PALAEONTOLOGICAL IMPACT ASSESSMENT

(DESKTOP STUDY)

PROPOSED POWERLINE ROUTING FOR ELECTRICITY GENERATION BY A KARPOWERSHIP

PORT OF SALDANHA TO ESKOM BLOUWATER SUBSTATION

SALDANHA BAY MUNICIPALITY, VREDENBURG MAGISTERIAL DISTRICT, WESTERN CAPE

By

John Pether, M.Sc., Pr. Sci. Nat. (Earth Sci.)
Geological and Palaeontological Consultant
P. O. Box 48318, Kommetjie, 7976
Tel./Fax (021) 7833023
Cellphone 083 744 6295
jpether@iafrica.com

Prepared at the Request of

Agency for Cultural Resource Management (ACRM)
5 Stuart Road, Rondebosch, 7700
Ph/Fax: 021 685 7589
Mobile: 082 321 0172
E-mail: acrm@wcaccess.co.za

For

Triplo4 Sustainable Solutions (Pty) Ltd.

2 October 2020

CONTENTS

GLOSSARY

~ (tilde): Used herein as "approximately" or "about".

Aeolian: Pertaining to the wind. Refers to erosion, transport and deposition of sedimentary particles by wind. A rock formed by the solidification of aeolian sediments is an aeolianite.

Alluvium: Sediments deposited by a river or other running water (alluvial).

Archaeology: Remains resulting from human activity which are in a state of disuse and are in or on land and which are older than 100 years, including artefacts, human and hominid remains and artificial features and structures.

asl.: above (mean) sea level.

Bedrock: Hard rock formations underlying much younger sedimentary deposits.

Calcareous: sediment, sedimentary rock, or soil type which is formed from or contains a high proportion of calcium carbonate in the form of calcite or aragonite.

Calcrete: An indurated deposit (duricrust) mainly consisting of Ca and Mg carbonates. The term includes both pedogenic types formed in the near-surface soil context and non-pedogenic or groundwater calcretes related to water tables at depth.

Clast: Fragments of pre-existing rocks, *e.g.* sand grains, pebbles, boulders, produced by weathering and erosion. Clastic – composed of clasts.

Colluvium: Hillwash deposits formed by gravity transport downhill. Includes soil creep, sheetwash, small-scale rainfall rivulets and gullying, slumping and sliding processes that move and deposit material towards the foot of the slopes.

Conglomerate: A cemented gravel deposit.

Coversands: Aeolian blanket deposits of sandsheets and smaller dunes.

Fluvial deposits: Sedimentary deposits consisting of material transported by, suspended in and laid down by a river or stream.

Fm.: Formation.

Fossil: The remains of parts of animals and plants found in sedimentary deposits. Most commonly hard parts such as bones, teeth and shells which in lithified sedimentary rocks are usually altered by petrification (mineralization). Also impressions and mineral films in fine-grained sediments that preserve indications of soft parts. Fossils plants include coals, petrified wood and leaf impressions, as well as microscopic pollen and spores. Marine sediments contain a host of microfossils that reflect the plankton of the past and provide records of ocean changes. Nowadays also includes molecular fossils such as DNA and biogeochemicals such as oils and waxes.

Heritage: That which is inherited and forms part of the National Estate (historical places, objects, fossils as defined by the National Heritage Resources Act 25 of 1999).

OSL: Optically stimulated luminescence. One of the radiation exposure dating methods based on the measurement of trapped electronic charges that accumulate in crystalline materials as a result of low-level natural radioactivity from U, Th and K. In OSL dating of aeolian quartz and feldspar sand grains, the trapped charges are zeroed by exposure to daylight at the time of deposition. Once buried, the charges accumulate and the total radiation exposure (total dose) received by the sample is estimated by laboratory measurements. Ages are obtained as the ratio of total dose to annual dose, where the annual dose is assumed to have been similar in the past.

Palaeontology: The study of any fossilised remains or fossil traces of animals or plants which lived in the geological past and any site which contains such fossilised remains or traces.

Palaeosol: An ancient, buried soil formed on a palaeosurface. The soil composition may reflect a climate significantly different from the climate now prevalent in the area where the soil is found. Burial reflects the subsequent environmental change.

Palaeosurface: An ancient land surface, usually buried and marked by a palaeosol or pedocrete, but may be exhumed by erosion (*e.g.* wind erosion/deflation) or by bulk earth works.

Pedogenesis/pedogenic: The process of turning sediment into soil by chemical weathering and the activity of organisms (plants growing in it, burrowing animals such as worms, the addition of humus *etc.*).

Pedocrete: A duricrust formed by pedogenic processes.

PIA: Palaeontological Impact Assessment.

Rhizolith: Fossil root. Most commonly formed by pedogenic carbonate deposition around the root and developed in palaeosols.

Stone Age: The earliest technological period in human culture when tools were made of stone, wood, bone or horn.

Stratotype locality: The place where deposits regarded as defining the characteristics of a particular geological formation occur.

Tectonic: Relating to the structure of the earth's crust and the large-scale processes which take place within it (faulting and earthquakes, crustal uplift or subsidence.

Trace fossil: A structure or impression in sediments that preserves the behaviour of an organism, such as burrows, borings and nests, feeding traces (sediment processing), farming structures for bacteria and fungi, locomotion burrows and trackways and traces of predation on hard parts (tooth marks on bones, borings into shells by predatory gastropods and octopuses).

GEOLOGICAL TIME SCALE TERMS

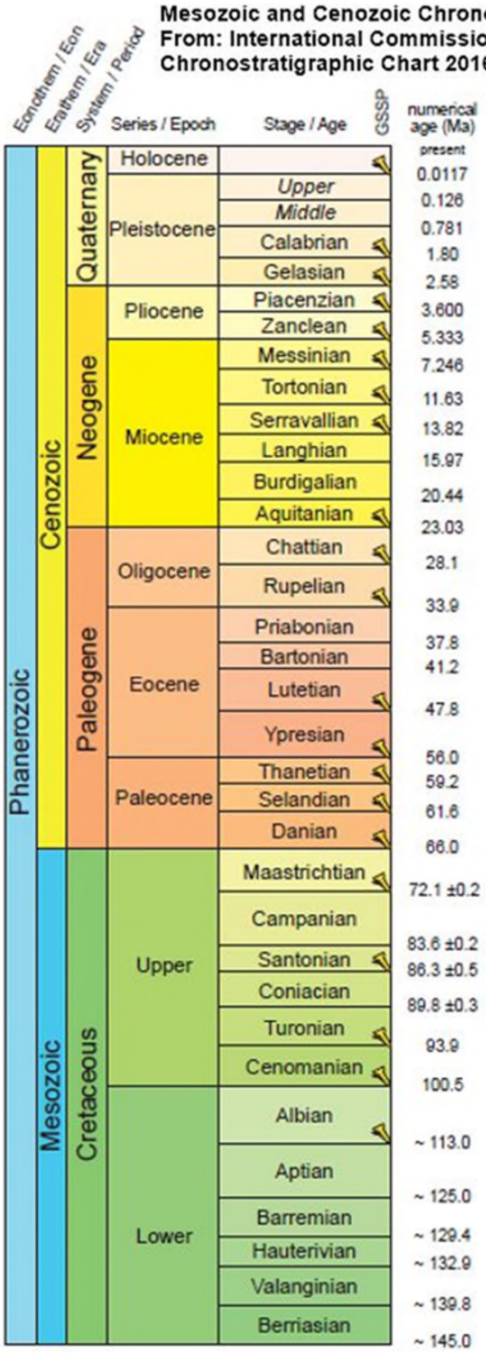
For more detail see www.stratigraphy.org.

ka: Thousand years or kilo-annum (10^3 years). Implicitly means “ka ago” *i.e*. duration from the present, but “ago” is omitted. The “Present” refers to 1950 AD. Not used for durations not extending from the Present. For a duration only “kyr” is used.

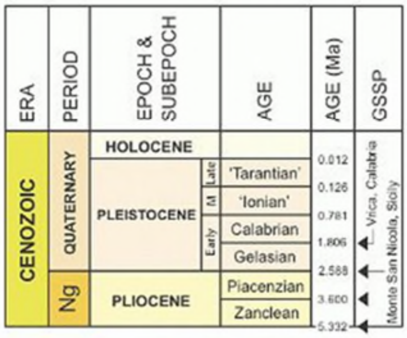
Ma: Millions years, mega-annum (10^6 years). Implicitly means “Ma ago” *i.e.* duration from the present, but “ago” is omitted. The “Present” refers to 1950 AD. Not used for durations not extending from the Present. For a duration only “Myr” is used.

Late Pliocene Warm Period: An interval of warm climate and high sea level around ~3 Ma. This interval was previously referred to as the Mid Pliocene Warm Period (MPWP) when the boundary between the Pliocene and Quaternary was set at ~1.8 Ma at the beginning of the Calabrian (see figure below). Now that the Pliocene/Quaternary boundary is set further back in time by international agreement to the beginning of the Gelasian at ~2.6 Ma, the MPWP at ~3 Ma is no longer “mid”, but is in the late Pliocene. However, for continuity it is still often referred to as the MPWP.

Mesozoic and Cenozoic Chronostratigraphy
From: International Commission on Stratigraphy.
Chronostratigraphic Chart 2016-12.pdf



ICS-approved 2009 Quaternary (SQS/INQUA) proposal



Holocene: The most recent geological epoch commencing 11.7 ka till the present.

Pleistocene: Epoch from 2.6 Ma to 11.7 ka.
Late Pleistocene 11.7–126 ka.
Middle Pleistocene 135–781 ka.
Early Pleistocene 781–2588 ka.

Quaternary: The current Period, from 2.6 Ma to the present, in the Cenozoic Era. The Quaternary includes both the Pleistocene and Holocene epochs. As used herein, early and middle Quaternary correspond with the Pleistocene divisions, but late Quaternary includes the Late Pleistocene and the Holocene.

