Vryburg region this succession mainly comprises of glacial tillite or boulder mudstone and interglacial shale. Exposure levels are generally very poor, because the mudrock matrix weathers easily, and therefore the Dwyka outcrop area is represented at the surface only by scattered erratic boulders (Keyser and Du Plessis 1993). The northern outcrops of the Dwyka Group, located within the development footprint, may comprise of a low diversity of non-marine trace fossil assemblages (fish and arthropod traces, *Rhizocorallium*) within interglacial mudrocks and dispersed vascular plant remains (*Glossopteris* leaves and petrified wood). Although these trace fossils and plants are considered to be a possibility, the likelihood of significant fossil heritage in the Vryburg area and the development footprint is considered to be low.

The southern (Fig. 2) portion of the development footprint is underlain by shallow marine or lagoon sediments as well as volcanic rocks of the Vryburg Formation. This formation is roughly 140m thick and overlies lavas of the Ventersdorp Supergroup. The lower portion of the Vryburg succession consists of basal conglomerates followed by the 20m thick Kobaga beds which show prominent weathering of cross-bedded feldspathic quartzites. The Kobaga beds are overlain by *c.* 20m andesitic or basaltic lavas of the Rosendal Member and finally by the Waterloo Member which consists of c. 20-50m of amydaloidal and non-amydaloidal basaltic or andesitic lavas and is overlain by 14m of interbedded pyroclastic sediments and thin lenticular limestones. These sediments form the top of the Vryburg Formation and are followed by the overlying carbonate-rich Boomplaas Formation.

Microbial stromatolites are present in the upper Vryburg Formation and were described by Smith (1991). Detailed descriptions of the Vryburg stromatolite occurrences are not present in the literature (Almond, 2013), although South African Archaean stromatolites have been discussed in detail (Altermann, 2001; Buick, 2001; and Schopf, 2006). The stromatolitic carbonates are interpreted to be intertidal (Altermann and Wotherspoon, 1995). Stromatolites and oolites from the Transvaal Supergroup have been described by various authors (Keyser and Du Plessis, 1993; Eriksson and Altermann, 1998).

The proposed development footprint consists of characteristics associated with the flat-lying terrain of the Ghaap Plateau (Fig. 3) region. This terrain is currently used for

agricultural purposes, primary cattle farming. The climate is semi-arid and the vegetation cover of grassy thornveld is mapped as Ghaap Plateau Vaalbosveld. Small, low and scattered bedrock exposure may be present on the development footprint, but the literature states that the exposures are rare apart from along river banks and steeper hill slopes (Almond, 2013). Images from Google Earth show a flat relief and bedrock mantled by reddish-brown soils. These sandy soils contain abundant gravel clasts, primarily cherty material down wasted from the underlying Boomplaas Formation (Eriksson, *et al.,* 2006).

4 GEOGRAPHICAL LOCATION OF THE SITE

The proposed development site is located approximately 10km south east of Vryburg and falls under the jurisdiction of the Naledi Local Municipality and the Dr Ruth Segomotsi Mompati District Municipality, North West Province (Fig.1).

5 METHODS

As part of the Palaeontological Impact Assessment, a field-survey of the development footprint proposed for the Woodhouse Solar 1 PV Facility was conducted on the 11 March 2016, to assess the potential risk to palaeontological material (fossil and trace fossils) in the proposed footprint of the development. A physical field-survey was conducted on foot within the proposed development footprint. The results of the field-survey, the author's experience, aerial photos (using Google Earth, 2015), topographical and geological maps and other reports from the same area were used to assess the proposed development footprint. No consultations were undertaken for this Impact Assessment.

5.1 ASSUMPTIONS AND LIMITATIONS

The accuracy and reliability of desktop Palaeontological Impact Assessments as components of heritage impact assessments are normally limited by the following restrictions:

- Old fossil databases that have not been kept up-to-date or are not computerised. These databases do not always include relevant locality or geological information. South Africa has a limited number of professional palaeontologists that carry out fieldwork and most development study areas have never been surveyed by a palaeontologist
- The accuracy of geological maps where information may be based solely on aerial photographs and small areas of significant geology have been ignored. The sheet explanations for geological maps are inadequate and little to no attention is paid to palaeontological material.
- Impact studies and other reports (*e.g*. of commercial mining companies) - is not readily available for desktop studies.

