Case No. 16092709AS1006E

HERITAGE IMPACT ASSESSMENT

PROPOSED WATER RESERVOIR AT THE KOEBERG NUCLEAR POWER STATION, FARM DUYNEFONTEIN 34, MALMESBURY REGISTRATION DIVISION WESTERN CAPE

Assessment conducted under Section 38 (3) of the National Heritage Resource Act (No. 25 of 1999)

Prepared for:

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On behalf of:

ESKOM HOLDINGS SOC LIMITED

By

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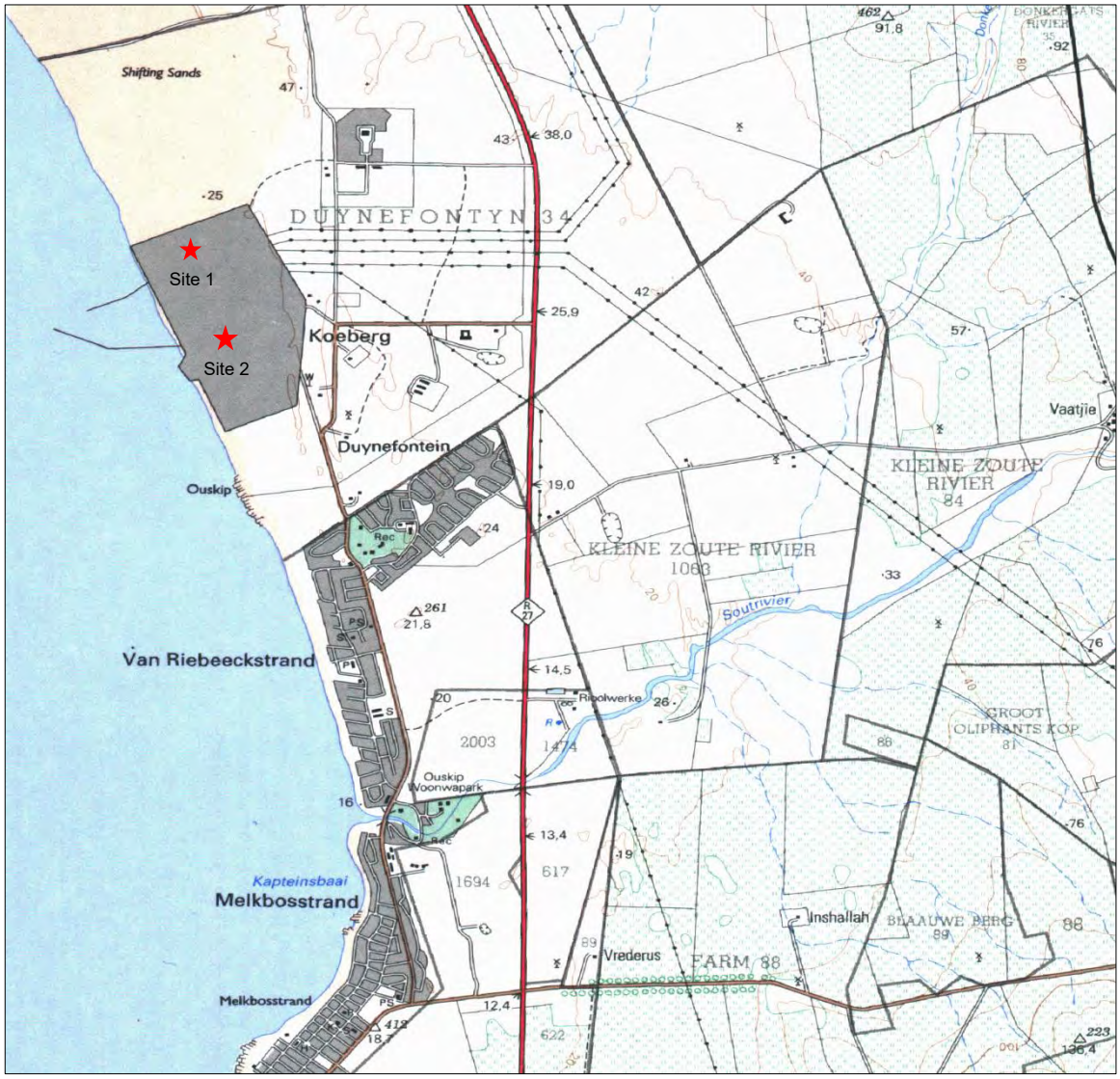
DECEMBER
2016

Executive summary

1. **Site Name**: Proposed Water Reservoir, Koeberg Nuclear Power Station, Melkbosstrand, Western Cape

2. **Location**: Koeberg Nuclear Power Station - Cape Farm No. 34 Duynefontein
   GPS co-ordinate: S33 40.603 E18 26.558

3. **Locality Map**:



Locality Map (3318 CB Melkbosstrand) showing the location of the proposed site alternatives.

Google satellite map showing the alternative location sites for the proposed reservoir.

4. Description of the Proposed Development

The project entails the construction of a new concrete water reservoir. Friction piles will be employed to support the base for the reservoir, which will be partially-subsurface (foundation base at ± 3.2 m). The footprint area for the new reservoir is less than 0.5ha in extent.

Two site alternatives have been identified:

Site Alterntative 1 (preferred site alternative)

The proposed site is located north of the reactor building, inside the security fence. The site was levelled in the 1980s prior to construction of the nuclear power station. The footprint area is partially covered in low vegetation, on a substrate of compact dune sand. In the past, the surface of the site included low dunes of the Witzand Formation, and possibly deflated exposures of calcrete and yellow sand deposits of the Springfontyn Formation. During the course of the excavations for the reactor site, excavated material was dumped over this area and levelled. A large portion of the site is covered in blue concrete stone and bits of old building rubble and waste.

Site Alternative 2

The proposed site is a small, vacant site located south of the reactor building, adjacent a service yard, surrounded by ancillary buildings and parking. The site is fundamaentally transformed.

5. Heritage process

A Notice of Intent to Develop (NID) was submitted to Heritage Western Cape (HWC) in October 2016, who requested that a Heritage Impact Assessment (HIA) consisting of an archaeological and palaeontological study be done, and that comments from the local municipality and registered conservation bodies be included in an integrated HIA report.

The HIA comprises a palaeontological desktop study and an archaeological field assessment.

ACRM was commissioned to undertake the field assessment and to write up the integrated HIA report.

Dr Graham Avery was appointed to undertake the palaeontological desktop study, which included an assessment of the potential impacts of the development on buried Pleistocene archaeological deposits.

6. Heritage Resources Identified

A field assessment of the proposed site alternatives was undertaken by ACRM in November, 2016.

The following observations were made:

Site Alternative 1

A broken Middle Stone Age (MSA) quartzite flake and a small nodule of silcrete were recorded on the proposed development site. Apart from a few small fragments of weathered shellfish (a-diagnostic limpets & Venus clams) and larger fragments of White Sand Mussel, no other archaeological resources were identified. No organic remains such as pottery or ostrich eggshell were found.

The archaeological resources have been graded as having *low* (Grade 3C) significance.

Site Alternative 2

No archaeological heritage was encountered on the proposed site.

7. Anticipated Impacts on Heritage Resources

Both site alternatives are located in a palaeontologically-sensitive region with a hard rock base of Malmesbury Group shale, which outcrops along the coast. Cover sands of the Holocene Witzand Formation may be present, although the surface is likely to have been disturbed through natural deflation and during construction of the power station. The likely depth of the semi-sunken reservoir will, however, probably encounter sediments from the Middle Pleistocene Langebaan and Springfontyn Formations of the Sandveld Group, the latter of which contains Middle Pleistocene palaeontological and archaeological remains. Sparse fossils are known from the Langebaan Formation elsewhere.

Any fossils of vertebrates or trace fossils from the Springfontyn Formation would be significant and would require careful recording and possible systematic excavation. Similarly, if Velddrif Formation molluscan deposits and/or recent mollusc/other deposits (e.g. mid-Holocene high sea level), which could be associated with the coastal Witzand Formation (Q5), are found, grab samples will need to be taken.

Palaeontological material is currently known from sediments underlying Duynefontyn Farm, and adjacent areas. Monitoring of excavations will therefore be required. However, geotechnical investigation or test excavations may provide an opportunity to better assess the possibility that palaeontological and archaeological remains will be encountered during excavations.

Any excavation for foundations that penetrates into underlying terrestrial and/or deeper marine sediments may therefore encounter fossils. Since such occurrences are not normally preserved, fossil finds would be significant and would require careful recording and possible systematic excavation.

Excavations into deep sediments, not normally accessible to palaeontologists, should also be seen as providing opportunities to recover potentially-important fossil material that enables observations to be made on geology, past sea levels, climates, environments and biodiversity that would otherwise not be possible.

Pre-colonial Khoisan burials may be exposed during bulk earthworks. Any Pleistocene human skeletal material, for example, would be of international significance, which is possible in this geological context.

8. Summary of Impacts

8.1 Site Alternative 1 (preferred site alternative)

	Negative Effects	Positive Effects	No Go Option	No Mitigation	With Mitigation
Pre-construction	Excavating into potentially fossil-bearing deposits	Opportunity to assess actual and recover information not otherwise accessible	N/A	Unknown loss manageable with monitoring and protocol	Loss negligible; material and information recovered and lodged in repository
Construction	Likely loss of heritage material and information	Opportunity to gain new information and recover material	N/A	Probable loss of heritage material and information	Any potential loss minimized
Operational phases	None	None	N/A	N/A	Any potential loss minimized
Cumulative Effects	N/A unless renewed excavation place or dismantling	Unknown	Prior assessment required	Unknown	Any potential loss minimized

Pre-construction: test of sediments to maximum depth of base. Possible methods include geotechnical coring to start; test holes by heritage specialist(s) dependent on result. Monitoring by an appropriately-qualified specialist to take place at each stage. Monitoring Protocols for dealing with heritage material pre-developed and implemented.

Construction: monitoring of excavations by appropriately-qualified palaeontologist. Protocols for managing heritage material embedded in EMP. Collection of information and material by specialist and deposition in approved repository.

Operational Phases: no issues expected unless maintenance or modification/ development requires excavation. Protocol to cover eventuality.

Cumulative Effects: None expected unless renewed excavation or dismantling is contemplated. In such an instance prior assessment of possible negative effects will be required. Decision to mitigate or not will follow from that assessment.

8.2 Site Alternative 2

	Negative Effects	Positive Effects	No Go Option	No Mitigation	With Mitigation
Pre-construction	Excavating into potentially fossil-bearing deposits	Opportunity to assess actual and recover information not otherwise accessible	N/A	Unknown loss manageable with monitoring and protocol	Loss negligible; any material and information recovered and lodged in repository
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Operational Phases: no issues expected unless maintenance or modification/ development requires excavation. Protocol to cover eventuality.

Cumulative Effects: None expected unless renewed excavation or dismantling is contemplated. In such an instance prior assessment of possible negative effects will be required. Decision to mitigate or not will follow from that assessment.

Provided that the recommendations in this report are followed, there is no reason why establishment of the proposed reservoirs should not proceed.

9. Recommendations

The following recommendations are made, which are subject to the approval of Heritage Western Cape.

1. A series of test pits must be dug across the proposed footprint area prior to construction work commencing. This could also form part of a geotechnical investigation of sub-surface sediments/formations. Excavations that extend into light orange coloured sands of the Springfontyn Formation may encounter undisturbed fossils (bone & shell), and Stone Age artefacts. It is important to establish the archaeological significance of buried sub-surface deposits before bulk earthworks commence, as it will enable the archaeologist and palaeontologist to develop an appropriate mitigation action plan.

2. Fossils and Stone Age artefacts are protected by law. Should anything of a palaeontological/palynological nature be found on site by the contractor (or any other party), e.g. bones not previously visible, work is to be stopped in that area immediately, and the Environmental Control Officer (ECO) notified. Failure to do so will result in a penalty and this must be carefully explained to workers during the Environmental Education Induction Programme undertaken by the ECO. The archaeologist must also assist with the induction programme. No palaeontological or archaeological material may be removed from the site without a permit from Heritage Western Cape, the Provincial Heritage Authority.

3. Permits to recover fossils and archaeological material should be applied for (by the monitoring heritage specialist) in advance of the Construction Phase commencing.

4. Excavations must be monitored by a palaeontologist or archaeologist with appropriate palaeontological knowledge. The frequency of this to be worked out *a priori* with the contractor to minimize time spent on site.

5. If possible, geotechnical information together should be provided prior to the commencement of construction. This may enable a better estimation of the time(s) when monitoring would be necessary.

6. Protocols for dealing with palaeontological/palynological (fossil pollens) monitoring and possible further mitigation must be included in the Environmental Management Plan (EMP).

7. Funds must be available *a priori* to cover costs of monitoring and any additional fieldwork and radiocarbon dates, should the opportunity/need arise.

8. Should palaeontological and/or archaeological material be encountered, the ECO will advise on demarcation of this area and notify the specialist palaeontologist/archaeologist to view material and ascertain whether further study of the area will be required.

9. Should a specialist confirm a genuine fossil or sub-fossil and recommend further study of the area, work in the applicable area is to cease until further notice. Heritage Western Cape is to be informed immediately.

10. Should any human remains be disturbed, exposed or uncovered during excavation, work in that area must stop and the find shall immediately be reported the South African Police Service and the monitoring heritage specialist. If it is suspected that the remains are older than 60 years, then the South African Heritage Resource Agency - SAHRA (021 462 4502) must be informed and established protocols followed.

11. The removal of discovered palaeontological remains by a contracted specialist shall be at the applicant's expense.

12. All palaeontological and archaeological material must be lodged in an appropriate Iziko Museums of South Africa collection.