1 EXECUTIVE SUMMARY

1. Site Name

Proposed powerline routing for electricity generation by a Karpowership, Port of Saldanha to ESKOM Blouwater Substation.

2. Location

The proposed Karpowership will be moored alongside the Saldanha Ore Terminal jetty in Saldanha Bay, with a powerline connecting to the ESKOM Blouwater Substation (Figure 1).

The relevant 1:50 000 map sheets are 3217DB&DD VREDENBURG, 3218CA&CC VELDDRIFand 3317BB & 3318AA SALDANHA.

3. Locality Plan

See Figures 1 and 2.

4. Proposed Development

The planned generation capacity of the Karpowership is 480 MW. Associated facilities and infrastructure include”

- Natural gas supply, storage and distribution.
- Powerlines (~7 km in length) for the transmission of the generated electricity to the national grid connection point at the ESKOM Blouwater Substation.

The power generated on the ship is converted by the onboard High Voltage substation and transmitted along 132 kV transmission lines. Existing distribution power lines will be used where possible to reduce costs. Therefore, minimal land is required and construction risk is minimal. The overhead transmission lines will be developed where possible within existing servitudes.

Three power transmission line routes to the ESKOM Blouwater Substation are under consideration (Figure 2):

- Option 1 route proceeds parallel to existing powerlines with minimal deviation.
- Option 2 differs from Option 1 in the initial part of the route (Figure 2B), but otherwise follows the Option 1 route.
- Option 3 follows the Option 1 route from the jetty, but deviates from it opposite the Saldanha Steel works where the route deviates southwards to parallel the 132 kV powerlines feeding Saldanha Steel works (Figure 2C). This route requires an additional small substation.

5. Palaeontological Heritage Resources Identified

The proposed route options for the transmission line to the Blouwater Substation are all situated on the calcreted Langebaan Formation, beneath a thin cover of Springfontyn Formation Q1 surficial sands (Figure 3). Close to the coast the Witzand Fm. dunes (Figure 3) are underlain by the older aeolianite of the Langebaan Formation and the interbedded shelly beach deposits of the Velddrif Fm. (Figure 4)

6. Anticipated Impacts

For the evaluation of the palaeontological impact it is the extent/scale of the deeper excavations to be made that are the main concern. The impact of the proposed overhead transmission line installation relates to the construction phase of the pylons when excavations are made for their foundations.

Buried archaeological material, such as artefacts, shell and bone scatters, could be uncovered in the loose coversands (Q1, Springfontyn Fm.), but the overall palaeontological sensitivity of the coversand deposits in this area may be classified as LOW.

The calcreted Langebaan Formation is classified to be of very high sensitivity (Figure 3, inset, red), due to previous fossil finds of significant scientific value. Most of the pylon foundations will be embedded in the compact to hard, upper Langebaan Fm. calcrete and aeolianite which will permit smaller foundations which will not likely exceed 2.0 to 2.6 m in depth. This shallow depth and the small footprints of the excavations for foundation plinths reduce the impact as the important fossil bones are overall sparse in the upper calcreted Langebaan Formation. However, there will be a considerable number of such "test pits" along the powerline traverse and thus there is a distinct possibility that fossil bones could be unearthed. Without mitigation the significance of the impact of the earthworks on the fossil bone content of the Langebaan Fm. is LOW NEGATIVE. Notwithstanding a similar low but positive significance with mitigation, depending on the scientific significance of the actual finds, the significance of the impact may range from MEDIUM POSITIVE to HIGH POSITIVE.

Close to the coast the surface has been much disturbed and no impact on the Witzand Fm. is expected. Along the initial ~1.5 km of the route it is possible that in places the shelly beds of the Velddrif Fm. may be intersected, although this is considered to be unlikely in shallow excavations. Without mitigation the significance of the impact of the earthworks on the fossil shell content of the Velddrif Fm. is VERY LOW NEGATIVE and with mitigation is VERY LOW POSITIVE.

The route options are not distinguished by differing palaeontological sensitivities and do not differ in their impacts.

7. Recommendations

Note that the probable presence of fossils in the subsurface does not have an a priori influence on the decision to proceed with the installation. However, mitigation measures are essential. The potential impact has a moderate influence upon the proposed project, consisting of implemented mitigation measures recommended below, to be followed during the Construction Phase of the transmission lines.

The rescue of fossils during earth works critically depends on spotting this material as it is uncovered during digging i.e. by monitoring excavation activity. As it is not feasible for a specialist monitor to be continuously present the earth works personnel must be involved in mitigation by watching for fossils. It is recommended that a requirement to be alert for possible fossils and archaeological material be included in the EMP for the Construction Phase of the pylons, with a Fossil Finds Procedure in place. The Fossil Finds Procedure included as Appendix 2 provides guidelines to be followed in the event of fossil finds in the excavations.

If a significant occurrence of fossil bones or shells is discovered a professional palaeontologist must be appointed to collect them and to record their contexts. Said palaeontologist must also undertake the recording of the stratigraphic context and sedimentary geometry of the exposure and the compilation of the report to Heritage Western Cape and the IZIKO S.A. Museum.

The Environmental Control Officer (ECO) or the Project Manager/Site Agent is welcome to contact the author with queries and for clarifications.

2 SPECIALIST DETAILS, EXPERTISE AND DECLARATION

CURRICULUM VITAE

John Pether, M.Sc., Pr. Sci. Nat. (Earth Sci.)

Independent Consultant/Researcher recognized as an authority with 37 years' experience in the field of coastal-plain and continental-shelf palaeoenvironments, fossils and stratigraphy, mainly involving the West Coast/Shelf of southern Africa. Has been previously employed in academia (South African Museum) and industry (Trans Hex, De Beers Marine). At present an important involvement is in Palaeontological Impact Assessments (PIAs) and mitigation projects in terms of the National Heritage Resources Act 25 (1999) (~300 PIA reports to date) and is an accredited member of the Association of Professional Heritage Practitioners (APHP). Continues to be involved as consultant to offshore and onshore marine diamond exploration ventures. Expertise includes:

- Coastal plain and shelf stratigraphy (interpretation of open-pit exposures, on/offshore cores and exploration drilling).
- Sedimentology and palaeoenvironmental interpretation of shallow marine, aeolian and other terrestrial surficial deposits.
- Marine macrofossil taxonomy (molluscs, barnacles, brachiopods) and biostratigraphy.
- Marine macrofossil taphonomy.
- Sedimentological and palaeontological field techniques in open-cast mines (including finding and excavation of vertebrate fossils (bones).

Membership of Professional Bodies

- South African Council of Natural Scientific Professions. Earth Science. Reg. No. 400094/95.
- Geological Society of South Africa.
- Palaeontological Society of Southern Africa.
- Southern African Society for Quaternary Research.
- Association of Professional Heritage Practitioners (APHP), Western Cape. Accredited Member No. 48.

Past Clients Palaeontological Assessments

AECOM SA (Pty) Ltd.	Guillaume Nel Environmental Management Consultants.
Agency for Cultural Resource Management (ACRM).	Klomp Group.
AMATHEMBA Environmental.	Megan Anderson, Landscape Architect.
Anél Blignaut Environmental Consultants.	Ninham Shand (Pty) Ltd.
Arcus Gibb (Pty) Ltd.	PD Naidoo & Associates (Pty) Ltd.
ASHA Consulting (Pty) Ltd.	Perception Environmental Planning.
Aurecon SA (Pty) Ltd.	PHS Consulting.
BKS (Pty) Ltd. Engineering and Management.	Resource Management Services.
Bridgette O'Donoghue Heritage Consultant.	Robin Ellis, Heritage Impact Assessor.
Cape Archaeology, Dr Mary Patrick.	Savannah Environmental (Pty) Ltd.
Cape EAPrac (Cape Environmental Assessment Practitioners).	Sharples Environmental Services cc
CCA Environmental (Pty) Ltd.	Site Plan Consulting (Pty) Ltd.
Centre for Heritage & Archaeological Resource Management (CHARM).	SRK Consulting (South Africa) (Pty) Ltd.
Chand Environmental Consultants.	Strategic Environmental Focus (Pty) Ltd.
CK Rumboll & Partners.	UCT Archaeology Contracts Office (ACO).
CNdV Africa	UCT Environmental Evaluation Unit
CSIR - Environmental Management Services.	Urban Dynamics.
Digby Wells & Associates (Pty) Ltd.	Van Zyl Environmental Consultants
Enviro Logic	Western Cape Environmental Consultants (Pty) Ltd, t/a ENVIRO DINAMIK.
Environmental Resources Management SA (ERM).	Wethu Investment Group Ltd.
Greenmined Environmental	Withers Environmental Consultants.

Stratigraphic consulting including palaeontology

Afri-Can Marine Minerals Corp	Council for Geoscience
De Beers Marine (SA) Pty Ltd.	De Beers Namaqualand Mines.
Geological Survey Namibia	IZIKO South African Museum.
Namakwa Sands (Pty) Ltd	NAMDEB

DECLARATION OF INDEPENDENCE

PALAEONTOLOGICAL IMPACT ASSESSMENT (DESKTOP STUDY).

PROPOSED POWERLINE ROUTING FOR ELECTRICITY GENERATION BY A KARPOWERSHIP.

PORT OF SALDANHA TO ESKOM BLOUWATER SUBSTATION.

SALDANHA BAY MUNICIPALITY, VREDENBURG MAGISTERIAL DISTRICT, WESTERN CAPE.

Terms of Reference

This assessment forms part of the Heritage Assessment and it assesses the overall palaeontological (fossil) sensitivities of formations underlying the Project Area in terms of the proposed development.

