**PALAEONTOLOGICAL IMPACT ASSESSMENT**

**(DESKTOP STUDY)**

# PROPOSED MIXED-USE RESIDENTIAL DEVELOPMENT ON PORTION 4 OF FARM 560, YZERFONTEIN

**Swartland Municipality, Malmesbury Magisterial District, Western Cape**

By

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**26 October 2023**

## EXECUTIVE SUMMARY

### 1. Site Name

Proposed development of part of Portion 4 of the farm Yzerfontein 560.

### 2. Location

The proposed development Project Area on Portion 4 of the farm Yzerfontein 560 is ~158 ha in extent and is an elongate area on higher ground located adjacent to the outskirts of the existing Yzerfontein town streets and houses (Figure 1).

### 3. Locality Plan

See Figures 1, 2 & 3.

### 4. Proposed Development

The proposed development requires the subdivision of Portion 4 of Yzerfontein 560 into the development area of ~158 ha, and the Remainder of ~614 ha (Figure 1). The development proposal (Figure 4) for the subdivided portion involves:

- Residential Zone 1: ~860 erven
- General Residential Zone 1 (Group House) erven: Total of 175 units.
- Open Space Zone 1: 11 erven.
- Business Zone 2: 2 erven.
- Transport Zone 2: Roads.

### 5. Palaeontological Resources Identified

The Project Area is situated practically entirely on **calcreted Langebaan Fm**. calcareous aeolianite (Figures 5 & 6), beneath a generally thin (<1 m) mantle of quartzose coversands of the **Springfontyn Fm. Q1 sandy soil** (Figure 7). Note that in Figures 5 and 6 the coversands are not depicted where they thinly overlie the Langebaan Fm. calcrete. In the north the Langebaan Fm. lapping onto the slopes of the Yzerfontein conical hill may be underlain by eroded remnants of marine deposits evident as residual rounded boulders and cobbles and possibly fossil shells.

### 6. Anticipated Impacts

The intensity or magnitude of impact relates to the palaeontological sensitivities of the affected formations (Appendix 2) and the volume of disturbance by excavation. The proposed development involves trenches for conventional building foundations (0.6-0.8 m depth) and services infrastructure (1.0-2.0 m depth). Deeper excavations are also involved in swimming pool installations.

The fossil bones in the Springfontyn Fm. coversands are expected to be of late Quaternary age and likely to be mainly members of the extant, modern fauna, but some extinct species could occur. With the exception of rare local “hotspots”, due to the overall scarcity of fossil bones in the coversands and underlying buried soils, the palaeontological sensitivity of the Springfontyn Fm. Q1 coversands is overall LOW (Figure 9, Appendix 2). Although the palaeontological sensitivity of the Springfontyn Fm. coversands is rated low, the intensity of impact of the construction phases is rated as MODERATE due to the large development footprint and the considerable volume of coversands which will be excavated.

The calcreted Langebaan Formation is classified to be of VERY HIGH sensitivity (Figure 9), due to previous fossil finds of significant scientific value, such as the fossils occurring on naturally-exposed deflating palaeosurfaces, in quarries and in ancient hyaena lairs. Most of the infrastructure trenches are likely to intersect the calcreted, upper Langebaan Fm. beneath the coversands. Most intersections are expected to be relatively shallow, affecting mainly the calcrete in which the fossil bones are overall

sporadic, but locally more common. As above, due to the large development footprint, the potential impact is rated HIGH in the absence of effective mitigation.

Residual marine deposits of Pliocene age might be encountered on the lower slopes of the Yzerfontein conical hill. It is likely these deposits would be decalcified, but robust shells such as oysters may be preserved, or the moulds of dissolved shells. Such occurrences are not expected to be a source of quality shell fossil specimens and the palaeontological sensitivity may be rated as LOW, but it is important to describe, record and sample any such exposures.

**7. Recommendations**

The possible presence of fossils in the subsurface does not have an *a priori* influence on the decision to proceed with the proposed construction activities on Portion 1 of Yzerfontein 560. However, mitigation measures are essential. The potential impact has a moderate influence during the Construction Phase, consisting of implemented mitigation measures recommended below.

The monitoring of construction earthworks by an archaeologist may be a recommendation of the Archaeological Impact Assessment, but can only take place at intervals. However, the rescue of fossil bones during earthworks critically depends on spotting this material as it is uncovered during digging *i.e*. by continuous monitoring of excavation activity. As it is not feasible for a specialist to be continuously present the construction personnel must be involved in mitigation by watching for fossils. It is recommended that a requirement to be alert for possible fossils be included in the EMP for the Construction Phase of the proposed development, with a **Fossil Finds Procedure** in place. The Fossil Finds Procedure (FFP) included as Appendix 3 provides guidelines to be followed in the event of fossil finds. The Project Manager, foremen and workers involved in excavating earthworks must be informed of the need to watch for fossils. Workers seeing potential objects are to cease work at that spot and to report to the Project Manager and/or the Environmental Control Officer (ECO). The ECO will inform the developer and contact the standby palaeontologist in the case of fossil finds. The latter will liaise with Heritage Western Cape on the nature of the find and suitable consequent actions such as immediate site inspection, application for a palaeontological collection permit and drafting of a work plan for the collection of the find.

It is recommended that management arranges that earthworks personnel visit the West Coast Fossil Park to be acquainted with fossil bones and palaeontological science.

If fossil bones are discovered, or if marine gravel deposits are exposed, a professional palaeontologist must be appointed to collect the fossils. Said palaeontologist must also undertake the recording of the stratigraphic context and sedimentary geometry of the fossil exposure site and the compilation of the report to Heritage Western Cape and the IZIKO S.A. Museum.

At each development node/precinct, at the times when the deeper excavations for infrastructure have been made and are open for inspection, a professional palaeontologist must record the exposures in detail and sample the ambient small fossil content and the sediments for future study of composition and microfossil content.

Fossil bones may be exposed in further earthworks by residents, such as the installation of swimming pools, foundations for building additions, landscaping and horticultural diggings. The Operational/Occupancy EMP must include a Heritage Management Plan with an ongoing mitigation component and the FFP.

The costs of palaeontological mitigation by a contracted specialist shall be at the Developer's expense.

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## 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) (~350 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 MIXED-USE RESIDENTIAL DEVELOPMENT ON PORTION 4 OF FARM 560, YZERFONTEIN

Swartland Municipality, Malmesbury Magisterial District, Western Cape

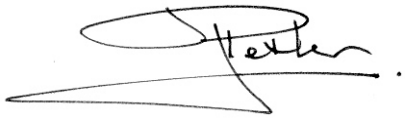
**Terms of Reference**

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: 26 October 2023

**ABBREVIATIONS**

| | |
|---|---|
| asl. | above (mean) sea level. Alternatively denoted by a plus sign *e.g*. +30 m. |
| bsl. | below (mean) sea level. Alternatively denoted by a minus sign *e.g*. -30 m. |
| CD-NGI | Chief Directorate – National Geo-spatial Information. |
| CGS | Council for GeoScience. |
| EMP | Environmental Management Plan/Programme. |
| Fm. | Formation. |
| HIA | Heritage Impact Assessment. |
| HWC | Heritage Western Cape. |
| ka | Thousand years ago. |
| LIG | Last Interglacial. |
| Ma | Million years ago. |
| OSL | Optically stimulated luminescence. |
| PIA | Palaeontological Impact Assessment. |
| SAHRA | South African Heritage Resources Agency. |
| SAHRIS | South African Heritage Resources Information System. |
| SRTM | Shuttle Radar Topography Mission – NASA. |

**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.

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.

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. The level of radioactivity (annual doses) to which the sample grains have been exposed is measured in the field or from the separated minerals containing radioactive elements in the sample. 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.

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).