Large areas of South Africa have not been studied palaeontologically. Fossil data collected from different areas but in similar Assemblage Zones might however provide

insight on the possible occurrence of fossils in an unexplored area. Desktop studies of this nature therefore usually assume the presence of unexposed fossil heritage within study areas of similar geological formations. Where considerable exposures of bedrocks or potentially fossiliferous superficial sediments are present in the study area, the reliability of a Palaeontological Impact Assessment may be significantly improved through field-survey by a professional palaeontologist.

In order to ensure that an accurate description of the area proposed for the development is considered a field survey was undertaken to ground truth any potential impacts that the facility may have on the palaeontological resources of the site. The field-survey was undertaken on 11 March 2016, as indicated in section 5 above.

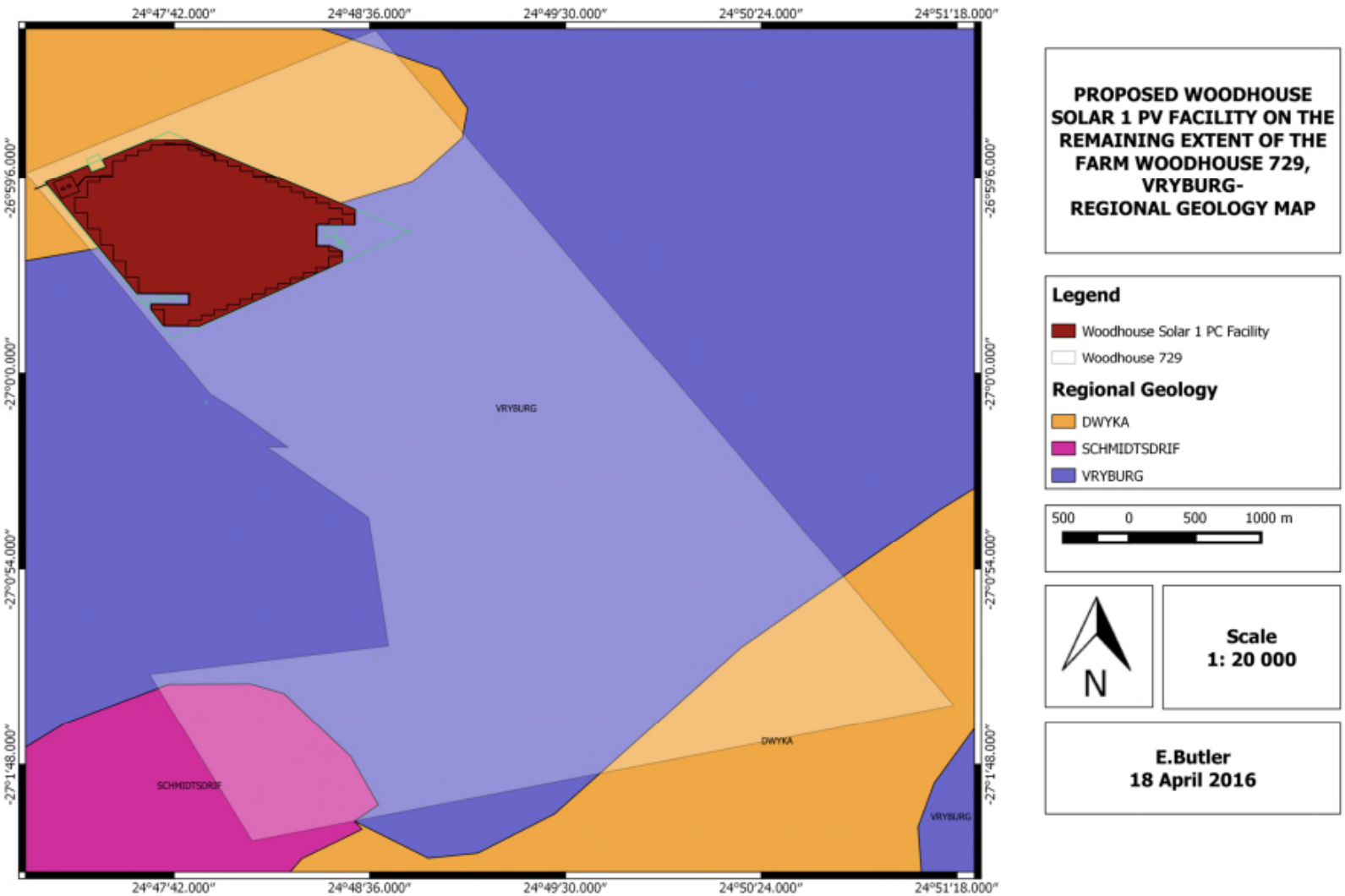

Figure 3. The surface geology of the proposed Woodhouse Solar 1 PV Facility development footprint on the Remaining Extent of the farm Woodhouse 729. The development footprint is underlain by Dwyka Permo-Carboniferous glacial sediments and Vryburg Formation (Ghaap Group, Transvaal Supergroup) (Modified from the 1: 250 000 geological map 2724 Christiana (Council for Geoscience, Pretoria).

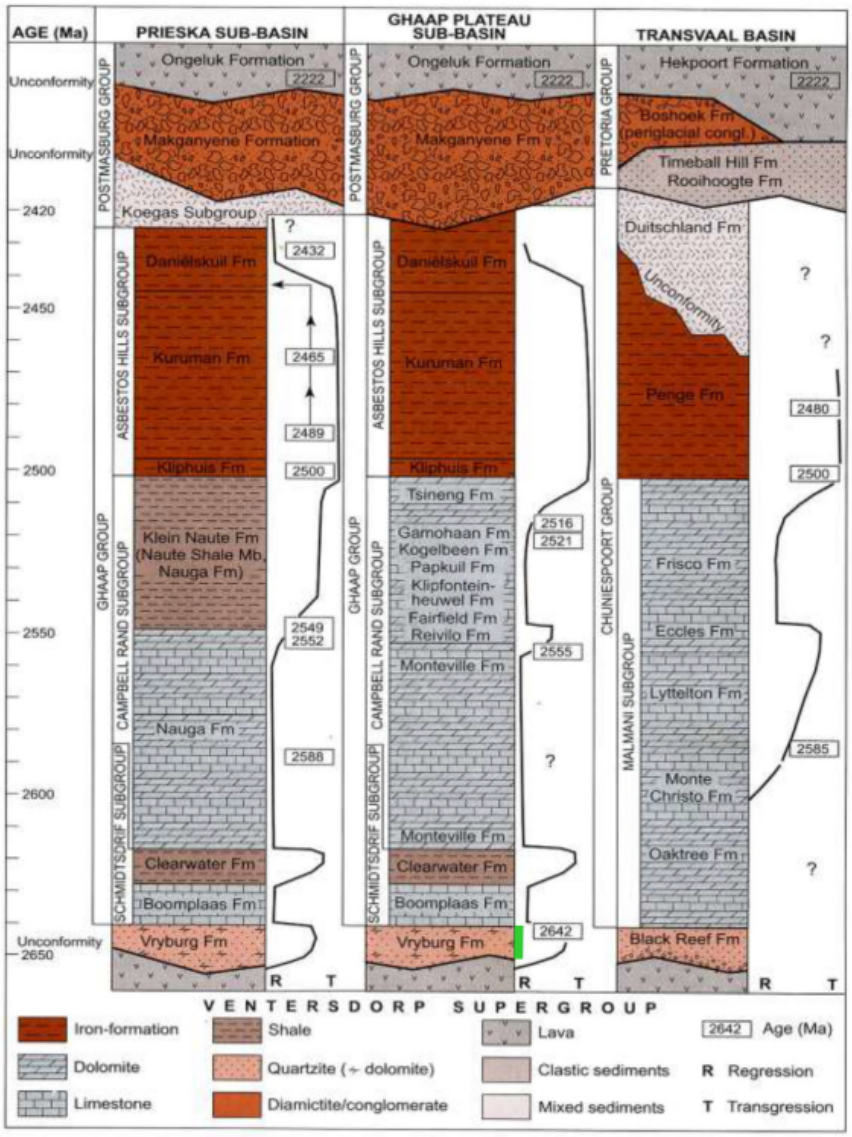

Figure 4. Stratigraphy of the Transvaal Supergroup of the Ghaap Plateau Basin. The middle column shows the rock units represented in the proposed development footprint (green line) (Eriksson, *et al.* 2006). The Vryburg Formation is incorporated within the base of the Schmidtsdrif Subgroup by some recent authors and is no longer correlated with the Black Reef Formation of the Transvaal Basin as shown here (*e.g.* Altermann and Wotherspoon, 1995, Sumner and Beukes, 2006).