Declaration

I …**John Pether**……, as the appointed independent specialist hereby declare that I:

- » act/ed as the independent specialist in the compilation of the above report;
- » regard the information contained in this report as it relates to my specialist input/study to be true and correct, and
- » do not have and will not have any financial interest in the undertaking of the activity, other than remuneration for work performed in terms of the NEMA, the Environmental Impact Assessment Regulations, 2014 and any specific environmental management Act;
- » have and will not have any vested interest in the proposed activity proceeding;
- » have disclosed to the EAP any material information that has or may have the potential to influence the decision of the competent authority or the objectivity of any report, plan or document required in terms of the NEMA, the Environmental Impact Assessment Regulations, 2014 and any specific environmental management act;
- » have provided the EAP with access to all information at my disposal regarding the application, whether such information is favourable to the applicant or not; and
- » am aware that a false declaration is an offence in terms of regulation 48 of the 2014 NEMA EIA Regulations.

Signature of the specialist

Date: 2 October 2020

3 BACKGROUND

This project entails the proposed generation of electricity from a floating mobile power station or powership. The advantage of a powership is that these power stations can travel easily to where there is a demand, moor in the relevant port, tie in to the national grid and start generating power immediately. The proposed project will involve the mooring, deploying and operation of the Karpowerships at South African Ports which are designated Strategic Economic Zones (SEZ's). The Port of Saldanha is among those ports identfied as suitable locations to deploy a powership. This topic of this assessment is the palaeontological sensitivity of the proposed powerline routes from the powership to their connection to the national grid at the ESKOM Blouwater Substation ((Figure 1).

Figure 1. Locations of the proposed powerline route options from the jetty to the ESKOM Blouwater Substation.

Triplo4 Sustainable Solutions (Pty) Ltd. (Triplo4) is the independent Environmental Assessment Practitioner (EAP) responsible for facilitating the environmental authorizations required in terms of the National Environmental Management Act (NEMA). Triplo4 has appointed the Agency for Cultural

Resource Management (ACRM) to undertake the Heritage Impact Assessment (HIA) for the proposed development and to submit the Notice of Intent to Develop (NID) to Heritage Western Cape (HWC). The HIA must include a Palaeontological Impact Assessment (PIA), the purpose of which is to inform about the palaeontological sensitivities of the Project Area and the probability of fossils being uncovered in the subsurface and being disturbed or destroyed during the Construction Phase of the proposed developments.

4 APPLICABLE LEGISLATION

The National Heritage Resources Act (NHRA No. 25 of 1999) protects archaeological and palaeontological sites and materials, as well as graves/cemeteries, battlefield sites and buildings, structures and features over 60 years old. According to the Act (Sect. 35), it is an offence to destroy, damage, excavate, alter of remove from its original place, or collect, any archaeological, palaeontological and historical material or object, without a permit issued by the South African Heritage Resources Agency (SAHRA) or applicable Provincial Heritage Resources Agency, *viz*. Heritage Western Cape (HWC).

Notification of SAHRA or the applicable Provincial Heritage Resources Agency is required for proposed developments exceeding certain dimensions (Sect. 38). If the areal scale of subsurface disturbance and exposure exceeds 300 m in linear length or 5000 m^2, the development must be assessed for heritage impacts (HIA) that may include an assessment of palaeontological heritage (PIA).

5 METHODOLOGY

5.1 THE LITERATURE

As a desktop study, this report relies on the author's familiarity with the scientific literature pertaining to the geology and palaeontology of the coastal plains, together with own observations. A considerable volume of scientific literature (several hundred published articles) has issued from the fossil finds made in the Southwestern Cape, most famously from finds in the old Langebaanweg phosphate mine that is now the West Coast Fossil Park. The important information for this report is in the articles dealing with the broader stratigraphy, palaeoenvironments, fossils and ages of the formations. These are, *inter alia*, Visser & Schoch (1972, 1973), Tankard (1974, 1975a,b, 1976), Dingle *et al.* (1979), Rogers (1980, 1982, 1983), Hendey (1981a,b,), Dingle *et al.* (1983), Hendey (1983a,b,c), Hendey & Dingle (1990), Pether *et al*. (2000), Roberts & Brink (2002), Roberts *et al*. (2006), Roberts *et al*. (2011) and Roberts & Siegfried (2014). Some differences in the interpretation of the coastal-plain stratigraphy of the southwestern Cape (the Sandveld Group) exist between researchers, part of which is merely historical as ongoing research has provided more insights, and part of which reflects different approaches in stratigraphic interpretation. Now that the history of global ice volumes, concomitant sea-level fluctuations and palaeoclimates are much better established, it is possible to apply the sequence stratigraphic approach (genetic or dynamic stratigraphy) to the interpretation of coastal-plain deposits. In effect this results in a finer-scale stratigraphy of the preserved sedimentary record. However, the endeavour to understand the deposits depends critically on fossil finds to determine their age and the past environments.

5.2 ASSUMPTIONS AND LIMITATIONS

The assumption is that the fossil potential of a formation in the Project Area will be typical of that found in the region and more specifically, similar to that already observed in the surrounds of the Project Area. In many cases the information on fossil content is limited to the basics, such as in the case of geological mapping when the fossils are not the immediate focus. Scientifically important fossil shell and bone material is expected to be sparsely scattered in these coastal-plain deposits, but unless large and obvious, is not generally seen, under-estimating the fossil prevalence. Much depends on careful scrutiny of exposures and on spotting fossils as they are uncovered during digging *i.e.* by monitoring excavations. A limitation on predictive capacity exists in that it is not possible to predict the buried fossil content of an area or formation other than in general terms.

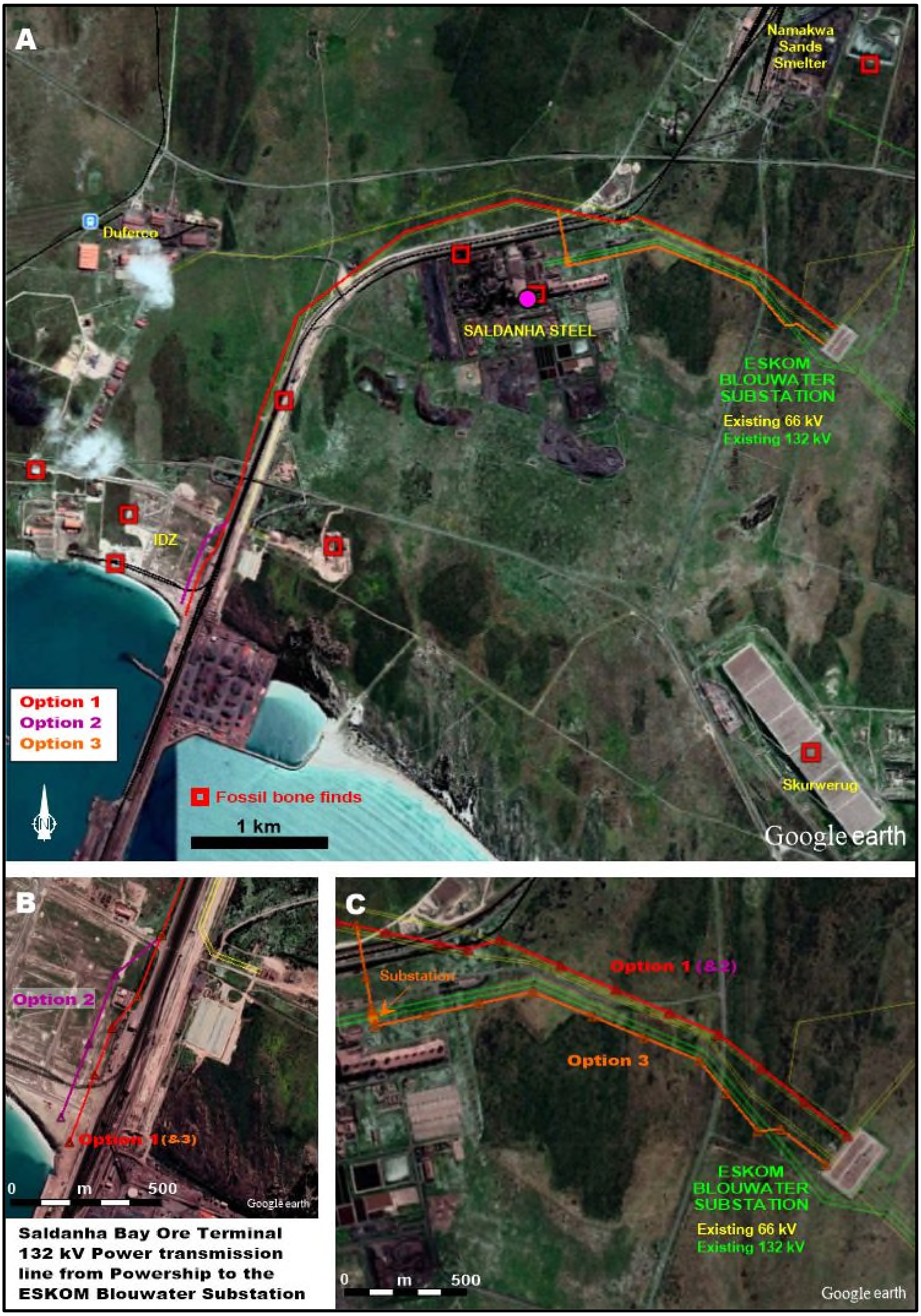


Figure 2. A: Proposed route options for the transmission lines. B: Detail showing Option 2 deviation from Option 1. C: Detail showing Option 3 deviation from Option 1.

6 DESCRIPTION OF THE PROPOSED DEVELOPMENT

6.1 LOCATION

The proposed Karpowership will be moored alongside the Saldanha Ore Terminal jetty in Saldanha Bay, with a powerline connecting to the ESKOM Blouwater Substation (Figure 1).

The relevant 1:50 000 map sheets are 3217DB&DD VREDENBURG, 3218CA&CC VELDDRIFand 3317BB & 3318AA SALDANHA.

Powerline at jetty: -32.999250°S / 17.996918°E. Blouwater Substation: -32.981806°S / 18.048437°E.

6.2 PROPOSED DEVELOPMENT

The planned generation capacity of the Karpowership is 480 MW. Associated facilities and infrastructure include"

- Natural gas supply, storage and distribution.
- Powerlines for the transmission of the generated electricity to the national grid connection point at the ESKOM Blouwater Substation.