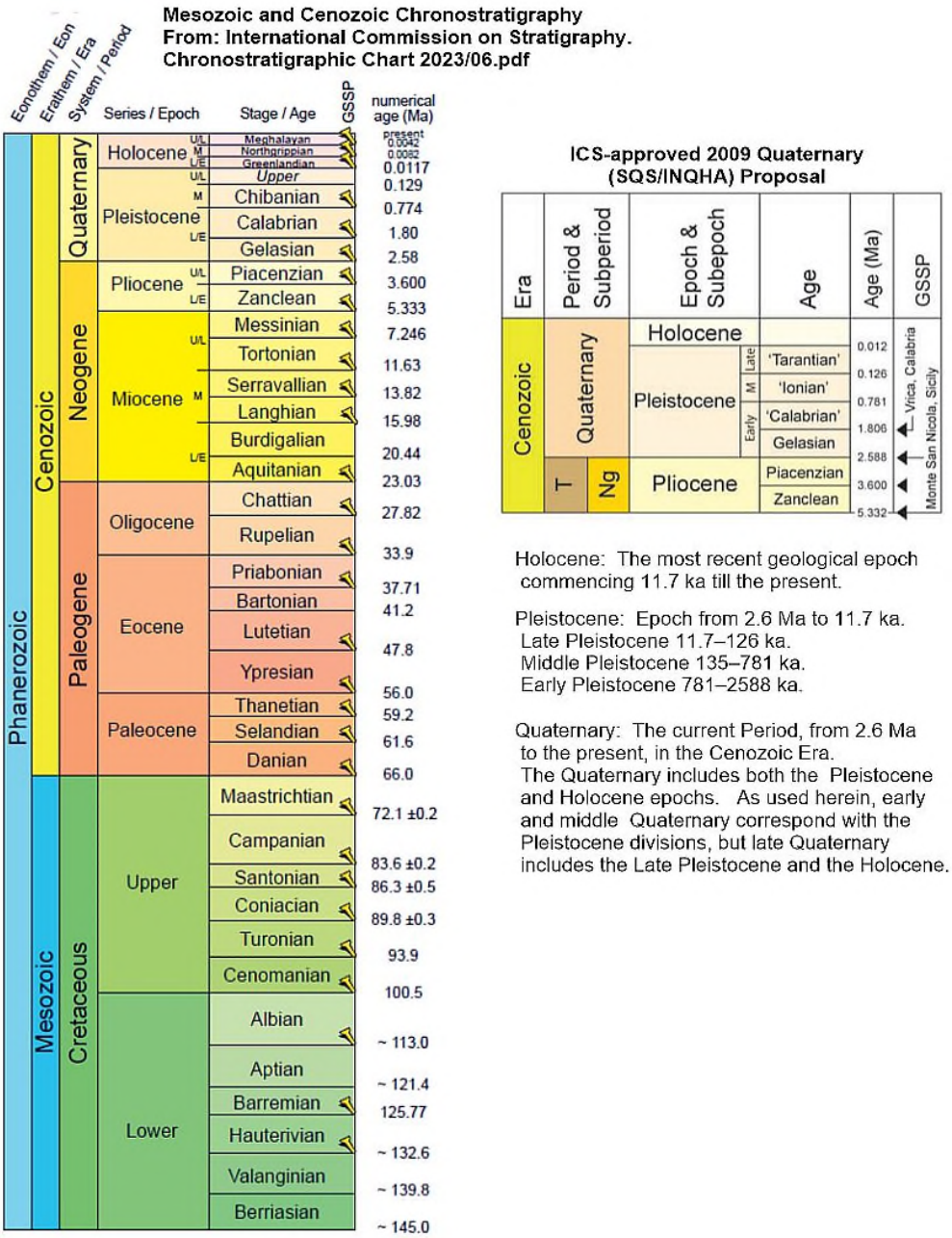
**GEOLOGICAL TIME SCALE TERMS**

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. Lately it has also been referred to as the Mid Piacenzian Warm Period, thus preserving the abbreviation and also being chronologically correct.







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.

**COMPLIANCE WITH APPENDIX 6 OF THE 2014 EIA REGULATIONS**

| **Requirements of Appendix 6 – GN R326 (7 April 2017)** | Addressed in the Specialist Report |
|---|---|
| 1. (1) A specialist report prepared in terms of these Regulations must contain-<br>a) details of-<br>i. the specialist who prepared the report; and<br>ii. the expertise of that specialist to compile a specialist report including a curriculum vitae; | Page v. |
| b) a declaration that the specialist is independent in a form as may be specified by the competent authority; | Page vi. |
| c) an indication of the scope of, and the purpose for which, the report was prepared; | Section 1. |
| (cA) an indication of the quality and age of base data used for the specialist report; | Section 4. |
| (cB) a description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change; | Section 9. |
| d) the duration, date and season of the site investigation and the relevance of the season to the outcome of the assessment; | N/A |
| e) a description of the methodology adopted in preparing the report or carrying out the specialised process inclusive of equipment and modelling used; | Section 4. |
| f) details of an assessment of the specific identified sensitivity of the site related to the proposed activity or activities and its associated structures and infrastructure, inclusive of a site plan identifying alternatives; | Sections 6 - 8. |
| g) an identification of any areas to be avoided, including buffers; | N/A |
| h) a map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers; | Figures 5 & 6. |
| i) a description of any assumptions made and any uncertainties or gaps in knowledge; | Section 4.2. |
| j) a description of the findings and potential implications of such findings on the impact of the proposed activity or activities; | Sections 8 & 9. |
| k) any mitigation measures for inclusion in the EMPr; | Section 10. |
| l) any conditions for inclusion in the environmental authorisation; | Section 10. |
| m) any monitoring requirements for inclusion in the EMPr or environmental authorisation; | Section 10. |
| n) a reasoned opinion-<br>i. whether the proposed activity, activities or portions thereof should be authorised;<br>(iA) regarding the acceptability of the proposed activity and activities; and<br>ii. if the opinion is that the proposed activity, activities or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the EMPr, and where applicable, the closure plan; | Section 10. |
| o) a description of any consultation process that was undertaken during the course of preparing the specialist report; | Not Applicable |
| p) a summary and copies of any comments received during any consultation process and where applicable all responses thereto; and | Not Applicable |
| q) any other information requested by the competent authority. | Not Applicable |
| 2. Where a government notice gazetted by the Minister provides for any protocol of minimum information requirement to be applied to a specialist report, the requirements as indicated in such notice will apply | Site sensitivity verification requirements where a specialist assessment is required but no specific assessment protocol has been prescribed.<br>See Appendix 2. |

# 1 INTRODUCTION

The owners propose to develop the seaward part of Portion 4 of the farm Yzerfontein 560 with the construction of residential housing and business premises inland of the existing town limits (Figure 1). C.K Rumboll & Associates are managing the Rezoning and Subdivision applications. In terms of the National Heritage Resources Act the scale of the proposed development triggers the requirement for a Heritage Impact Assessment (HIA). CTS Heritage has commissioned this Palaeontological Impact Assessment (PIA) which is part of the HIA for submission to Heritage Western Cape (HWC).

This PIA 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 of the proposed development.

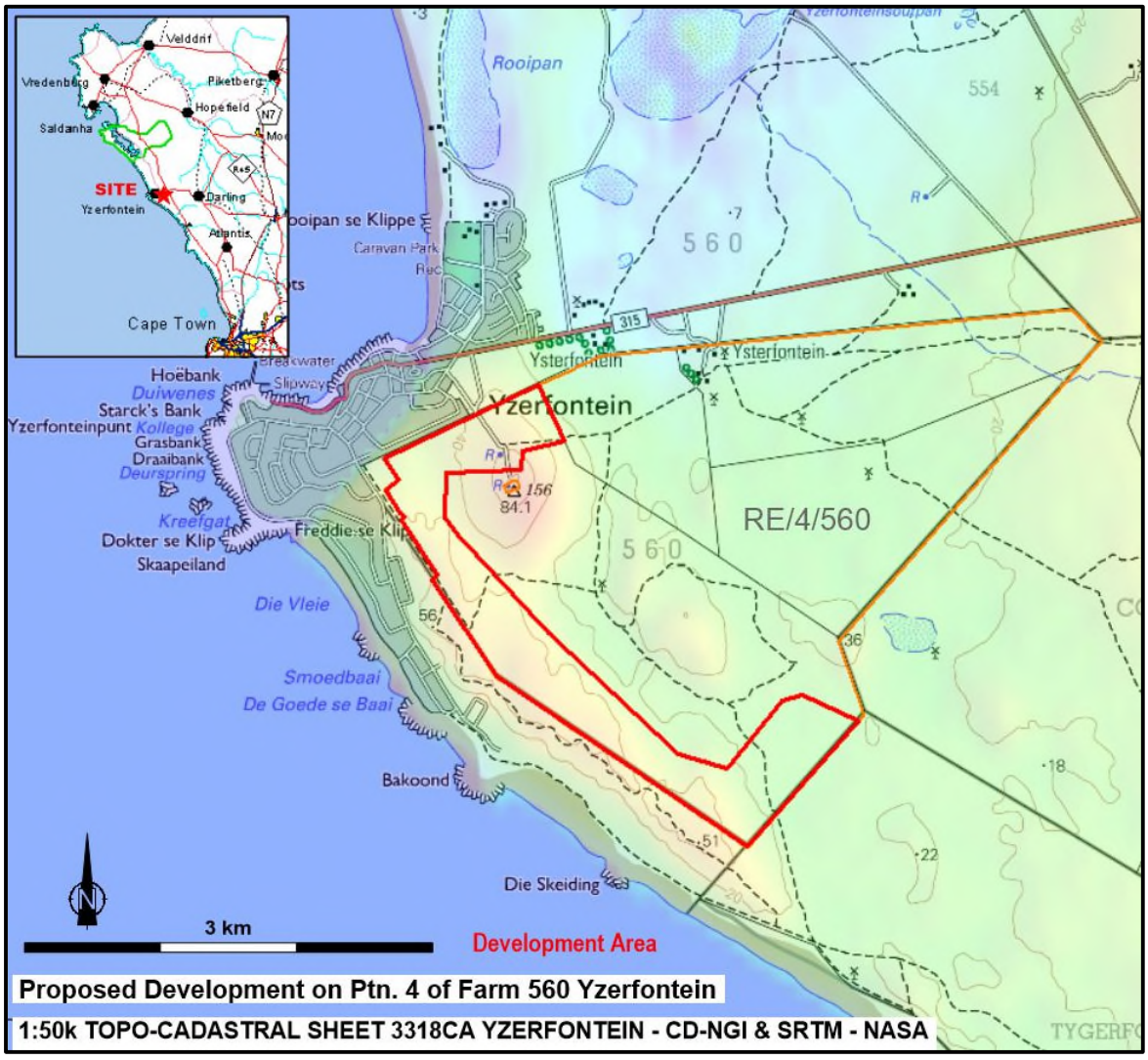



**Figure 1. Location of the proposed development on Portion 4 of Farm 560.**

# 2 DESCRIPTION OF THE PROPOSED DEVELOPMENT

## 2.1 LOCATION

The proposed development Project Area on Portion 4 of the farm Yzerfontein 560 is ~158 ha in extent and is an elongate area on higher ground located adjacent to the outskirts of the existing Yzerfontein town streets and houses (Figures 1, 2 & 3).




