PALAEONTOLOGICAL IMPACT ASSESSMENT
(Desktop Study)

Proposed construction of a marine outfall pipeline and associated infrastructure in Danger Bay in the Saldanha Bay region, Western Cape, South Africa

The Saldanha Regional Marine Outfall Project

By

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SUMMARY

The context of this report is the proposed Saldanha Regional Marine Outfall (SRMO) Project. The proposal involves the disposal into the sea at Danger Bay of treated industrial effluent, from:

- The Rare Earth Element (REE) Separation Plant proposed by Frontier Separation Pty (Ltd) (Frontier Separation), referred to as the Saldanha Separation Plant (SSP), which will refine REE feedstock mined at the Zandkopsdrift Mine in southern Namaqualand by Sedex Minerals (Pty) Ltd.
- The associated Chlor-Alkali Production Facility (CAPF) proposed by Chlor-Alkali Holdings Pty (Ltd) (CAH), a supplier of reagents situated adjacent to the SSP.
- A regional Waste Water Treatment Works (WWTW) proposed by the Saldanha Bay Municipality (SBM).

The treated effluents are to be collected and transported via a pipeline and pump stations to a proposed marine outfall in Danger Bay, west of Saldanha Bay town (Figure 1). The SRMO project's terrestrial pipeline corridors in the Saldanha Bay area will follow a similar route than that of the proposed West Coast District Municipality (WCDM) Sea Water Reverse Osmosis Plant (SWROP) study that is proposed to feed potable water from Danger bay to the Besaansklip Reservoir.

Frontier Saldanha Utilities (Pty) Ltd (Frontier Utilities), a subsidiary of Frontier Separation, appointed the Council for Scientific and Industrial Research (CSIR) to undertake the Environmental Impact Assessment (EIA) for the proposed SRMO Project.

This assessment forms part of the Heritage Impact Assessment (HIA) in the EIA process and it addresses the probability of palaeontological materials (fossils) being uncovered in the subsurface and being disturbed or destroyed in the process of bulk earth works undertaken during the construction phase.

The main purposes are to:

- Outline the nature of possible palaeontological/fossil heritage resources in the subsurface of the affected areas; and
- Suggest the mitigatory actions to be taken with respect to the occurrence of fossils during bulk earth works.

The project components and the alternative options under consideration are illustrated in Figure 1. The terrestrial pipeline corridor will extend for approximately 27 km from the SSP and CAPF to the outfall in Danger Bay. Five pump stations along the pipeline servitude are planned at Pump station positions A, B, C, D and E. With reference to the geology (Figures 2 and 4), from the SSP and CAPF (Pumpstation A) the initial ~12 km of the pipeline route traverses the flat coastal plain underlain by the **Langebaan Formation** calcretes beneath thin coversands. Between Pumpstation C and the intersection with the Vredenburg road the route passes onto the **Springfontyn Formation** sands and soils, mainly Q2 "heuweltjiesveld", that covers the gentle slope, with granite outcrops, that forms the eastern flank of the broad granite ridge highground along the western part of the Vredenburg Peninsula. Thereafter the pipeline route crosses over onto the calcrete capping of the

Prospect Hill Formation aeolianites which are banked up against the western, seaside flank of the granite ridge. Further west the Prospect Hill Formation calcretes are overlain by the younger Langebaan Formation aeolianites and near Jacobsbaai is the branch point for the two alternative routes south, the Jacobsbaai Eastern Corridor and the Jacobsbaai Western Corridor. Both these routes cross the Langebaan Formation up to where it is overlain by recent dunes of the **Witzand Formation** about 1 km from the seashore, upon which the proposed WCDM SWROP, Pumpstation E and both outfall route options are situated. The **Velddrif Formation** beach deposits occur beneath the Witzand dunes and are expected to be within ~300 m inland of the beach. It is possible that the pipeline trench could intersect these deposits if it is made quite deep in the dune slope down to sea level.

Primarily aeolian deposits will be intersected by the project earthworks. The palaeontological sensitivities are summarised below.

Table 1. Affected formations of the Sandveld Group in the study area.

FORMATION	**Age and description**	**Sensitivity**
WITZAND - Q5	Holocene and recently active dune fields and cordons <~12 ka.	Mainly archaeological sites.
SPRINGFONTYN - Q1 & Q2	Quaternary to Holocene, mainly quartzose dune and sandsheet deposits, interbedded palaeosols, basal fluvial deposits <~2 Ma.	Fossil bones very sparse, local to high signif. Basal fluvial deposits locally – high signif.
VELDDRIF - VD	Quaternary raised beaches & estuarine deposits, <~1.2 Ma. Sea-levels below ~15 m asl.	Shell fossils common, local signif. Fossil bones very sparse, high signif.
LANGEBAAN - LB	Late Pliocene to Late Quaternary aeolianites <~3 Ma to ~60 ka.	Fossil bones mod. common, local to high signif.
PROSPECT HILL - PH	Late Miocene aeolianite 12-9 Ma?	Fossils very sparse – high signif.

For the evaluation of palaeontological impacts it is the extent/scale of the bulk earth works that are the main concern. The main impact is the bulk earth works for the trenches in which the pipeline will be buried. For a pipe ~900 mm in diameter it is assumed the trench will be about 1.5 to 2.0 metres wide and ~1.5 metres deep. Other earth works, dimensions not yet specified, are involved in the construction of the pump stations (transfer tanks, bund walls and sumps). The subsurface of the area has a distinct probability of containing fossils that will be exposed during earth works along the pipeline route. The main “bulk” of aeolianites is not very fossiliferous, but the fossils already discovered in aeolianites in the Saldanha area are of international significance.

A practical monitoring and mitigation programme must be implemented during the Construction Phase of the proposed SRMO Project. Immediate interventions are required if fossil bones are turned up during earth works, but it is not usually practical for a specialist to be continuously present during the Construction Phase. It is therefore proposed that personnel involved in the making of excavations must keep a lookout for fossil material during digging. Appendices 1 and 2 outline monitoring by construction personnel and general Fossil Find Procedures for various scenarios, for inclusion in the Environmental Management Plan (EMP). In the event of possible fossil and/or archaeological finds, the contracted archaeologist or palaeontologist must be contacted. For possible fossil finds, the palaeontologist will assess the information and liaise with the developer and the Environmental Control Officer (ECO) and a suitable response will be established.

In addition to effecting the rescue of fossil material that has been uncovered, it is recommended that the contracted palaeontologist carry out field inspections at appropriate stages in the making of the excavations. The aim of field inspection is to record the ephemeral, last chance to see, exposures of the deposits in the temporary construction earthworks. Target sites would be those where deeper excavations have exposed more vertical section, or any exposure that has features that are informative about the geometry, lateral variation and aspects of the genesis of the deposits.

The details of the programme must await the finalization of the proposals for the project, when the contracted palaeontologist will liaise with Frontier Utilities, the appointed environmental manager and construction contractors about the specifics of setting up a monitoring and inspection programme.

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DECLARATION BY THE INDEPENDENT PERSON WHO COMPILED A SPECIALIST REPORT OR UNDERTOOK A SPECIALIST PROCESS

PALAEONTOLOGICAL IMPACT ASSESSMENT (Desktop Study).

Proposed construction of a marine outfall pipeline and associated infrastructure in Danger Bay in the Saldanha Bay region, Western Cape, South Africa. The Saldanha Regional Marine Outfall Project

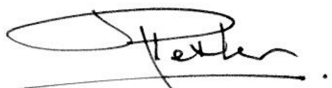
Terms of Reference

This assessment forms part of the Heritage Impact Assessment in the EIA process and it assesses the probability of palaeontological materials (fossils) being uncovered in the subsurface and being disturbed or destroyed in the process of bulk earth works. Mitigatory actions to be taken with respect to the occurrence of fossils during bulk earth works are proposed.

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, 2010 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, 2010 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 71 of GN No. R. 543, 2010.



Signature of the specialist

Date: 7 August 2014

The author is an independent consultant/researcher and is a recognized authority in the field of coastal-plain and continental-shelf palaeoenvironments and is consulted by exploration and mining companies, by the Council for Geoscience, the Geological Survey of Namibia and by colleagues/students in academia pursuing coastal-plain/shelf projects.

Expertise

- Shallow marine sedimentology.
- Coastal plain and shelf stratigraphy (interpretation of open-pit exposures and on/offshore cores).
- Marine macrofossil taxonomy (molluscs, barnacles, brachiopods).
- 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.
- Heritage Western Cape. Member, Permit Committee for Archaeology, Palaeontology and Meteorites.
- Accredited member, Association of Professional Heritage Practitioners, Western Cape.

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ABBREVIATIONS

CAH	Chlor-Alkali Holdings Pty (Ltd)
CAPF	Chlor-Alkali Production Facility
CSIR	Council for Scientific and Industrial Research
ECO	Environmental Control Officer
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
DEA&DP	Western Cape Department of Environmental Affairs and Development Planning
GRP	Glass Reinforced Plastic
HDPE	High Density Poly-Ethylene
HIA	Heritage Impact Assessment
HWC	Heritage Western Cape
MV	Medium Voltage
NEMA	National Environmental Management Act
NID	Notification of Intent to Develop
REE	Rare Earth Elements
SAHRA	South African Heritage Resources Agency
SBM	Saldanha Bay Municipality
SRMO	Saldanha Regional Marine Outfall
SWROP	Sea Water Reverse Osmosis Plant
SSP	Saldanha Separation Plant
OHL	Overhead lines
WCDM	West Coast District Municipality
WWTW	Waste Water Treatment Works

1 INTRODUCTION

1.1 BACKGROUND

The context of this report is the proposed Saldanha Regional Marine Outfall (SRMO) Project. The proposal involves the disposal into the sea at Danger Bay of treated industrial effluent, from:

- The Rare Earth Element (REE) Separation Plant proposed by Frontier Separation Pty (Ltd) (Frontier Separation), referred to as the Saldanha Separation Plant (SSP), which will refine REE feedstock mined at the Zandkopsdrift Mine in southern Namaqualand by Sedex Minerals (Pty) Ltd.
- The associated Chlor-Alkali Production Facility (CAPF) proposed by Chlor-Alkali Holdings Pty (Ltd) (CAH), a supplier of reagents situated adjacent to the SSP.
- A regional Waste Water Treatment Works (WWTW) proposed by the Saldanha Bay Municipality (SBM).

The treated effluents are to be collected and transported via a pipeline and pump stations to a proposed marine outfall in Danger Bay, west of Saldanha Bay (Figure 1).

The outcome is the proposed SRMO Project, a project that envisages the integration of these brine disposal requirements, and probable future requirements, into a regional facility for Saldanha Industrial developments.

The feasibility of a marine outfall in the Danger Bay area was initially investigated for the proposed West Coast District Municipality (WCDM) Sea Water Reverse Osmosis Plant (SWROP) study, for the disposal of brine generated by the desalination process. This project also investigated the feasibility of various terrestrial pipeline routes to transport potable water from the proposed SWROP sites to the reservoir on Besaansklip. The EIA study, undertaken by the CSIR, included a desktop PIA (Pether, 2012).