13. The above recommendations must be included with the Environmental Management Plan for the project.

10. Authors' Note

Kaplan, J. 2016. Heritage Impact Assessment, proposed water reservoir at the Koeberg Nuclear Power Station Farm Duynefontein 34, Malmesbury District, Western Cape. Report prepared for Doug Jeffery Environmental Consultants. ACRM Cape Town

Avery, G. 2016. Palaeontological Assessment. 1:50 000 3318CB Melkbosstrand. Report prepared for Doug Jeffery Environmental Consultants. Archaeozoology, Stone Age Archaeology and Quaternary Palaeontology. Cape Town

Table of Contents

BIO SKETCH

Name: Jonathan Michael Kaplan

Profession: Archaeologist/Heritage Practitioner

Date of Birth: 23-09-1961

Name of Company: Agency for Cultural Resource Management (ACRM)

Position: Director

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Qualifications:
MA (Archaeology) 1989, University of Cape Town

Professional registration:
Association of Southern African Professional Archaeologists (ASAPA) accredited Cultural Resources Management (CRM) practitioner (Membership No # 253).

Declaration:

I confirm that the above bio sketch is an accurate description of my qualifications.

Signature **Date**: 15 December, 2016

Declaration of independence

I, **Jonathan Kaplan** (MA in archaeology, University of Cape Town, 1989), hereby confirm that I am a professional member, in good standing, of the Association of South African Professional Archaeologists (ASAPA membership # 253).

I am an accredited Principal Investigator for coastal shell middens and Stone Age archaeology, and Field Director for Rock Art.

As the appointed independent specialist archaeologist for this project, I hereby declare that I:

- Act as an independent specialist in this application;
- Regard the information contained in this report as it relates to my specialist input to be true and correct;
- Do not have any financial interest in the undertaking of the activity, other than remuneration for work performed.

Signature of the specialist:

Name of company: Agency for Cultural Resource Management

Date: 15 December, 2016

1. INTRODUCTION

ACRM was instructed by Doug Jeffery Environmental Consultants, on behalf of Eskom Holdings SOC Limited to conduct a Heritage Impact Assessment (HIA) for the proposed construction of a concrete water reservoir at the Koeberg Nuclear Power Station (Cape Farm No. 34 Duynefontein) near Melkbosstrand in the Western Cape (Figures 1 & 2).

Two site alternatives have been identified, with Site Alternative 1 being the preferred location site for the new reservoir.

Friction piles will be employed to support the base for the reservoirs, which will be partially-subsurface (foundation base at ± 3.2m) (Figure 5).

The footprint area for the proposed reservoir is less than 0.5ha in extent.

Site Alternative 1 is located north of the reactor building, inside the security fence (Figure 3)

Site Alternative 2 is located south of the reactor building on a vacant piece of land adjacent a service yard (Figure 4).

A Notice of Intent to Develop (NID) was submitted to Heritage Western Cape (HWC) in October 2016, who requested that a Heritage Impact Assessment (*Case No. 16092709AS1006E*), consisting of an archaeological and palaeontological study must be done.

HWC requested that comments from the local municipality and registered conservation bodies must be also included in an integrated HIA report.

ACRM was commissioned to undertake the archaeological study, and to write up the final HIA report.

Dr G. Avery was appointed to undertake a specialist palaeontological desktop study, which included an assessment of the potential impacts of the development on buried Pleistocene archaeological deposits.

Doug Jeffery Environmental Consultants is the appointed independent Environmental Assessment Practitioner (EAP) responsible for facilitating the assessment process

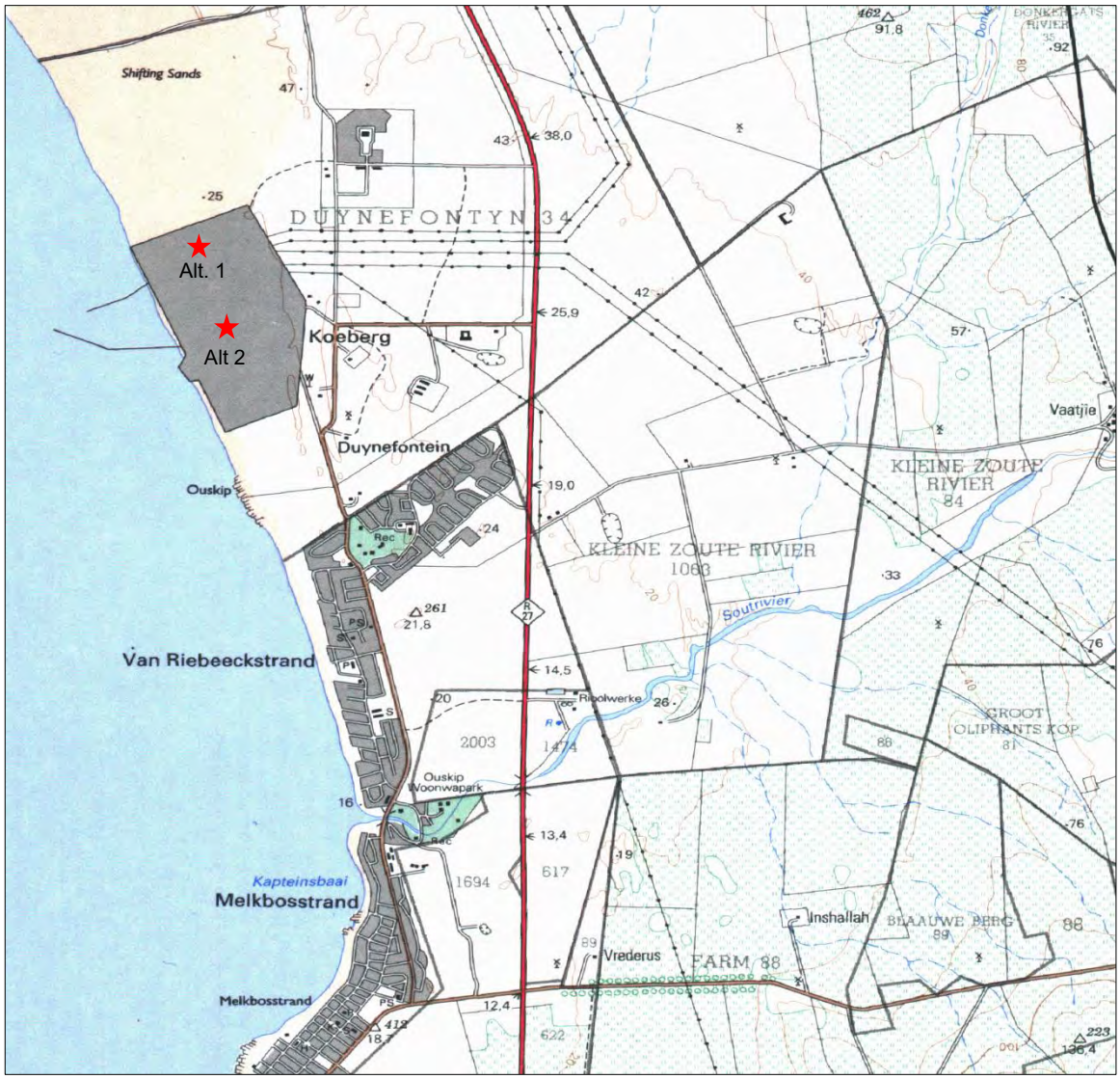

Figure 1. Map (3318 CB Melkbosstrand) showing the location of the proposed site alternatives.

Figure 2. Google satellite map aerial photograph indicating the proposed and proposed alternative location sites for the water reservoir. Alternative 1 is the preferred site

Figure 3. Proposed location for Site Alternative 1

Figure 4. Proposed location for Site Alternative 2

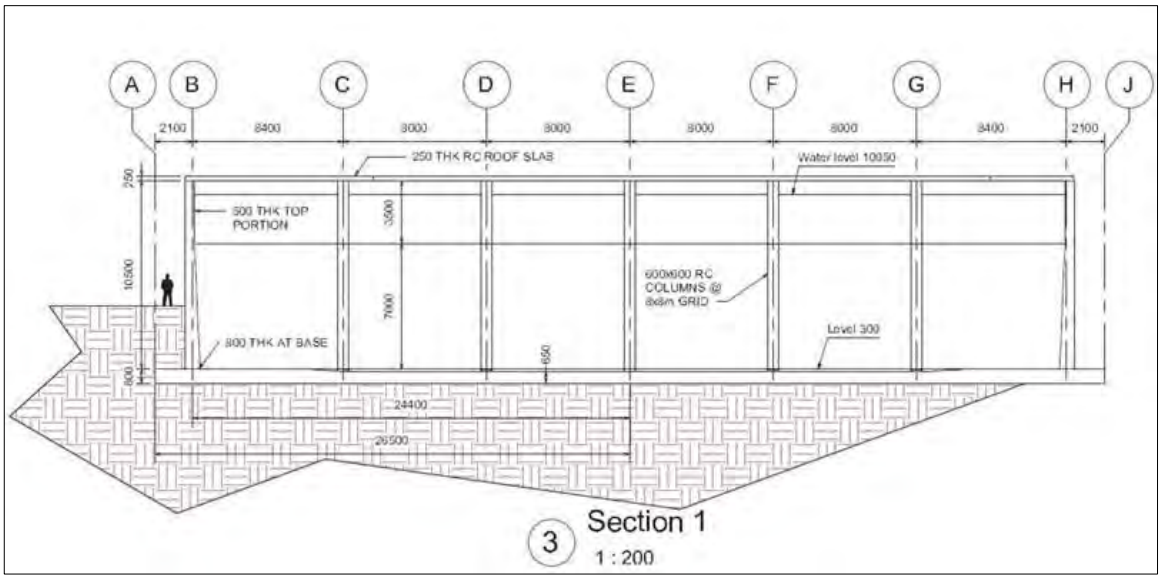

Figure 5. Detail showing sub-surface depth (~ 3.2m) to which the proposed construction will extend

2. HERITAGE 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 (Sect. 35), it is an offence to destroy, damage, excavate, alter of remove from its original place, or collect, any archaeological, palaeontological and historical material or object, without a permit issued by the SAHRA or applicable Provincial Heritage Resources Agency, *viz*. Heritage Western Cape (HWC).

Notification of HWC is required for proposed developments exceeding certain dimensions (Sect. 38), upon which they will decide whether or not the development must be assessed for heritage impacts (an HIA) that may include an assessment of archaeological (a AIA) or palaeontological heritage (a PIA).

3. TERMS OF REFERENCE

The terms of reference for the study were to:

- Determine whether there are likely to be any important archaeological and palaeontological resources that may be impacted by the proposed development;
- Indicate any constraints that would need to be taken into account in considering the development proposal;
- Recommend mitigation action

4. DESCRIPTION OF THE RECEIVING ENVIRONMENT

Two site alternatives have been identified for the proposed water. Site Alternative 1 is the preferred development site.

4.1 Site Alternative 1

Site Alternative 1 is located north of the reactor building, inside the security fence on Cape Farm 34 Duynefontein. The proposed site was levelled in the 1980s prior to construction of the power station. The footprint area is vegetated, on a substrate of compact dune sand (Figures 7-9). The surface area is covered in blue concrete stone and bits of old building rubble. Much of it can be seen on open patches of sand. In the past, the surface of the site included low dunes of the Witzand Formation, and possibly deflated exposures of calcrete and yellow sand deposits of the Springfontyn Formation. During the course of the preparation of the reactor site, excavated material was dumped over this area. According to Avery (2014) and Richard Klein (pers. comm. 2014), the low hummock dunes surrounding the power station were levelled when construction of the nuclear reactor units commended in the 1980's. The site slopes fairly gently to the west, but then dips fairly suddenly onto a gravel road. The proposed development site thus constitutes a transformed landscape.

Figure 7. Site Alternative 1. View facing east

Figure 8. Site Alternative 1. View facing west.

Figure 9. Site Alternative 1. View facing south. The building housing the spent fuel rods is visible in the background of the plate.

4.2 Site Alternative 2

Site Alternative 2 is located south of the reactor building, alongside a service yard (Figures 10 & 11). The small piece of land is currently being used to dump excavated material, from a construction site alongside. The proposed site is fundamaentally transformed.

Figure 10. Site Alternative 2. View facing north west. Note the excavated material from the adjacent excavations

Figure 11. Site Alternative 2. View facing north

5. STUDY APPROACH

5.1 Method

The purpose of the HIA is to assess the sensitivity of archaeological and palaeontological resources in the study area, to determine the potential impacts on such resources, and to avoid and/or minimize such impacts by means of management and/or mitigation measures.

The significance of archaeological resources was assessed in terms of their content and context. Attributes considered in determining significance include artefact and/or ecofact types, rarity of finds, exceptional items, organic preservation, potential for future research, density of finds and the context in which archaeological traces occur.

To this end, a field assessment was undertaken by J Kaplan on 18th November 2016. The position of identified archaeological resources were plotted using a hand held GPS unit set on the map datum wgs 84. A track path of the survey was also captured. Access to the site was facilitated by Ms Annei Kloppers of Koeberg Operating Unit.

A literature survey was carried out to assess the heritage context surrounding the proposed development site.

Heritage Western Cape (2012) uses a system in which archaeological resources of local significance are divided into Grade 3A, 3B and 3C. These equate to *high*, *medium* and *low* local significance. This grading system is employed in the present report.

The PIA, which includes an assessment of the potential impacts of the proposed activity on sub-surface palaeontological and Pleistocene archaeology, was limited to a desk top study (Avery 2016). The 1:250 000 Geological series 3318 Cape Town and other geological sources were consulted by Avery. Since little is known about the palaeontological potential of the specific locality, literature describing known palaeontological sites in the vicinity was consulted. The site was not visited.

5.2 Constraints and limitations

There were no limitations or constraints. Archaeological visibility was very good.