6 Field Observations

Figure 5. Vegetation on the proposed Woodhouse Solar 1 PV Facility development footprint.

Figure. 6. Vegetation and the lack of appropriate exposure at the proposed Woodhouse Solar 1 PV Facility development footprint.

7 IMPACT ASSESSMENTS

An assessment of the impact significance of the proposed Woodhouse Solar1 PV Facility on local fossil heritage within the Remaining Extent of Farm Woodhouse 729 is presented below:

7.1 Nature of the impact

The excavations and site clearance will involve substantial excavations into the superficial sediment cover as well as locally into the underlying bedrock. These excavations will modify the existing topography and may disturb damage, destroy or permanently seal-in fossils at or below the ground surface that are then no longer available for scientific research. According to the Geology of the study area there is a possibility of finding stromatolites (laminated microbial mounds).

7.2 Sensitive areas

The development footprint is underlain by Ghaap Group (Vryburg Formation), as well as the Dwyka Group of the Karoo Supergroup. Small outcrops of Permo-Carboniferous Dwyka Group (located within the northern portion of the development footprint) and Vryburg Formation (located within the southern portion of the development footprint) is present in the development site. Although trace fossils and plants could be present in the Dwyka the likelihood of significant fossil heritage in the Vryburg area is considered to be **low**.

7.3 Geographical extent of impact

The impact on fossil materials and thus palaeontological heritage will be limited to the construction phase when new excavations into fresh potentially fossiliferous bedrock take place. The extent of the area affected by this potential impact is restricted to the development footprint and therefore categorised as **local**.

7.4 Duration of impact

The expected duration of the impact is assessed as potentially permanent to long-term. In the absence of mitigation procedures (should fossil material be present within the affected area) the damage or destruction of any palaeontological materials will be **permanent**.

7.5 Potential significance of the impact

Should the project progress without due care to the possibility of fossils being present within the proposed development footprint within the Vryburg Formation the resultant damage, destruction or inadvertent relocation of any affected fossils will be **permanent and irreversible**. Thus, any fossils occurring within the development footprint are potentially scientifically and culturally significant and any negative impact on them would be of **high significance**.

7.6 Severity / benefit scale

The development of the proposed Woodhouse Solar 1 PV Facility is **beneficial** on not only a local level, but regional and national levels as well. The facility will provide a long

term benefit to the surrounding communities in terms of the provision of electricity to a progressively stressed national electricity grid.

A potential **secondary advantage** of the construction of the project would be that the excavations may uncover fossils that were hidden beneath the surface exposures and, as such, would have remained unknown to science.

7.7 Probability of the impact occurring

Impacts on palaeontological heritage during the construction phase could potentially occur and are regarded as improbable.

7.8 Intensity

The intensity of the impact on fossil heritage is rated as **low**

7.9 Assessment of power line route alternatives

In order for the facility to evacuate the generated electricity into the Eskom national grid four grid connection options are being considered which includes the following:

- Alternative 1: a direct connection to the authorised Eskom Bophirima Substation to be constructed within the northern portion of the affected property;
- Alternative 2: a direct connection to the existing Woodhouse 88/22kV Substation located north of the boundary of the affected property;
- Alternative 3: a turn-in turn-out connection to the existing Delareyville Munic / Vryburg 1 88kV Feeder located along the northern boundary of the affected property; and
- Alternative 4: a turn-in turn-out connection to the authorised 132kV Eskom Bophirima–Mookodi power line to be constructed by Eskom[1].

Four alternative power line routes are being considered to connect the facility via a 132kV power line to the national grid (see **Figure 7** below).