The power generated on the ship is converted by the onboard High Voltage substation and transmitted along 132 kV transmission lines. Existing distribution power lines will be used where possible to reduce costs. Therefore, minimal land is required and construction risk is minimal. The overhead transmission lines will be developed where possible within existing servitudes.

Three power transmission line routes to the ESKOM Blouwater Substation are under consideration (Figure 2):

Option 1 route proceeds parallel to existing powerlines with minimal deviation (6768 m length).

Option 2 differs from Option 1 in the initial part of the route (Figure 2B), but otherwise follows the Option 1 route.

Option 3, 7041 m in length, follows the Option 1 route from the jetty, but deviates from it opposite the Saldanha Steel works where the route deviates southwards to parallel the 132 kV powerlines feeding Saldanha Steel works (Figure 2C). This route requires an additional small substation.

7 REGIONAL GEOLOGICAL SETTING

The bedrock of the area consists of the **Cape Granite Suite**, in this area being a variety of granites comprising the **Vredenburg** and **Saldanha Batholiths**, which are large volumes of the once-molten, deep Earth's crust which are now exposed by the erosion of a few kilometres thickness of the overlying rocks. There are no fossils in these crystalline igneous rocks. The Cape Granites intruded the **Malmesbury Group** basement rocks of the wider region about 550 Ma (Ma = million years ago, Mega-anna). The Malmesbury Group comprises the deposits in an ancient ocean basin that existed ~900-600 Ma and which were subsequently highly deformed, heated and metamorphosed when the basin was compressed by crustal tectonic forces and intruded by the granites. The Malmesbury Group bedrock shales are not exposed in the Saldanha area.

7.1 THE SANDVELD GROUP

The hard granites now form the hills such as around Darling, Saldanha and Vredenburg. Beneath much of the coastal plain the softer shale bedrock of the Malmesbury Group has been eroded away by ancient rivers to well below sea level and is buried beneath the sediments of the **Sandveld Group** (Hendey & Dingle, 1990). These sediments are of later Cenozoic age, deposited during the Neogene and Quaternary periods, *i.e*. during the last 23 million years.

Figure 3. Surface geology of the area of interest.

7.1.1 Early Miocene Tropical Forests

The buried valleys eroded in the Malmesbury shales are filled with the **Elandsfontyn Formation**, the oldest formation of the Sandveld Group, consisting of sandy fluvial and muddy marsh deposits laid down by meandering rivers under humid, tropical to subtropical climatic conditions (Rogers, 1980, 1982). The formation has abundant plant fossils in places, including lignified logs and plant material. Fossil pollen is indicative of forest vegetation with palms and is considered to be early to middle Miocene in age (Coetzee, 1978; Rogers, 1982; Hendey, 1981b, Roberts *et al*., 2017). This was an interval 23-16 Ma of slow global warming and episodically rising sea level which culminated in the Mid-Miocene Climatic Optimum ~16 Ma. Saldanha Bay is situated over one of these buried palaeochannels. A drill core into it provided by Transnet has been the subject of multi-disciplinary study by an international scientific team (Roberts *et al*., 2017), providing much new information about the Elandsfontyn Formation, when yellowwood forest covered the granite hills and mangroves lined the shoreline.

7.1.2 Mio-Pliocene Marine Formations

The older marine formations are generally not exposed, being buried beneath several metres of ancient sandy dune rock (aeolianite) such as the Langebaan Formation (Figure 3), but are revealed in the deep excavations of mine and quarry pits.

The oldest marine deposits of the southwestern coastal plain, the **Saldanha Formation,** were laid down during and just after the Mid-Miocene Climatic Optimum ~16-14 Ma. The ancient shoreline of the transgression maximum (highest level reached by the sea) is now found about 90-100 m asl., to which it has been uplifted by the continental edge rising up slightly. Residual marine gravels and sands above ~50 m asl. belong to this formation, while patches of it are likely preserved in places beneath younger, Pliocene marine deposits.

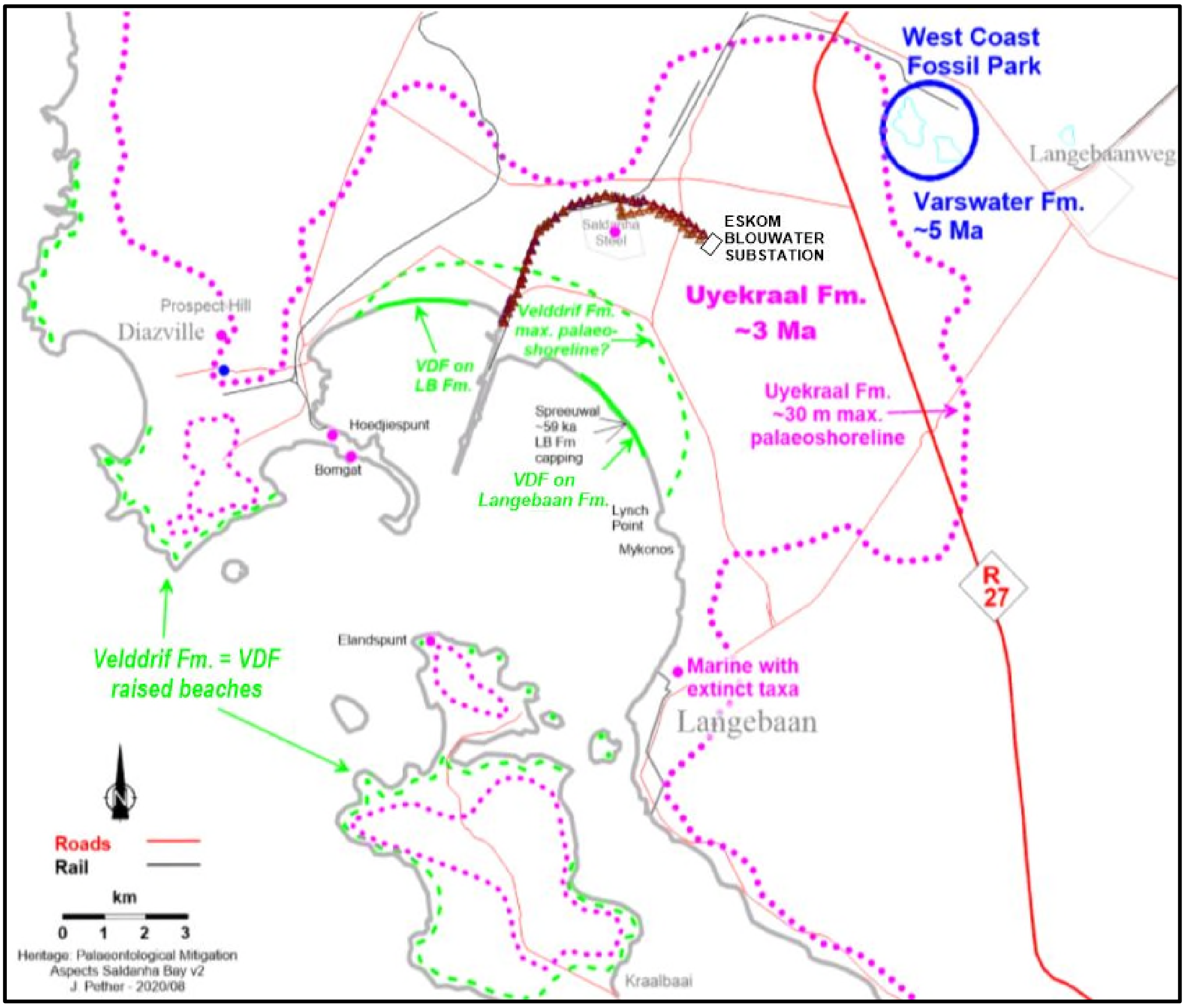


Figure 4. Schematic marine geology of the Saldanha area, showing approximate subsurface extents of the late Pliocene Uyekraal Formation and the Velddrif Formation raised beaches.

Subsequent Pliocene palaeoshoreline deposits (5-3 Ma) are found below ~50 m asl. (Pether *et al.*, 2000). In the southwestern Cape, these marine deposits are collectively known as the **Varswater Formation**. The stratotype locality is at the **West Coast Fossil Park** (Figure 4), where the extensive fossil bone assemblage recovered from the phosphate quarry indicates the early Pliocene age (Hendey, 1981a). These fossils were deposited in an estuarine setting during the transgression to ~50 m asl., about 5 Ma during the global warming of the Early Pliocene Warm Period. In the wider area, when sea level later receded from ~50 m asl., fossiliferous shallow-marine deposits were left mantling the emerged coastal plain.

Sea level rose again during the warming of the Late Pliocene Warm Period (~3.0 Ma), to a level now ~30 m asl. In the Saldanha embayment west of the West Coast Fossil Park, the flat plain extending towards the coast is underlain by these deposits, called the "**Uyekraal Formation**", after Rogers (in Rogers *et al*., 1990) (Figure 4). The Uyekraal marine beds are equivalent to the Hondeklipbaai Formation of the Namaqualand coast, seen in diamond mines as a substantial, prograded marine formation built out seawards from a sea-level maximum of 30-33 m asl. (Pether, 1994; Pether, in Roberts *et al*., 2006). The late Pliocene marine beds are the youngest marine deposits which make up a large volume and underlie the outer part of the coastal plain.

7.1.3 The Quaternary Raised Beaches

The Pliocene Epoch came to an end ~2.6 Ma with global cooling and the growth of the polar ice sheets, particularly in the Northern Hemisphere, and the "Ice Ages" of the Quaternary Period set in. Water was subtracted from the oceans and sea level fluctuated at positions well below present for most of the Quaternary, at times as much as 80 to 130 m below present sea level at times of Ice Age glacial maxima. The generally colder conditions were interrupted by brief intervals of global warming (interglacials), of which the present time is an example, when sea level was similar to the present level and only several metres above or below present level. The slightly higher than present sea level intervals resulted in the deposition of the Quaternary "raised beaches" found at low elevations (<15 m asl.) around the coast. These raised beaches typically occur as shelly gravels and sands on wave-cut terraces fringing the modern coast and collectively comprise the **Velddrif Formation** (Figure 4, VDF) , being well exposed in the Velddrif area. Within Saldanha Bay the Velddrif Formation laps inland onto aeolianites of the Langebaan Fm. (VDF on LB Fm., Figure 4).