5.3 Potential risks

Based on available information (for example, Avery 2014; Deacon 1975; Hart 2008, 2010; Klein 1975; Klein et al 1999; Pether 2013, 2007), it is possible that potentially significant sub-surface archaeological and palaeontological heritage will be impacted by excavations for the proposed new reservoir. Early Stone Age (ESA) and Middle Stone Age (MSA) tools, vertebrate fossils (i. e. bone) and shell may be found, embedded or lying on ancient buried land surfaces underlying the cover sands of the Witzand Formation.

Light orange coloured sands of the Springfontyn Formation are also indicators shown to have been associated with Middle Pleistocene fossils and Stone Age tools (Avery 2014, 2016; Pether 2013, 2007).

According to Avery (2014, 2016), the proposed development site is located in a known palaeontologically-sensitive region. Any excavation for foundations and/or infrastructure that penetrates into underlying terrestrial and/or deeper marine sediments, if preserved, may also encounter fossils.

Later Stone Age (LSA) surface archaeological heritage will likely not be impacted by the proposed development. In the past, the surface of the site included low hummock dunes of the Witzand Formation, and deflated exposures of calcrete and yellow sand deposits of the Springfontyn Formation. But during the course of the preparation of the reactor site, the dunes were levelled, and excavated material was dumped and spread over this area (Avery 2014; Richard Klein pers. comm. 2014).

There is a possibility that Khoisan burials may be uncovered or intersected during bulk earthworks and excavations. Any Pleistocene human skeletal material would, however, be of international significance, `which is possible in this geological context' (Hart 2008).

6. HERITAGE CONTEXT

Superficial Witzand Formation sands cover most of the Duinefontein dune field (Avery 2014). This Holocene element of the Duinefontein Dune Plume, which extends from the coast towards Darling, overlies sandy Springfontyn Formation sediments. Surface scatters of Later Stone Age (LSA) tools, shellfish, marine molluscs, bone, pottery, ostrich eggshell and hearth features have been encountered in the Duinefontein dunes in the Koeberg Nature Reserve north of the power station, but these types of sites are quite sparse and ephemeral (Hart 2010; Kaplan 1993; Klein 1975). Sub-fossil remains from the more recent Witzand sands can also provide records of species present in the past 10,000 years and the historical period. For example, the remains of a black rhinoceros found in the Witsand dune field provide a specimen record confirming observations by the first European settlers in the area (Avery 2014).

But undoubtedly, it is the excavations in the Duinefontein dune field, about 1 km north of the nuclear reactor that established Koeberg as a `place of world class scientific discovery' (Hart 2010:27). During the 1950s and 1960s the Duinefontein dune field extended from Melkbosstrand to Groot Springfontein (Avery 2014). The archaeological site known as Duinefontein 2 (DFT 2) was first discovered in 1973 when fragments of fossil bone were uncovered during geotechnical excavations for the power station (G. Avery & R. Klein pers. comm. 2014) and has been excavated during the mid-1970's and late 1990's/early 2000s. DFT 2 has produced a wealth of Pleistocene fauna (about 330 000 years old), and associated ESA implements on buried land surfaces around wetlands (Cruz-Uribe *et al* 2003; Klein *et al* 1999). Hart (2010 & pers. comm. 2013) has argued that the Duinefontein archaeological deposits were not a fortuitous discovery, and that similar deposits lie buried beneath the windblown sands of the Witzand Formation, in what he calls the Nuclear - 1 Corridor both north and south of the reactor.

In Duinefontein, the Varswater Formation includes Late Miocene-Early Pliocene marine palaeontological material dating to about 5 million years (Ma) and Middle Pleistocene Springfontyn sediments, which are of particular relevance to this study, include palaeontological and archaeological material dated to 330 000 years. Avery (2014) notes that, although Late Pleistocene MSA artefacts have been recovered elsewhere in the

area, the DFT 2 artefacts, which were originally ascribed to the MSA, were in fact shown to be ESA during later excavations at the site.

Other significant excavated samples in the Duinefontein dune field include hyaena dens, which yielded a wide range of fossils of terrestrial mammals and birds; material from the excavations for the reactor yielded the earliest example of the South African Fur Seal, and ESA artefacts on ancient land surfaces (Avery 2014).

According to Avery (2014, 2016) material from the excavations for the reactors was dumped between the fore dunes and access track just north of the security fence. Fragments of fossilized bone and bones of seabirds can be found when the surface is eroded. This area coincides with Site Alternative 1 and overlies the original surface on which Middle Pleistocene fossils were, and may still be, encountered during construction activities (Kaplan 2014).

6.1 Burials

Pre-colonial graves can occur at any location where sand suitable for excavation and burial exists. This is particularly the case in coastal areas where dunes abound. No unmarked or buried pre-colonial human remains have been recovered at Koeberg or in the Duinefontein dune fields, but Melkbosstrand has produced a large number of burials (Morris 1992). Most of the unmarked human remains were discovered during excavations for water pipelines, substations, foundations, roads and bulk services. Nearly 60 Khoisan burials have so far been found between Milnerton and Melkbosstrand (Orton 2010) including a rare double burial near Ou Skip at Duinefontein Village (Kaplan 2013; Friedling 2013). Two burials associated with stone tools and ostrich eggshell beads were also excavated from a sand dune on the farm Groot Oliphantskop east of the R27 (Kaplan 1996).

7. FINDINGS

7.1 Site Alternative 1

A broken Middle Stone Age (MSA) quartzite flake (Site 1053) and a small nodule of silcrete (Site 1052) were recorded on the proposed development site. Apart from a few small fragments of weathered shellfish (a-diagnostic limpets & Venus clams) and larger fragments of White Sand Mussel, no other archaeological resources were identified. No organic remains such as pottery or ostrich eggshell were found.

Grading of the resources: The archaeological remains have been rated as having *low* (Grade 3C) significance

Site	Name of Farm	Lat/long	Description of finds	Grading	Suggested mitigation
Alternative 1	Cape Farm 34 Duynefontein				
1052		S33° 40.336' E18° 25.874'	Small lump of silcrete	3C	None required
1053		S33° 40.363' E18° 25.879'	Broken quartzite MSA flake	3C	None required

Table 1. Spreadsheet of waypoints and description of archaeological finds (Site Alternative 1).

Figure 12. Site Alternative 1. Archaeological waypoints and track path (in red)

7.2 Site Alternative *2*

No archaeological remains were encountered in the footprint area of site Alternative 2 (Figure 13).

Figure 13. Site Alternative 2. Track path is in red. The yellow dashed line is the eastern boundary of the proposed alternative reservoir site.

8. ASSESSMENT OF IMPACTS

8.1 Site Alternative 1 (preferred site alternative)

	Negative Effects	Positive Effects	No Go Option	No Mitigation	With Mitigation
Pre-construction	Excavating into potentially fossil-bearing deposits	Opportunity to assess actual and recover information not otherwise accessible	N/A	Unknown loss manageable with monitoring and protocol	Loss negligible; material and information recovered and lodged in repository
Construction	Likely loss of heritage material and information	Opportunity to gain new information and recover material	N/A	Probable loss of heritage material and information	Any potential loss minimized
Operational phases	None	None	N/A	N/A	Any potential loss minimized
Cumulative Effects	N/A unless renewed excavation place or dismantling	Unknown	Prior assessment required	Unknown	Any potential loss minimized

Pre-construction: test of sediments to maximum depth of base. Possible methods include geotechnical coring to start; test holes by heritage specialist(s) dependent on result. Monitoring by an appropriately-qualified specialist to take place at each stage. Monitoring Protocols for dealing with heritage material pre-developed and implemented.

Construction: monitoring of excavations by appropriately-qualified palaeontologist. Protocols for managing heritage material embedded in EMP. Collection of information and material by specialist and deposition in approved repository.

Operational Phases: no issues expected unless maintenance or modification/ development requires excavation. Protocol to cover eventuality.

Cumulative Effects: None expected unless renewed excavation or dismantling is contemplated. In such an instance prior assessment of possible negative effects will be required. Decision to mitigate or not will follow from that assessment.

8.2 Site Alternative 2

	Negative Effects	Positive Effects	No Go Option	No Mitigation	With Mitigation
Pre-construction	Excavating into potentially fossil-bearing deposits	Opportunity to assess actual and recover information not otherwise accessible	N/A	Unknown loss manageable with monitoring and protocol	Loss negligible; any material and information recovered and lodged in repository
Construction	Likely loss of heritage material and information	Opportunity to gain new information and recover material	N/A	Probable loss of heritage material and information	Any potential loss minimized
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Operational Phases: no issues expected unless maintenance or modification/ development requires excavation. Protocol to cover eventuality.

Cumulative Effects: None expected unless renewed excavation or dismantling is contemplated. In such an instance prior assessment of possible negative effects will be required. Decision to mitigate or not will follow from that assessment.

Provided that the recommendations in this report are followed, there is no reason why establishment of the proposed reservoirs should not proceed

9. CONCLUSION

Both site alternatives are located in a paleontologically-sensitive region with a hard rock base of Malmesbury Group shale, which outcrops along the coast. Cover sands of the Holocene Witzand Formation may be present, although the surface is likely to have been disturbed through natural deflation and during construction of the power station. The

likely depth of the semi-sunken reservoir will, however, probably encounter sediments from the Middle Pleistocene Langebaan and Springfontyn Formations of the Sandveld Group, the latter of which contains Middle Pleistocene palaeontological and archaeological remains. Sparse fossils are known from the Langebaan Formation elsewhere (Avery 2016).

Any fossils of vertebrates or trace fossils from the Springfontyn Formation would be significant and would require careful recording and possible systematic excavation. Similarly, if Velddrif Formation molluscan deposits and/or recent mollusc/other deposits (e.g. mid-Holocene high sea level), which could be associated with the coastal Witzand Formation (Q5), are found, grab samples will need to be taken.

Palaeontological material is currently known from sediments underlying Duynefontyn Farm, and adjacent areas. Monitoring of excavations will therefore be required. However, geotechnical investigation or test excavations may provide an opportunity to better assess the possibility that palaeontological and archaeological remains will be encountered during excavations.

Any excavation for foundations that penetrates into underlying terrestrial and/or deeper marine sediments may therefore encounter fossils. Since such occurrences are not normally preserved, fossil finds would be significant and would require careful recording and possible systematic excavation.

Excavations into deep sediments, not normally accessible to palaeontologists, should also be seen as providing opportunities to recover potentially-important fossil material that enables observations to be made on geology, past sea levels, climates, environments and biodiversity that would otherwise not be possible (Avery 2016).

Pre-colonial Khoisan burials may be exposed during bulk earthworks.

Any Pleistocene human skeletal material, for example, would be of international significance, which is possible in this geological context

10. RECOMMENDATIONS

The following recommendations are made, subject to the following recommendations and the approval of Heritage Western Cape.

1. A series of test pits must be dug across the proposed footprint area prior to construction work commencing. This could also form part of a geotechnical investigation of sub-surface sediments/Formations. Excavations that extend into light orange coloured sands of Springfontyn Formation deposits, may encounter undisturbed fossils (bone & shell), and Stone Age artefacts. It is important to establish the archaeological significance of buried sub-surface deposits before bulk earthworks commence, as it will enable the archaeologist and palaeontologist to develop an appropriate mitigation action plan.

2. Fossils and Stone Age artefacts are protected by law. Should anything of a palaeontological/palynological nature be found on site by the Contractor (or any other party), e.g. bones not previously visible, work is to be stopped in that area

immediately, and the Environmental Control Officer (ECO) notified. Failure to do so will result in a penalty and this must be carefully explained to workers during the Environmental Education Programme undertaken by the ECO. No palaeontological or archaeological material may be removed from the site without a permit from Heritage Western Cape.

3. Permits to recover fossils and archaeological material should be applied for (by the monitoring specialist) in advance of the Construction Phase commencing.

4. Bulk earth works and excavation for foundations/infrastructure should be monitored by a palaeontologist or archaeologist with appropriate palaeontological knowledge. The frequency of this to be worked out *a priori* with the contractor to minimize time spent on site.

5. If possible, geotechnical information together with the proposed locations and depths of excavations for foundations and/or infrastructure should be provided prior to the commencement of construction. This may enable a better estimation of the time(s) when monitoring would be necessary

6. Protocols for dealing with palaeontological/palynological (fossil pollens) monitoring and possible further mitigation must be included in the Environmental Management Plan (EMP).

7. Funds must be available *a priori* to cover costs of monitoring and any additional fieldwork and two dates should the opportunity/need arise.

8. Should palaeontological and/or archaeological material be encountered, the ECO will advise on demarcation of this area and notify the specialist (palaeontologist/archaeologist with appropriate experience) to view material and ascertain whether further study of the area will be required.

9. Should a specialist confirm a genuine fossil or sub-fossil and recommend further study of the area, work in the applicable area is to cease until further notice. Heritage Western Cape is to be informed immediately by the ECO.

10. Should any human remains be disturbed, exposed or uncovered during excavation, work in that area must stop and the find shall immediately be reported the South African Police Service and the monitoring specialist. If suspected that the remains are older than 60 years, the SAHRA (021 462 4502) must be informed and established protocols followed.

11. The removal of discovered palaeontological remains, by a contracted specialist shall be at the applicants and will include the cost of any dating.

12. All palaeontological and archaeological material must be lodged in an appropriate Iziko Museums of South Africa collection.

13. The above recommendations must be included in the Environmental Management Plan for the proposed project.

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Appendix A

Palaeontological Assessment

Palaeontological Assessment: New Fresh Water Reservoirs at Koeberg Nuclear Power Station, Farm Duynefontyn 34, Malmesbury Division, Western Cape (1:50 000 3318CB Melkbosstrand)

by
Graham Avery
(Sole Proprietor)

Archaeozoology, Stone Age Archaeology and Quaternary Palaeontology

Prepared for
Jonathan Kaplan (ACRM)

November 2016

Contents

Executive Summary

Graham Avery was commissioned by Jonathan Kaplan (ACRM) on behalf of his client to provide a desktop Palaeontology Assessment related to the proposed establishment of new water reservoirs in the Koeberg Nuclear Power Station precinct.