The project proponent is **Frontier Saldanha Utilities (Pty) Ltd** (Frontier Utilities), a subsidiary of Frontier Separation (Pty) Ltd (the proposed Frontier REE SSP). The latter is a subsidiary of the main corporate company, Frontier Rare Earths Ltd, which will mine REEs at the Zandkopsdrift Mine in southern Namaqualand (subsidiary Sedex Minerals (Pty) Ltd).

In 2013 Frontier Utilities commissioned Royal HaskoningDHV (Pty) Ltd (RHDHV) to complete a Pre-Feasibility Study and design for the SRMO Project. The three brine streams will converge to a single, redesigned marine outfall in Danger Bay, ideally joining there with the proposed WCDM SWROP brine discharge outfall. However, the construction of the WCDM SWROP may be delayed. Thus an option under consideration is the construction of an interim Pump Station E and outfall option in Danger Bay to be used until the WCDM SWROP becomes operational, after which all brines will be redirected, combined and discharged via the single, new outfall with the WCDM SWROP brine return.

Frontier Utilities has appointed the Council for Scientific and Industrial Research (CSIR) to undertake the Environmental Impact Assessment (EIA) for the proposed SRMO.

This assessment forms part of the Heritage Impact Assessment in the EIA process and it assesses the probability of palaeontological materials (fossils) being uncovered in the subsurface and being disturbed or destroyed in the process of bulk earth works undertaken during the construction phase of the proposed SRMO.

Notably, palaeontological interventions happen once fossil material is exposed at depth, *i.e*. once the EIA process is done and construction commences. Unless formations bearing rare fossils crop out at a project site, palaeontological concerns do not usually impede developments. The main purposes of this palaeontological assessment are to:

- Outline the nature of possible palaeontological/fossil heritage resources in the subsurface of the affected areas.
- Suggest the mitigatory actions to be taken with respect to the occurrence of fossils during bulk earth works.

The action plans and protocols for palaeontological mitigation must therefore be EMP and embodied in the Agreed Terms of Reference for the appointed mitigation practitioner. Included herein is a general fossil-finds procedure for the appropriate responses to the discovery of paleontological materials during construction-phase bulk earth works.

1.2 PROPOSED PROJECT LOCATION AND COMPONENTS

The project components and the alternative options under consideration are illustrated in Figure 1. The proposed SRMO transfer pipeline will follow to a large extent the same terrestrial corridor as that proposed in the EIA for the WCDM SWROP potable water pipeline leading to the Besaansklip reservoir.

The terrestrial pipeline corridor will extend for ~27 km from the SSP and CAPF to the outfall in Danger Bay. The pipeline, which will be buried, will have a pipe diameter of ~900 mm and will be made of high density polyethylene (HDPE) pipe or will be a glass-reinforced plastic (GRP) pipe.

Five pump stations along the pipeline servitude are planned at positions A, B, C, D and potentially E (Figure 1). The pump stations, confined in bunded areas, will include brine transfer tanks, mechanical pumps, electrical distribution networks and standby generators. Pump Station A is located at the SSP and CAPF. Pump Station B is located in the vicinity of the proposed SBM WWTW. The route west is serviced by Pump Station C and Pump Station D. Near Jacobsbaai the pipeline will turn south towards Pump Station E or the WCDM SWROP. From Pump Station D the route will either follow the Jacobsbaai Eastern Corridor or the Jacobsbaai Western Corridor (Figure 1, JEC & JWC).

The SRMO terminates in the marine outfall diffuser system in Danger Bay. Option 1 routes the outfall pipeline from the WCDM SWROP site or Pump Station E into the northwestern corner of Danger Bay. Option 2 is an alternative marine outfall position that is considered prior to the commissioning of the WCDM SWROP (Figure 1).

Electric power for the pump stations will be supplied either by buried Medium Voltage cabling or by Medium Voltage Overhead Lines (OHL) supported on wooden-pole Delta A-Frames at a height of 12 m. Gravel service roads will be required for access to the pump stations.

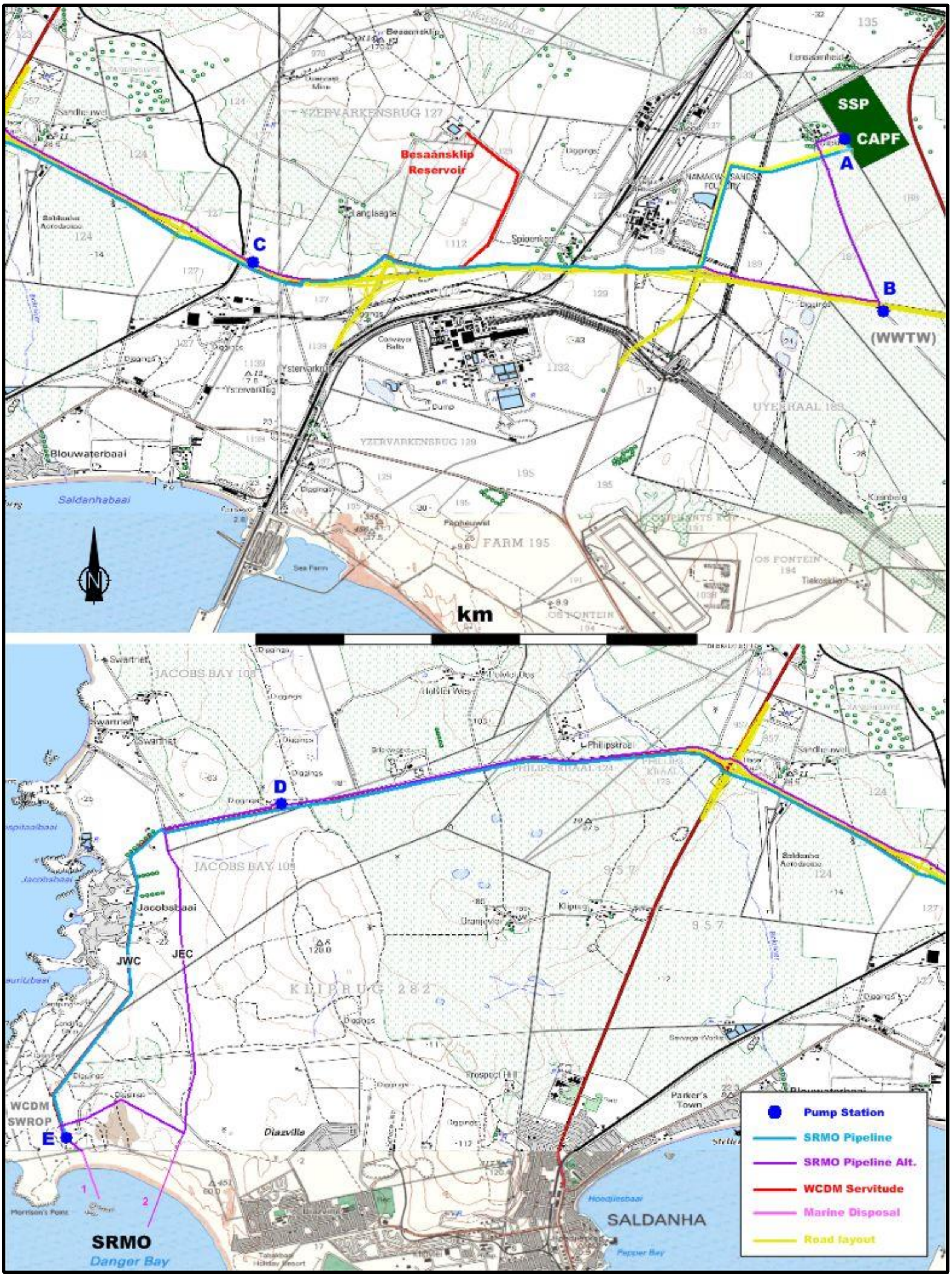


Figure 1. Proposed project location and components. Adapted from 1:50000 topo-cadastral raster maps 3217DB_DD_2003_ED5, 3218CA_CC_2003_ED & 3317BB_3318AA_1998_ED4. (Chief Directorate National Geo-spatial Information of South Africa). Frontier Utilities kindly provided the KMZ vector files.

2 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. The South African Heritage Resources Agency (SAHRA) administers this legislation nationally, with Heritage Resources Agencies acting at provincial level.

According to the Act (Section 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 (Section 38).

3 THRESHOLDS

The spatial scale of subsurface disturbance and exposure of the SRMO pipeline exceeds 300 m in linear length and 5000 m^2. In terms of the NHRA 25 (1999) Section 38 (1), the proposed project must be assessed for heritage impacts (an HIA) that includes assessment of potential palaeontological heritage (a PIA).

For the evaluation of palaeontological impacts it is the extent/scale of the bulk earth works that are the main concern. The main impact is the bulk earth works for the trench in which the pipeline will be buried. For a pipe ~900 mm in diameter it is assumed the trench will be about 1.5 to 2.0 metres wide and ~1.5 metres deep. The pipes will be buried along existing servitudes, road reserves or cadastral boundaries. Parts of the routes will be in previously disturbed subsurface, while other parts will involve excavation of “fresh ground”.

Other earth works, dimensions not yet specified, are involved in the construction of effluent storage tanks at the plant sites and at the pump stations (transfer tanks, bund walls and sumps).

Although most of the excavations will be shallow (<2 m deep), the subsurface of the area has a distinct probability of containing fossils that will be exposed during earth works, as is elucidated below.

4 TERMS OF REFERENCE

Review of provided plans and data on proposed development, *e.g*., location of footprints and scale of bulk earth works envisaged.

Desktop review of all relevant palaeontological and geological literature and application of specialist knowledge of the proposed area.

Identify and rank sensitivities of fossil heritage within project area with respect to the proposed development.

Make specific recommendations for palaeontological mitigation, for inclusion in the Construction EMP, including a "Fossil Finds Procedure".

5 APPROACH AND METHODOLOGY

5.1 AVAILABLE INFORMATION

Early geological and palaeontological work in the Saldanha Bay area described the calcareous aeolianites, their basal marine beds and occurrences of phosphatic deposits (Du Toit, 1917; Wybergh, 1919, 1920; Haughton, 1932a,b). The overall perspective on the surface geology in this area has been provided by Visser & Schoch (1973) and the accompanying map. They document valuable observations from the earlier phosphate exploration phase. Further details of the "Langebaan" or "Coastal Limestones" are provided by Siesser (1970, 1972).

Mining of the phosphatic deposits led to the discovery of fossil-rich "bone beds" at Langebaanweg (LBW) which is now an internationally significant palaeontological site renowned for its prolific, diverse and exceptionally well preserved Mio-Pliocene vertebrate faunas. Scientific papers that refer to the LBW faunas number in the several hundreds.