The higher-lying, older raised beach occurs at 8-12 m asl., but it is very poorly known and is often missing, have been eroded away by the subsequent highstand. Where preserved, it is probable that it relates to the interglacial high sea level that occurred around 400 ka (ka = thousand years ago), which is called the **MIS 11 Interglacial** (MIS = Marine Isotope Stage). Most of the Velddrif Formation deposits that are exposed date to the **Last Interglacial** (LIG) about 125 ka and are found up to ~8 m asl. due to storm deposition, but the mean sea level was about 5-6 m asl. The youngest raised beach of the Velddrif Formation is 2-3 m asl. and is known as the "**Holocene High**". It was deposited between 7-4 ka in as the coastline was slightly uplifted. It is only present where there has been some protection from erosion during major storms.

7.1.4 The Aeolian Formations

The aforementioned formations are generally not exposed at the surface and do not feature on geological maps as they are covered by extensive dune plumes and sand sheets which were blown inland from the ancient shorelines by southerly winds. The calcareous dunes, which are mainly composed of tiny shell fragments, are evident in the coastal landscape as the ridges, low hills and mounds beneath a capping calcrete crust. The aeolianites overlie the wind-deflation erosion surfaces formed on the marine deposits.

The oldest dunes recognized comprise the **Prospect Hill Formation** which is the high aeolianite ridge backing the coastal plain between Saldanha Bay to Paternoster. It includes fossil eggshell fragments of the extinct ostrich *Diamantornis wardi* and extinct forms of land snails (Roberts & Brink, 2002). Based on dated occurrences of fossil ostrich eggshell in the Namib, East Africa and Arabia, an age of 12-9 Ma is indicated for the Prospect Hill Formation (Stidham, 2008).

Surface outcrops of the younger, calcified aeolianites of **Langebaan Formation** occupy large areas of the landscape (Figure 3). At this stage, the Langebaan Formation includes various aeolianites of different ages and is an "amalgam" of the dune plumes that formed on the coastal plain, at differing places and times, mainly during the last ~4 Ma (Pliocene to the late Quaternary). This is reflected in the different ages indicated from fossils found at various places:

- a late Pliocene or younger age (Diazville lower quarry, Roberts & Brink, 2002).
- early Quaternary (Skurwerug, Hendey & Cooke, 1985).
- middle and late Quaternary ages (Kraal Bay Member) are indicated by relationships to Last Interglacial (~125 ka) and earlier shoreline deposits and by dating of aeolianites by luminescence methods (OSL) (Roberts *et al*., 2009).

The **Springfontyn Formation** accommodates the mainly non-calcareous, quartzose windblown sand sheets and dunes that have covered parts of the coastal landscape during the Quaternary Period. As with the Langebaan Formation, the Springfontyn Formation at this stage also includes units of different ages. The youngest quartzose sands overlie the calcreted Langebaan Fm. Older "Springfontyn" sands underlie the Langebaan Fm. in places and considerable thicknesses of older non-calcareous sands occur inland from the coast which may be broadly of similar age as the calcareous Langebaan Fm. dunes which blew inland from beaches. In the context of the Project Area the Springfontyn Formation is represented by the latest surficial unit, *viz*. the **Q1** pale coversand unit which thinly covers the Langebaan Fm. capping calcrete and which is mainly of Holocene age. In the wider region is the older "heuweltjiesveld" soil cover surface unit **Q2** formed in coversands of middle Quaternary age.

The latest addition of dunes to the coastal plain is known as the **Witzand Formation** (Rogers, 1980), (Figure 3), comprising partly calcareous sands blown from the beach in the last several thousand years of the Holocene and accumulated in the form of a narrow dune cordon or "sand wall" parallel to the coast, where the dunes cover the Velddrif Fm. deposits, or as dune plumes transgressing several kilometres inland.

8 LOCAL GEOLOGY

The proposed route options for the transmission line to the Blouwater Substation are all situated on the calcreted Langebaan Formation, beneath a thin cover of Springfontyn Formation Q1 surficial sands (Figure 3). Close to the coast the Witzand Fm. dunes (Figure 3) are underlain by the older aeolianite of the Langebaan Formation and the interbedded beach deposits of the Velddrif Fm. Deposits of the Velddrif Formation fringe the inner shores of Saldanha Bay (Figure 4), where the Last Interglacial (LIG) raised beach (~125 ka) overlies eroded, calcreted Langebaan Formation aeolianites. The deposits of the older MIS 11 (~400 ka) raised beach extend further inland for approximately 1.5 km to a maximum level of about 12-15 m asl. (Figure 4). Further inland the Langebaan Fm. is underlain at depth by the late Pliocene Uyekraal Fm. (Figure 4). Coastal exposures correlated with the Uyekraal Fm. occur on Hoedjiespunt, Elandspunt and inland in the Lower Quarry near Prospect Hill. A deep pit made at Saldanha Steel (Figures 3 & 4) revealed that the marine deposits occur at ~12 m depth beneath the Langebaan Formation calcreted aeolianites (Roberts, 1997).

9 ANTICIPATED IMPACTS

For the evaluation of the palaeontological impact it is the extent/scale of the deeper excavations to be made that are the main concern. The impact of the proposed overhead transmission line installation relates to the construction phase of the pylons when excavations are made for their foundations.

Buried archaeological material, such as artefacts, shell and bone scatters, could be uncovered in the loose coversands (Q1, Springfontyn Fm.), but the overall palaeontological sensitivity of the coversand deposits in this area may be classified as LOW.

The calcreted Langebaan Formation is classified to be of very high sensitivity (Figure 3, inset, red), due to previous fossil finds of significant scientific value. The dimensions of the footings (foundations) for the powerline pylons are still to be specified. The footings vary according to the size of the pylon and the geotechnical characteristics at each pylon site, with more substantial footings required in soft or yielding sands and soils. Most of the pylon foundations will be embedded in the compact to hard, upper Langebaan Fm. calcrete and aeolianite which will permit smaller foundations which will not likely exceed 2.0 to 2.6 m in depth. This shallow depth and the small footprints of the excavations for foundation plinths reduce the impact as the important fossil bones are overall sparse in the upper calcreted Langebaan Formation. However, there will be a considerable number of such "test pits" along the powerline traverse and thus there is a distinct possibility that fossil bones could be unearthed.

Close to the coast the surface has been much disturbed and no impact on the Witzand Fm. is expected. Along the initial ~1.5 km of the route it is possible that in places the shelly beds of the Velddrif Fm. may be intersected, although this is considered to be unlikely in shallow excavations. Farther inland the marine Uyekraal Fm. is too deep to be intersected in the pylon foundations excavations.

The route options are not distinguished by differing palaeontological sensitivities and do not differ in their impacts.

10 PALAEONTOLOGY

10.1 MARINE FOSSILS IN THE VELDDRIF FORMATION

The shell fossil content of the Quaternary Velddrif Formation is essentially comprised of modern species that inhabit the West Coast today. In the lengthy time span between ~3 Ma and 0.4 Ma the open-coast warm-water fauna disappeared and many species became extinct as the modern Benguela upwelling regime became established, or evolved into our new endemic species.

An interesting aspect of the Velddrif Fm. Last Interglacial is that shallow-water coastal embayments, estuaries and lagoons were enlarged and more numerous due to the higher sea-level which inundated the lower reaches of rivers. Several species of exotic fossil bivalve shells of West African origin, today found living in the tropics along the Angolan coast and farther northwards, are found in the deposits of these sheltered embayments. A few extinct species and subspecies occur in Velddrif Formation equivalent deposits of the southern Cape (Kilburn & Tankard, 1975) and may occur in the Southwestern Cape deposits. The taxonomy of these extinct and exotic or "extralimital" species has been dealt with in Kilburn & Tankard (1975) and Kensley (1974, 1985a, b).

The sparse fossil bones in the Velddrif Fm. (*e.g.* seabirds, marine mammals) are likely to be closely related or identical to modern marine species, but may include species that we would not expect nowadays and finds may be of scientific importance.

10.2 FOSSILS IN THE AEOLIAN FORMATIONS

In aeolianites such as the Langebaan Fm. the fossil material most commonly seen is the ambient fossil content of dune sands: land snails, tortoise shells and mole bones. Other small bones occur very sparsely such as bird and small mammal bones. The fossil content is more abundant in association with old, buried land surfaces (palaeosurfaces) and their soils (palaeosols), formed during periods of dune stabilization and which define aeolian packages and larger formations. Importantly, the bones of larger animals (*e.g*. antelopes) are more persistently present along palaeosurfaces formed on top of marine deposits and the palaeosurfaces which separate the major aeolianite units. Blowout or deflation erosional palaeosurfaces carry fossils concentrated by the removal of sand by the wind, such as land snails and tiny rodent fossils which reflect the palaeoenvironment such as the vegetation type.

The interdune areas between dune ridges may host deposits associated with small springs/seeps and marshy vleis which are richly fossiliferous, including fossil plant material, aquatic snails and frogs. Sites of international renown are on Duynefontyn 34 just north of Koeberg and on Elandsfontyn 349 (historic Hopefield Site) where richly fossiliferous beds in the older sands of the Springfontyn Formation are associated with the margins of local vleis.

The most spectacular bone concentrations found in aeolianites are due to the bone-collecting behaviour of hyaenas which store bones in and around their lairs. The calcrete ledges of the eroding slopes of the Langebaan Fm. provide sheltering overhangs for hyaena and other carnivore dens. The Hoedjiespunt and Sea Harvest hyaena den sites in the Langebaan Fm. slopes surrounding Saldanha harbour are famous examples.