Proposed activity: Construction of water reservoirs (Case 16092709AS1006E)

Location: Koeberg Nuclear Power Station

The proposed reservoir alternatives are located in a palaeontologically-sensitive region of potentially fossiliferous sediments. Cover sands of the Holocene Witzand Formation may be present, although the surface is likely to have been disturbed through natural deflation and during construction of the power station. The likely depth of the semi-sunken reservoir will, however, probably encounter sediments from the Middle Pleistocene Langebaan and Springfontyn Formations of the Sandveld Group, the latter of which contains Middle Pleistocene palaeontological and archaeological remains. Sparse fossils are known from the Langebaan Formation elsewhere.

Any fossils of vertebrates or trace fossils from the Springfontyn Formation would be significant and would require careful recording and possible systematic excavation. Similarly, if Velddrif Formation molluscan deposits and/or Recent mollusc/other deposits (e.g. mid-Holocene high sea level), which could be associated with the coastal Witzand Formation (Q5), are found, grab samples will need to be taken.

Palaeontological material is currently known from sediments underlying Duynefontyn 34 and adjacent areas. Monitoring of excavations will be necessary. However, geotechnical investigation or test excavations may provide an opportunity to better assess the possibility that palaeontological and archaeological remains will be encountered during excavations. In that connection, a previous geotechnical study conducted at or near the alternative site to assess conditions for a possible pebble bed reactor (PBMR) may be instructive.

Excavations into sediments not normally accessible to palaeontologists should be seen to provide opportunities to recover potentially-important fossil material that would enable observations to be made about our past biodiversity and environments.

Palaeontological remains are rare, protected by the South African National Heritage Resources Act of 1999 and, if encountered, must be recorded by an appropriately qualified person. Permit and a Work Plan approval from Heritage Western Cape would be required to deal with any palaeontological occurrence. Protocols for managing palaeontological eventualities during excavation/construction should be in place before any excavation takes place. This would include monitoring by an appointed specialist.

Negative impacts in both alternatives can be minimized through monitoring and, if necessary more formal mitigation.

Summary of Impacts
Preferred Alternative

	Negative Effects	Positive Effects	No Go Option	No Mitigation	With Mitigation
Pre-construction	Excavating into potentially fossil-bearing deposits	Opportunity to assess actual and recover information not otherwise accessible	N/A	Unknown loss manageable with monitoring and protocol	Loss negligible; material and information recovered and lodged in repository
Construction	Likely loss of heritage material and information	Opportunity to gain new information and recover material	N/A	Probable loss of heritage material and information	Any potential loss minimized
Operational phases	None	None	N/A	N/A	Any potential loss minimized
Cumulative Effects	**N/A unless renewed excavation place or dismantling**	**Unknown**	**Prior assessment required**	**Unknown**	**Any potential loss minimized**

Pre-construction: test of sediments to maximum depth of base. Possible methods include geotechnical coring to start; test holes by heritage specialist(s) dependent on result. Monitoring by an appropriately-qualified specialist to take place at each stage. Monitoring Protocols for dealing with heritage material pre-developed and implemented.

Construction: monitoring of excavations by appropriately-qualified palaeontologist. Protocols for managing heritage material embedded in EMP. Collection of information and material by specialist and deposition in approved repository.

Operational Phases: no issues expected unless maintenance or modification/ development requires excavation. Protocol to cover eventuality.

Cumulative Effects: None expected unless renewed excavation or dismantling is contemplated. In such an instance prior assessment of possible negative effects will be required. Decision to mitigate or not will follow from that assessment.

Alternative 2

	Negative Effects	Positive Effects	No Go Option	No Mitigation	With Mitigation
Pre-construction	Excavating into potentially fossil-bearing deposits	Opportunity to assess actual and recover information not otherwise accessible	N/A	Unknown loss manageable with monitoring and protocol	Loss negligible; any material and information recovered and lodged in repository
Construction	Likely loss of heritage	Opportunity to gain new	N/A	Probable loss of heritage	Any potential loss minimized

	Negative Effects	Positive Effects	No Go Option	No Mitigation	With Mitigation
	material and information	information and recover material		material and information	
Operational phases	None	None	N/A	N/A	Any potential loss minimized
Cumulative Effects	**N/A unless renewed excavation place or dismantling**	**Unknown**	**Prior assessment required**	**Unknown**	**Any potential loss minimized**

Pre-construction: test of sediments to maximum depth of base. Possible methods include geotechnical coring to start; test holes by heritage specialist(s) dependent on result. Monitoring by an appropriately-qualified specialist to take place at each stage. Monitoring Protocols for dealing with heritage material pre-developed and implemented.

Construction: monitoring of excavations by appropriately-qualified palaeontologist. Protocols for managing heritage material embedded in EMP. Collection of information and material by specialist and deposition in approved repository.

Operational Phases: no issues expected unless maintenance or modification/ development requires excavation. Protocol to cover eventuality.

Cumulative Effects: None expected unless renewed excavation or dismantling is contemplated. In such an instance prior assessment of possible negative effects will be required. Decision to mitigate or not will follow from that assessment.

Provided that the recommendations in this report are followed, there is no reason why establishment of the proposed reservoirs should not proceed.

Palaeontological Assessment Proposed New Reservoirs, at Koeberg Nuclear Power Station, Farm Duynefontyn 34, Malmesbury Division, Western Cape (1:50 000 3318CB Melkbosstrand)

Introduction

Dr Graham Avery (see Appendices 1, 2) was commissioned by Jonathan Kaplan (ACRM) on behalf of his client Doug Jeffrey Environmental Consultants to provide a desktop assessment report on the palaeontological potential of the proposed water reservoirs on the Koeberg Nuclear Power site (Figures 1-4).

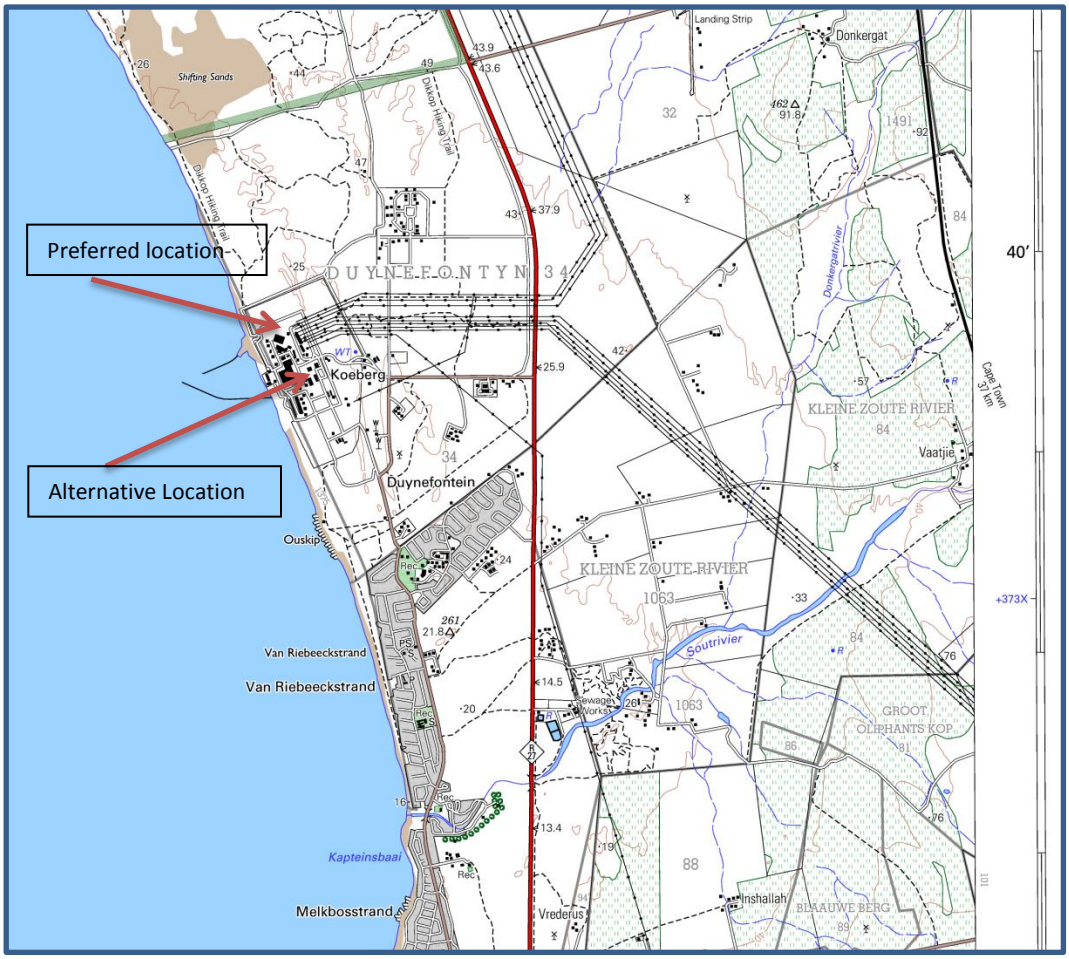

Figure 1. General location of the proposed reservoir alternatives (red arrows) (1: 50 000 3318CB Melkbosstrand).

Friction Piles will be employed to support the base for the reservoirs, which will be partially-subsurface (foundation base at -3.2 m) (see Figure 4). In addition, given the sandy substrate, it

is likely that machines will disturb surfaces on which work is conducted to a slightly greater depth.

Declaration

I have no financial or interest other than palaeontological or archaeological in the proposed development and will derive no benefits other than fair remuneration for consulting services provided.

Method

A background study of the proposed alternative areas was conducted by Dr G. Avery Archaeozoologist. The 1:250 000 Geological series 3318 Cape Town and other geological sources were consulted (Rogers, 1979, Rogers, 1980, Rogers, 2006, Pether, et al., 2000, Roberts, et al., 2006). Since little is known about the palaeontological potential of the specific locality, literature describing known palaeontological sites in the vicinity was consulted.

The site was not visited, since it is well-known that the surface will have been modified during construction of the power station.

Figure 2. Google Earth view showing the location of the Preferred Alternative (red polygon) (from SVA International).

Figure 3. showing the location of the Alternative site (red polygon) (from SVA International).

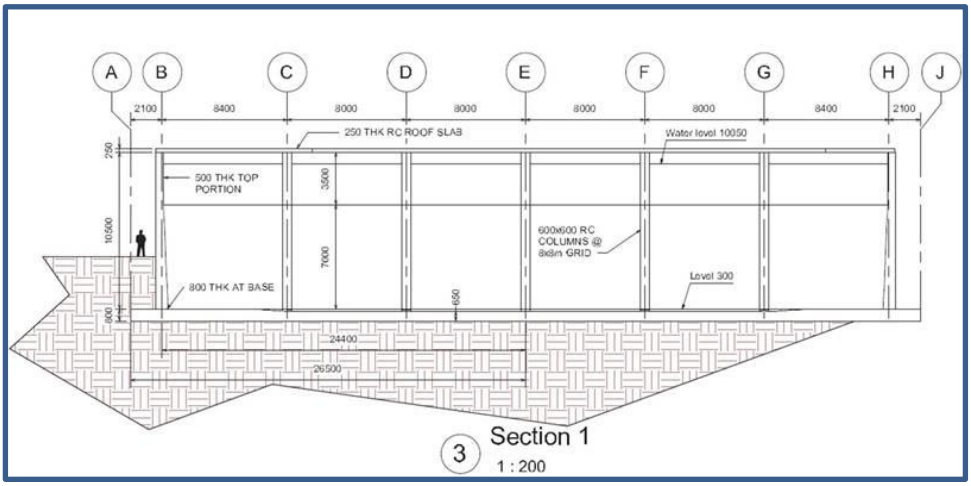

Figure 4. Detail showing sub-surface depth (~3.2 m) to which the proposed construction will extend (from SVA International).

Results of the Study

Geology and lithology

Terminology in Rogers (1980) has been updated; the Bredasdorp Formation is now named The Sandveld Group – the Cenozoic sediments in the Sandveld Group (Pether, et al., 2000, Roberts, et al., 2006), (Table 1, Figure 5) include shallow marine, back barrier, estuarine, fluvial and aeolian contexts dating from the Miocene, through the Pliocene, Pleistocene and Holocene (Rogers, 1980, Rogers, 2006, Roberts, et al., 2006, Rogers, 1982, Roberts and Brink, 2002) The area is underlain by Malmesbury Group shales, which outcrop in places.

General surface geology is shown in Figure 5 and a summary of the regional stratigraphy and lithology of the Sandveld Group is shown in Table 1. A composite for the Sandveld Group is illustrated in Figure 6.

The Springfontyn and Langebaan Formations through which the excavations will penetrate are a complex series of dune build up over considerable time (Table 1), during the late Pliocene and Pleistocene (Roberts, et al., 2006). The Formation reaches depths of >20 m in the Saldanha area. Vertebrate and molluscan fossils occur patchily in parts. Middle Pleistocene Springfontyn Formation sediments, are particularly relevant to this project. At the DFT 2 location Langebaan Formation calcrete dated to 160 ka occurs unconformably under the Holocene Witzand Formation dunes. It is overlain by deflated Pleistocene Springfontyn sediments and overlies two additional fossiliferous horizons in the Springfontyn Formation dated to 330 ka and 400 ka respectively (Cruz-Uribe, et al., 2003); further calcrete is present at the latter level (Cruz-Uribe, et al., 2003, Feathers, 2002, Klein, et al., 1999). Springfontyn Formation sediments are likely to be encountered at the projected depth of the excavations (Rogers, 1980, Rogers, 2006) (Figures 7, 8).