The exposures provided by mining and exploratory drilling greatly expanded the knowledge of the stratigraphy and fossil record of the area (Tankard 1974a,b, 1975a,b,c; Dingle *et al.*, 1979; Hendey, 1981a,b,c and many earlier publications). Kensley (1972, 1977) described the taxa and palaeoenvironmental significance of the invertebrates present in the Gravel and Quartzose Sand members of the Varswater Formation. Just recently, Roberts *et al.* (2011) produced a valuable review of the literature pertaining to the LBW site, citing 176 references.

Rogers (1980, 1982, 1983) reviewed and described the wider-scale geology of the Saldanha coastal plain, *viz*. gross bedrock topography, sediment thicknesses and lithostratigraphy, as revealed by a Department of Water Affairs drilling programme. Useful reviews and summaries that include the geology and palaeontology around Saldanha are Dingle *et al.* (1983), Hendey (1983a,b,c), Hendey and Dingle (1990), Pether *et al.* (2000) and Roberts *et al.* (2006).

The point of departure is the geological map of the area *viz*. 1:125000 Sheet 255 and the accompanying explanation (Visser & Schoch (1972, 1973). The relevant part of the geological map is reproduced as Figure 2. Since then, ongoing research has added various refinements of the geology, but the map remains essentially valid.

The later research contributions relevant to this assessment are cited in the normal manner as references in the text and are included in the References section.

5.2 ASSUMPTIONS AND LIMITATIONS

The assumption is that the fossil potential of the formations underlying the site (Langebaan and Springfontyn formations) will be typical of that found in the region and more specifically, similar to that already discovered nearer to the site. Scientifically important fossil bone material is expected to be sparsely scattered in these deposits and much depends on spotting this material as it is 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 very general terms. Certain processes/agents can produce significant concentrations of fossil bones, but the possibility of these specific buried palaeoenvironments being present may be only evident once the formation is exposed in excavations.

OVERLEAF

Figure 2. Surface geology of the study area. Annotated extract from Visser & Schoch (1972), 1:125000 Map Sheet 255: 3217D & 3218C (St Helenabaai), 3317B & 3318A (Saldanhabaai). Legend below in order of youngest to oldest formations.

Q5: Recent windblown sands and dunes along the beach are mapped as unit Q5. Prominent dune plumes extend north from sandy beaches. Called the **Witzand Formation**.

Q1: Another surface unit is the recent soil-unit Q1, white to slightly-reddish sandy soil, which is mainly a stabilized sand sheet blanketing the underlying geology.

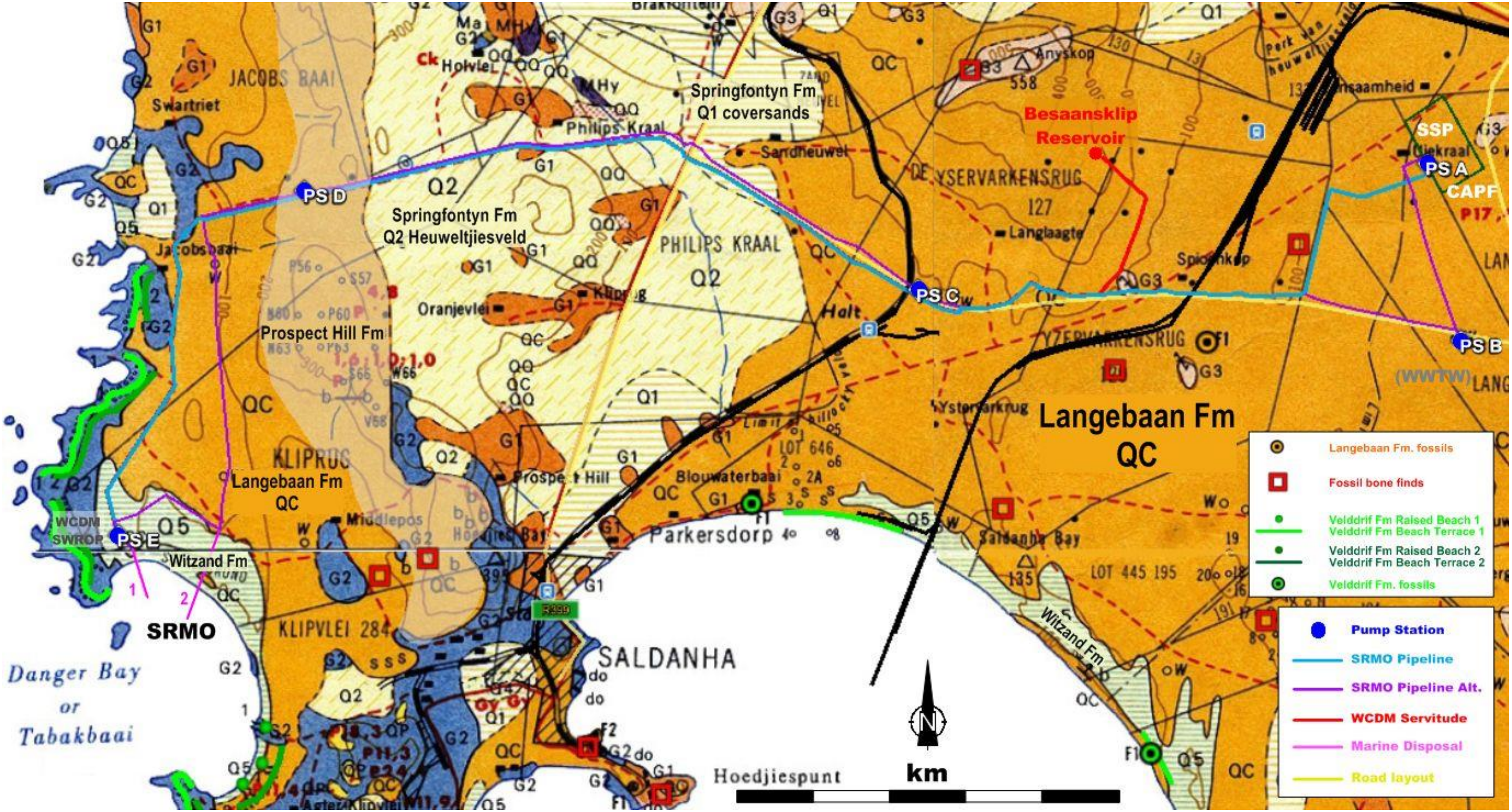
Q2: An older surface unit Q2, shallow sandy soil with heuweltjies (heuweltjiesveld), occurs inland the coast. Incipient calcretes occur in Q2.

QC: The **Langebaan "Limestone" Formation**, aeolianite Unit QC, is underlain mainly by marine deposits of Pliocene age (**Varswater** & **Uyekraal** fms).

The **Prospect Hill Formation.** Part of the Langebaan Fm between Saldanha Bay and Paternoster has now been separated as this new formation, due to fossil finds indicating that it is significantly older than the other aeolianites included in the Langebaan Formation.

G1, G2, G3, G4 and **G5** are outcrops of various bedrock granites of the Cape Granite Suite.

Figure 2.


Springfontyn Fm
Q1 coversands
Besaansklip
Reservoir
PS D
PS C
PS A
PS B
PS E
SSP
CAPF
(WWTW)
Springfontyn Fm
Q2 Heuweltjiesveld
Prospect Hill Fm
Langebaan Fm
QC
Langebaan Fm
QC
Witzand Fm
WCDM
SWROP
SRMO
Danger Bay
or
Tabakbaai
SALDANHA
Parkersdorp
Saldanha Bay
Hoedjiespunt
Witzand Fm
km
Langebaan Fm. fossils
Fossil bone finds
Velddrif Fm Raised Beach 1
Velddrif Fm Beach Terrace 1
Velddrif Fm Raised Beach 2
Velddrif Fm Beach Terrace 2
Velddrif Fm. fossils
Pump Station
SRMO Pipeline
SRMO Pipeline Alt.
WCDM Servitude
Marine Disposal
Road layout

6 GEOLOGICAL AND PALAEONTOLOGICAL SETTING

6.1 THE BEDROCK

The older bedrock of the region consists of **Malmesbury Group** shales. Their origin dates from over 560 Ma (Ma: million years ago, Mega-annum), when mainly muddy sediments were deposited on the margins of an ancient ocean. The ocean basin subsequently was compressed by tectonic forces and the Malmesbury sediments were transformed into shales and were then intruded by molten magma that cooled to form the crystalline "**Cape Granites**". These bedrock formations are not of palaeontological interest.

6.2 THE OLDER SANDVELD GROUP

During the early history of the coastal plain it was deeply eroded by courses of the ancestral Berg River and the soft Malmesbury shales along the coast have mostly been eroded away to below sea level, while the hard granites form the hills. The deposits that overlie this erosion surface are much younger than the bedrock, being of Cenozoic age. These various formations are grouped together as the **Sandveld Group**.

During the early Miocene about 20 Ma, rising sea level caused the rivers in the valleys to "back up", filling the valleys with river (fluvial) sediments and peat beds with plant fossils. This fluvial valley fill is the **Elandsfontyn Formation**, the oldest formation of the Sandveld Group of coastal deposits. It is not exposed, being deeply covered by marine deposits and ancient dunes.

Eventually, by ~16 Ma during the Mid-Miocene Climatic Optimum, enough of the Antarctic ice cap had melted to raise sea level to the extent that the coastal plain was submerged as a shallow sea and the granite hills were islands upon which seabirds roosted, their guano leaching into and phosphatizing the granites. This ancient shoreline is now uplifted to ~100 m asl. and in places along the West Coast is marked by marine gravels occurring seaward of a prominent slope "nick" or even vertical "fossil" sea cliffs. However, to the writer's knowledge, *in situ* mid-Miocene marine deposits at high elevations have not been exposed or recognized in the Saldanha area. Notwithstanding, phosphatic, ostensibly marine deposits are recognized in boreholes and just to the north of Elandsfontein extend to 90 m asl. (borehole S22, Rogers, 1980). Should the age of these deposits indeed prove to mid-Miocene, precedence dictates that it is named the **Saldanha Formation.**

At lower elevations marine deposits of Pliocene age drape the bedrock and older sediments on the coastal plain. These include two formations, *viz*. the early Pliocene **Varswater Formation** and the mid-Pliocene "**Uyekraal Formation**". The type area of the former is the exposures at the West Coast Fossil Park (Langebaanweg) where the fossils from the upper part show that the age of the deposits is about 5 Ma and that the origin of the deposits is related to rising sea level during the warming of the early Pliocene Warm Period. The peak palaeoshoreline of this sea level high is now uplifted to 50-60 m asl. The equivalent deposits on the Namaqualand Coast comprise the "50 m Package" or Avontuur Formation.