11 ASSESSMENT OF IMPACTS

11.1 NATURE OF FOSSIL HERITAGE

Fossils are rare objects, often preserved due to unusual circumstances. This is particularly applicable to vertebrate fossils (fossil bones), which tend to be sporadically preserved and have high value with respect to palaeoecological and biostratigraphic (dating) information. Such fossils are non-renewable resources. Provided that no subsurface disturbance occurs, the fossils remain sequestered there.

Overall the palaeontological sensitivity of coastal deposits is HIGH (Almond & Pether, 2009) due to previous fossil finds of high scientific importance. When excavations are made they furnish the "windows" into the coastal plain depository that would not otherwise exist and thereby provide access to the hidden fossils. The impact is positive for palaeontology, if efforts are made to watch out for and rescue the fossils. The very scarcity of fossils makes for the added importance of looking out for them. Fossils and significant observations will be lost in the absence of management actions to mitigate such loss. There remains a medium to high risk of valuable fossils being lost despite management actions to mitigate such loss. Machinery involved in excavations may damage or destroy fossils, or they may be hidden in "spoil" of excavated material. This loss of the opportunity to recover them and their contexts when exposed at a site is irreversible. The status of the potential impact for palaeontology is not neutral or negligible.

11.2 IMPACT CRITERIA – CONSTRUCTION PHASE

The primary impact on palaeontological resources takes place during the construction phases of the proposed development. The criteria for rating is according to Appendix 3.

11.2.1 Extents

The physical extent of impacts on potential palaeontological resources relates directly to the extents of subsurface disturbance involved in the installation of infrastructure and buildings during the Construction Phase, *i.e.* limited to the SITES of construction activity.

However, unlike an impact that has a defined spatial extent (*e.g.* loss of a portion of a habitat), the cultural, heritage and scientific impacts are of regional to national extent, as is implicit in the National Heritage Resources Act No. 25 (1999) and, if scientifically important specimens or assemblages are uncovered, are of INTERNATIONAL interest. This is evident in the amount of foreign-funded palaeontological research that takes place in South Africa by scientists of other nationalities.

11.2.2 Duration

The initial duration of the impact is SHORT TERM (<5 years) and primarily related to the Construction Phase when excavations for infrastructure are made. This is the "time window" for mitigation.

The impact of both the finding or the loss of fossils is permanent. The found fossils must be preserved "for posterity"; the lost, overlooked or destroyed fossils are lost to posterity. The duration of impact is therefore PERMANENT with or without mitigation.

11.2.3 Intensity/Magnitude

The intensity or magnitude of impact relates to the palaeontological sensitivities of the affected formations (Appendix 1) and the degree or volume of disturbance.

The construction activity mainly entails shallow excavations of small footprint made into the calcreted upper part of the Langebaan Fm. Although the Langebaan Formation aeolianite is rated as being of very high palaeontological sensitivity, the relatively limited depths of disturbance and sparse distribution of fossil bones serve to ameliorate the associated intensity of impact to a MEDIUM level.

There is some possibility that the fossil shell beds of the Velddrif Fm. could be intersected close to the coast. As exposures of the Velddrif Fm. occur in the wider region and the fossil shell content is mainly of extant species the intensity of impact is rated as LOW.

11.2.4 Consequence of impact or risk

Permanent loss of material palaeontological heritage (fossil specimens) and the scientific discovery and knowledge implicit in their origin and context.

11.2.5 Probability of occurrence

Notwithstanding that fossil bones are sparse in the upper Langebaan Fm. there will be a considerable number of pylon foundation excavations analogous to "test pits" along the powerline traverse and thus it is distinctly POSSIBLE (40-70% chance) that fossil bones could be discovered.

Fossil shell beds of the Velddrif Fm. may be intersected near the coast, but this is considered to be IMPROBABLE (<40% chance) due to the limited depth of excavations.

11.2.6 Irreplaceable loss of resources

Without mitigation and rescue of unearthed fossils there will be a COMPLETE LOSS OF RESOURCES within the footprints of the development.

11.2.7 Reversibility

Palaeontological resources are unique and their loss is IRREVERSIBLE.

11.2.8 Indirect impacts

The material fossil evidence of "deep time" is embedded in the creation of the sacred landscape and contributes to the "sense of place" cultural aesthetic of the region. The loss of fossils and concomitant interpreted knowledge impoverishes the tangible testimony of the prehistoric landscape and ecological context of ancient humans.

11.2.9 Cumulative impacts

The cumulative impact of coastal developments and coastal mining is the inevitable and permanent loss of fossils and the associated scientific implications. As mentioned, the impact of both the finding or the loss of fossils is permanent. Diligent and successful mitigation contributes to a positive cumulative impact as the rescued fossils are preserved and accumulated for scientific study. Even though just a very minor portion of the bone fossils exposed in coastal excavations has been seen and saved, the rescued fossils have proved to be of fundamental scientific value.

11.2.10 Degree to which impact can be avoided

There is a risk of valuable fossils being lost despite management actions to mitigate such loss. The avoidance of impact is LOW to MODERATE.

11.2.11 Degree to which impact can be managed

Experience of coastal developments has shown that the impact is difficult to manage and will require significant mitigation co-operation and effort on the part of excavation contractors and supervisors, *i.e*. MODERATE. Seldom are fossil bone finds reported from contexts where they are expected to occur. The conclusion is that the monitoring of digging is generally inadequate for the capture of small-scale fossil bone occurrences as the fossils are only briefly exposed, while large bones or bone clusters are seen. In contrast, fossil shell beds are easily seen, the fossils are usually abundant and mitigation by sampling and recording is readily accomplished.

11.2.12 Degree to which an impact can be mitigated

Given unavoidable loss of fossils the impact can only be partly mitigated, *i.e*. MODERATE.

11.2.13 Residual impacts

Negative residual impact arises from the unavoidable loss of fossils of unknown significance in spite of mitigation efforts. Positive residual impact arises from the successful rescue of fossil material for posterity, resulting in material for future research, employment opportunities for budding, young researchers and enhanced insights into the prehistory of the SW Cape.

11.2.14 Significance

Without mitigation the significance of the impact of the earthworks on the fossil bone content of the Langebaan Fm. is LOW NEGATIVE. Notwithstanding a similar low but positive significance with mitigation, depending on the scientific significance of the actual finds, the significance of the impact may range from MEDIUM POSITIVE to HIGH POSITIVE.

Without mitigation the significance of the impact of the earthworks on the fossil shell content of the Velddrif Fm. is VERY LOW NEGATIVE and with mitigation is VERY LOW POSITIVE.

11.2.15 Summary impacts tables

The following impact rating table refers to pylon foundation excavations with respect to fossil bones.

Loss of fossil bones during excavation of pylon foundations.								
	Extent	**Intensity**	**Duration**	**Consequence**	**Probability**	**Significance**	**Status**	**Confidence**
Without mitigation	Local 1	Medium 2	Long 3	Medium 6	Possible (40-70% chance)	LOW	-ve	Medium
Essential mitigation measures • Identify and appoint stand-by palaeontologist should paleontological finds be uncovered by earthworks. • Construction personnel to be alert for rare fossil bones and follow “Fossil Finds Procedure”. • Cease construction on (chance) discovery of fossil bones and protect fossils from further damage. • Contact appointed palaeontologist providing information and images. • Palaeontologist will assess information and establish suitable response, such as the importance of the find and recommendations for preservation, collection and record keeping. • Exposed fossiliferous sections in earthworks recorded and sampled by appointed palaeontologist.								
With mitigation	Local 1	Medium 2	Long 3	Medium 6	Possible (40-70% chance)	LOW	+ve	Medium

The following impact rating table refers to the fossil shells of the Velddrif Formation.

<table>
<tr><th colspan="9">Loss of fossil shells during excavation of pylon foundations</th></tr>
<tr><th></th><th>Extent</th><th>Intensity</th><th>Duration</th><th>Consequence</th><th>Probability</th><th>Significance</th><th>Status</th><th>Confidence</th></tr>
<tr><td>Without mitigation</td><td>Locall
1</td><td>LOW
1</td><td>Long term
3</td><td>Low
5</td><td>Improbable</td><td>VERY LOW</td><td>-ve</td><td>High</td></tr>
<tr><td colspan="9">Essential mitigation measures
• Identify and appoint stand-by palaeontologist should paleontological finds be uncovered by earthworks.
• Construction personnel and ECO to be aware that a substantial temporary exposure of marine shelly beds may require sampling and recording.
• In the event of a large exposure of shell beds, the appointed palaeontologist must be notified and provided with information and images. Palaeontologist will assess information and establish suitable response, such as the importance of the find and recommendations for sample collection and record keeping.
• Selected exposed fossiliferous sections in earthworks recorded and sampled by appointed palaeontologist.</td></tr>
<tr><td>With mitigation</td><td>1</td><td>Low
1</td><td>Long term
3</td><td>Low
5</td><td>Improbable</td><td>VERY LOW</td><td>+ve</td><td>High</td></tr>
</table>

12 RECOMMENDATIONS

12.1 MONITORING

Note that the probable presence of fossils in the subsurface does not have an *a priori* influence on the decision to proceed with the installation. However, mitigation measures are essential. The potential impact has a moderate influence upon the proposed project, consisting of implemented mitigation measures recommended below, to be followed during the Construction Phase of the transmission lines.

The rescue of fossils during earth works critically depends on spotting this material as it is uncovered during digging *i.e.* by monitoring excavation activity. As it is not feasible for a specialist monitor to be continuously present the earth works personnel must be involved in mitigation by watching for fossils. It is recommended that a requirement to be alert for possible fossils and archaeological material be included in the EMP for the Construction Phase of the pylons, with a Fossil Finds Procedure in place.

The Fossil Finds Procedure included as Appendix 2 provides guidelines to be followed in the event of fossil finds in the foundation excavations. The field supervisor/foreman and workers involved in excavating must be informed of the need to watch for fossils and archaeological material. Workers seeing potential objects are to cease work at that spot and to report to the field supervisor who, in turn, will report to the Environmental Control Officer (ECO). The ECO will contact the palaeontologist or archaeologist contracted to be on standby in the case of finds. The latter will liaise with Heritage Western Cape on the nature of the find and suitable consequent actions such as an immediate site inspection, application for a palaeontological collection permit and the drafting of a work plan for the collection of the find.