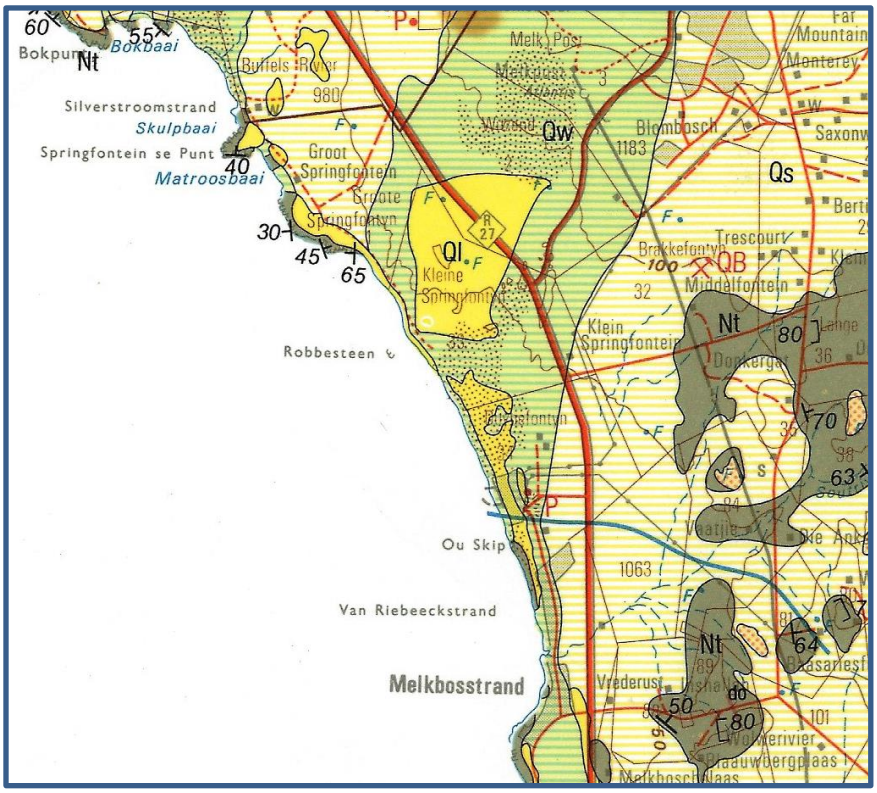

Figure 5. Surface geology in the region (from 1:250 000 Geological series 3318 Cape Town) and see Table 1. Witzand Formation (Qw = Holocene Recent dune field); Springfontyn Formation (Qs = Middle Pleistocene – light-grey to pale-red sandy soil and Langebaan Formation (Ql = Middle Pleistocene limestone and calcrete, partially cross-bedded; calcified parabolic dune sand); (and see Table 1). Nt = Malmesbury Group basal Greywacke, Phyllite and quartzitic sandstone; interbedded lava and tuff).

Table 1. Modified from (Pether, et al., 2000, Roberts, et al., 2006, Pether, 2013) and G Avery (pers. observation). Ma = Million years ago; ka = Thousand years ago. Note: chronology for the base of the Lower Pleistocene Boundary has been formally re-defined to an earlier date of 2.58 Ma; the base of the Holocene has also been formalized at 11.8 ka (Gibbard, et al., 2010).

Formation	Age and Lithologies	Fossil Potential
Witzand	Holocene and recently active calcareous dune fields and cordons (<~12 ka)	Rare sub-fossils of importance for historical faunal distribution. Mainly Later Stone Age archaeological sites.
Springfontyn	Pleistocene to Recent (Holocene) quartzose sand dunes, silts and peats (<~2 Ma)	Mineralized bones generally sparse, but can be prolific in some areas, e.g. Elandsfontein and part of Baard's Quarry. High significance
Langebaan	Late Quaternary aeolianites <~3 Ma	Mineralized bones moderately common. Local to high significance. Extends under sea. Local to high significance
Velddrif	Quaternary raised beaches and estuarine deposits <~1.2 Ma. Sea levels below ~15 m asl	Marine molluscs common and rare bones at or near the coast. High significance
Marine erosion surfaces below ~15 m asl.		
Old indet. sands		
Langebaan	Late Pliocene to mid- Quaternary aeolianites. <~3 Ma	Molluscs and sparse (can be patchy concentrations, e.g. Langebaanweg, bones of terrestrial and marine forms. Extends under sea. Local to high significance
Uyekraal -- Previously subsumed in the upper Varswater Fm	Mid-Pliocene marine deposits ~3 Ma. Sea-level max. ~35 m asl	Shell fossils common, local significance. Fossil bones very sparse, high significance
Marine erosion surface to ~35 m asl		
Old indet. sands		
Langebaan	Earlier Pliocene aeolianites <~3 Ma.	Fossil bones moderately common, local to high significance
Varswater – upper	Later early Pliocene regressive deposits of wider area. 5-4 Ma. Sea-level max. ~50-60 m asl	Fossil bone rare, high significance. Poorly known, fossil shells of high significance
Varswater – lower	Early Pliocene transgressive marine deposits in embayments (upper KGM?, LQSM and MPPM members	Fossil bone common locally, high significance. Shells very sparse, high significance
Marine erosion surface to ~ 60 m asl		
Very old indet sands		
Prospect Hill	Miocene aeolianite 12 to 9 Ma	Fossils very sparse – high significance
Saldanha	Mid-Miocene marine deposits (predicted presence), 17-14 Ma. Sea-level max. ~90 m asl. May Include the lower KGM?	Very few fossils recovered, high significance if found.
Marine erosion surface to ~100 m asl		
Langeenheid Clayey Sand -- Previously a member of the Lower Varswater Fm	Mid Miocene early-transgression estuarine deposits (prev. LCSM Member in lower Varswater Fm.). 18-17 Ma.	Plant microfossils – high significance
Elandsfontyn	Middle to late Miocene fluvial coarse, angular sands, muds and carbonaceous sediments. ~15 Ma to ~12 Ma	Microfossils, including pollens, and macro remains of plants, high significance

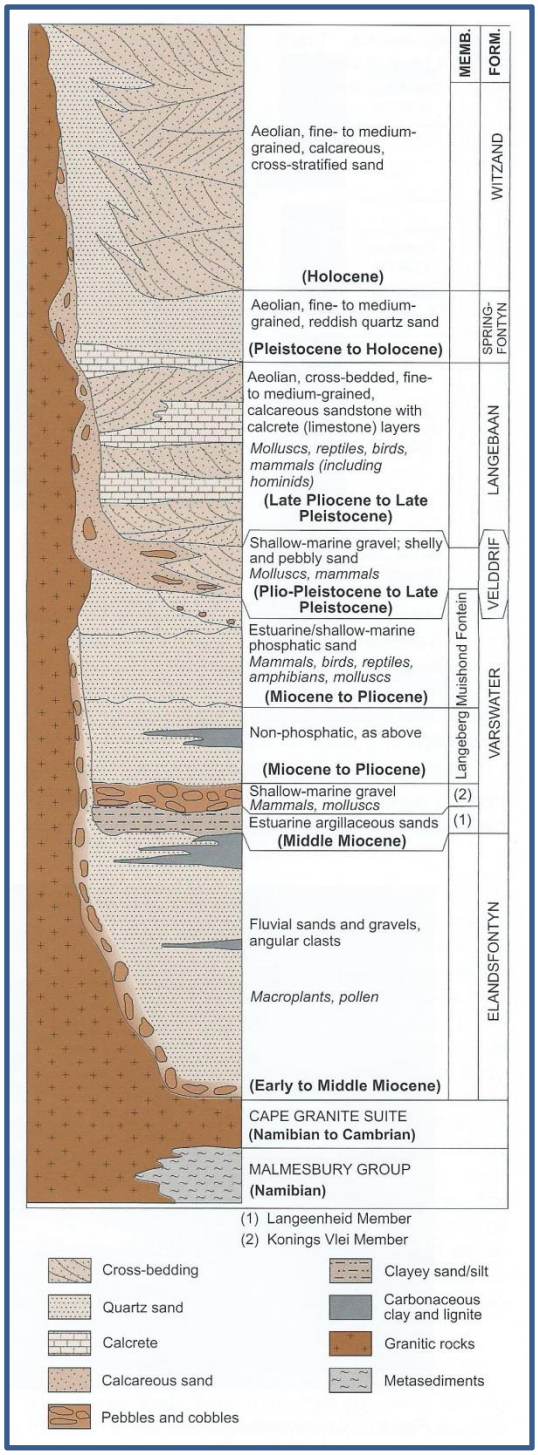

Figure 6. Composite summary of the lithostratigraphy of the Sandveld Group (Roberts, et al., 2006). Note that fossils occur in the upper and lower parts of the Langebaan Formation and Early Stone Age artefacts and fossil bone may also occur in the Springfontyn Formation.

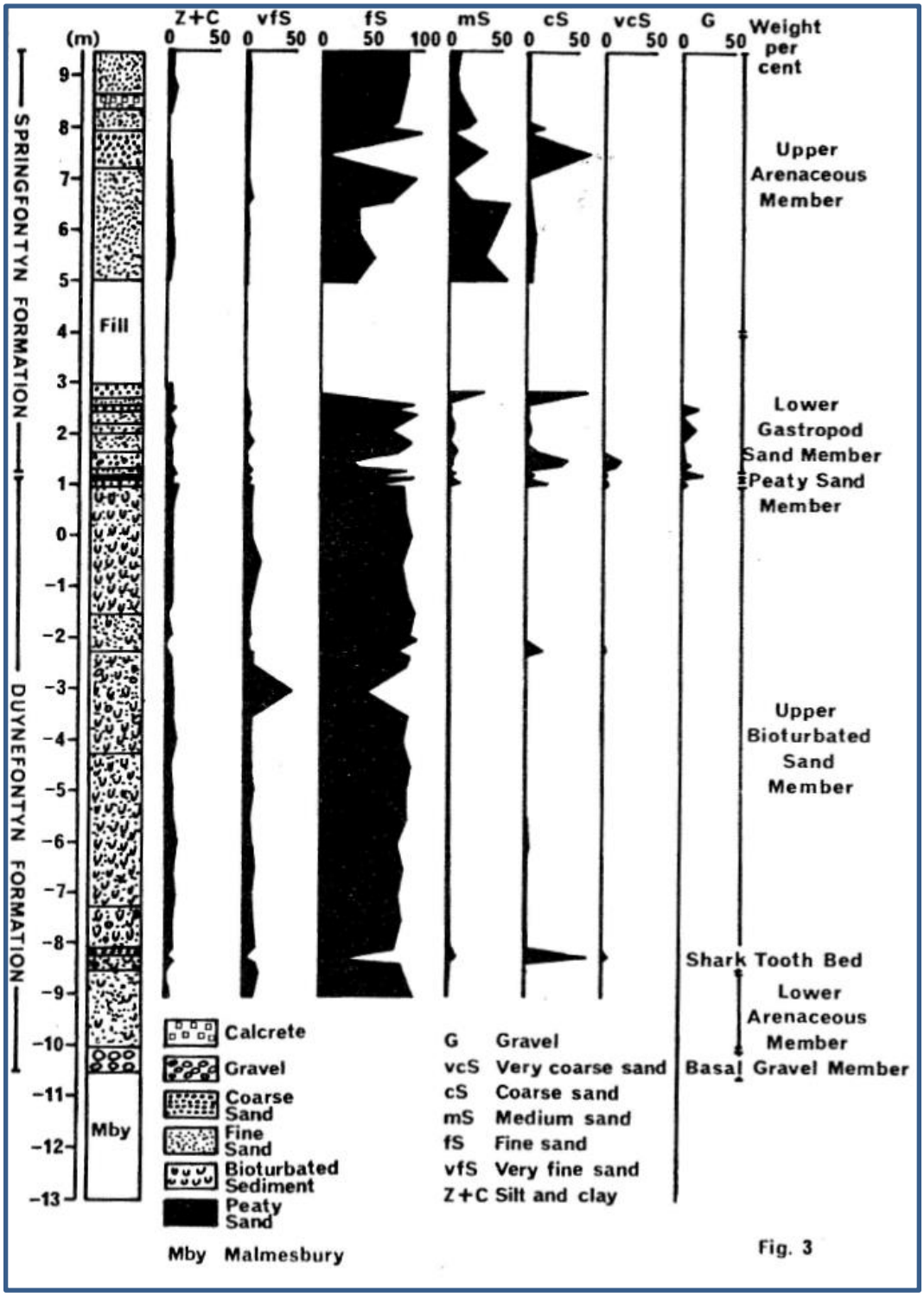

Figure 7. Stratigraphy and lithology recorded in the excavations for the Koeberg Nuclear Power Station reactors (Rogers, 1979), fig 3. Duynefontyn Formation = Varswater Formation.