**Figure 2. Landscape setting of the proposed development.**




**Figure 3. Landscape setting - simulated oblique view looking southeast.**

## 2.2 PROPOSED DEVELOPMENT

The proposed development requires the subdivision of Portion 4 of Yzerfontein 560 into Portion 1, the development area of ~158 ha, and the Remainder of ~614 ha (Figure 1).

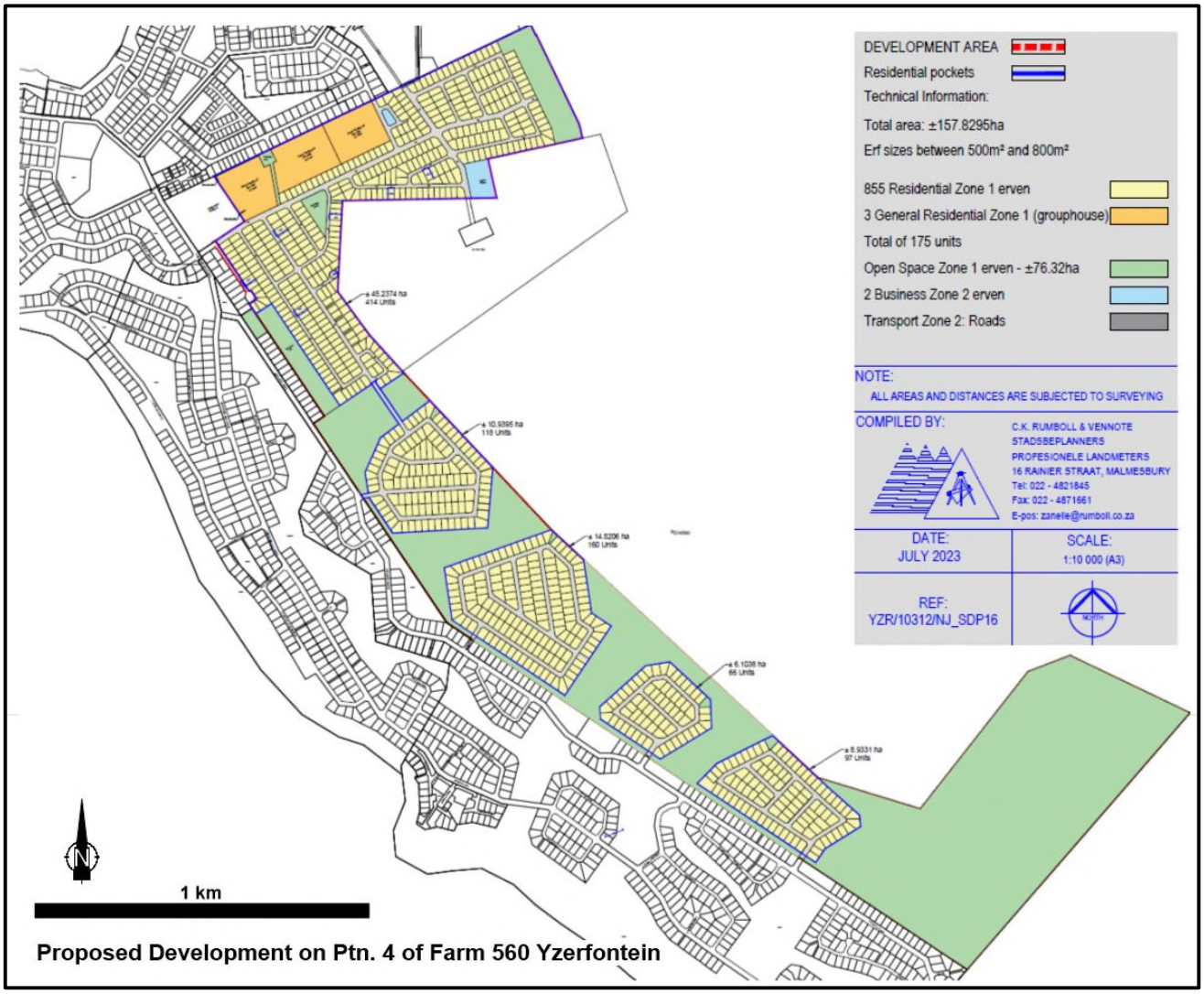



**Figure 4. The proposed Site Develop Plan for the subdivided Ptn. 1 of Ptn. 4 of Yzerfontein 560.**

The development proposal (Figure 4) for the subdivided portion involves:

- Residential Zone 1: ~860 erven
- General Residential Zone 1 (Group House) erven: Total of 175 units.
- Open Space Zone 1: 11 erven.
- Business Zone 2: 2 erven.
- Transport Zone 2: Roads.

# 3 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).

# 4 METHODOLOGY

## 4.1 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).

In this report the regional geological context is first summarised and subsequently the local geology and palaeontological sensitivities of the Project Area are described and the impact of the subsurface disturbance entailed by the development is assessed.

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 and fossil finds have provided more insights, and part of which reflects different approaches in stratigraphic interpretation. However, the endeavour to understand the deposits depends critically on fossil finds to refine their ages and the associated past environments.

## 4.2 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 broad-scale geological map making when details of 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.

# 5 REGIONAL GEOLOGICAL SETTING

The **bedrock** of the wider area consists of the basement rocks of the **Malmesbury Group** shales and limestones whose origin dates from over ~600 Ma (Ma: million years ago) as the deposits in an ancient ocean basin which have been metamorphosed when the basin was compressed by crustal tectonic forces and intruded by the **Cape Granites** about 550 to 520 Ma. The erosion-resistant crystalline "Cape Granites" are now exposed as the Darling hills just inland of the R27. while the softer Malmesbury Group shales have mostly been eroded away to low elevations and are usually buried beneath the much younger coastal-plain formations. The igneous bedrock in the Yzerfontein area however, the Yzerfontein Diorite (Figure 5), differs from the usual composition of the Cape Granites in that it is a darker rock comprised of more magnesium and iron-containing dark minerals and which had a deeper source in the earth's mantle.

These bedrock formations are not of palaeontological interest.