If a significant occurrence of fossil bones or shells is discovered a professional palaeontologist must be appointed to collect them and to record their contexts. Said palaeontologist must also undertake the recording of the stratigraphic context and sedimentary geometry of the exposure and the compilation of the report to Heritage Western Cape and the IZIKO S.A. Museum.

12.2 MITIGATION SUMMARY FOR THE CONSTRUCTION PHASE EMP

OBJECTIVE: To see and rescue fossil material that will be exposed in the excavations made for construction of the foundations of the transmission pylons.		
Project components	Excavations for foundations, spoil from excavations.	
Potential impact	Loss of fossils by their being unnoticed and/ or destroyed.	
Activity/ risk source	All bulk earthworks.	
Mitigation: target/ objective	To facilitate the likelihood of noticing fossils and ensure appropriate actions in terms of the relevant legislation.	
Mitigation: Action/ control	**Responsibility**	**Timeframe**
Inform staff of the need to watch for potential fossil occurrences.	The Client, the EAP, the ECO & contractors.	Pre-construction.
Inform staff of the procedures to be followed in the event of fossil occurrences.	EAP & ECO.	Pre-construction.
Monitor for presence of fossils, especially fossil bones	Contracted personnel and ECO.	Construction.
Liaise on nature of potential finds and appropriate responses.	ECO and specialist.	Construction.
Excavate main finds, inspect pits & record and sample excavations.	Specialist.	Construction.
Obtain permit from HWC for collection of fossil finds.	Specialist.	Construction
Performance Indicator	Reporting of and liaison about possible fossil finds. Fossils noticed and rescued. Scientific record of fossil contexts and temporary exposures in earthworks. Input to the Heritage Inventory and Management Plan of the local municipality.	

13 REFERENCES

Almond, J.E. & Pether, J. 2009. Palaeontological Heritage of the Northern Cape. SAHRA Palaeotechnical Report, Natura Viva cc., Cape Town.

Coetzee, J.A. 1978. Climatic and biological changes in south-western Africa during the late Cainozoic. *Palaeoecology of Africa* **10**: 13-29.

Davies, O. 1973. Pleistocene shorelines in the western Cape and South West Africa. *Annals of the Natal Museum* **21** (3): 719-765.

Dingle, R.V., Lord, A.R. & Hendey, Q.B. 1979. New sections in the Varswater Formation (Neogene) of Langebaan Road, south-western Cape, South Africa. *Annals of the South African Museum* **78**: 81-92.

Dingle, R.V., Siesser, W.G. & Newton, A.R. 1983. *Mesozoic and Tertiary Geology of Southern Africa*. Rotterdam: A.A. Balkema. 375 pp.

Haughton, S.H. 1932. The Late Tertiary and Recent deposits of the west coast of South Africa. *Transactions of the Geological Society of South Africa* **34**: 19-58.

Hendey, Q.B. 1981a. Palaeoecology of the Late Tertiary fossil occurrences in "E" Quarry, Langebaanweg, South Africa, and a re-interpretation of their context. *Annals of the South African Museum* **84**: 1-104.

Hendey, Q.B. 1981b. Geological succession at Langebaanweg, Cape Province, and global events of the Late Tertiary. *South African Journal of Science* **77**: 33-38.

Hendey, Q.B. 1983a. Cenozoic geology and palaeogeography of the Fynbos region. In: Deacon, H.J., Hendey, Q.B. & Lambrechts, J.J.N. (eds), *Fynbos palaeoecology: a preliminary synthesis.* South African National Scientific Programmes Report No. **75**: 35-60.

Hendey, Q.B. 1983b. Palaeontology and palaeoecology of the Fynbos region: an introduction. In: Deacon, H.J., Hendey, Q.B. & Lambrechts, J.J.N. (eds.), *Fynbos palaeoecology: a preliminary synthesis.* South African National Scientific Programmes Report No. **75**: 87-99.

Hendey, Q.B. 1983c. Palaeoenvironmental implications of the Late Tertiary vertebrate fauna of the Fynbos region. In: Deacon, H.J., Hendey, Q.B. & Lambrechts, J.J.N. (eds.), *Fynbos palaeoecology: a preliminary synthesis.* South African National Scientific Programmes Report No. **75**: 100-115.

Hendey, Q.B. & Cooke, H.B.S. 1985. *Kolpochoerus paiceae* (Mammmalia, Suidae) from Skurwerug, near Saldanha, South Africa, and its palaeoenvironmental implications. *Annals of the South African Museum* **97**: 9-56.

Hendey, Q.B. & Dingle, R.V. 1990. Onshore sedimentary phosphate deposits in south-western Africa. In: Burnett, W. C. & Riggs, S.R. (eds.), *Phosphate Deposits of the World*, Vol. **2**: 200-206. Cambridge: Cambridge University Press.

Kensley, B. 1974. The status of the Plio-Pleistocene *Panopea* in southern Africa (Mollusca, Bivalvia, Hiatellidae). *Annals of the South African Museum* 65: 199-215.

Kensley, B. 1985a. The faunal deposits of a Late Pleistocene raised beach at Milnerton, Cape Province, South Africa. *Annals of the South African Museum* **95**: 183-226.

Kensley, B. 1985b. Cementing bivalves of the genus Chlamys ('*Hinnites*') in Southern Africa. *South African Journal of Science* **81** (10): 629-631.

Kensley, B. and Pether, J. 1986. Late Tertiary and Early Quaternary fossil Mollusca of the Hondeklip, area, Cape Province, South Africa. *Annals of the South African Museum* **97** (6): 141-225.

Kilburn, R.N. & Tankard, A.J. 1975. Pleistocene molluscs from the West and South coasts of the Cape Province, South Africa. *Annals of the South African Museum* 67: 111-122.

Pether, J, Roberts, D.L. & Ward, J.D. 2000. Deposits of the West Coast (Chapter 3). In: Partridge, T.C. & Maud, R.R. (eds.), The Cenozoic of Southern Africa. *Oxford Monographs on Geology and Geophysics, Oxford University Press, New York*. No. **40**: 33-55.

Pether, J. 1994. *The sedimentology, palaeontology and stratigraphy of coastal-plain deposits at Hondeklip Bay, Namaqualand, South Africa.* M.Sc. thesis (unpubl.), Univ. Cape Town, South Africa, 313 pp.

Roberts, D.L. 1997. Alpha Saldanha Cement Project – Environmental Impact Assessment. Specialist Report 10 – Palaeontology. For Mark Wood Consultants, 32 pp.

Roberts, D. L.; Neumann, F. H.; Cawthra, H. C.; Carr, A. S.; Scott, L.; Durugbo, E. U.; Humphries, M. S.; Cowling, R. M.; Bamford, M. K.; Musekiwa, C.; MacHutchon, M. 2017. Palaeoenvironments during a terminal Oligocene or early Miocene transgression in a fluvial system at the southwestern tip of Africa. *Global and Planetary Change* 150: 1-23.

Roberts, D.L. & Brink, J. (2002). Dating and correlation of Neogene coastal deposits in the Western Cape (South Africa): implications for neotectonism. *S. Afr. J. Geol.*, **105**, 337–352.

Roberts, D.L., Bateman, M.D., Murray-Wallace, C.V., Carr, A.S., Holmes, P.J. 2009. West Coast dune plumes: climate driven contrasts in dunefield morphogenesis along the western and southern South African coasts. *Palaeogeogr. Palaeoclimatol. Palaeoecol*. **271**: 24–38.

Roberts, D.L., Botha, G.A., Maud, R.R. & Pether, J. 2006. Coastal Cenozoic Deposits. In: Johnson, M. R., Anhaeusser, C. R. & Thomas, R. J. (eds.), *The Geology of South Africa*. Geological Society of South Africa, Johannesburg/Council for Geoscience, Pretoria. 605-628.

Roberts, D.L., Matthews, T., Herries, A.I.R., Boulter, C., Scott, L., Dondoa, C., Mtembia, P., Browning, C., Smith, R.M.H., Haarhoff, P & Bateman, M.D. 2011. Regional and global context of the Late Cenozoic Langebaanweg (LBW) palaeontological site: West Coast of South Africa. Earth-*Science Reviews* **106**: 191-214.

Roberts, D.L., Siegfried, H.P., 2014. The Geology of the Saldanha, Vredenburg and Velddrif Environs. EXPLANATION 1:50000 SHEETS 3317BB & 3318AA, 3217DB & DD and 3218CA & CC. Council for Geoscience. 98 pp.

Rogers, J. 1980. First report on the Cenozoic sediments between Cape Town and Eland's Bay. *Geological Survey of South Africa Open File* **136**.

Rogers, J. 1982. Lithostratigraphy of Cenozoic sediments between Cape Town and Eland's Bay. *Palaeoecology of Africa* **15**: 121 137.

Rogers, J. 1983. Lithostratigraphy of Cenozoic sediments on the coastal plain between Cape Town and Saldanha Bay. *Technical Report of the Joint Geological Survey/University of Cape Town Marine Geoscience Unit* **14**: 87-103.

Rogers, J., Pether, J., Molyneux, R., Hill, R.S., Kilham, J.L.C., Cooper, G. & Corbett, I. 1990. Cenozoic geology and mineral deposits along the west coast of South Africa and the Sperrgebiet. *Guidebook Geocongress '90 Geological Society of South Africa*, PR1: 1 111.

Stidham, T.A. 2008. The importance of *Diamantornis* eggshell (Aves: Struthionidae) in the age and correlation of the Prospect Hill Formation. S. African Journal of Geology **111**, 459-461.

Tankard, A.J. 1974. Varswater Formation of the Langebaanweg-Saldanha area, Cape Province. Transactions of the Geological Society of South Africa **77**: 263-283.