[1] In the event that Eskom is unable to complete the construction of the proposed 132kV Eskom Bopirima-Mookodi Overhead Line Genesis Eco-Energy Developments would consider undertaking the construction of the authorised power line within the authorised corridor (DEA Ref.: 12/12/20/1929) to connect the PV Facility via the completed 132kV power line to the existing Mookodi 400/132KV Substation located to the west of the project site.

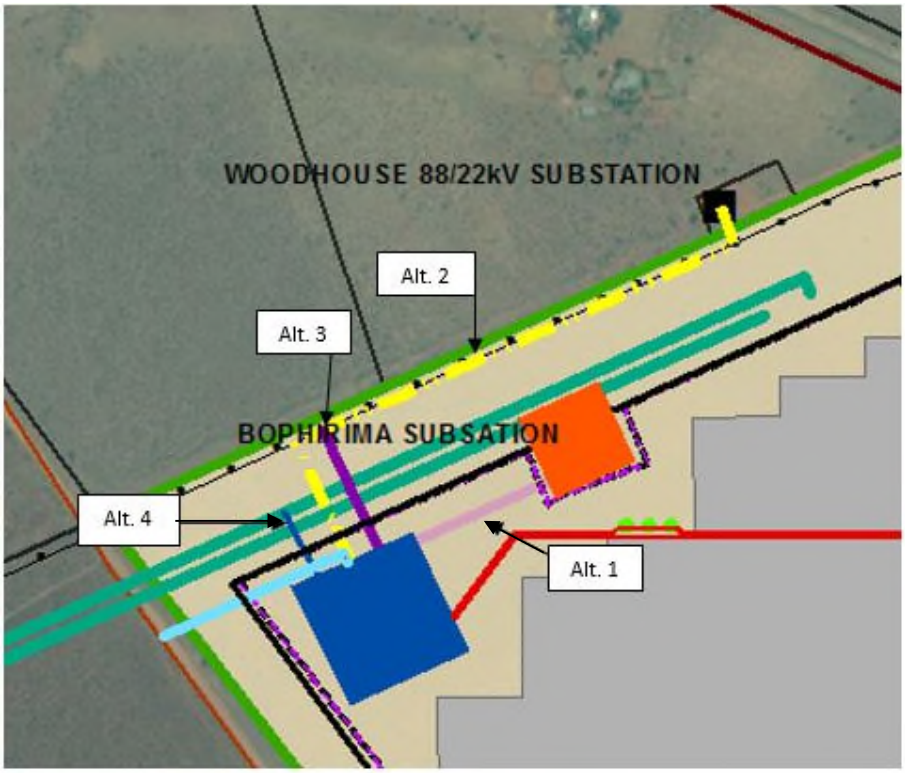

Figure 7. An illustration of the alternative power line routes showing where the power line will be connected at the on-site substation and where it connects to the grid connection alternative.

The power line alternative routes have been considered from a palaeontological perspective to identify the impact of each power line route on the palaeontological resources. Table 1 considers the power line alternatives in a comparative assessment.

Aspect	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Palaeontology	Acceptable – • Fossil potential low	Acceptable – • Fossil potential low	Acceptable – • Fossil potential low	Acceptable – • Fossil potential low

After the consideration of the power line alternatives it is considered that all the proposed power line routes are acceptable and appropriate from a palaeontological perspective and can all be considered as feasible options.

7.10 Assessment of the area proposed for the development

A preferred area, located within the northern portion of the Remaining Extent of the farm Woodhouse 729, has been identified by the developer as the preferred area for the construction and operation of the Woodhouse Solar 1 PV Facility. From a palaeontological perspective the area (less than 300ha) is considered suitable and appropriate for the development and is therefore considered as being acceptable.

8. DAMAGE MITIGATION, REVERSAL AND POTENTIAL IRREVERSIBLE LOSS

8.1 Mitigation

Should fossil material exist within the development footprint any negative impact upon it could be mitigated by surveying, recording, describing and sampling of well-preserved fossils by a professional palaeontologist. This should take place after initial vegetation clearance has taken place but *before* the ground is levelled for construction. Excavation of fossil heritage will require a permit from SAHRA and the material must be housed in a 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 and infrastructure moved.