Sea level rose again during the Mid Pliocene Warm Period (~3.0 Ma) up to a level now at ~30-35 m asl. The associated deposits on the Namaqualand Coast comprise the "30 m Package" or Hondeklip Bay Formation (informal). Equivalent marine deposits underlie the flat plain extending west from the West Coast Fossil Park and were named the Uyekraal Shelly Sand Member of the "Bredasdorp Formation" by Rogers (1983) (the latter now superseded by the Sandveld Group). The unit has a capping hardpan calcrete, beneath which is green-hued shelly, gravelly sand with phosphatic casts (steinkerns) of molluscs and shark teeth (Rogers, 1982, 1983). The evidence from wider afield proves that this marine formation is a discrete stratigraphic unit that underlies the outer part of the coastal plains below ~30 m below sea level. It is thus deserving of separate recognition as the Uyekraal Formation, in the Sandveld Group.

The aforementioned fossiliferous marine deposits are generally too deeply buried beneath old dune deposits (aeolianites) to be intersected in shallow excavations.

6.3 THE YOUNGER SANDVELD GROUP

Aeolianites or "dune rocks/fossil dunes" overlie the marine deposits of the coastal plain, *i.e.* the "Saldanha", upper Varswater and Uyekraal formations. They rest on wind-deflation erosion surfaces formed on the marine deposits and are comprised of calcareous sand reworked from the marine deposits by wind and also blown off the beaches of the receding sea levels. The calcareous aeolianites are evident in the coastal landscape as the ridges, low hills and mounds beneath a capping calcrete crust.

Much of the aeolianite sand is tiny fragments of shell. The cementing of this "calcarenite" is generally quite weak, but much denser cementing has taken place in the uppermost part of the fossil dunes in the form of a "carapace" or capping of calcrete (Figure 5). The calcrete is a type of cemented soil called a pedocrete, formed in the near-surface by evapo-transpiration after the dunes became inactive and were vegetated.

The aeolianites contain further calcretes and leached *terra rosa* soils at depth, attesting to a number of periods of reduced rates of sand accumulation, surface stability and soil formation. There are more marked breaks between periods of sand accumulation, shown by erosion surfaces or very thick calcretes formed over a long time.

The dune plumes accumulated episodically, under the influence of climate (windiness, rainfall) and available sand source areas (sea-level position, sediment supply), with erosion and re-deposition of previous dunes also taking place in some areas, separated by periods of stability and soil formation.

6.3.1 The Prospect Hill Formation - aeolianite

The inner aeolianite ridge stretching north from Saldanha Bay up the coast to near Paternoster has been found to have fossil eggshell fragments of extinct ostriches (*Diamantornis wardi*) and extinct land snail forms (Roberts & Brink, 2002). *Diamantornis wardi* is dated as Miocene 10-12 Ma in the Namib Desert (Senut & Pickford, 1995) and, based on dated occurrences in East Africa and Arabia, an age of 12-9 Ma is indicated. These aeolianites, previously belonging to the Langebaan Formation, are now called the Prospect Hill Formation (Figure 2), due to the significantly older age indicated by the fossils (Roberts & Brink, 2002; Roberts *et al*., 2006). Separation of this aeolianite as a distinct formation is also justified by it being lithologically distinct from the younger aeolianites that abut it.

6.3.2 The Langebaan Formation - aeolianites

Most of the calcareous aeolianites of the southern portion of the west coast are included in the Langebaan Formation or "Langebaan Limestones" (Figure 2, deep yellow, QC). The Langebaan Fm. thus includes various aeolianites of different ages, as an "amalgam" of the dune plumes that formed on the coastal plain, at differing places and times. This is reflected in the different ages indicated from fossils found at various places.

Of course, the aeolianites must be younger than the underlying "foundation" of marine deposits. Potentially the oldest Miocene aeolianites would overlie mid-Miocene Saldanha Fm., mid-Pliocene and younger aeolianites would overlie the Varswater Fm. and early Quaternary and younger aeolianites would overlie the Uyekraal Fm. The youngest Langebaan Fm. aeolianites postdate the Velddrif Formation (Figure 3) and are as young as ~60 ka. In the case of the younger Quaternary dunes, the most favourable sand supply conditions seem to have prevailed at sea levels below present, in the range of 10-40 m bsl.

6.3.3 The Springfontyn Formation

The Springfontyn Formation is an informal category that accommodates the mainly non-calcareous, windblown sand sheets and dunes that have covered parts of the landscape during the Quaternary. Its spatial extent is depicted on the geological map in pale yellow hues wherein Visser & Schoch (1972, 1973) differentiate the coversands by their surface appearance into 2 surficial units, **Q2** (older cover) and **Q1** (younger cover). The Springfontyn Fm. consists of the sequences beneath these "coversands", *i.e*. SubQ2 and SubQ1.

Unit Q2 is characterized by its surface manifestation as the distinct "heuweltjiesveld", the densely dot-patterned landscape of low hillocks that are termitaria made by *Microhodotermes viator*. Its true spatial extent is not immediately appreciated as it laps onto bedrock and onto the Langebaan Fm., but for the purposes of geological mapping these overlap areas are not shown. It is also apparent that Q2 underlies large areas now covered by Q1.

The dot-patterned "heuweltjiesveld" is merely the surface-soil characteristic of Unit Q2. Not much detail is known about Unit Q2 at depth (Sub-Q2). Pedogenic layers of ferruginous concretions, clayey beds and minor calcretes occur among sandy-soil beds. Clearly Q2 will differ from place to place according to the local setting. In this area, in addition to mainly windblown sands from the south, Sub-Q2 will likely comprise the local colluvial/hillwash/sheetwash deposits, small slope-stream deposits, alluvium in the lower valleys and vlei and pan deposits.

Surface Unit Q1 is a younger "coversand" geological unit and is "white to slightly-reddish sandy soil" (Visser & Toerien, 1971; Visser & Schoch, 1973). These are patches of pale sand deposited in geologically-recent times. In places these sands are undergoing semi-active transport and locally have been remobilized into active sandsheets and dunes.

Chase & Thomas (2007) have cored Q1 coversands in a regional survey of various settings along the West Coast and applied optically stimulated luminescence (OSL) dating techniques to establish the timing of sand accumulation. Their results indicate several periods of deposition of Q1 during the last 100 ka, with activity/deposition at 63–73, 43–49, 30–33, 16–24 and 4–5 ka. Notably, underlying sands produced dates from ~150 to ~600 ka, reflecting the accumulation of Unit Q2 in the middle Quaternary.

The Springfontyn Formation aeolianites date from at least ~600 ka, if not older and, in parts, may be of similar ages as parts of the Langebaan Fm. (Figure 3), but derived from less calcareous sources and/or deposited in settings more prone to subsequent groundwater leaching in water tables. The reworking of older coastal-plain deposits was likely the major sediment source. It is also possible that decalcified marine sands have not been recognized as marine in origin, especially if only encountered in boreholes, and been included in the Springfontyn Fm.

6.3.4 The Witzand Formation - aeolian

The latest addition of dunes to the coastal plain is shown in Figure 2 as **Unit Q5**, called "Holocene dunes" and otherwise known as the Witzand Formation (Rogers, 1980), for obvious reason. These are sands blown from the beach in the last few thousand years and added to the fossil dune cordon or "sand wall" parallel to the coast, or have blown further as dune plumes transgressing a few to several kilometres inland.

6.3.5 The Velddrif Formation – marine and estuarine

After ~2.6 Ma the Earth went into "Ice House" mode (the Quaternary Period) and major ice caps formed in the polar regions, subtracting water from the oceans. During Ice Ages sea levels fluctuated at positions mainly below present (Figure 3) and coastal rivers eroded their valleys to deeper levels. These now-submerged shorelines were also the source of the sand for further additions to the Langebaan Formation in the form of dune plumes blown far inland.

During the Quaternary period there were brief intervals of global warming (interglacials), of which the present time is an example, when sea levels were similar to the present level or several metres above or below present level. The higher sea levels are the Quaternary "raised beaches" found at low elevations (<15 m asl.) around the coast, where they are exposed in cliffs beneath dune rocks, on top of low marine platforms fringing the coast and within the lower reaches of valleys, *e.g*. the Berg River. They comprise the Velddrif Formation (Figure 2).

Most of the Velddrif Formation deposits that are exposed date to the Last Interglacial (LIG) about 125 ka (ka: thousand years ago) and are found up to ~8 m asl. due to storm deposition, but the mean sea level was about 5-6 m asl. The LIG is also known as Marine Isotope Stage 5e (MIS 5e). In Figure 2 the LIG deposits are shown as the lower "Raised Beach 1" and "Beach Terrace 1".

Farther inland are higher-lying marine terrace deposits up to 12-15 m asl. This older raised beach is very poorly known and it is possible that beach deposits of differing ages are preserved from place to place. It is probable that most of such occurrences relate to an older interglacial high sea level around 400 ka (MIS 11). In Figure 2 these older deposits are shown as the upper "Raised Beach 2" and "Beach Terrace 2".

Deposits relating to the MIS 7 interglacial about 200 ka are often found interbedded in the bases of the Langebaan Formation aeolianite seacliffs and exposed in the intertidal zone and below sea level. These include estuarine/lagoonal and coastal vlei deposits, the latter reflecting high water tables associated with the nearby high sea level. The vlei deposits include organic-rich and peaty beds with terrestrial fossil bones.