Tankard, A.J. 1975a. Thermally anomalous Late Pleistocene molluscs from the south-western Cape Province, South Africa. *Annals of the South African Museum* **69**: 17-45.

Tankard, A.J. 1975b. The marine Neogene Saldanha Formation. Transactions of the Geological Society of South Africa **7**: 257-264.

Tankard, A.J. 1976. Pleistocene history and coastal morphology of the Ysterfontein-Elands Bay area, Cape Province. *Annals of the South African Museum* **69**: 73-119.

Visser, H.N. & Schoch, A.E. 1972. Map Sheet 255: 3217D & 3218C (St Helenabaai), 3317B & 3318A (Saldanhabaai). *Geological Survey of South Africa*.

Visser, H.N. & Schoch, A.E. 1973. The geology and mineral resources of the Saldanha Bay area. *Memoir Geological Survey of South Africa* **63**: 156 pp.

14 APPENDIX 1. PALAEONTOLOGICAL SENSITIVITY RATING

Palaeontological Sensitivity refers to the likelihood of finding significant fossils within a geologic unit.

VERY HIGH: Formations/sites known or likely to include vertebrate fossils pertinent to human ancestry and palaeoenvironments and which are of international significance.

HIGH: Assigned to geological formations known to contain palaeontological resources that include rare, well-preserved fossil materials important to on-going palaeoclimatic, palaeobiological and/or evolutionary studies. Fossils of land-dwelling vertebrates are typically considered significant. Such formations have the potential to produce, or have produced, vertebrate remains that are the particular research focus of palaeontologists and can represent important educational resources as well.

MODERATE: Formations known to contain palaeontological localities and that have yielded fossils that are common elsewhere, and/or that are stratigraphically long-ranging, would be assigned a moderate rating. This evaluation can also be applied to strata that have an unproven, but strong potential to yield fossil remains based on its stratigraphy and/or geomorphologic setting.

LOW: Formations that are relatively recent or that represent a high-energy subaerial depositional environment where fossils are unlikely to be preserved, or are judged unlikely to produce unique fossil remains. A low abundance of invertebrate fossil remains can occur, but the palaeontological sensitivity would remain low due to their being relatively common and their lack of potential to serve as significant scientific resources. However, when fossils are found in these formations, they are often very significant additions to our geologic understanding of the area. Other examples include decalcified marine deposits that preserve casts of shells and marine trace fossils, and fossil soils with terrestrial trace fossils and plant remains (burrows and root fossils)

MARGINAL: Formations that are composed either of volcaniclastic or metasedimentary rocks, but that nevertheless have a limited probability for producing fossils from certain contexts at localized outcrops. Volcaniclastic rock can contain organisms that were fossilized by being covered by ash, dust, mud, or other debris from volcanoes. Sedimentary rocks that have been metamorphosed by the heat and pressure of deep burial are called metasedimentary. If the meta sedimentary rocks had fossils within them, they may have survived the metamorphism and still be identifiable. However, since the probability of this occurring is limited, these formations are considered marginally sensitive.

NO POTENTIAL: Assigned to geologic formations that are composed entirely of volcanic or plutonic igneous rock, such as basalt or granite, and therefore do not have any potential for producing fossil remains. These formations have no palaeontological resource potential.

Adapted from Society of Vertebrate Paleontology. 1995. Assessment and Mitigation of Adverse Impacts to Nonrenewable Paleontologic Resources - Standard Guidelines. News Bulletin, Vol. 163, p. 22-27.

15 APPENDIX 2. FOSSIL FINDS PROCEDURE

15.1 MONITORING

A constant monitoring presence over the period during which excavations for developments are made, by either an archaeologist or palaeontologist, is generally not practical.

The field supervisor/foreman and workers involved in digging excavations must be encouraged and informed of the need to watch for potential fossil and buried archaeological material. Workers seeing potential objects are to report to the field supervisor who, in turn, will report to the ECO. The ECO will inform the archaeologist and/or palaeontologist contracted to be on standby in the case of fossil finds.

To this end, responsible persons must be designated. This will include hierarchically:

» The field supervisor/foreman, who is going to be most often in the field.

» The Environmental Control Officer (ECO) for the project.

» The Project Manager/Site Agent.

If the monitoring of the excavations is a stipulation in the Archaeological Impact Assessment, the contracted Monitoring Archaeologist (MA) can also monitor for the presence of fossils and make a field assessment of any material brought to attention. The MA is sufficiently informed to identify potential fossil material and liaise with the palaeontologist.

15.2 RESPONSE BY PERSONNEL IN THE EVENT OF FOSSIL FINDS

In the process of digging the excavations fossils may be spotted in the hole sides or bottom, or as they appear in excavated material on the spoil heap.

» Stop work at fossil find. The site foreman and ECO must be informed.

» Protect the find site from further disturbance and safeguard all fossil material in danger of being lost such as in the excavator bucket and scattered in the spoil heap.

» The ECO or site agent must immediately inform the standby palaeontologist and/or Heritage Western Cape (HWC) and provide via email the information about the find, as detailed below:

  * Date
  * Position of the excavation (GPS) and depth.
  * A description of the nature of the find.
  * Digital images of the excavation showing vertical sections (sides) and the position of the find showing its depth/location in the excavation.
  * A reference scale must be included in the images (tape measure, ranging rod, or object of recorded dimensions).
  * Close-up, detailed images of the find (with scale included).

Heritage Western Cape and/or the contracted standby palaeontologist will assess the information and a suitable response will be established which will be reported to the developer and the ECO, such as whether rescue excavation or rescue collection by a palaeontologist is necessary or not.

The response time/scheduling of the rescue fieldwork is to be decided in consultation with developer/owner and the ECO. It will probably be feasible to “leapfrog” the find and continue excavation farther along, so that the work schedule and machine time is minimally disrupted. The strategy is to rescue the material as quickly as possible.

15.3 APPLICATION FOR A PERMIT TO COLLECT FOSSILS

A permit from HWC and a Work Plan is required to excavate fossils. The applicant should be the qualified specialist responsible for assessment, collection and reporting (palaeontologist). Should fossils be found that require rapid collecting, application for a palaeontological permit must be made to HWC immediately.

In addition to the information and images of the find, the application requires details of the registered owners of the sites, their permission and a site-plan map. All fossils must be deposited at a HWC-approved institution.

16 APPENDIX 3 - IMPACT SIGNIFICANCE RATING METHODOLOGY

The **significance** of an impact is defined as a combination of the **consequence** of the impact occurring and the **probability** that the impact will occur. The criteria used to determine impact consequence are presented in the Table below (adapted Plomp methodology).

Criteria used to determine the Consequence of the Impact

Rating	Definition of Rating	Score
A. *Extent* *– the area in which the impact will be experienced*		
None		0
Local	Confined to project or study area or part thereof (*e.g.* site)	1
Regional	The region, which may be defined in various ways, *e.g.* cadastral, catchment, topographic	2
(Inter) national	Nationally or beyond	3
B. ***Intensity*** *– the magnitude or size of the impact*		
None		0
Low	Natural and/or social functions and processes are negligibly altered	1
Medium	Natural and/or social functions and processes continue albeit in a modified way	2
High	Natural and/or social functions or processes are severely altered	3
C. ***Duration*** *– the time frame for which the impact will be experienced*		
None		0
Short-term	Up to 2 years	1
Medium-term	2 to 15 years	2
Long-term	More than 15 years	3

The combined score of these three criteria corresponds to a **Consequence Rating**, as set out in the Table below:

Method used to determine the Consequence Score

***Combined Score* (A+B+C)**	0 – 2	3 – 4	5	6	7	8 – 9
Consequence Rating	Not significant	Very low	Low	Medium	High	Very high

Once the consequence is derived, the probability of the impact occurring will be considered, using the probability classifications presented in the Table below.

Probability Classification

Probability of impact – the likelihood of the impact occurring	
Improbable	< 40% chance of occurring
Possible	40% - 70% chance of occurring
Probable	> 70% - 90% chance of occurring
Definite	> 90% chance of occurring

The overall s**ignificance** of impacts will be determined by considering consequence and probability using the rating system prescribed in the table below.

Impact Significance Ratings

Significance Rating	***Consequence***		***Probability***
Insignificant	Very Low	&	Possible
	Very Low	&	Improbable
Very Low	Very Low	&	Definite
	Very Low	&	Probable
	Low	&	Possible
	Low	&	Improbable
Low	Low	&	Definite
	Low	&	Probable
	Medium	&	Possible
	Medium	&	Improbable
Medium	Medium	&	Definite
	Medium	&	Probable
	High	&	Possible
	High	&	Improbable
High	High	&	Definite
	High	&	Probable
	Very High	&	Possible
	Very High	&	Improbable
Very High	Very High	&	Definite
	Very High	&	Probable

Finally the impacts will also be considered in terms of their status (positive or negative impact) and the confidence in the ascribed impact significance rating. The prescribed system for considering impacts status and confidence (in assessment) is laid out in the Table below.

Impact Status and Confidence Classification

Status of impact	
Indication whether the impact is adverse (negative) or beneficial (positive).	+ ve (positive – a 'benefit')
	– ve (negative – a 'cost')
	Neutral
Confidence of assessment	
The degree of confidence in predictions based on available information and/or specialist knowledge.	Low
	Medium
	High

The impact significance rating should be considered by the competent authorities in their decision-making process based on the implications of ratings ascribed below:

- **Insignificant**: the potential impact is negligible and **will not** have an influence on the decision regarding the proposed activity/development.
- **Very Low**: the potential impact **should not** have any meaningful influence on the decision regarding the proposed activity/development.

- **Low**: the potential impact **may not** have any meaningful influence on the decision regarding the proposed activity/development.
- **Medium**: the potential impact **should** influence the decision regarding the proposed activity/development.
- **High**: the potential impact **will** affect the decision regarding the proposed activity/development.
- **Very High**: The proposed activity should **only** be approved under special circumstances.

In the EIA practicable mitigation measures are recommended and impacts rated in the prescribed way both without and with the assumed effective implementation of mitigation measures.