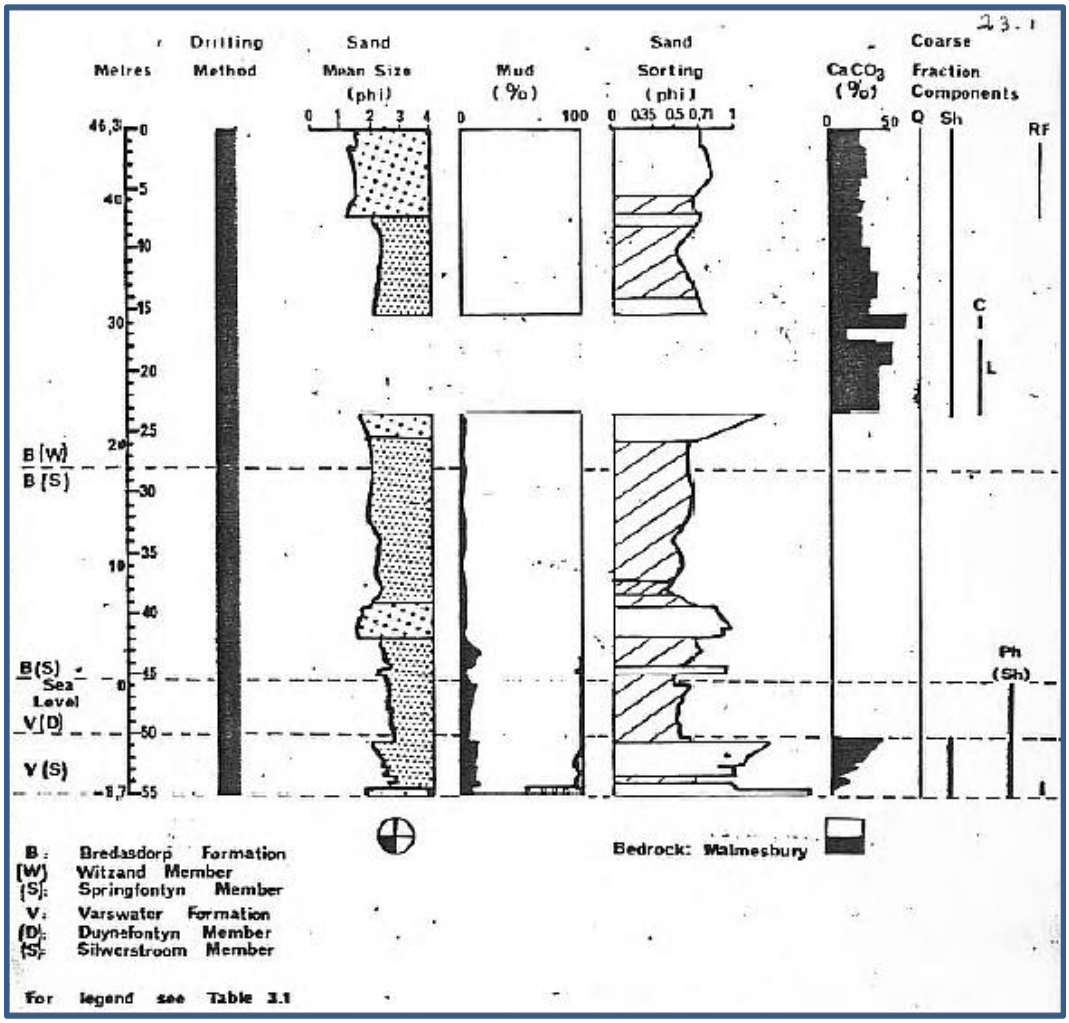

Figure 8. Stratigraphy and lithology recorded at the Springfontyn Formation cliffs just north of DFT 2 (Rogers, 1980), fig 3.12.

Known Sites in the Region

Bones, recorded on the surface could be very recent; however, others, particularly if mineralized and associated with stone artefacts, may indicate the disturbed presence of Early, Middle and/or Later Stone Age archaeological sites (Figure 9a, 9b; Table 2; and see Kaplan report).

Figure 9a. Google Earth view showing the location of known palaeontological and Pleistocene archaeological sites on and near Duynefontyn 34. The green circle indicates the rough position of a Velddrif Formation occurrence within the reactor excavation.

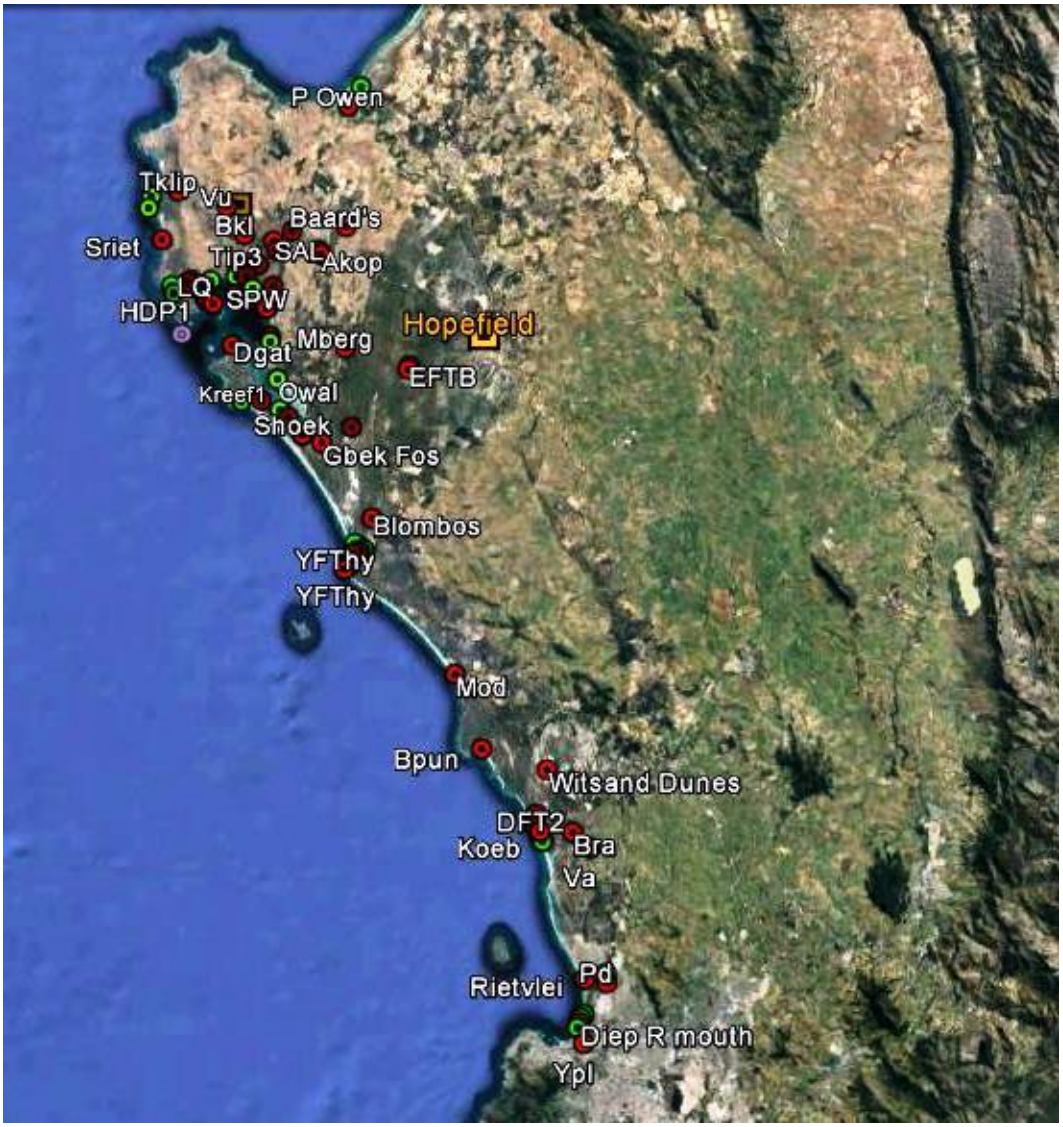

Figure 9b. Google Earth view showing the location of some known palaeontological and Pleistocene archaeological occurrences in the region. Green circles indicate known Velddrif Formation occurrences.

Palaeontological remains are widely distributed through the Springfontyn Formation and sparsely in the Langebaan Formation (Pether, 2009, Pether, 2010). While a fossil record for the proposed reservoir alternatives does not currently exist, sufficient regional information is available to make at least general comments on what may be encountered in the sediments within the power station precinct (Figures 9 to 13; Table 2). It should be appreciated that, although there are exceptions such as Besaansklip (Brink, 2005), Sea Harvest (Grine and Klein 1993) and Hoedjiespunt (Berger and Parkington, 1995, Kyriacou, et al., 2015, Stynder, 1997, Will, et al., 2013) in which large numbers of vertebrate bones are preserved in, or contiguous with, Langebaan Formation contexts, palaeontological and archaeological remains are more likely to be sparsely distributed in patches or as isolated items in this formation (Pether, 2013,

Pether, 2006). Sediments of the Springfontyn Formation that continue below the proposed depth of the reservoir base also include palaeontological remains as do those of the deeper Varswater Formation (Rogers, 1980, Rogers, 2006); deposits at depth are unlikely to be affected by excavations for this project. It should also be noted that friction piles, which will extend below the reservoir base, will displace, but not remove material they pass.

Palaeontological material is currently known from sediments underlying Duynefontyn 34 and adjacent areas (Figure 9 to 13; Table 2). Monitoring of excavations will be necessary. Geotechnical investigation or test excavations may provide an opportunity to better assess the possibility that palaeontological and archaeological remains will be encountered during excavations. In that connection, a previous geotechnical study (report not found) conducted at or near the alternative site to assess conditions for a possible pebble bed reactor (PBMR) may be instructive.

In addition to much older marine fossils, sediments exposed during construction of the Koeberg Nuclear Power Station and in the Koeberg Nature Reserve have yielded important traces of Pleistocene terrestrial fossils and Early Stone Age human activity.

Further afield, to the south, fossils were encountered in Rietvlei sediments being extracted for fill during the construction of Cape Town's container harbour (Avery, 1995). Early Pliocene marine mammal (whale bone) remains have been recovered from the Potsdam Sewerage Pumping Station (GA pers. observation); whale bone and sharks' teeth occur on Milnerton Beach at the Diep River estuary (Hendey, 1969) and whale bone, sharks' teeth and penguin bones at Ysterplaats (Tankard, 1975).

To the north, Mio-Pliocene fossils and Pleistocene fossils occur in the Varswater and Langebaan Formations at Langebaanweg (West Coast Fossil Park) and Early, Middle and Later Stone Age artefacts in Springfontyn Formation sediments at nearby Anyskop. Middle Pleistocene terrestrial fossils and Early, Middle and Later Stone Age stone artefacts also occur at Bokbaai (Mabbutt, et al., 1955). A number of Pleistocene hyaena and human occurrences occur in the Saldanha area. Inland, at Elandsfontein (aka Hopefield Fossil Site) (Klein, et al., 2007, Inskeep and Hendey, 1966), a significant fossil occurrence in Middle and Late Pleistocene Springfontyn Formation sediments of the dune plume extending from the Ysterfontein area (Roberts, et al., 2009) to near Hopefield, has yielded important Middle Pleistocene animal fossils (700 ka to 400 ka) and the earliest human remains (archaic *Homo sapiens*) found so far in the Western Cape. Late Pleistocene fossil occurrences occur along the coast from Melkbosstrand to Ysterfontein and Saldanha (GA pers. obs.) and at Elandsfontein (Inskeep and Hendey, 1966, Klein, 1983).

Underlying the Koeberg Power Station, the Varswater Formation includes Late Miocene-Early Pliocene marine palaeontological material dating to about 5 Ma (Rogers, 2006) and the Middle Pleistocene Springfontyn sediments, which are of particular relevance to this study; they include palaeontological and archaeological (Early Stone Age) material dated to 330 ka (Cruz-Uribe, et al., 2003, Klein, et al., 1999). Note that, although Late Pleistocene Middle Stone Age artefacts have been recovered elsewhere in the area, the DFT 2 artefacts, which were originally ascribed to the Middle Stone Age, were shown to be Early Stone Age during the later

excavations. Sub-fossil remains from the Witzand Formation can provide records of species present in the past 11, 000 years and the historical period (G Avery, pers. observation).

Duinefontein/Springfontein Dune Field

Superficial Witzand Formation dune sands cover most of the area. This Holocene (<10 ka) element of the Duinefontein Dune Plume (Roberts, et al., 2009), which includes the Witsand Nature Reserve dune field, extends from the coast towards Darling, overlies sandy Springfontyn Formation sediments. Later Stone Age surface occurrences, with pottery, stone artefacts and marine molluscs, attesting to human activity, occur in the dunes on Duinefontein (L. Stoch unpublished records, Pre-Colonial Archaeology, Iziko Museums Social History Collections Department) and are similar to those in the nearby Witsand Dune Field (G Avery pers. observation). Remains of a black rhinoceros in the Witsand dune field provide a specimen record confirming observations by the first European settlers in the area. Wind erosion in these areas does not normally penetrate the underlying calcretes, which are often exposed. Middle Pleistocene Springfontyn Formation deposits that underlie the Witsand dunes (as at Duinefontein 2) have yielded fossils.

During the 1950s and 1960s the Duinefontein dune field, which extended from Melkbosstrand to Groot Springfontein also yielded many fossils and early and Middle Stone Age artefacts (Hendey, 1969, Inskeep, 1976, Hendey, 1968), which were exposed and sand polished. However, erosion also exposed better-preserved fossils and stone artefacts in *in situ* light orange (iron stained) Pleistocene sediments, which have been carefully excavated and/or collected and published (Cruz-Uribe, et al., 2003, Klein, et al., 1999, Klein, 1976, Sampson, 2003).

Springfontyn Cliffs

This is the type locality for the Springfontyn Formation. Located at the beach, it comprises a series of calcretes and soil horizons with sparse Middle Pleistocene fossils between Holocene Witzand Formation cover sands and Early Pliocene Varswater Formation (Figure 9, Table 2) (Rogers, 1980).

DFT 2 and DFT 4

Two significant excavated samples, DFT 4, a hyaena den and DFT 2 (Figures 9 to 13; Table 2) on ancient land surfaces around wetlands, have yielded 330 ka (thousand years old) and 400 ka Middle Pleistocene fossils of a wide range of mainly terrestrial mammals and birds and Early Stone Age artefacts (Cruz-Uribe, et al., 2003, Sampson, 2003). Depth below the surface of undisturbed fossiliferous sediment ranges from 0.0 m on deflated surfaces (Horizon 1) to approximately 1.5 m, at which level the water table prevented further excavation.