## 5.1 THE SANDVELD GROUP

**Table 1. The Sandveld Group – an expanded stratigraphic scheme.**

| FORMATION | AGE AND DESCRIPTION | SIGNIFICANCE/SENSITIVITY | |
|---|---|---|---|
| WITZAND | Holocene and recently active dune fields and cordons <~12 ka. | Mainly archaeological sites. | Quaternary |
| VELDDRIF 3 | Holocene High ~3 m as., 7-4 ka. | Shell fossils common, local significance. | |
| SPRINGFONTYN Q1 | Late Quaternary coversands and dunes. | Poorly fossiliferous, local significance. | |
| LANGEBAAN | Late Quaternary calc. aeolianites <~125 ka. | Fossil bones mod. common, local to medium significance. | |
| VELDDRIF 2 | Last Interglacial raised beach & estuarine ~6 m asl., ~125 ka. | Shell fossils common, local significance. Fossil bones very sparse, high significance. | |
| SPRINGFONTYN Q2 | Later mid-Quaternary heuweltjiesveld soils & underlying sands & palaeosols. | Poorly fossiliferous, medium significance. | |
| LANGEBAAN | Mid Quaternary calc. aeolianites. | Fossil bones mod. common, local to high significance. | |
| VELDDRIF 1 | Mid-Quaternary raised beach & estuarine deposits, ~0.4 Ma. Sea-levels below ~8-12 m asl. | Extents & fossil content poorly known, high significance. | |
| ***Marine erosion surfaces to ~15 m asl. (Velddrif 1), to ~6-8 m asl (Velddrif 2) and ~3 m asl. (Velddrif 3)*** | | | |
| SPRINGFONTYN | Latest Pliocene to mid-Quaternary <~3 Ma. Mainly quartzose dune and sandsheet deposits, inter-bedded palaeosols. Marsh beds, alluvium & colluvium locally. | Fossil bones very sparse, high significance. Basal Baards Quarry type fluvial deposits locally. Elandsfontein & Duynefontyn Fossil Beds.– v high significance. | |
| LANGEBAAN | Latest Pliocene to early Quaternary calcareous aeolianites <~3 Ma. Diazville Mb. | Fossil bones mod. common, local to high significance. | Pliocene |
| UYEKRAAL (2) | Late Pliocene transgression to ~35 m asl., ~3 Ma. Subsequent marine regression deposits. | Shell fossils common, local significance. Fossil bones very sparse, high significance. | |
| ***Marine erosion surface to ~35 m asl.*** | | | |
| "Springfontyn Fm." | Pliocene leached and altered sands. | Largely unfossiliferous, possible peats/lignite. | |
| LANGEBAAN | Earlier Pliocene calcareous aeolianites >~3 Ma. | Fossil bones mod. common, local to high significance. | |
| VARSWATER upper Regression facies | Later early Pliocene regressive marine deposits of wider area. 5-4 Ma. | Fossil bone rare, high significance. Poorly known, fossil shells of high significance. | |
| VARSWATER lower Transgression facies in major embayments | Early Pliocene transgressive marine deposits in embayments (upper ?KGM, Langeberg Quartzose Sand and Muishond Fontein Pelletal Phosphorite members. Sea-level max ~50-60 m asl. | Fossil bone common locally, high significance. Shells very sparse, high significance. | |
| ***Marine erosion surface to ~60 m asl.*** | | | |
| "Springfontyn Fm." | Miocene leached and altered sands. | Largely unfossiliferous, possible peats/lignite. | Miocene |
| PROSPECT HILL | Miocene calcareous aeolianite 12-9 Ma? (this age controversial, could be Pliocene) | Fossils very sparse – high significance. | |
| SALDANHA | Mid-Miocene marine deposits (predicted presence), 17-14 Ma. Sea-level max. ~100 m asl. May Include the lower Konings Vlei Gravel Member (KGM). | Very few fossils recovered, high significance. if found. | |
| ***Marine erosion surface to ~100 m asl.*** | | | |
| LANGEENHEID CLAYEY SAND (LCSM) (1) | Mid Miocene early-transgression estuarine deposits (prev. LCS Member in lower Varswater Fm.). 18-17 Ma. | Plant microfossils – high significance. | |
| ELANDSFONTYN | Oligocene-early Miocene fluvial muds, peats, sands and gravels, ~26-18 Ma. | Plant fossils – high significance. | |
| **PRE-SANDVELD GROUP BEDROCK – Malmesbury Group shales and Cape Granites.** | | | |
| (1) Previously a member of the Varswater Fm.<br>(2) Previously subsumed in the Varswater Fm. | | | |

The eroded bedrock of the coastal plain 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*. mainly during the last 23 million years. A tabulated summary of the formations comprising the Sandveld Group (**Table 1**) is based primarily on the chronological history of the major times of high sea level during periods of global warming as evidenced in oceanic palaeoclimatic records and the corresponding fossiliferous marine deposits preserved on the coastal plain farther north along Namaqualand where they are extensively exposed in diamond mine open-cast pits. The dated marine formations interfinger with the terrestrial aeolian formations, bracketing the ages of the aeolian formations. The terrestrial formations of the Sandveld Group, such as the Langebaan and Springfontyn formations, are very broadly defined at present and incorporate deposits of different ages, but by analogy with the coastal-plain record of Namaqualand, must also be similarly bracketed by sea-level history. The repetition of the formation names in Table 1 reflects their composite nature comprising members of various ages.

### 5.1.1 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. A drill core into the Elandsfontyn palaeochannel deposits beneath Saldanha Bay, kindly 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.

### 5.1.2 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, 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 Saldanha Fm. deposits are substantially eroded away, but 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.

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** 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). These late Pliocene marine beds are the youngest marine deposits which make up a large volume and underlie the outer part of the coastal plain.

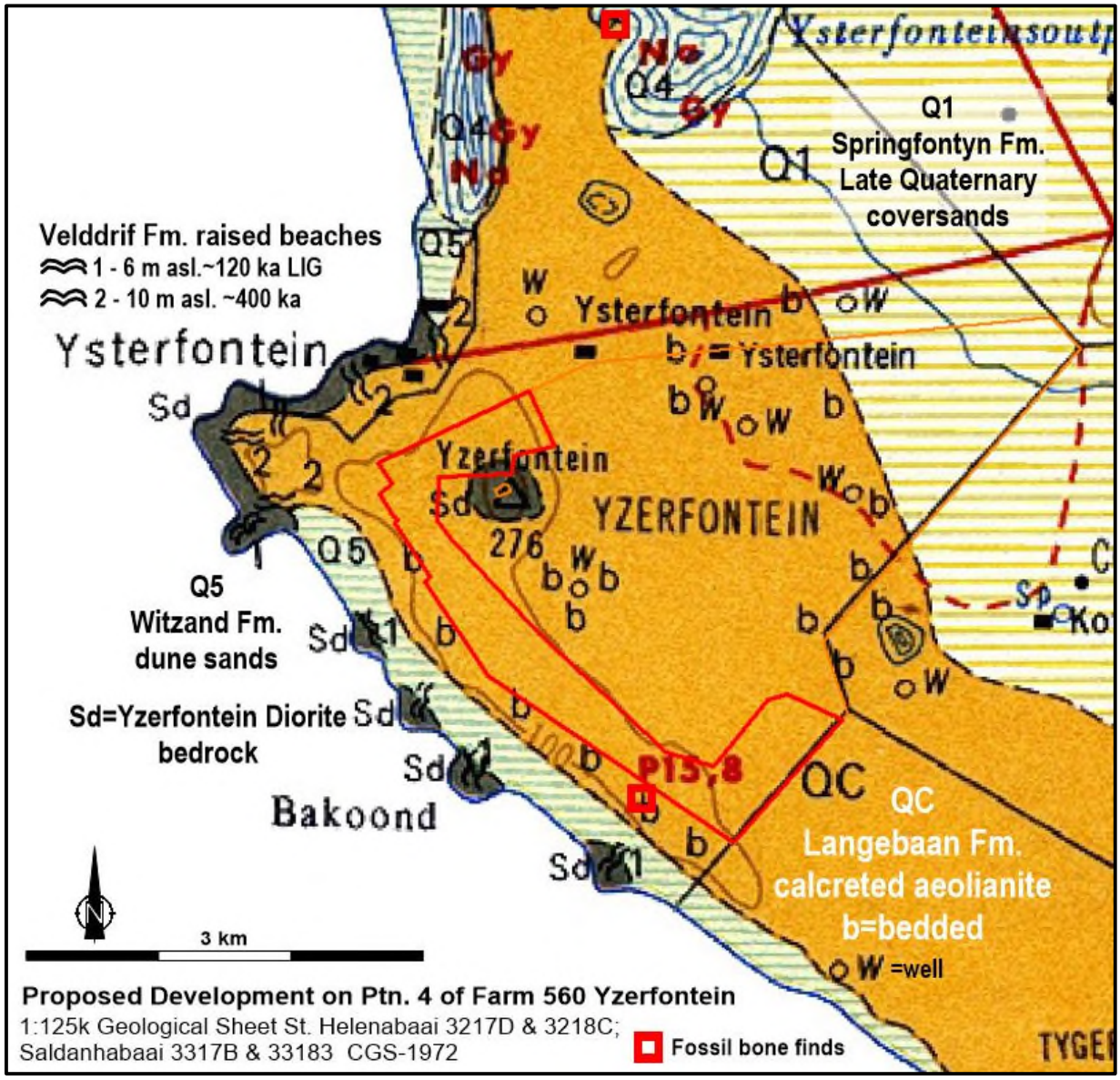



**Figure 5. Surface geology of the Yzerfontein area – Visser & Schoch, 1973.**

### 5.1.3 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 and the "Ice Ages" of the Quaternary Period set in. 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) when sea level was several metres above present level. The higher 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**, being well exposed in the Velddrif area. Velddrif Fm. deposits are more extensive within embayments, with estuarine deposits extending inland up river valleys such as forming the banks of the Berg River.

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 +13 m 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 as the coastline was slightly uplifted since ~7 ka and is usually beneath Witzand Fm. dunes along sandy shorelines.

The Velddrif Fm. is represented on the Yzerfontein headland by the older MIS 11 raised beach on the top of the bedrock cliffs at around 10 m asl. (Figure 5, raised beach 2). To the south the younger LIG raised beach overlies the lower +6 m rock platform (Figures 5 & 6). Covered LIG lagoonal deposits of the Velddrif Fm. underlying and surrounding the Yzerfontein salt pan are depicted in Figure 6.