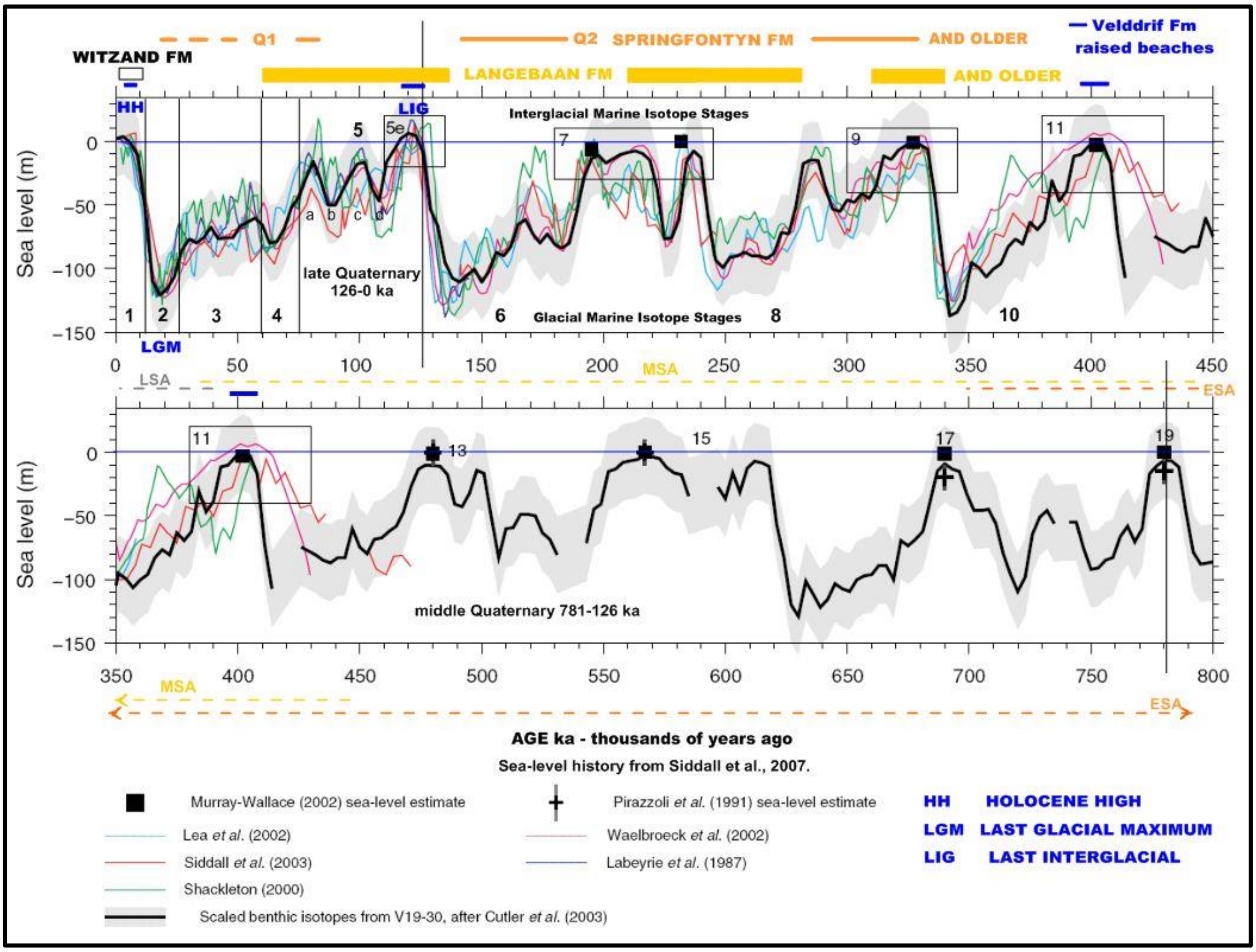


Figure 3. Sea level history for the middle and late Quaternary, showing glacial/interglacial Marine Isotope Stages. From Siddall et al., 2007.

7 EXPECTED PALAEONTOLOGY

From the SSP and CAPF (Pump Station A) the initial ~12 km of the pipeline route traverses the flat coastal plain and gentle slopes of Yzervarkensrug, underlain by the **Langebaan Formation** calcretes beneath thin coversands (Figures 2 & 4).

About 2 km northwest of Pump Station C the route passes onto Q1 coversands on low-lying ground on Philips Kraal. Past the Vredenburg road intersection the route proceeds over the older Q2 “heuweltjiesveld” that covers the gentle slope, with granite outcrops, that forms the eastern flank of the broad granite ridge highground along the western part of the Vredenburg Peninsula. This traverse of **Springfontyn Formation** sands and soils is ~5.7 km in length.

Thereafter the pipeline route crosses over onto the calcrete capping of the **Prospect Hill Formation** aeolianites which are banked up against the western, seaside flank of the granite ridge (traverse = 1.3 km) (Figures 2 & 4).

About 400 m west of Pump Station D the Prospect Hill Formation calcretes are overlain by the younger Langebaan Formation aeolianites and about 1 km further downhill the branch point is reached for the two alternative routes south, just short of bedrock outcrop (Figures 2 & 4). The Jacobsbaai Eastern Corridor traverses Langebaan Formation up to a point ~800 m from the seashore where it is overlain by recent dunes of the **Witzand Formation**. At this point it is routed ~NW along the edge of the dunes for ~840 m before turning ~SW and crossing the dunes to PS E. Alternatively, as in the interim outfall Option 2, the pipeline will continue directly south across the Witzand dunes and the beach to the offshore diffuser. The Jacobsbaai Western Corridor initially skirts bedrock outcrops and thin Langebaan Formation and then proceeds across a low mound of Langebaan aeolianite (old plume) before crossing onto the Witzand dunes.

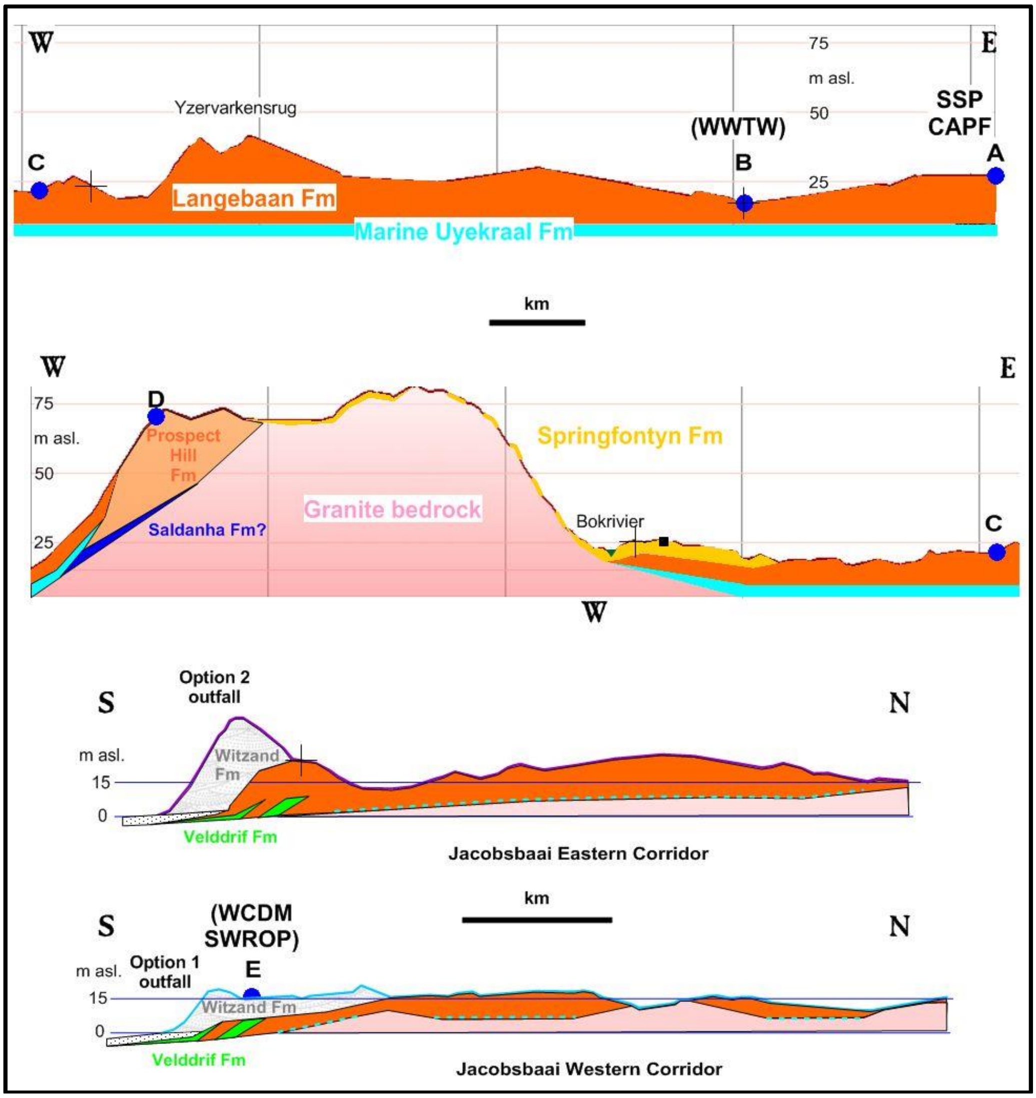


Figure 4. Schematic profiles of sections along the proposed SRMO pipeline corridor.

The **Velddrif Formation** beach deposits occur beneath the Witzand dunes and are expected to be within ~300 m inland of the beach. It is possible that the pipeline trench could intersect these deposits if it is made quite deep in the dune slope down to sea level.

7.1 *FOSSILS IN AEOLIAN SETTINGS*

Aeolian deposits will primarily be intersected by the project earthworks. Many fossils are associated with old, buried surfaces in the aeolianites (palaeosurfaces), usually formed during wetter or less windy periods, with reduced rates of sand accumulation and with soil formation showing the surface stability. The common fossils include shells of extinct land snails, fossil tortoises, ostrich including egg fragments and generally sparsely scattered bones. Conversely "blowout" erosional palaeosurfaces may carry fossils concentrated by the removal of sand by the wind.

The bone concentrations most commonly found are due to hyaenas. The bones often occur in the lairs of hyaenas, such as tunnels made into the softer material beneath a calcrete "roof" (Figure 5). These most often occur on slopes where some erosion of the calcrete, producing overhangs and crevices, has facilitated the making of a burrow. Burrows made by aardvarks are also exploited by hyaenas. Hyaena lairs can be found at depth in the aeolian deposits, where they relate to buried palaeosurfaces.

Figure 5. Fossil bone concentration (circled) in the infill of a cavity below the calcrete capping of the Langebaan Formation.

Hollows between dunes (interdune areas) are the sites of ponding of water seeping from the dunes, leading to the deposits of springs and small vleis. These are usually muddy, with plant fossils, but being waterholes, are usually richly fossiliferous, with concentrations of large mammal bones due to predator activity, including Stone Age hunters.

Particularly thick calcretes formed in the upper aeolianite often underlie flatter areas on the coastal plain. Such thick calcrete develops beneath long-lived surfaces on the aeolianite, where increments of deposition have been small and the "fossil" dune topography is subdued. The thick calcrete is polyphase in origin and disguised within it are discrete, small phases of sand deposition separated by cryptic palaeosurfaces on which fossils may occur. Fossils in cemented aeolianites and calcretes are quite difficult to spot as they are usually coated with a white limey deposit (Figure 6) and do not stand out well amongst the nodules and generally bumpiness of a fresh exposure.

The aforegoing applies primarily to the highly calcareous Langebaan Formation, within which fossil bones are well preserved. In contrast, the Springfontyn Formation is mainly quartz sands and pedogenic muds and few fossils have been found. Notwithstanding, it has clearly accumulated episodically over a considerable time span and thus will include palaeosurfaces with bone fossils and other settings such as vlei deposits with considerable fossil potential.

7.1.1 Buried archaeological material

It is possible that buried archaeological material may occur locally within or below the thin, loose Q1 sandy-soil cover covering the capping calcrete of the aeolianites. This is indicated by "out of place' marine shells (limpets, mussels), pottery pieces and quartz or silcrete stone tools. Buried archaeological material may also occur on top of the calcrete or in crevices and solution pits in it. Early and Middle Stone Age artefacts and associated fossil bones are found within and below the capping calcretes.

Figure 6. Example of fossil antelope jaw coated with a white limey deposit from a shallow trench into the calcrete capping of the Langebaan Formation at SALKOR. Image courtesy André Carstens.