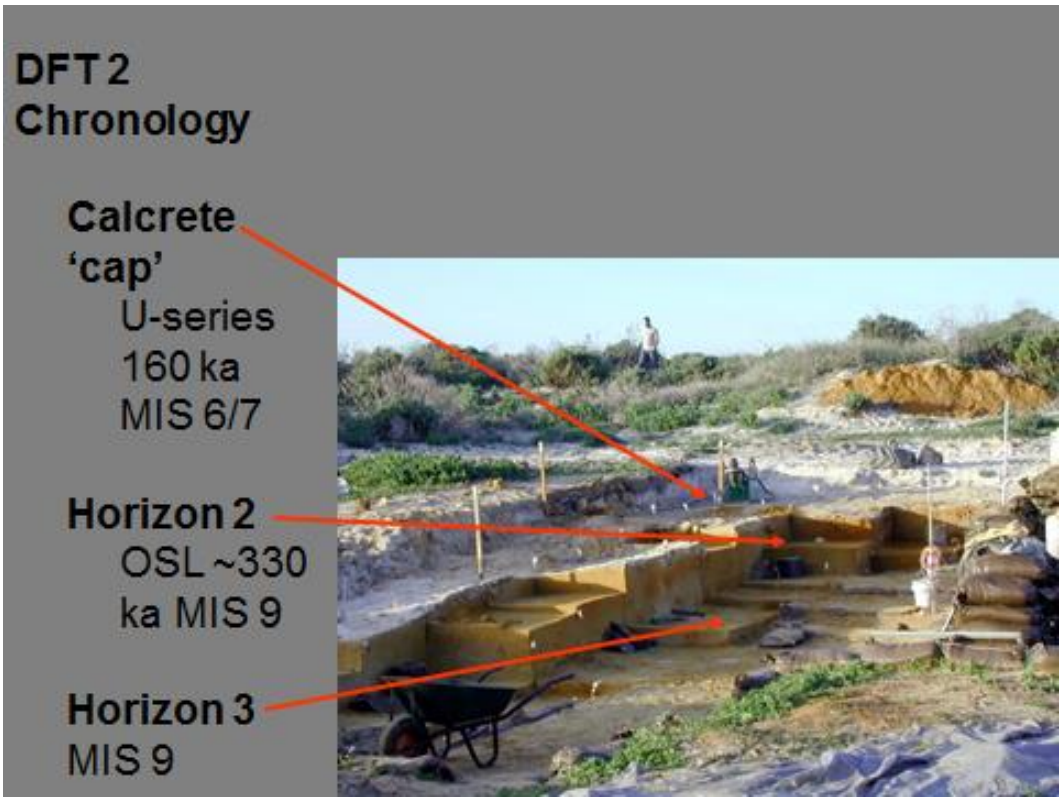

Figure 10. DFT 2 stratigraphy. Surface is white Witzand Formation dune; 160 ka hard calcrete capping overlying 330 ka light orange Springfontyn Formation sediments with fossil bones and Early Stone Age artefacts located <1 m below the surface at this locality. Spoil heap right back. Vegetation in the excavation is growing at the exposed water table.

Figure 11. Upper Langebaan Formation calcrete dated to 160 ka overlying orange Middle Pleistocene Springfontyn Formation sediments with fossil bones and Early Stone Age artefacts.

Figure 12. DFT 2 excavated surface with fossilized eland vertebrae in light orange (iron-stained) Springfontyn Formation sands.

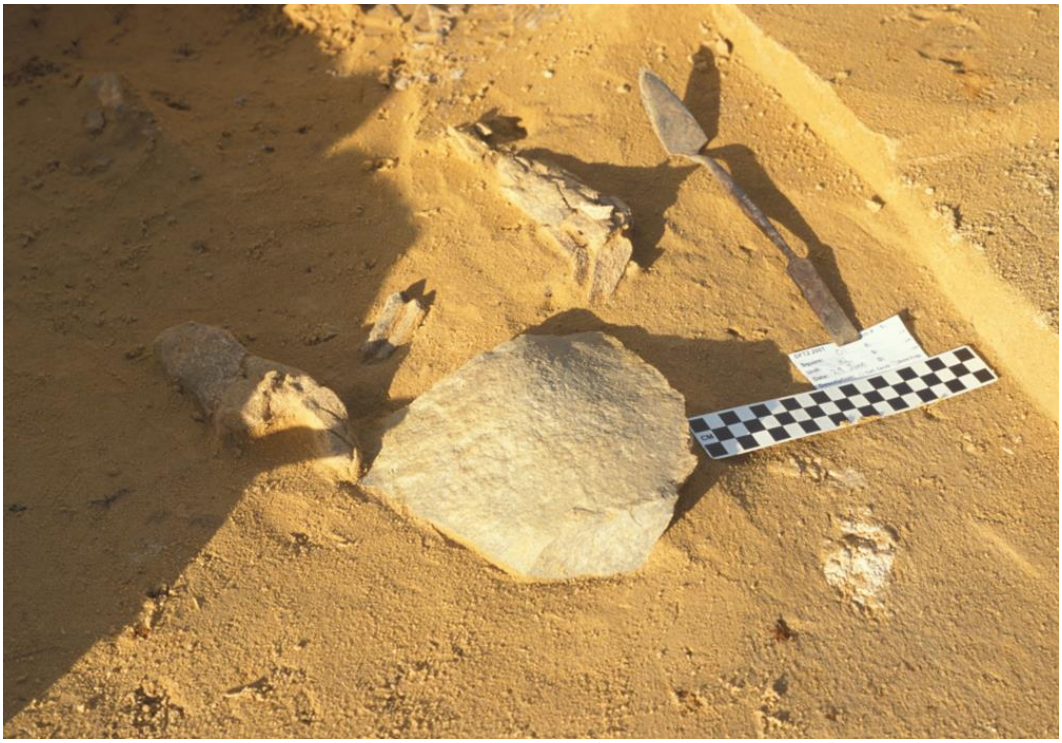

Figure 13. DFT 2. Large silcrete flake with fossil bones and antelope tooth.

DFT n

This is a similar-aged temporary surface exposure, probably mainly a hyaena accumulation, in the northernmost area of the coastal Duinefontein Dune Plume, which has yielded the earliest example of the South African Fur Seal, the species that lives around our coasts today, terrestrial mammals, marine and terrestrial birds and Early Stone Age artefacts (Avery and Klein, 2011).

Klein Springfontein

A temporary surface exposure in the Duinefontein Dune Plume near the R27 yielded many fossils of terrestrial mammals, reptiles and birds, which were collected by GA and RG Klein and lodged in the Cenozoic Section of Iziko Museum's Natural History Collections Department.

Koeberg Nuclear Power Station

During construction of the Koeberg Nuclear Power Station, which reached Malmesbury Group bedrock at -10 m below sea level (Rogers, 1979, Rogers, 1980, Rogers, 2006, Rogers, 1982), The 5 Ma Early Pliocene Varswater Formation sediments yielded marine mammals, mainly whales, but also a range of marine fish, seabirds and, possibly, an even earlier (than DFTn) species of fur seal (Avery and Klein, 2011, Simpson, 1975, Olson, 1985, Govender, In Press).

It is clear from the above that the region and Koeberg site are palaeontologically important.

Table 2. Summary of known palaeontological and Pleistocene archaeological sites in the region. See Table 1 for lithological and chronological details regarding the formations within which fossils and/or stone artefacts occur.

Site	Formation	Selected References	Type of Occurrence	Acronym
Besaansklip	Springfontyn	(Brink, 2005) National Museum, Bloemfontein	Palaeontology. Significant brown hyaena den accumulation in crevices in Langebaan Formation.	Bklhy
Bok Punt	Springfontyn	(Mabbutt, et al., 1955)	Palaeontological and Pleistocene archaeological. Terrestrial taxa.	BPun
Brakkefontein	Springfontyn	(Avery and Kaplan, 2016)	Archaeological. Pleistocene. Very sparse ESA/MSA artefacts in test holes.	Bra
DFT 2	Langebaan Springfontyn	(Cruz-Uribe, et al., 2003, Klein, et al., 1999, Sampson, 2003)	Palaeontological and Pleistocene archaeological. Terrestrial and marine taxa and fresh/brak water molluscs and anurids.	DFT2
DFT 4	Springfontyn	Klein unpublished (pers. Comm.)	Palaeontological. Terrestrial Taxa. Hyaena accumulation.	DFT4hy
DFT n	Springfontyn	(Avery and Klein, 2011)	Palaeontological and Pleistocene archaeological. Terrestrial and marine taxa. Hyaena and human.	DFTn
Elandsfontein – "Main"	Springfontyn; Langebaan; Varswater; Elandsfontyn	(Klein, et al., 2007, Inskeep and Hendey, 1966, Archer, 2010, Avery, 1988, Braun, et al., 2013a, Braun, et al., 2013b, Klein, 1978, Klein and Cruz-Uribe, 1991, Luyt, et al., 2000, Roberts and Braun, 2014, Singer and Wymer, 1968, Stynder, 2009, Klein, 2009, Volman, 1984, Goodwin, 1953); Iziko South African Museum Cenozoic Collections, UCT	Palaeontological and Pleistocene Archaeological. Provincial Heritage Site. Well-preserved fossils and artefacts exposed in extensive dune slacks by wind erosion. Diverse terrestrial vertebrate taxa, plants (pollens); Early Stone Age (ESA) – Late Acheulean.in probable association with fossils in the Cutting 10 excavation. Rare Middle Stone Age (MSA) – Still Bay artefacts. Early *Homo sapiens* (*Homo heidelbergensis*) cranial remains contemporary with ESA. Hyaena accumulations contiguous with general surface.	EFT Main
Hoedjiespunt – MSA	Langebaan	(Kyriacou, et al., 2015, Will, et al., 2013)	Archaeological. Middle Pleistocene shell midden with mostly marine and some terrestrial taxa.	HDP1hu

Site	Formation	Selected References	Type of Occurrence	Acronym
Hoedjiespunt – hyaena	Langebaan	(Berger and Parkington, 1995, Stynder, 1997, Klein, 1983, Hare and Sealy, 2013, Stynder, et al., 2001, Churchill, et al., 2000, Woodborne, 2000); Iziko South African Museum Cenozoic Collections	Palaeontological. Significant brown hyaena den in eroded ridge of Langebaan Formation with terrestrial and marine taxa and modern *Homo sapiens* remains.	HDP1hy
Jacobuskraal 560	Springfontyn	(Avery, 1994a, Avery, 1994b)	Palaeontological. Sparse terrestrial taxon.	J560s
Jacobuskraal 560	Velddrif	(Avery, 1994a, Avery, 1994b)	Palaeontological. Marine molluscs.	J560v
Koeberg Reactors	Varswater	(Rogers, 1980, Rogers, 2006, Govender, In Press)	Palaeontological. Early Pliocene, Pleistocene. 5 Ma to 2.8 Ma. Marine and/or terrestrial taxa.	Koeb
Langebaanweg – E Quarry	Langebaan Varswater	(Roberts, et al., 2011, Halkett and Hart, 1999, Hendey, 1981, Hendey, 1982)	Palaeontological. Early Pliocene, Late Pliocene. 5 Ma to >2 Ma. Marine and terrestrial taxa.	LBW
Langebaanweg – E Quarry	Elandsfontyn	(Coetzee, 1978a, Coetzee, 1978b); Iziko South African Museum Cenozoic Collections	Macro and micro plant remains, underlying Varswater Formation, encountered during boring for water.	LBW
Milnerton Beach	Velddrif	(Kensley, 1985, Theron, et al., 1992)	Palaeontological and Pleistocene archaeological. Late Pleistocene. Marine molluscs.	Mil
Modder River	Springfontyn	J. Kramer (pers. observation)	Palaeontological. Late Pleistocene Brown hyaena den	Modhy
Namaqua Sands Smelter	Langebaan ?Uyekraal ?Varswater	(Pether, 2006)	Palaeontology. Bones, from Langebaan Formation noted in nearby pipe line. Likelihood of intersecting fossiliferous formations if excavation is deep enough.	NSand
Potsdam	?Saldanha = Varswater	G Avery (pers. observation), Iziko South African Museum Cenozoic Collections	Palaeontological. ? Late Miocene/Early Pliocene >7 Ma to 5 Ma. Marine taxa.	Pd
Rietvlei	?Springfontyn	(Grindley and Dudley, 1988)	Palaeontological and Palynological. Pleistocene.	Rvl

Site	Formation	Selected References	Type of Occurrence	Acronym
Sea Harvest – hyaena	Langebaan	(Grine and Klein 1993, Klein, 1983, Butzer, 2004); Iziko South African Museum Cenozoic Collections	Palaeontological. Significant brown hyaena den with terrestrial and marine taxa and modern *Homo sapiens* remains. In crevices eroded into the Langebaan Formation. Rhizoliths (root castes) and *Trigonephrus globulus* in aeolianites.	SHhy
Sea Harvest – Middle Stone Age	Langebaan	(Volman, 1978); Iziko South African Museum Cenozoic Collections	Archaeological. Middle Stone Age shell midden contiguous with adjacent hyaena dens. In eroded Langebaan Formation crevice/overhang.	SHhu
Skurwerug	Langebaan	(Hendey and Cooke, 1985); Iziko South African Museum Cenozoic Collections	Palaeontological. Excavations for crude oil storage encountered a small patch of important terrestrial fossils, including an extinct pig.	Srug
Spreeuwalle	Langebaan	(Avery, et al., In Prep); Iziko South African Museum Cenozoic Collections	Palaeontological and Pleistocene archaeological. Diverse terrestrial taxa; aquatic and terrestrial molluscs. Date on overlying calcrete duricrust of 59 ka (W. Sharp, pers. comm.). Currently intertidal – formed during period of lower sea level.	SPW
Springfontein – cliffs	Langebaan Springfontyn	(Rogers, 1980, Rogers, 2006, Rogers, 1982, Theron, et al., 1992)	Palaeontological. Middle Pleistocene terrestrial taxa and fresh/brak water molluscs.	Scliff
Springfontein – Klein	Springfontyn	Klein unpublished (pers. Comm.)	Palaeontological. Middle Pleistocene terrestrial taxa.	Kspr
Vaatjie	Springfontyn	R Fullergill (pers. comm.)	Pleistocene archaeological. Early Stone Age artefacts.	Va
Ysterfontein 1 – MSA	Springfontyn	(Avery, et al., 2008, Halkett, et al., 2003, Klein, et al., 2004, Wurz, 2012)	Palaeontological and Pleistocene archaeological. Terrestrial and marine taxa.	YFT 1
Ysterfontein – hyaena	Springfontyn	Klein (pers. comm.); (G Avery pers. observation)	Palaeontological. Brown hyaena accumulations of terrestrial taxa – 3 localities in burrows/crevices in Langebaan Fm.	YFThy
Ysterplaats	Saldanha = Varswater	(Tankard, 1975, Simpson, 1973)	Palaeontological. Late Miocene/Early Pliocene >7 Ma to 5 Ma. Marine taxa	Ypl

Palaeontological Potential

Known localities with good palaeontological records are described above.