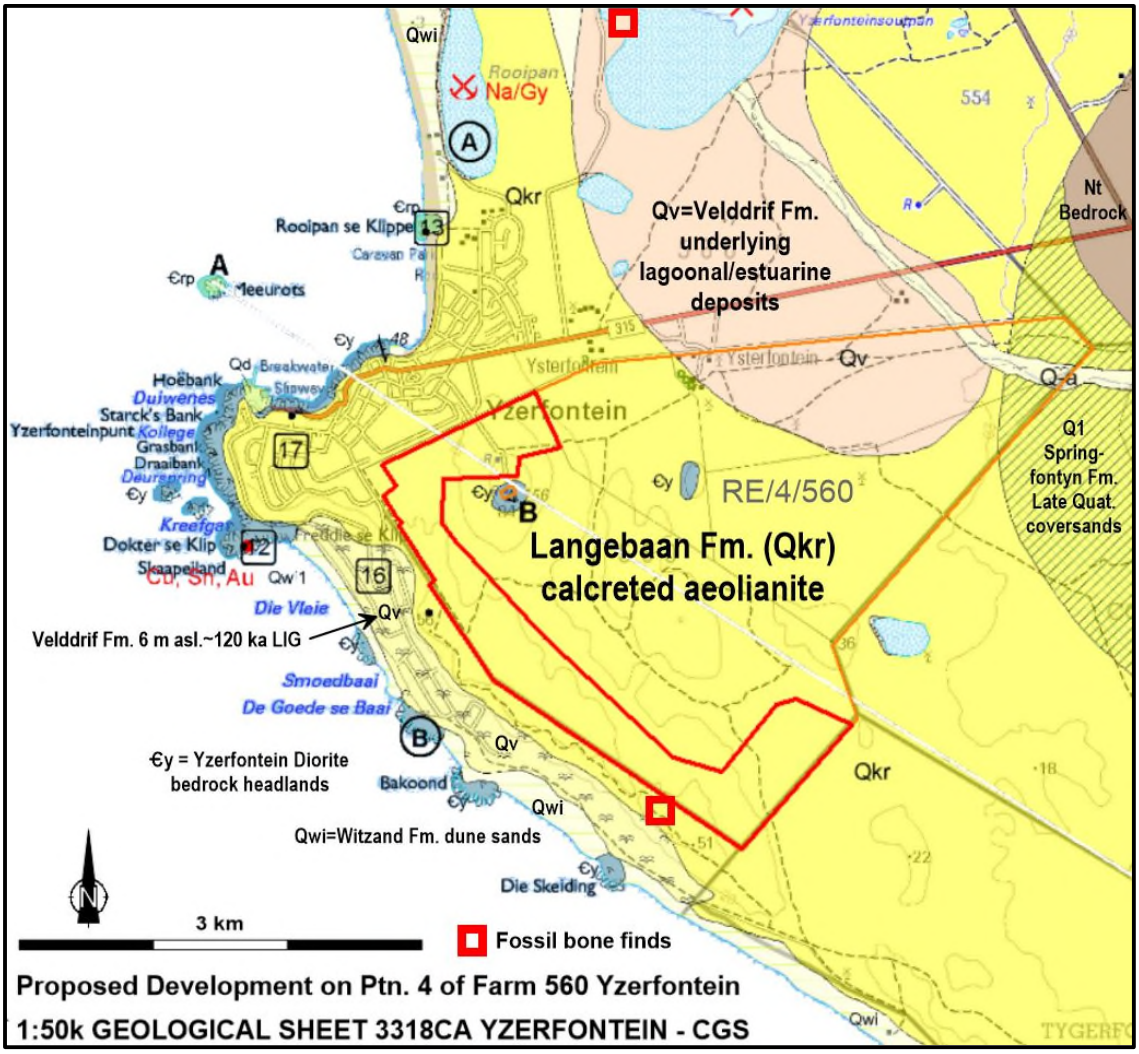



**Figure 6. Surface geology of the Yzerfontein area – later 1:50 000 edition, CGS 2015.**

### 5.1.4 The Aeolian Formations

The aforementioned Miocene and Pliocene marine formations are generally not exposed at the surface and do not feature on geological maps as they are covered by extensive dune plumes and coversand sheets which were blown inland from the successions of ancient shorelines by mainly southerly winds. Near the coast the ages of the marine formations underlying and interbedded with the aeolianite formations provide the prime age control for the aeolianite formations, while inland the main aeolian formations are separated by well-developed fossil soil pedocretes which, if exposures exist, can be traced inland from the coast. Sea-level fluctuations were the major influence on the large-scale architecture of the aeolian formations.

Two main variants of aeolianites recognized in the Sandveld Group:

- **Calcareous aeolianites** which are comprised of sand with a high calcareous content in the form of tiny shell fragments and which includes the semi-lithified and calcreted, older aeolianites of different ages such as the Miocene **Prospect Hill Formation** and the Pliocene and Quaternary **Langebaan Formation**. These calcareous aeolianites formations are evident in the coastal landscape as the ridges, low hills and mounds which have a surface calcrete crust or carapace capping the softer dune rock below. The modern dunes at the coast, called the **Witzand Formation**, generally also have significant shell fragment content.
- **Quartzose aeolianites** which are thicknesses of mainly aeolian sands dominated by quartz sand with limited calcareous content and which are assigned to the **Springfontyn Formation**. The Springfontyn Fm. as applied herein accommodates the quartzose windblown sand sheets and dunes that have covered parts of the coastal landscape during the Quaternary Period. Much older quartzose aeolianites have also been assigned to the Springfontyn Fm., but these are treated separately in Table 1 as later Miocene and Pliocene to early Quaternary formations.

### *Calcareous aeolianites*

The older calcareous dunes recognized comprise the **Prospect Hill Formation** which is the high calcareous 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 5). 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). The Langebaan Fm. has been subdivided into an older Diazville Member and a younger Kraal Bay Member (Roberts & Brink, 2002). The composite nature is reflected in the different ages indicated from fossils found at various places:

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

### *Quartzose aeolianites*

Older quartzose “Springfontyn” aeolianites of considerable thicknesses comprise the coastal plain deposits inland from the coast which are of broadly similar age as the calcareous Mio-Pliocene aeolianites, but not necessarily contemporaneous. These deposits include “glass sands” which are evidently older aeolianites which have been leached by percolating groundwater and which are probably of later Miocene age, as well as aeolianites which have a reworked marine phosphatic sand content, likely of Pliocene to early Quaternary ages (Table 1). These older “Springfontyn” sands are extensively altered by groundwater, with iron-oxide staining and formation of ferruginous and phosphatic concretions, nodules and rinds.

The younger Quaternary Springfontyn Formation is manifest in the landscape in the form of two surficial units of coversands which are widely distributed, with different degrees of soil development. Visser & Schoch (1972, 1973) distinguished the older surface soil cover of dot-patterned hillocky veld (heuweltjiesveld) as **surface unit Q2** and the overlying pale white to slightly reddened sandsheets and low dunes as **surface unit Q1**.

The **Q2** heuweltjiesveld soil is just the surface of a formation of coversands and dunes of mid-Quaternary age, ~800-150 ka. The deposits beneath the Q2 surface are thicker at the locations of old dune plumes

and generally thicken into lower areas in the landscape. In addition to mainly windblown sandsheets, the deposits also comprise the local colluvial/sheetwash deposits, local alluvial stream and flood deposits, and vlei or pan deposits where the water table was near the surface. Pedogenic features such as palaeosols, minor calcretes and ferruginous concretions are also present.

The latest addition to the Springfontyn Formation, the **pale Q1 coversands** (Figures 5, 6), have clearly accumulated episodically, as is evident in sand swathes with differing vegetation patterns seen in aerial images. In places these sands are undergoing semi-active transport and locally have been remobilized into active sandsheets and dunes. The ages obtained from OSL-dating suggest episodic deposition during the last 100 kyr during the late Quaternary.

The latest addition of dunes to the coastal plain is the **Witzand Formation** (Rogers, 1980), 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.




**Figure 7. Exposure of dark, humic Springfontyn Fm. coversands overlying calcrete and a lower pink palaeosol in the underlying Langebaan Fm., in a cut-back in the seaward scarp of the Yzerfontein aeolianite ridge. An informative exposure, but not inspected or recorded.**

## 6 LOCAL GEOLOGICAL SETTING – AFFECTED FORMATIONS

The seaward, western part of the Project Area is located along the crest and landward slopes of a coast-parallel, calcreted aeolianite ridge which crests at 40-50 m asl. and slopes inland down to about 25 m asl. (Figures 2 & 3). In the north the Project Area extends NE-wards, occupying the northern slopes of the conical hill which has the reservoirs and telecoms tower on its summit. In the south the subdivision area extends NE-wards across flat land at ~20 m asl., but this area is to be zoned as Open Space (Figure 4).

The age of the Yzerfontein ridge of Langebaan Fm. aeolianite is approximated from the contexts of marine deposits and sea-level history. Due to its geomorphological position the base of the aeolianite ridge is likely underlain by the Uyekraal Fm. and post-dates the late Pliocene (~3 Ma). Visser and Schoch (1973) record that the higher +10 m asl. raised beach occupies the rock platform fringing the Yzerfontein headland, but importantly, note that the "upper terrace" has been cut into the Langebaan limestone. To the south there is no outcrop of the "upper terrace/raised beach", but there is a prominent scarp eroded in the aeolian ridge above about +15 m (Figure 2). On this basis it would seem that the Langebaan Fm. ridge pre-dates the MIS 11 sea level high of +13 m at about 400 ka.

In the north the Langebaan Fm. lapping onto the slopes of the Yzerfontein conical hill may be underlain by eroded remnants of marine deposits evident as residual rounded boulders and cobbles and possibly fossil shells.