8.2 Degree of irreversible loss

Impacts on fossil heritage are generally irreversible. Well-documented records and further palaeontological studies of any fossils exposed during construction would represent a positive impact from a scientific perspective. The possibility of a negative impact on the palaeontological heritage of the area can be reduced by the implementation of adequate damage mitigation procedures. If damage mitigation is properly undertaken the benefit scale for the project will lie within the beneficial category.

8.3 Degree to which the impact may cause irreplaceable loss of resources

Although trace fossils and plants could be present in the Dwyka the likelihood of significant fossil heritage in the Vryburg area is considered to be **low**. Stromatolites assemblages are recorded within the upper Vryburg Formation (Smith, 1991). Detailed descriptions of the Vryburg stromatolite occurrences are not present in the literature (Almond, 2013).

8.4 Cumulative impacts

Five known solar projects, other than the proposed development, are located within a 10km radius from the Woodhouse Solar 1PV Facility development site. These include the following:

- Proposed 60MW Carocraft PV Solar Park and associated infrastructure (a.k.a. the Carocraft Solar Park) on the Remaining Extent and Portion 1 of Farm Weltevrede 681.
- Construction of the 75MW Photovoltaic facility and associated infrastructure in Naledi (a.k.a. the Sediba Solar Energy Facility) on the Remaining Extent of the Farm Rosendal 673.
- Proposed Tiger Kloof Solar Photovoltaic energy facility near Vryburg, North West Province (a.k.a. the Tiger Kloof Solar Energy Facility) on Portion 3 (RE) and Portion 4 of the Farm Waterloo 730.
- Proposed construction of the 75MW Photovoltaic Solar Plant and associated infrastructure on a Portion of the Farm Waterloo 992 in the Naledi Local Municipality of the North West Province (a.k.a. the Waterloo Solar Park) on the Remaining Extent of Farm Waterloo 992.

- Proposed Woodhouse Solar 2 PV Facility, North West Province on the Remaining Extent of the farm Woodhouse729.

The cumulative effect of the development of the Woodhouse Solar 1 PV Facility within the proposed location, and taking into consideration the five other proposed solar energy facilities located in the surrounding area is considered to be low provided that environmental impacts are mitigated to suitable standards by strict control and implementation of EMPrs for each project. . This is as a result of the broader area not being considered as fossiliferous.

9 FINDINGS AND RECOMMENDATIONS

The development footprint located within the Remaining Extent of the farm Woodhouse 729 is underlain by Ghaap Group, Vryburg Formation, and the Dwyka Group of the Karoo Supergroup. Small outcrops of Permo-Carboniferous Dwyka Group are present in the development footprint. Although trace fossils and plants could be present in the Dwyka the likelihood of significant fossil heritage in the Vryburg area is considered to be low.

The development site is underlain by the Vryburg Formation of the Ghaap Group, and the Dwyka Group of the Karoo Supergroup. The Dwyka Group (Karoo Supergroup) is represented by small outcrops in the north of the development footprint. Although trace fossils and plants could be present in the Dwyka, the likelihood of significant fossil heritage is considered to be low. The southern area of the development footprint consists of the Vryburg Formation, which is apparently unfossiliferous in this area. The sensitivity of the site for the development of the Woodhouse Solar 1 PV Facility can therefore be regarded as low.

The scarcity of fossil heritage and a lack of appropriate exposure at the proposed development footprint indicate that the impact of Woodhouse Solar 1 PV Facility on the Remaining Extent of the farm Woodhouse 729 is of low significance in palaeontological terms. **It is therefore considered that the construction and operation of the PV facility within the proposed development site is deemed appropriate and feasible and will not lead to detrimental impacts on the palaeontological resources of the area.**

It is thus recommended that no further palaeontological heritage studies, ground truthing and/or specialist mitigation are required for the commencement of this development, pending the discovery or exposure of any fossil remains during the construction phase.