7.2 PALAEONTOLOGY OF THE VELDDRIF FORMATION

The shelly fauna of the open-coast, LIG parts of the Velddrif Formation (Figure 7) is mainly modern and thus its palaeontological sensitivity is moderate and of local significance overall. Nevertheless, faunal changes are present and surprises occur. Furthermore, rare bones may be spotted in the deposits, such as those of marine mammals (cetaceans and seals) and seabirds.

The LIG deposits that occur in protected embayment settings at various locations around the coast of the western and southern Cape are of particular interest due to the occurrence of several species of exotic fossil shells of West African origin, today found living in the tropics along the Angolan coast and farther northwards. The taxonomy of these exotic or "extralimital" species has been dealt with in Kilburn & Tankard (1975) and Kensley (1974, 1985a,b).

To account for the occurrence of the West African species, Tankard (1975a) suggested that, during the LIG, shallow-water coastal embayments were more numerous due to the higher sea-level. Water temperature in the sheltered embayments was warmer than at present due to increased insolation, but open-coast sea-temperatures were similar to the present day regime. Postulating a poleward shift of the LIG South Atlantic Anticyclone relative to its present mean position, he suggested a concomitant southward shift of isotherms and the West African molluscan province, bringing tropical taxa closer to the Cape. Periodic southward incursions of tropical (Angolan) water carried the larvae of tropical taxa through the environmental barrier of Benguela upwelling, to warm embayments along the LIG coast. Further southward dispersal could have been accomplished by inshore southward currents developed during westerly winds associated with the passage of mid-latitude cyclones.

The episodic southward incursions of tropical Angolan water into the northern Benguela invoked by Tankard (1975a) have subsequently become known as Benguela *Niños* (Shannon *et al*., 1986). The molluscan evidence therefore suggests that oceanographic conditions in the LIG northern Benguela involved frequent or extended Benguela *Niño* situations.

The older, higher Velddrif Fm. units ~8-15 m asl. are poorly exposed and practically unstudied.

Figure 7. Velddrif Formation near Velddrif showing open-coast, shelly beach deposits.

8 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 (bones), which tend to be sporadically preserved and have high value w.r.t. palaeoecological and biostratigraphic (dating) information. Such fossils are non-renewable resources. Provided that no subsurface disturbance occurs, the fossils remain sequestered there.

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, provided that efforts are made to watch out for and rescue the fossils. Fossils and significant observations will be lost in the absence of management actions to mitigate such loss. This loss of the opportunity to recover them and their contexts when exposed at a particular site is irreversible.

The status of the potential impact for palaeontology is not neutral or negligible and can be positive with mitigation

Although coastal dunes and coversands are not generally very fossiliferous, it is quite possible that fossiliferous material could occur. The very scarcity of fossils makes for the added importance of watching for them.

There remains a medium to high risk of valuable fossils being lost in spite of management actions to mitigate such loss. Machinery involved in excavation may damage or destroy fossils, or they may be hidden in "spoil" of excavated material.

9 SIGNIFICANCE

The fossils that have been found in the Langebaan Fm. aeolianites are of profound scientific value, raising international interest in the region. The Langebaan Fm. aeolianites have been a prime source of information on Quaternary faunas and archaeology.

At the Diazville lower quarry, Langebaan Fm. aeolianite overlying the mid-Pliocene, marine Uyekraal Formation enclosed vertebrate material indicative of a late Pliocene or younger age (Roberts & Brink, 2002) (Diazville Member). The fossil suid (bushpig) from Skurwerug dates the fossil dune-plume there to the early Pleistocene ~1.2 Ma (Hendey & Cooke, 1985).

At Elandsfontein a fossil interdunal vlei was exposed by deflation, the large number of fossil bones and ESA tools indicate an age of ~600 ka (Klein et al., 2007). Notably, prior to the wind erosion of coversands at Elandsfontein, there would have been no indication of the fossil wealth just below, which included a cranium of the pre-modern human *Homo heidelbergensis*.

At Geelbek Dunefield the deflation hollows located between the wind-blown, actively-mobile sand dunes are a source of mammalian fossils and Stone Age tools, with more being constantly exposed (Kandel *et al*., 2003). The older aeolianites surrounding Geelbek dunefield exhibit three sequential calcretes which are dated at ~250, ~150 and ~65 ka, *i.e*. stability/soil formation during glacial periods (Felix-Henningsen et al., 2003).

At Kraalbaai the aeolianite with human tracks preserved in it (Kraal Bay Member) is dated to 117-79 ka (Roberts & Berger, 1997). Dating of aeolianites near Cape Town by luminescence methods shows accumulation during MIS 7 and MIS 5 (interglacials), with calcrete formation in the intervening glacial (ice age) periods (Roberts *et al*., 2009).

Examples of hyaena bone accumulations in dens within the partly-lithified dune rocks are the Sea Harvest and Hoedjiespunt sites in Saldanha Bay. Hoedjiespunt is the find site of fossil teeth of a hominid in deposits 200-300 ka old. The Sea Harvest site produced an essentially modern human tooth that is older than 40 ka. Both sites provided considerable samples of the faunas of those times, thanks to the activities of the brown hyaenas.

At Spreeuwal on the shore of Big Bay, Velddrif Fm. (MIS 7) coastal fossil vlei deposits are exposed in the intertidal zone and contain large mammal bones and some MSA artefacts (Avery & Klein, 2009). The larger mammal component includes extinct species and others not recorded historically in the Western Cape. Small mammals, birds, reptiles, amphibians, freshwater gastropods and ostracods also occur.

The formations affected by the pipeline routes are summarised below, with a brief indication of their palaeontological sensitivity.

Table 1. Surface formations of the Sandveld Group in the study area.

FORMATION	Age and description	Sensitivity
WITZAND - Q5	Holocene and recently active dune fields and cordons <~12 ka.	Mainly archaeological sites.
SPRINGFONTYN - Q1 & Q2	Quaternary to Holocene, mainly quartzose dune and sandsheet deposits, interbedded palaeosols, basal fluvial deposits <~2 Ma.	Fossil bones very sparse, local to high signif. Basal fluvial deposits locally – high signif.
VELDDRIF - VD	Quaternary raised beaches & estuarine deposits, <~1.2 Ma. Sea-levels below ~15 m asl.	Shell fossils common, local signif. Fossil bones very sparse, high signif.
LANGEBAAN - LB	Late Pliocene to Late Quaternary aeolianites <~3 Ma to ~60 ka.	Fossil bones mod. common, local to high signif.
PROSPECT HILL - PH	Late Miocene aeolianite 12-9 Ma?	Fossils very sparse – high signif.

The application of dating techniques to shells, such as amino-acid racemisation, requires spatially-distributed samples, from many localities, to build a comparative database. The shells may not be interesting from a fossil enthusiast's point of view as rare species, but they contain a geochemical record of environmental conditions at the time they lived, preserved in stable isotopes and trace elements. Bulk earth works into the Velddrif Formation, that create significant exposure, must be mitigated by sampling and recording.

The general significance of coastal-plain fossils involves:

- The history of coastal-plain evolution.
- The history of past climatic changes, past biota and environments.
- Associations of fossils with buried archaeological material and human prehistory.
- For radiometric and other dating techniques (rates of coastal change).
- Preservation of materials for the application of yet unforeseen investigative techniques.

10 IMPACT ASSESSMENT

This impact assessment refers to the occurrence of sparse, “high value” fossil bone material in the affected formations and pertains to the construction phase. The operational and decommissioning phases do not involve adverse impacts on palaeontological heritage.

10.1 NATURE OF THE IMPACT

Construction activities (excavations) will result in a negative direct impact on the probable fossil content of the affected subsurface. Fossils and significant observations will be lost in the absence of management actions to mitigate such loss. This loss of the opportunity to recover them and their contexts when exposed at a particular site is irreversible.

Conversely, construction excavations 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, provided that efforts are made to watch out for and rescue the fossils.

10.2 EXTENT

The physical extent of impacts on potential palaeontological resources relates directly to the extents of subsurface disturbance, *i.e*. site specific.

Notwithstanding, the cultural, heritage and scientific impacts are of regional to national extent, as is implicit in the NHRA 25 (1999) legislation and, if scientifically important specimens or assemblages are uncovered, are of international interest. This is evident in the amount of foreign-funded research that is undertaken by scientists of other nationalities. Loss of opportunities that may arise from a significant fossil occurrence (tourism, employment) filters down to regional/local levels.

10.3 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.

10.4 INTENSITY

Thus the potential impact of bulk earth works on fossil resources is high in the absence of mitigation. It is quite likely that scientifically valuable fossils may be lost in spite of mitigation.

10.5 PROBABILITY

The likelihood of impact is medium *i.e*. it is likely to occur under most conditions, particularly in view of the length of pipeline trenches.

10.6 REVERSIBILITY

The loss of fossil material such as rare fossil bone is irreversible.

10.7 *IRREPLACEABILITY*

The loss of fossil material such as rare fossil bones is irreplaceable.

10.8 *STATUS OF THE IMPACT*

Negative without mitigation, positive with mitigation.

10.9 *CONFIDENCE*

The level of confidence of the probability and intensity of impact is medium to high.

10.10 *SIGNIFICANCE*

In terms of the provided rating methodology, the significance is Medium both with and without mitigation. This reflects the probability of loss of sparse, valuable bone fossils, even with diligent mitigation.

Note that the presence of fossils in the subsurface does not have an *a priori* influence on the decision to proceed with the development. However, mitigation measures are essential. It is probable that sparse, valuable bone fossils will go undetected, even with the most diligent mitigation practicable. On the other hand, the finding and recovery of fossils will have a positive impact ranging from local to international in extent, depending on the nature of the finds.

Table 2. Summary Impact Ratings

Nature		
Impact on Fossil Resource	**Without mitigation**	**With mitigation**
Extent	Site specific	Site specific
Duration	Permanent loss	Permanent (part loss, part gain)
Intensity	High (destruction)	Medium (partly rescued)
Probability	Probable	Probable
SIGNIFICANCE	**MEDIUM**	**MEDIUM**
Status	Negative	Positive
Reversibility	Irreversible	Irreversible
Irreplaceable loss of resources?	Yes	Partly
Can impacts be mitigated?	Partly	
Mitigation:	Monitoring and inspection of construction-phase excavations	

11 RECOMMENDATIONS

The potential impact has a moderate influence upon the proposed project, consisting of implemented mitigation measures recommended below, to be followed just prior to and during the construction phase.

11.1 MONITORING

Interventions are particularly required if fossil bones are turned up during earth works. These are rare and valuable and every effort should be made to spot them and effect rescue of them. However, it is not usually practical for a specialist or a designated monitor to be continuously present during the Construction Phase.

It is therefore proposed that personnel involved in the making of excavations keep a lookout for fossil material during digging. The field supervisor/foreman and workers involved in digging excavations must be informed of the need to watch for fossil bones and buried potential 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 developer/owner who will contact the palaeontologist contracted to be on standby in the case of fossil finds.