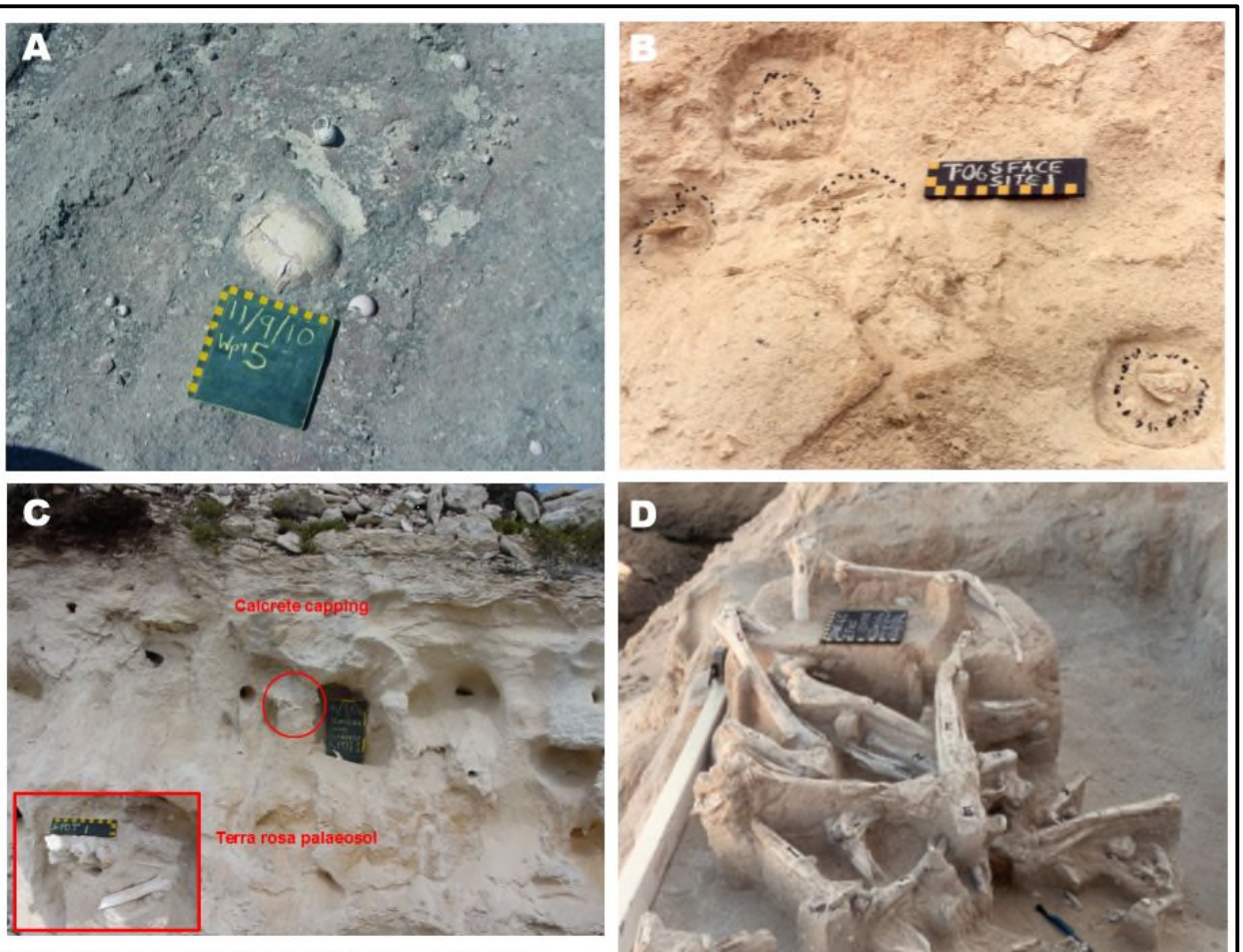
The Project Area is situated practically entirely on **calcreted Langebaan Fm**. calcareous aeolianite (Figures 5 & 6), beneath a generally thin (<1 m) mantle of quartzose coversands of the **Springfontyn Fm.**

**Q1 sandy soil** bearing Strandveld vegetation (Figure 7). Note that in Figures 5 and 6 the coversands are not depicted where they thinly overlie the Langebaan Fm. calcrete.

The subsurface impact of the proposed development primarily affects the fossils which occur in aeolian deposits.

## 7 FOSSILS IN AEOLIAN FORMATIONS

In aeolianites such as the sandsheets and dunes of the Springfontyn and Langebaan formations the fossil material most commonly seen is the ambient fossil content of dune sands: land snails, tortoise shells and mole bones (Figure 8A). 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), usually with abundant fossil plant roots, 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.




A. Fossil tortoise and Trigonephrus land snails on a palaeo-surface in aeolianites.
B: Cryptic occurrence of scattered fossil bones in calcrete.
C: Fossil bone concentration (circled) in the infill of a cavity below the calcrete capping of the Langebaan Formation.
D: Excavated fossil bone concentration in the infill of a hyaena burrow.

**Figure 8. Examples of fossil bones in aeolianites.**

The deposits of wetlands are interbedded locally in the aeolianites and have proven to be important sources of fossils. Dune ridges soak up rainwater which then percolates out at lower elevation in the interdune areas between dune ridges. The low areas may host deposits associated with small springs/seeps and marshy vleis which are richly fossiliferous, including fossil plant material, aquatic snails and frogs. Calcretes and clayey palaeosols within the dune ridge can act as perched aquifers, producing local water-source seeps on ridge flanks. Water-source associated 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 springs and 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. In well-cemented aeolianite the snapped-off bones in a vertical face are not easy to spot, but a cluster of bones (Figure 8B) is probably a bone-filled burrow. Often the bone-filled burrow is in softer, excavatable sands beneath the calcrete (Figure 8C & D).

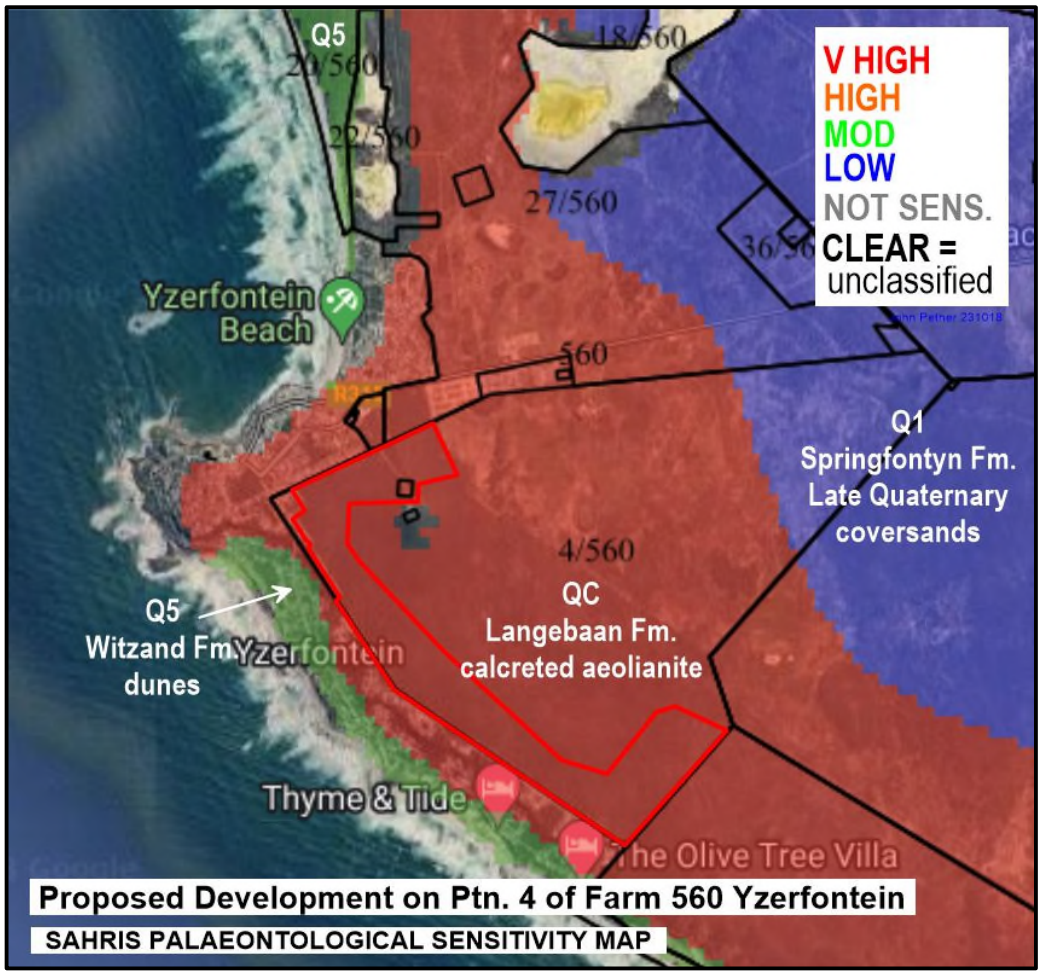



**Figure 9. Palaeontological Sensitivity classification of the surface formations.**

## 8 PALAEONTOLOGICAL SENSITIVITIES

Fossil bones are the main concern and are overall quite sparse in the **Springfontyn Fm. Q1 coversands** and soils. Fossil bones and shells bones in the subsurface of the Q1 coversands are often in an archaeological context and within about a kilometre of the coast there is a higher probability that fossil bones could be encountered in excavations in the Springfontyn Fm. sands.