10 ASSESSMENT OF IMPACTS

10.1 Assessment Methodology

Direct, indirect and cumulative impacts of the impacts identified above will be assessed according to the following standard methodology:

- The **nature** which shall include a description of what causes the effect, what will be affected and how it will be affected.
- The **extent** wherein it will be indicated whether the impact will be local (limited to the immediate area or site of development) or regional, and a value between 1 and 5 will be assigned as appropriate (with 1 being low and 5 being high).
- The **duration** wherein it will be indicated whether:
    - The lifetime of the impact will be of very short duration (0 - 1 years) – assigned a score of 1;
    - The lifetime of the impact will be of short duration (2 - 5 years) – assigned a score of 2;
    - Medium-term (5 - 15 years) – assigned a score of 3;
    - Long-term (> 15 years) – assigned a score of 4; or
    - Permanent – assigned a score of 5.
- The **magnitude** quantified on a scale from 0 - 10 where 0 is small and will have no effect on the environment, 2 is minor and will result in an impact on processes, 4 is low and will cause a slight impact on processes, 6 is moderate and will result in processes continuing but in a modified way, 8 is high (processes are altered to the extent that they temporarily cease) and 10 is very high and results in complete destruction of patterns and permanent cessation of processes.
- The **probability** of occurrence, which shall describe the likelihood of the impact actually occurring. Probability will be estimated on a scale of 1 - 5 where 1 is very improbable (probably will not happen), 2 is improbable (some possibility, but of low likelihood), 3 is probable (distinct possibility), 4 is highly probable (most likely) and 5 is definite (impact will occur regardless of any prevention measures).
- The **significance** which shall be determined through a syntheses of the characteristics described above and can be assessed as low, medium or high; and
- The **status**, which is described as positive, negative or neutral.
- The degree to which the impact can be reversed.
- The degree to which the impact may cause irreplaceable loss of resources.
- The degree to which the impact can be mitigated.

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

$$S = (E + D + M) \times P$$

S = Significance weighting

E = Extent

D = Duration

M = Magnitude

P = Probability

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

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

Nature: The excavations and site clearance during the construction phase will involve substantial excavations into the superficial sediment cover as well as locally into the underlying bedrock. These excavations will modify the existing topography and may disturb, damage, destroy or permanently seal-in fossils at or below the ground surface that are then no longer available for scientific research.

This impact is likely to occur only within the construction phase. No impacts are expected to occur during the operation phase.

	Without mitigation	**With mitigation**
Extent	Local(1)	N/A
Duration	Long term/permanent (4)	N/A
Magnitude	Minor (2)	N/A
Probability	Improbable (2)	N/A
Significance	**Low (14)**	N/A
Status (positive or negative)	Negative	N/A
Reversibility	Irreversible	N/A
Irreplaceable loss of resources?	No	N/A
Can impacts be mitigated?	No	N/A

Mitigation: Not necessary

Trace fossils and plants could be present in the Dwyka but the likelihood of

significant fossil heritage is considered to be low. The southern area of the development area consists of the Vryburg Formation, which is unfossiliferous in this area.
Residual Risk: Not applicable.

11 ASSESSMENT OF CUMULATIVE IMPACTS

Nature: Cumulative impacts on fossil remains preserved at or beneath the ground surface		
	Cumulative Contribution of Proposed Project	**Cumulative Impact without Proposed Project**
Extent	Local (1)	Low (1)
Duration	Long-term (4)	Long-term (4)
Magnitude	Minor (1)	Minor (1)
Probability	Very improbable (1)	Very improbable (2)
Significance	**Low (6)**	**Low (6)**
Status (positive/negative)	Neutral	Neutral
Reversibility	Irreversible	Reversible
Loss of resources?	No	No
Can impacts be mitigated?	None required	None required
Confidence in findings: High.		
Mitigation: Not necessary None required .		

12 RECOMMENDATIONS CONCERNING FOSSIL HERITAGE MANAGEMENT DURING THE CONSTRUCTION PHASE

OBJECTIVE: Prevent the loss of Palaeontological Heritage		
Project component/s	Damaging impacts on palaeontological heritage occur during the **construction** phase which will modify the existing topography. Project components include: • PV Panels; • Underground cabling; • Substation; • Access roads; and • Buildings	
Potential Impact	Disturb damage, destroy or permanently seal-in fossils at or below the ground surface that are then no longer available for scientific study.	
Activity/risk source	• Activities associated with the construction of the solar energy facility.	
Mitigation: Target/Objective	Protection of identified fossils uncovered during the construction phase.	
Mitigation: Action/control	**Responsibility**	**Timeframe**
Should fossil material exist within the development footprint any negative impact upon it could be mitigated by surveying, recording, describing and sampling of well-preserved fossils by a professional palaeontologist. This should take place after initial vegetation clearance has taken place but *before* the ground is levelled for construction. Excavation of fossil heritage will require a permit from SAHRA and the material must be housed in a 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 and infrastructure moved.	ECO	Construction phase