Workers should be given a short course which explains what to look for. An excursion to the Langebaan Fossil Park could raise interest in fossils by the workers.

Appendices 1 and 2 outline monitoring by construction personnel and general Fossil Find Procedures for various scenarios. In the event of possible fossil and/or archaeological finds, the contracted archaeologist or palaeontologist must be contacted. For possible fossil finds, the palaeontologist will assess the information and liaise with the developer and the ECO and a suitable response will be established. If an important find, a field inspection must be undertaken to document and sample the exposed fossiliferous strata.

11.2 MITIGATION

In addition to effecting the rescue of fossil material that has been uncovered, it is recommended that the contracted palaeontologist carries out field inspections at appropriate stages in the making of the excavations. The aim of field inspection is to record the ephemeral, last chance to see, exposures of the deposits in the temporary construction earthworks. Further to describing fossil-bearing spots in detail, these additional target sites would be those where deeper excavations have exposed more vertical section, or any exposure that has features that are informative about the geometry, lateral variation and aspects of the genesis of the deposits.

Once the extent of earthworks required for various project components have been determined, the deepest excavations can be identified for field recording (*e.g*. the pump stations?) and the mitigation plan can be more specific. The contracted palaeontologist will liaise with Frontier Utilities, the CSIR (or the appointed environmental contractor) and the construction contractors about the specifics of setting up a monitoring and inspection programme.

11.3 SUMMARY FOR THE CONSTRUCTION PHASE EMP

Table 3. Basic measures for the Construction EMP

OBJECTIVE: To see and rescue fossil material that may be exposed in the bulk earth works for the project.		
Project components	Trenches for pipelines and excavations for pump stations, tanks, bunds, foundations etc. Spoil from excavations.	
Potential impact	Loss of fossils by their being unnoticed and/ or destroyed.	
Activity/ risk source	All bulk earthworks.	
Mitigation: target/ objective	To facilitate the likelihood of noticing fossils and ensure appropriate actions in terms of the relevant legislation.	
Mitigation: Action/ control	**Responsibility**	**Timeframe**
Inform staff of the need to watch for potential fossil occurrences.	Frontier Utilities, the CSIR, the ECO & contractors.	Pre-construction.
Inform staff of the procedures to be followed in the event of fossil occurrences.	ECO/specialist.	Pre-construction.
Monitor for presence of fossils	Contracted personnel and ECO, monitoring archaeologist.	Construction.
Liaise on nature of potential finds and appropriate responses.	ECO and specialist.	Construction.
Excavate main finds, inspect pits & record selected, key/higher-risk excavations.	Specialist.	Construction.
Obtain permit from HWC for finds.	Specialist.	Construction
Performance Indicator	Reporting of and liaison about possible fossil finds. Fossils noticed and rescued.	
Monitoring	Due effort to meet the requirements of the monitoring procedures.	

12 APPLICATION FOR A PALAEONTOLOGICAL PERMIT

A permit from Heritage Western Cape (HWC) is required to excavate fossils. The applicant should be the qualified specialist responsible for assessment, collection and reporting (palaeontologist).

The appointed palaeontologist should apply to HWC for a palaeontological permit prior to the commencement of earthworks

The application requires details of the registered owners of the sites, their permission and a site-plan map.

All samples of fossils must be deposited at a SAHRA-approved institution where specialist study can be facilitated *e.g*. the IZIKO S. A. Museum. Thereafter it should be feasible for the display of selected fossils and geoheritage information at an approved local, educational / interpretational centre, *e.g.* the West Coast Fossil Park.

13 REPORTING

Should fossils be found a detailed report on the occurrence/s must be submitted to HWC. This report is in the public domain and copies of the report must be deposited at the IZIKO S.A. Museum and Heritage Resources Western Cape. It must fulfil the reporting standards and data requirements of these bodies.

The report will be in standard scientific format, basically:

- A summary/abstract
- Introduction
- Previous work/context
- Observations (incl. graphic sections, images)
- Palaeontology
- Interpretation
- Concluding summary
- References
- Appendices

The draft report will be reviewed by the client, or externally, before submission of the Final Report.

14 REFERENCES

Avery, G & Klein, R.G. 2009. Spreeuwal: an Upper Pleistocene Wetland on the Western Cape Coast, South Africa. *SASQUA 2009, Programme & Abstracts*, p. 11.

Chase, B.M., Thomas, D.S.G. 2007. Multiphase late Quaternary aeolian sediment accumulation in western South Africa: timing and relationship to palaeoclimatic changes inferred from the marine record. *Quaternary International* **166**: 29–41.

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

Du Toit, A.L. 1917. Report on the phosphates of Saldanha Bay. *Memoir of the Geological Survey of the Union of South Africa* **10**: 38 pp.

Felix-Henningsen, P., Kandel, A.W., Conard, N.J., 2003. The significance of calcretes and paleosols on ancient dunes of the Western Cape, South Africa, as stratigraphic markers and paleoenvironmental indicators. *British Archaeological Reports International Series* **1163**: 45-52.

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

Haughton, S.H. 1932b. On the phosphate deposits near Langebaan Road. *Transactions of the Geological Society of South Africa* **35**: 119-124.

Hendey, Q.B. 1978. The age of the fossils from Baard's Quarry, Langebaanweg, South Africa. *Annals of the South African Museum* **75** : 1-24.

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

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

Hendey, Q.B. 1983a. Cenozoic geology and palaeogeography of the Fynbos region. In: Deacon, H.J., Hendey, Q.B. and 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. and 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. and 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. and Dingle, R.V. 1990. Onshore sedimentary phosphate deposits in south-western Africa. In: Burnett, W. C. and Riggs, S.R. (eds.), *Phosphate Deposits of the World*, Vol. **2**: 200-206. Cambridge: Cambridge University Press.

Kandel, A.W., Felix-Henningsen, P. & Conard, N.J. 2003. An overview of the spatial archaeology of the Geelbek Dunes, Western Cape, South Africa. *British Archaeological Reports International Series* **1163**: 37-44. Kensley, B. 1974. The status of the Plio-Pleistocene *Panopea* in southern Africa (Mollusca, Bivalvia, Hiatellidae). *Annals of the South African Museum* 65: 199-215.

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

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

Kensley, B.F. 1972. Pliocene marine invertebrates from Langebaanweg, Cape Province. *Annals of the South African Museum* **60**: 173-190.

Kensley, B.F. 1977. A second assemblage of Pliocene invertebrates from Langebaanweg, Cape. *Annals of the South African Museum* **72**: 189-210.

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

Klein, R.G., Avery, G., Cruz-Uribe, K. & Steele, T.E. 2007. The mammalian fauna associated with an archaic hominin skullcap and later Acheulean artifacts at Elandsfontein, Western Cape Province, South Africa. *Journal of Human Evolution* **52**: 164-186.

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

Pether, J. 2012. Palaeontological Impact Assessment (Desktop Study). As part of the Environmental Impact Assessment (EIA) and Environmental Management Plan (EMP) for a sea water reverse osmosis desalination plant in the Saldanha Bay region, Western Cape, South Africa. For CSIR - Environmental Management Services. Client: WorleyParsons South Africa (Pty) Ltd.

Roberts, D.L. and 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., Berger, L., 1997. Last interglacial c.117 kyr human footprints, South Africa. *S. Afr. J. Sci*. **93**: 349–350.

Roberts, D.L., Botha, G.A., Maud, R.R. and Pether, J. 2006. Coastal Cenozoic Deposits. In: Johnson, M. R., Anhaeusser, C. R. and 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 and 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.

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

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.

Senut, B. and Pickford, M. 1995. Fossil eggs and Cenozoic continental biostratigraphy of Namibia. *Palaeontologia Africana* **32**: 33-37.

Shannon, L. V., Boyd, A. J., Brundrit, G. B. and Taunton-Clark, J., 1986. On the existence of an *El Niño*-type phenomenon in the Benguela System. *Journal of Marine Research* **44**: 495-520.

Siddall, M., Chappell, J. and Potter, E.-K. 2007. Eustatic sea level during past interglacials. *The Climate of Past Interglacials: Developments in Quaternary Science* **7**: 75-92.

Siesser, W.G. 1970. Carbonate components and mineralogy of the South African coastal limestones and limestones of the Agulhas Bank. *Transactions of the Geological Society of South Africa* **73**: 49-63.

Siesser, W.G. 1972. Petrology of the Cainozoic coastal limestones of the Cape Province, South Africa. *Transactions of the Geological Society of South Africa* **75**: 177-185.

Tankard, A.J. 1974a. Petrology and origin of the phosphorite and aluminium phosphate rock of the Langebaanweg-Saldanha area, south-western Cape Province. *Annals of the South African Museum* **65**: 217-249.

Tankard, A.J. 1974b. 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 late Cenozoic History and Palaeoenvironments of the coastal margin of the south-western Cape Province. Unpublished Ph.D. thesis. Rhodes University, Grahamstown.

Tankard, A.J. 1975c. 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.

Visser, H.N. & Toerien, D.K. 1971. Die geologie van die gebied tussen Vredendal en Elandsbaai. Explanation of Sheet 254: 3118C (Doring Bay) and 3218A (Lambert's Bay). *Geological Survey of South Africa.* 63 pp.

Wybergh, W. 1919. The coastal limestones of the Cape Province. *Transactions of the Geological Society of South Africa* **22**: 46-67.

Wybergh, W. 1920. The Limestone Resources of the Union. *Memoir of the Geological Survey of South Africa* **11**: Vol. 2.

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15 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.

AIA: Archaeological Impact Assessment.

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

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

asl.: above (mean) sea level.

Bedrock: Hard rock formations underlying much younger sedimentary deposits.

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

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

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

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

Coversands: Aeolian blanket deposits of sandsheets and dunes.

Duricrust: A general term for a zone of chemical precipitation and hardening formed at or near the surface of sedimentary bodies through pedogenic and (or) non-pedogenic processes. It is formed by the accumulation of soluble minerals deposited by mineral-bearing waters that move upward, downward, or laterally by capillary action, commonly assisted in arid settings by evaporation. Classified into calcrete, ferricrete, silcrete.

ESA: Early Stone Age. The archaeology of the Stone Age between 2 000 000 and 250 000 years ago.

EIA: Environmental Impact Assessment.

EMP: Environmental Management Plan.

Ferricrete: Indurated deposit (duricrust) consisting predominantly of accumulations of iron sesquioxides, with various dark-brown to yellow-brown hues. It may form by deposition from solution or as a residue after removal of silica and alkalis. Like calcrete it has pedogenic and groundwater forms. Synonyms are laterite, iron pan or “koffieklip”.

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

Fm.: Formation.

Fossil: Mineralised bones of animals, shellfish, plants and marine animals. A trace fossil is the disturbance or structure produced in sediments by organisms, such as burrows and trackways.

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).

HIA: Heritage Impact Assessment.