Fossil bones in a primary context are occasionally discovered and are typically exposed during construction of coastal developments where the finds are of large bones that get readily noticed, such as bigger antelopes and buffalo, rhino, hippo, bush pigs and elephants. The fossil bones are often on a palaeosurface underlying the loose coversands such as on top of the calcrete of the underlying Langebaan Fm. In places sometimes scattered bones occur more persistently in an area several tens of metres in extent and are likely to reflect a nearby, pre-existing water source and activity by humans and other predators.

The fossil bones in the coversands are expected to be of late Quaternary age and likely to be mainly members of the extant, modern fauna, but some extinct species could occur. With the exception of rare local "hotspots", due to the overall scarcity of fossil bones in the coversands and underlying buried soils, the palaeontological sensitivity of the Springfontyn Fm. Q1 coversands is overall LOW (Figure 9, Appendix 2).

The top of the **Langebaan Fm**. calcrete is a long duration palaeosurface subjected to weathering and solution processes and may bear weathered-out fossil bones, as well as fossil material deposited later on but prior to the accumulation of the coversands, including fossils accumulated in solution holes. The calcreted Langebaan Formation is classified to be of VERY HIGH sensitivity (Figure 9), due to previous fossil finds of significant scientific value, such as the fossils occurring on naturally-exposed deflating palaeosurfaces, in quarries and in ancient hyaena lairs.

As noted above, previous observations suggest that the Langebaan Fm. Yzerfontein aeolianite ridge is older than about 400 ka and the fossil bones which may occur are representatives of a more archaic fauna of earlier middle Quaternary age or older, *e.g*. 400 – 1000 ka.

Phosphatized, petrified bone fragments are reported from a site on the seaward scarp of the Yzerfontein aeolian ridge, near its southern end (Figures 2, 5 & 6, red square). The mineralized bone occurs "very commonly" in association with phosphatic nodules (Visser & Schoch, 1973). Evidently the dunes had an original phosphatic sand content, derived from reworking of Pliocene marine sands, which was later subject to solution and local re-precipitation in the mineralizing groundwater. This relatively high phosphatic content and more advanced groundwater alteration supports the older age for the Yzerfontein Langebaan Fm. dune ridge. However, coastal dune cordons are usually composite accumulations and the uppermost, last additions, such as may now be calcreted, may be younger. Shallow excavations into the calcrete capping may not intersect the underlying, mineralized older aeolianite bearing petrified bones. Nevertheless, in terms of the sensitivity rating scheme employed (Appendix 2), the Langebaan Fm. is rated HIGH.

The Langebaan Fm. calcretes and compact calcareous beds contain palaeontological resources of profound scientific value which include rare, well-preserved fossil bones important to on-going palaeoclimatic, palaeobiological and/or evolutionary studies, raising international interest in the region. The Langebaan beds do not appear to be very fossiliferous and although fossil bones are overall sparsely present, they are more common than perceived from initial impressions.

**Residual marine deposits** of Pliocene age might be encountered on the lower slopes of the Yzerfontein conical hill. It is likely these deposits would be decalcified, but robust shells such as oysters may be preserved, or the moulds of dissolved shells. Such occurrences are not expected to be a source of quality shell fossil specimens and the palaeontological sensitivity may be rated as LOW, but it is important to describe, record and sample any such exposures.

# 9 ASSESSMENT OF IMPACTS

## 9.1 NATURE OF THE IMPACT OF BULK EARTH WORKS ON FOSSILS

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.

### 9.1.1 Extents

The physical extent of impacts on potential palaeontological resources relates directly to the extents of subsurface disturbance involved in the Construction Phase, *i.e*. LOCAL.

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.

### 9.1.2 Duration

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.

### 9.1.3 Intensity/Magnitude

The intensity or magnitude of impact relates to the palaeontological sensitivities of the affected formations (Appendix 2) and the volume of disturbance by excavation. The proposed development involves trenches for conventional building foundations (0.6-0.8 m depth) and services infrastructure (1.0-2.0 m depth). Deeper excavations are also involved in swimming pool installations.

Although the palaeontological sensitivity of the Springfontyn Fm. coversands is rated low, the intensity of impact of the construction phases is rated as MODERATE due to the large development footprint and the considerable volume of coversands which will be excavated.

Most of the infrastructure trenches are likely to intersect the calcreted, upper Langebaan Fm. beneath the coversands. Most intersections are expected to be relatively shallow, affecting mainly the calcrete in which the fossil bones are overall sporadic, but locally more common. As above, due to the large development footprint, the potential impact is rated HIGH in the absence of effective mitigation.

### 9.1.4 Probability of occurrence

Although fossil bones are overall sparse in the Springfontyn Fm. coversands and the underlying Langebaan Fm. calcrete, given the considerable footprint of the proposed development, it is PROBABLE that fossil bones could be discovered, most likely in association with archaeological material.

The intersection of residual marine deposits on the north slopes of the Yzerfontein conical hill is IMPROBABLE, *i.e*. some possibility, but low likelihood.

### 9.1.5 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.

### 9.1.6 Irreplaceable loss of resources

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

### 9.1.7 Reversibility

Palaeontological resources are unique and their loss is IRREVERSIBLE.

### 9.1.8 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.

### 9.1.9 Cumulative impacts

The cumulative impact of coastal developments is the inevitable and permanent loss of fossils and the associated scientific implications. As mentioned, the impact of both the finding and 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.

### 9.1.10 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.

### 9.1.11 Degree to which impact can be managed

Experience of coastal developments and mining 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. 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. The success of management is thus LOW to MODERATE.

### 9.1.12 Degree to which an impact can be mitigated

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

### 9.1.13 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.

## 9.2 SUMMARY IMPACT TABLES

According to the rating scheme in Appendix 1.

### 9.2.1 Springfontyn Formation Q1 Coversands

| **Loss of fossil bones and archaeological material from excavations in the Springfontyn Formation loose coversands.** | | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Extent** | **Duration** | **Intensity** | **Status** | **Probability** | **Significance** | **Confidence** |
| **Without mitigation** | Local<br>1 | Permanent<br>5 | Low<br>4 | Negative | Probable<br>3 | MEDIUM<br>30 | M |
| Essential mitigation measures<br>• Construction personnel to be alert for rare fossil bones and follow "Fossil Finds Procedure".<br>• Cease construction on (chance) discovery of fossil bones and protect fossils from further damage.<br>• Contact appointed palaeontologist providing information and images.<br>• Palaeontologist will assess information and establish suitable response, such as the importance of the find and measures for preservation, collection and record keeping.<br>• Exposed fossiliferous sections in earthworks recorded and sampled by appointed palaeontologist. | | | | | | | |
| **With mitigation** | Local<br>1 | Permanent<br>5 | Low<br>4 | Positive | Probable<br>3 | MEDIUM<br>30 | M |

### 9.2.2 Langebaan Formation Calcrete

| **Loss of fossil bones from excavations in the Langebaan Formation calcrete.** | | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Extent** | **Duration** | **Intensity** | **Status** | **Probability** | **Significance** | **Confidence** |
| **Without mitigation** | Local<br>1 | Permanent<br>5 | High<br>8 | Negative | Probable<br>3 | MEDIUM<br>42 | M |
| Essential mitigation measures<br>• Construction personnel to be alert for rare fossil bones and follow "Fossil Finds Procedure".<br>• Cease construction on (chance) discovery of fossil bones and protect fossils from further damage.<br>• Contact appointed palaeontologist providing information and images.<br>• Palaeontologist will assess information and establish suitable response, such as the importance of the find and recommendations for preservation, collection and record keeping.<br>• Exposed fossiliferous sections in earthworks recorded and sampled by appointed palaeontologist. | | | | | | | |
| **With mitigation** | Local<br>1 | Permanent<br>5 | High<br>8 | Positive | Probable<br>3 | MEDIUM<br>42 | M |

### 9.2.3 Residual Marine deposits

| **Loss of past sea-level observations and possible loss of fossil shells.** | | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Extent** | **Duration** | **Intensity** | **Status** | **Probability** | **Significance** | **Confidence** |
| **Without mitigation** | Local<br>1 | Permanent<br>5 | Low<br>4 | Negative | Improbable<br>2 | Low<br>20 | M |
| Essential mitigation measures<br>• Construction personnel and ECO to be aware that a temporary exposure of rounded marine gravels and possible shelly beds will require sampling and recording.<br>• In the event of an exposure of marine deposits 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.<br>• Selected exposed fossiliferous sections in earthworks recorded and sampled by appointed palaeontologist. | | | | | | | |
| **With mitigation** | Local<br>1 | Permanent<br>5 | Low<br>4 | Positive | Improbable<br>2 | Low<br>20 | M |

## 9.3 SIGNIFICANCES

Without mitigation the significance of the impact of the proposed development on the fossil bone content of the Springfontyn Fm. is MEDIUM NEGATIVE and with mitigation is MEDIUM POSITIVE.