Performance Indicator	• No impacts on valuable fossil resources.
Monitoring	None

13 REFERENCES

ALMOND, J. E. 2013. *Proposed PV solar facility on a portion of the farm Waterloo 992 near Vryburg, Naledi local Municipality, North-West Province*, 29 pp.

ALTERMANN, W. 2001. *The oldest fossils of Africa – a brief reappraisal of reports from theArchaean.* African Earth Sciences 33, 427-436.

ALTERMANN, W. and WOTHERSPOON, J. McD. 1995. *The carbonates of the Transvaal and Griqualand West sequences of the Kaapvaal craton, with special reference to the Lime Acres limestone deposit.* Mineralium Deposita 30, 124-134

BUICK, K. 2001. *Life in the Archaean*. In: Briggs, D.E.G. & Crowther, P.R. (eds.) Palaeobiology II, 13-21. Blackwell Science, London.

ERIKSSON, K.A. & TRUSWELL, J.F. 1973. *High inheritance elongate stromatolitic mounds from the Transvaal Dolomite*. Palaeontologia Africana 15, 23-28.

ERIKSSON, K.A. & TRUSWELL, J.F. 1974. *Tidal flat associations from a Lower Proterozoic carbonate sequence in South Africa.* Sedimentology 21: 293-309.

ERIKSSON, P.G. and ALTERMANN, W. 1998. *An overview of the geology of the Transvaal Supergroup dolomites (South Africa).* Environmental Geology 36, 179-188.

ERIKSSON, P.G., ALTERMANN, W. & HARTZER, F.J. 2006. *The Transvaal Supergroup and its precursors.* In: Johnson, M.R., Anhaeusser, C.R. & Thomas, R.J. (Eds.) The geologyof South Africa, pp. 237-260. Geological Society of South Africa, Marshalltown.

KEYSER, N. & DU PLESSIS, C.P. 1993. The geology of the Vryburg area. Explanation to 1: 250 000 geology sheet 2624 Vryburg, 28 pp. Council for Geoscience, Pretoria.

MCCARTHY, T. & RUBIDGE, B. 2005. *The story of Earth and life: a southern African perspective on a 4.6-billion-year journey*. 334pp. Struik, Cape Town.

SCHOPF, J.W. 2006. *Fossil evidence of Archaean life*. Philosophical Transactions of the Royal Society B361, 869-885.

SMIT, P.J., BEUKES, N.J., JOHNSON, M.R., MALHERBE, S.J. & VISSER, J.N.J. 1991. *Lithostratigraphy of the Vryburg Formation (including the Kalkput, Geelbeksdam, Rosendal*,*Waterloo and Oceola Members*). South African Committee for Stratighraphy Lithostratigraphic Series No. 14, 1-10.

SUMNER, D.Y. & BEUKES, N.J. 2006. *Sequence stratigraphic development of the Neoarchaean Transvaal carbonate platform, Kaapvaal Craton, South Africa. South African* Journal of Geology 109, 11-22.

14 QUALIFICATIONS AND EXPERIENCE OF THE AUTHOR

Elize Butler has an MSc in Palaeontology from the University of the Free State, Bloemfontein, South Africa. She has been working at the National Museum since 1993 and currently holds the position of Collection Manager of the Karoo Vertebrate Collection of the Palaeontology Department at the National Museum in Bloemfontein. Her current research interests comprise of Permo-Triassic vertebrate palaeobiology, with a special focus on gorgonopsians at the End-Permian Mass Extinction.

15 DECLARATION OF INDEPENDENCE

I, Elize Butler, declare that I am an independent consultant and have no business, financial, personal or other interest in the proposed project, application or appeal in respect of which I was appointed other than fair remuneration for work performed in connection with the activity, application or appeal. There are no circumstances that compromise my objectivity in this work.

Sincerely

Mrs. Elize Butler