LSA: Late Stone Age. The archaeology of the last 20 000 years associated with fully modern people.

LIG: Last Interglacial. Warm period 128-118 ka BP. Relative sea-levels higher than present by 4-6 m. Also referred to as Marine Isotope Stage 5e or "the Eemian".

Midden: A pile of debris, normally shellfish and bone that have accumulated as a result of human activity.

MSA: Middle Stone Age. The archaeology of the Stone Age between 20-300 000 years ago associated with early modern humans.

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 whose 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.

Peat: partially decomposed mass of semi-carbonized vegetation which has grown under waterlogged, anaerobic conditions, usually in bogs or swamps.

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

Pedocrete: A duricrust formed by pedogenic processes.

PIA: Palaeontological Impact Assessment.

SAHRA: South African Heritage Resources Agency – the compliance authority, which protects national heritage.

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

15.1 GEOLOGICAL TIME SCALE TERMS (YOUNGEST TO OLDEST).

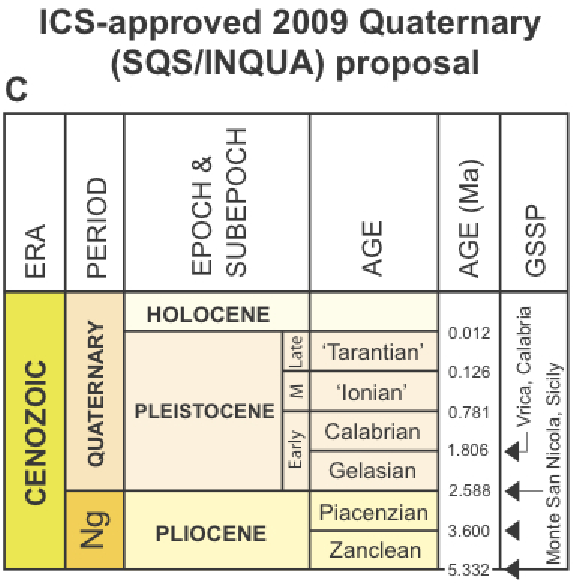
For more detail see www.stratigraphy.org.

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. Generally not used for durations not extending from the Present. Sometimes "kyr" is used instead.

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. Generally not used for durations not extending from the Present.

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 (0.78-2.6.Ma).



Quaternary: The current Period, from 2.6 Ma to the present, in the Cenozoic Era. The Quaternary includes both the Pleistocene and Holocene epochs. The terms early, middle or late in reference to the Quaternary should only be used with lower case letters because these divisions are informal and have no status as divisions of the term Quaternary. The sub-divisions 'Early', 'Middle' or 'Late' apply only to the word Pleistocene. As used herein, early and middle Quaternary correspond with the Pleistocene divisions, but late Quaternary includes the Late Pleistocene and the Holocene.

Pliocene: Epoch from 5.3-2.6 Ma.

Miocene: Epoch from 23-5 Ma.

Oligocene: Epoch from 34-23 Ma.

Eocene: Epoch from 56-34 Ma.

Paleocene: Epoch from 65-56 Ma.

Cenozoic: Era from 65 Ma to the present. Includes Paleocene to Holocene epochs.

Cretaceous: Period in the Mesozoic Era, 145-65 Ma.

Jurassic: Period in the Mesozoic Era, 200-145 Ma.

Precambrian: Old crustal rocks older than 542 Ma (pre-dating the Cambrian).

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16 APPENDIX 1 – MONITORING FOR FOSSILS

A regular monitoring presence over the period during which excavations 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.

Should the monitoring of the excavations be a stipulation in the Archaeo-logical Impact Assessment, the contracted Monitoring Archaeologist (MA) can also monitor for the presence of fossils and make a field assessment of any material brought to attention. The MA is usually sufficiently informed to identify fossil material and this avoids additional monitoring by a palaeontologist. In shallow coastal excavations, the fossils encountered are usually in an archaeological context.

The MA then becomes the responsible field person and fulfils the role of liaison with the palaeontologist and coordinates with the developer and the Environmental Control Officer (ECO). If fossils are exposed in non-archaeological contexts, the palaeontologist should be summoned to document and sample/collect them.

Other alternatives could be considered, such as the employment of a dedicated monitor for the construction period. For instance, a local person could be detached from or trained by personnel at the West Coast Fossil Park.

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17 APPENDIX 2 - FOSSIL FIND PROCEDURES

In the context under consideration, it is improbable that fossil finds will require declarations of permanent "no go" zones. At most a temporary pause in activity at a limited locale may be required. The strategy is to rescue the material as quickly as possible.

The procedures suggested below are in general terms, to be adapted as befits a context. They are couched in terms of finds of fossil bones that usually occur sparsely, such as in the aeolian deposits. However, they may also serve as a guideline for other fossil material that may occur.

In contrast, fossil shell layers are usually fairly extensive and can be easily documented and sampled.

Bone finds can be classified as two types: isolated bone finds and bone cluster finds.

17.1 ISOLATED BONE FINDS

In the process of digging the excavations, isolated bones may be spotted in the hole sides or bottom, or as they appear on the spoil heap. By this is meant bones that occur singly, in different parts of the excavation. If the number of distinct bones exceeds 6 pieces, the finds must be treated as a bone cluster (below).

Response by personnel in the event of isolated bone finds

- **Action 1:** An isolated bone exposed in an excavation or spoil heap must be retrieved before it is covered by further spoil from the excavation and set aside.
- **Action 2:** The site foreman and ECO must be informed.
- **Action 3:** The responsible field person (site foreman or ECO) must take custody of the fossil. The following information to be recorded:
    - Position (excavation position).
    - Depth of find in hole.
    - Digital image of hole showing vertical section (side).
    - Digital image of fossil.
- **Action 4:** The fossil should be placed in a bag (*e.g.* a Ziplock bag), along with any detached fragments. A label must be included with the date of the find, position info., depth.
- **Action 5:** ECO to inform the developer, the developer contacts the standby archaeologist and/or palaeontologist. ECO to describe the occurrence and provide images asap. by email.

Response by Palaeontologist in the event of isolated bone finds

The palaeontologist will assess the information and liaise with the developer and the ECO and a suitable response will be established.

17.2 BONE CLUSTER FINDS

A bone cluster is a major find of bones, *i.e*. several bones in close proximity or bones resembling part of a skeleton. These bones will likely be seen in broken sections of the sides of the hole and as bones appearing in the bottom of the hole and on the spoil heap.

Response by personnel in the event of a bone cluster find

- **Action 1:** Immediately stop excavation in the vicinity of the potential material. Mark (flag) the position and also spoil that may contain fossils.
- **Action 2:** Inform the site foreman and the ECO.
- **Action 3:** ECO to inform the developer, the developer contacts the standby archaeologist and/or palaeontologist. ECO to describe the occurrence and provide images asap. by email.

Response by Palaeontologist in the event of a bone cluster find
The palaeontologist will assess the information and liaise with the developer and the ECO and a suitable response will be established. It is likely that a Field Assessment by the palaeontologist will be carried out asap.

It will probably be feasible to "leapfrog" the find and continue the excavation farther along, or proceed to the next excavation, so that the work schedule is minimally disrupted. The response time/scheduling of the Field Assessment is to be decided in consultation with developer/owner and the environmental consultant.

The field assessment could have the following outcomes:

- If a human burial, the appropriate authority is to be contacted (see AIA). The find must be evaluated by a human burial specialist to decide if Rescue Excavation is feasible, or if it is a Major Find.
- If the fossils are in an archaeological context, an archaeologist must be contacted to evaluate the site and decide if Rescue Excavation is feasible, or if it is a Major Find.
- If the fossils are in an palaeontological context, the palaeontologist must evaluate the site and decide if Rescue Excavation is feasible, or if it is a Major Find.

17.3 RESCUE EXCAVATION

Rescue Excavation refers to the removal of the material from the just the "design" excavation. This would apply if the amount or significance of the exposed material appears to be relatively circumscribed and it is feasible to remove it without compromising contextual data. The time span for Rescue Excavation should be reasonably rapid to avoid any or undue delays, *e.g.* 1-3 days and definitely less than 1 week.

In principle, the strategy during mitigation is to "rescue" the fossil material as quickly as possible. The strategy to be adopted depends on the nature of the occurrence, particularly the density of the fossils. The methods of collection would depend on the preservation or fragility of the fossils and whether in loose or in lithified sediment. These could include:

- On-site selection and sieving in the case of robust material in sand.
- Fragile material in loose/crumbly sediment would be encased in blocks using Plaster-of Paris or reinforced mortar.

If the fossil occurrence is dense and is assessed to be a "Major Find", then carefully controlled excavation is required.

17.4 MAJOR FINDS

A Major Find is the occurrence of material that, by virtue of quantity, importance and time constraints, cannot be feasibly rescued without compromise of detailed material recovery and contextual observations.
A Major Find is not expected.

Management Options for Major Finds
In consultation with developer/owner and the environmental consultant, the following options should be considered when deciding on how to proceed in the event of a Major Find.

Option 1: Avoidance

Avoidance of the major find through project redesign or relocation. This ensures minimal impact to the site and is the preferred option from a heritage resource management perspective. When feasible, it can also be the least expensive option from a construction perspective.

The find site will require site protection measures, such as erecting fencing or barricades. Alternatively, the exposed finds can be stabilized and the site refilled or capped. The latter is preferred if excavation of the find will be delayed substantially or indefinitely. Appropriate protection measures should be identified on a site-specific basis and in wider consultation with the heritage and scientific communities.

This option is preferred as it will allow the later excavation of the finds with due scientific care and diligence.

Option 2: Emergency Excavation

Emergency excavation refers to the "no option" situation wherein avoidance is not feasible due to design, financial and time constraints. It can delay construction and emergency excavation itself will take place under tight time constraints, with the potential for irrevocable compromise of scientific quality. It could involve the removal of a large, disturbed sample by excavator and conveying this by truck from the immediate site to a suitable place for "stockpiling". This material could then be processed later.

Consequently, emergency excavation is not a preferred option for a Major Find.

17.5 EXPOSURE OF FOSSIL SHELL BEDS

Response by personnel in the event of intersection of fossil shell beds
- **Action 1:** The site foreman and ECO must be informed.
- **Action 2:** The responsible field person (site foreman or ECO) must record the following information:
    - Position (excavation position).
    - Depth of find in hole.
    - Digital image of hole showing vertical section (side).
    - Digital images of the fossiliferous material.
- **Action 3:** A generous quantity of the excavated material containing the fossils should be stockpiled near the site, for later examination and sampling.
- **Action 4:** ECO to inform the developer, the developer contacts the standby archaeologist and/or palaeontologist. ECO to describe the occurrence and provide images asap. by email.

Response by Palaeontologist in the event of fossil shell bed finds
The palaeontologist will assess the information and liaise with the developer and the ECO and a suitable response will be established. This will most likely be a site visit to document and sample the exposure in detail, before it is covered up.

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