Without mitigation the significance of the impact of the proposed development on the fossil bone content of the Langebaan Fm. is MEDIUM NEGATIVE. Notwithstanding such medium significances, but 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 significances of the impacts of the proposed development on scientific observations relating to sea-level history and marine shell fossils are LOW NEGATIVE and with mitigation are LOW POSITIVE. Although unlikely, the discovery of well-preserved fossil shells will have a HIGH POSITIVE impact.

# 10 RECOMMENDATIONS

## 10.1 CONSTRUCTION PHASE MONITORING

### 10.1.1 Construction Personnel – Fossil Finds Procedure

The monitoring of construction earthworks by an archaeologist may be a recommendation of the Archaeological Impact Assessment, but can only take place at intervals. However, the rescue of fossil bones during earthworks critically depends on spotting this material as it is uncovered during digging *i.e.* by continuous monitoring of excavation activity. As it is not feasible for a specialist to be continuously present the construction personnel must be involved in mitigation by watching for fossils. It is recommended that a requirement to be alert for possible fossils be included in the EMP for the Construction Phase of the proposed development, with a **Fossil Finds Procedure** in place. The Fossil Finds Procedure included as Appendix 3 provides guidelines to be followed in the event of fossil finds.

The Project Manager, foremen and workers involved in excavating earthworks must be informed of the need to watch for fossils. Workers seeing potential objects are to cease work at that spot and to report to the Project Manager and/or the Environmental Control Officer (ECO). The ECO will inform the developer and contact the standby palaeontologist in the case of fossil finds. The latter will liaise with Heritage Western Cape on the nature of the find and suitable consequent actions such as immediate site inspection, application for a palaeontological collection permit and drafting of a work plan for the collection of the find.

It is recommended that management arranges that earthworks personnel visit the West Coast Fossil Park to be acquainted with fossil bones and palaeontological science.

If fossil bones are discovered, or if marine gravel deposits are exposed, a professional palaeontologist must be appointed to collect the fossils. Said palaeontologist must also undertake the recording of the stratigraphic context and sedimentary geometry of the fossil exposure site and the compilation of the report to Heritage Western Cape and the IZIKO S.A. Museum.

### 10.1.2 Field Recording of Excavations

At each development node/precinct, at the times when the deeper excavations for infrastructure have been made and are open for inspection, a professional palaeontologist must record the exposures.

The aim of periodic field inspections and recording of excavation exposures over the Construction Phase is to acquire an overall and representative scientific record of the shallow stratigraphy of the Project Area and the characteristic features of the various formations encountered, in order to provide a more complete context of the fossil finds. As for the latter, at appropriate informative sites, the exposed sections must be described, photographed in detail, the ambient small fossil content collected and the sediments sampled for future study of composition and microfossil content.

The specifics of setting up the periodic inspection and recording programme will be agreed between The Developer and the ECO, who must liaise with the contracted palaeontologist and inform about the nature of the strata being exposed in the excavations in the development areas, the aim being to timeously record the most instructive, deeper stratigraphic exposures. For each development area this should involve a day for fieldwork and 2-3 days for fossil preparation and report compilation. The field visit may also include the taking custody of *ad hoc* fossil finds, such as discovered in spoil material.

The rescue of discovered palaeontological remains and recording of exposures by a contracted specialist shall be at the Developer's expense.

### 10.1.3 Mitigation Summary for the Construction Phase EMP

The following measures apply to all earthworks affecting the formations discussed above.

| **OBJECTIVE: To see and rescue fossil material that may be exposed in the excavations made for construction of the proposed developments.** | | |
|---|---|---|
| **Project components** | Excavations for foundations and water, power and waste infrastructure. | |
| **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 Developer, the EIA practitioner, the ECO & contractors. | Construction. |
| Inform staff of the Fossil Finds Procedures to be followed in the event of fossil occurrences. | ECO/specialist. | Construction. |
| Monitor for presence of fossils. | Contracted personnel and ECO. | Construction. |
| Liaise on nature of potential finds and appropriate responses. | ECO and specialist, HWC. | Construction. |
| Obtain permit from HWC for fossil finds collection. | Specialist. | Construction. |
| Excavate main finds, inspect pits & record and sample excavations. | 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. | |

## 10.2 POST-CONSTRUCTION MITIGATION – ONGOING OCCUPANCY PHASE

Fossil bones may be exposed in further earthworks by residents, such as the installation of swimming pools, foundations for building additions, landscaping and horticultural diggings. The Operational/Occupancy EMP must include a Heritage Management Plan with an ongoing mitigation component. It must include a

Heritage Information Document for distribution to residents which includes a summary of the broader geohistory and archaeology of the area and the nature and significance of the archaeology and fossils discovered during the Construction Phase. The Fossil Finds Procedure must also be included, with residents aware that fossil finds must not be further disturbed and that the Development Management must be informed and HWC and the West Coast Fossil Park must be notified.

## 11 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.

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.

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.quarr

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.

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.

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.

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.

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.

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# 12 APPENDIX 1. METHODOLOGY FOR ASSESSING THE SIGNIFICANCE OF IMPACTS

| EFFECT | | | |
|---|---|---|---|
| | **Extents/Spatial Scale** | | **E** |
| | Localized | At localized scale and a few hectares in extent. | 1 |
| | Study area | The proposed site and its immediate environs. | 2 |
| | Regional | District and Provincial level. | 3 |
| | National | Country. | 4 |
| | International | Internationally. | 5 |
| | **Duration/Temporal Scale** | | **D** |
| | Very short | Less than 1 year. | 1 |
| | Short term | Between 2 to 5 years. | 2 |
| | Medium term | Between 5 and 15 years. | 3 |
| | Long term | Exceeding 15 years and from a human perspective almost permanent. | 4 |
| | Permanent | Resulting in a permanent and lasting change. | 5 |
| | **Magnitude/Intensity (Palaeontological Sensitivity)** | | **M** |
| | No potential | Formations entirely lacking fossils such as igneous rocks. | 0 |
| | Marginal | Limited probability for producing fossils from certain contexts at localized outcrops. | 2 |
| | Low | Depositional environment where fossils are unlikely to be preserved, or are judged unlikely to produce unique fossil remains. | 4 |
| | Medium | Strong potential to yield fossil remains based on stratigraphy and/or geomorphologic setting. | 6 |
| | High | Formations known to contain palaeontological resources that include rare, well-preserved fossil materials. | 8 |
| | Very high | Formations/sites known or likely to include vertebrate fossils pertinent to human ancestry and palaeoenvironments and which are of international significance. | 10 |
| | **Probability/Likelihood** | | **P** |
| | Very improbable | Probably will not happen. | 1 |
| | Improbable | Some possibility, but low likelihood. | 2 |
| | Probable | Distinct possibility of these impacts occurring. | 3 |
| | Highly probable | The impact is most likely to occur. | 4 |
| | Definite | The impact will definitely occur regardless of prevention measures. | 5 |
| | | | |

| **SIGNIFICANCE = (E+D+M)P** | | |
|---|---|---|
| < 30 | LOW | The impact would not have a direct influence on the decision to develop in the area |
| 30-60 | MEDIUM | The impact could influence the decision to develop in the area unless it is effectively mitigated |
| >60 | HIGH | The impact must have an influence on the decision process to develop in the area |

# 13 APPENDIX 2. 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. Sediments that have been altered by advanced weathering involving decalcification are also 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.*

# 14 APPENDIX 3. FOSSIL FINDS PROCEDURE

## 14.1 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.

## 14.2 RESPONSE BY PERSONNEL IN THE EVENT OF FOSSIL FINDS

In the process of digging the excavations fossils may be spotted in the excavation sides or bottom, or as they appear in excavated material during loading.

» 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 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.

Fossil material may also be spotted amongst disturbed material during its further handling, *e.g*. loading and discharging sand into stockpiles, such as fossil bones embedded in the chunks of calcrete and compact sands, or revealed in crumbing lumps of sandy soil. The fossil material must be rescued immediately and the heap in the vicinity of the find should be searched for material still hidden. Bone-bearing chunks and loose fossil bones must be moved to an appropriate storage spot for safekeeping. The ECO or site agent

must inform the standby archaeologist or palaeontologist, providing context information and images of the finds.

### 14.3 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. The rescue of discovered palaeontological remains by a contracted specialist shall be at the Developer's expense.

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## 14.4 HERITAGE WESTERN CAPE RECORDING FORM

| FOSSIL DISCOVERIES: HWC PRELIMINARY RECORDING FORM | | |
|---|---|---|
| Name of project: | | |
| Name of fossil location: | | |
| Date of discovery: | | |
| Description of situation in which the fossil was found: | | |
| Description of context in which the fossil was found: | | |
| Description and condition of fossil identified: | | |
| GPS coordinates: | Lat: | Long: |
| If no co-ordinates available then please describe the location: | | |
| Time of discovery: | | |
| Depth of find in hole | | |
| Photographs (tick as appropriate and indicate number of the photograph) | Digital image of vertical section (side) | |
| | Fossil from different angles | |
| | Wider context of the find | |
| Temporary storage (where it is located and how it is conserved) | | |
| Person identifying the fossil | Name:<br>Contact: | |
| Recorder | Name:<br>Contact: | |
| Photographer | Name:<br>Contact: | |

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