It is not possible to exclude the possibility that sparsely-distributed sub-surface fossils will be encountered during excavation of Springfontyn and Langebaan Formation aeolianites/ calcretes. In addition to wider scatters, such as at DFT 2, smaller pockets of bone can occur, for instance, where bone accumulators like hyaenas, Jackals or porcupines used pre-existing holes/burrows dug, e.g., by aardvarks or natural erosional crevices as at Besaansklip, Hoedjiespunt, Sea Harvest, Ysterfontein and DFT 4; older and younger sediments, too, may contain ancient wetland deposits and/or more-recent sub-fossils.

Pether (2013) comments as follows on the potential for fossils being encountered in the Langebaan Formation "The main bulk of aeolianites [in the Langebaan Formation] is not very fossiliferous, but fossil bones from the Langebaan Formation have been a prime source of information on past (different) Quaternary faunas and archaeology. Most of the finds are expected to be sporadic occurrences of local significance, but significant bone concentrations occur in certain contexts. Depending on the nature of the discovery, the significance may escalate to high (international interest), such as finds of unexpected or new species or hominid finds". The same can be said of Springfontyn sediments, which have yielded large assemblages of fossils and stone artefacts.

At the immediate coast Velddrif Formation mollusc deposits, which occur on or within the Langebaan Fm. complex and/or more recent mollusc deposits (e.g. mid-Holocene high sea level, which could be associated with the coastal Witzand Formation may occur. Should these be encountered, grab samples will need to be taken. The Langebaan Formation deposits are relatively thin and unlikely to have palaeontologically great potential, unless a feature like a crevice with bone infill or the Springfontyn/Langebaan erosion surface is encountered. In this context, it should be noted that, at DFT 2 and the Springfontein Cliffs, the Springfontyn deposits are sandwiched between layers of Langebaan calcrete.

Construction of the reservoirs will not affect palaeontological or archaeological deposits beyond the depth affected by foundations' excavations. The effect of piling is unknown, but probably minimal.

The sub-surface palaeontological potential at the Alternative sites cannot be further assessed without digging; but it is entirely possible, as elsewhere, that excavations into sub-surface deposits not normally accessible to palaeontologists may encounter palaeontological remains during excavations for the reservoir. Rather than treating this as a negative, however, through appropriate management may provide opportunities to recover important fossil material that enables observations otherwise impossible to be made.

Impacts

Preferred Alternative

	Negative Effects	Positive Effects	No Go Option	No Mitigation	With Mitigation
Pre-construction	Excavating into potentially fossil-bearing	Opportunity to assess actual and recover	N/A	Unknown loss manageable with monitoring	Loss negligible; material and information

	Negative Effects	Positive Effects	No Go Option	No Mitigation	With Mitigation
	deposits	information not otherwise accessible		and protocol	recovered and lodged in repository
Construction	Likely loss of heritage material and information	Opportunity to gain new information and recover material	N/A	Probable loss of heritage material and information	Any potential loss minimized
Operational phases	None	None	N/A	N/A	Any potential loss minimized
Cumulative Effects	**N/A unless renewed excavation place or dismantling**	**Unknown**	**Prior assessment required**	**Unknown**	**Any potential loss minimized**

Pre-construction: test of sediments to maximum depth of base. Possible methods include geotechnical coring to start; test holes by heritage specialist(s) dependent on result. Monitoring by an appropriately-qualified specialist to take place at each stage. Monitoring Protocols for dealing with heritage material pre-developed and implemented.

Construction: monitoring of excavations by appropriately-qualified palaeontologist. Protocols for managing heritage material embedded in EMP. Collection of information and material by specialist and deposition in approved repository.

Operational Phases: no issues expected unless maintenance or modification/ development requires excavation. Protocol to cover eventuality.

Cumulative Effects: None expected unless renewed excavation or dismantling is contemplated. In such an instance prior assessment of possible negative effects will be required. Decision to mitigate or not will follow from that assessment.

Alternative 2

	Negative Effects	Positive Effects	No Go Option	No Mitigation	With Mitigation
Pre-construction	Excavating into potentially fossil-bearing deposits	Opportunity to assess actual and recover information not otherwise accessible	N/A	Unknown loss manageable with monitoring and protocol	Loss negligible; any material and information recovered and lodged in repository
Construction	Likely loss of heritage material and information	Opportunity to gain new information and recover material	N/A	Probable loss of heritage material and information	Any potential loss minimized
Operational	None	None	N/A	N/A	Any potential

	Negative Effects	Positive Effects	No Go Option	No Mitigation	With Mitigation
phases					loss minimized
Cumulative Effects	**N/A unless renewed excavation place or dismantling**	**Unknown**	**Prior assessment required**	**Unknown**	**Any potential loss minimized**

Pre-construction: test of sediments to maximum depth of base. Possible methods include geotechnical coring to start; test holes by heritage specialist(s) dependent on result. Monitoring by an appropriately-qualified specialist to take place at each stage. Monitoring Protocols for dealing with heritage material pre-developed and implemented.

Construction: monitoring of excavations by appropriately-qualified palaeontologist. Protocols for managing heritage material embedded in EMP. Collection of information and material by specialist and deposition in approved repository.

Operational Phases: no issues expected unless maintenance or modification/ development requires excavation. Protocol to cover eventuality.

Cumulative Effects: None expected unless renewed excavation or dismantling is contemplated. In such an instance prior assessment of possible negative effects will be required. Decision to mitigate or not will follow from that assessment.

Conclusion

- While no specific fossil evidence is available for the proposed sites, it is evident from local (and regional) observations, that this does not mean that potential is lacking.
- Palaeontological remains are often sparsely distributed and rare but, if encountered, are important and must be recorded appropriately. It is clear from the examples provided that palaeontological potential exists and that important finds might be made during construction.
- Excavations should be monitored by a palaeontologist or archaeologist with appropriate palaeontological knowledge. The frequency of this to be worked out *a priori* with the contractor to minimize time spent on site.
- Excavations into sediments not normally accessible to palaeontologists should be seen to provide opportunities to recover potentially-important fossil material that enables observations to be made, about geology and past sea levels, climates, environments and biodiversity, that would otherwise be impossible.
- Given the known palaeontological potential of the region, mitigationary action, beyond simple recording and recovery during monitoring, including the possibility of systematic excavations, while unlikely, may be necessary.

- Provided that the recommendations in this report are followed, current information indicates that construction of the proposed reservoirs will not impact significantly on palaeontological remains; if fossils are encountered, protocols will be in place.

Provided that the recommendations herein are adhered to the proposed construction at either one of the alternatives can be allowed to proceed from the palaeontological and Pleistocene archaeological perspectives.

Recommendations

1. Protocols for dealing with palaeontological monitoring and possible further mitigation must be included in the Environmental Management Plan (EMP).
2. Relevant Heritage permit(s) (HWC) should be applied for well ahead of construction.
3. Any material recovered will be lodged in the Quaternary collection of Iziko South African Museum.
4. Funds must be available *a priori* to cover costs of fieldwork, curation and one date should the need arise.

General Points for EMP

- Pether (2011) and Avery (2016) provide useful guidelines for the formulation of palaeontological protocols.
- The reservoirs will provide an opportunity to assess the sub-surface palaeontological/ Pleistocene potential and geology of the site.
- All fossils are protected by law. Should anything of a palaeontological or archaeological nature be encountered on site by the Contractor (or any other party), e.g. bones, trace fossils or wetland deposits and/or stone artefacts, work is to be stopped in that area immediately, and the Environmental Manager (OM) / Principal Agent notified. Established protocols would 'kick in' and this must be carefully explained to workers during the Environmental Education Programme undertaken by the OM. The author of this report can assist with training in basic recognition of palaeontological material.
- In the event of palaeontological material being encountered, the OM will demarcate the area and notify the appointed specialist (palaeontologist/archaeologist with appropriate experience) who will view the material and ascertain whether further study of the area is required.
- Should the specialist confirm a genuine fossil or sub-fossil and recommend further study of the area, work in the applicable area is to cease until further notice while arrangements are put in place. Heritage Western Cape (HWC) is to be informed immediately by the specialist/OM.
- Should any human remains be disturbed, exposed or uncovered during excavation, these shall immediately be reported to the appointed palaeontologist/archaeologist, South African

Police Service and, if suspected that the remains are older than 60 years, the HWC (tel 021 483 9543).

- The removal of discovered palaeontological remains, by a contracted specialist, and their storage shall be at the Developer's expense.

Heritage Permits Required

- The primary heritage legislation that needs to be considered is The National Heritage Resources Act 25 of 1999, amendments and regulations (www.sahra.org.za). All heritage material, including human burials, is protected.
- Clearance in terms of the National Heritage Resources Act of 1999 will be required before the development can proceed.
- A permit and a Work Plan approval for the tests and/or disturbance and removal of palaeontological material may be required by the HWC.
- Potential delays during excavation could be minimized by submitting applications for permits before construction is initiated.
- If human remains are encountered, or the presence of a burial is suspected, the appointed Palaeontological/Archaeological specialist and HWC must be notified immediately; no bones may be further moved until the occurrence has been assessed and, if necessary, a Work Plan approval from HWC, is granted. Laid down procedures, including notification of the SAPS, must be followed.

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Honorary Research Associate: University of Cape Town, Archaeology Department
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Appendix 1 (Qualifications)

- I have an MA (UCT, 1976) and PhD (UCT, 1990), each in archaeology/archaeozoology and have worked extensively in the Quaternary palaeontological field, focusing on the south-western coast of South Africa, in both research and commercial contexts. I have conducted research on a variety of Early, Middle and Later Stone Age and palaeontological sites and published the findings.

- I am a member of the Palaeontological Society of South Africa and accredited with the Association of Southern African Professional Archaeologists (ASAPA) CRM section (Member #008, 1998) as Principal Investigator: Stone Age, Shell Middens, Middle Pleistocene studies and archaeozoology.

Appendix 2 (Curriculum Vitae: Graham Avery)

Curriculum Vitae: Graham Avery

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Business Details

Graham Avery (Sole Proprietor): Archaeozoology, Stone Age Archaeology and Quaternary Palaeontology.
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Professional Qualifications

PhD (archaeology) 1990 Archaeological and palaeoenvironmental interpretation of avian remains from archaeological sites. University of Cape Town.
MA (archaeology) 1976 Systematic Investigation of Coastal Shell Middens in the South Western Cape. University of Cape Town.
BA (Archaeology, Social Anthropology, African History, History and Geography) 1969 University of Cape Town.

Current Positions

- Research Associate Natural History Collections Department, Cenozoic Studies, Iziko South African Museum (April 2012–).
- Research Associate, Archaeology Department, University of Cape Town (July 2012–).

Positions Held

- Retired 31 January 2012.
- Archaeozoologist, Curator of Quaternary Collections, Cenozoic Studies Section, Natural History Department, Iziko South African Museum (2002–January 2012). [moved to Natural History Collections Department when Iziko came into being].
- Head of Human Sciences Division, South African Museum (1993–2002).
- Head of Archaeology Department, South African Museum (1990–1993).
- Acting Head of Archaeology Department, South African Museum (1985–1990).
- Researcher, Archaeology Department, South African Museum (1980–2002).
- Manager: Archaeological Data Recording Centre, South African Museum (1974–1979).
- Environmental Archaeologist, South African Museum (1970–1973).
- Manager (temporary): Archaeological Data Recording Centre, South African Museum (1969).

Research (publications not included here)

Research Interests

- The Late Quaternary palaeoecology of south-western Africa covering material from the Pliocene to the Holocene: Archaeozoological studies—mammals, birds and molluscs in the palaeo-ecological and human history of South Africa;
- Experimental and comparative actualistic studies – taphonomy of human and non-human bone accumulations resulting from carnivores, scavengers and raptors, such as hyaenas, jackals, leopards, eagles and the larger owls. These include a 29-year long-term project monitoring beached birds and mammals;
- Past climates and environments using evidence from birds and mammals (including pollens from hyaena coprolites); and
- The application of archaeozoological and palaeontological research to modern issues of global change, conservation, heritage resource management and education.

Research Projects

- Taphonomy of Verreaux's Eagle prey (with Aaron Armstrong, University of Minnesota), 2013–2015 – Paper Published in Journal of Archaeological Science.
- Prey of Verreaux's Eagles in the Cedarberg and Sandveld (with Megan Murgatroyd, UCT), 2015 – Paper in press Avian Biology.
- Prey of African Crowned Eagles in Urban areas of Kwazulu Natal (with Malan, et al.). 2008 – 2014 – Paper published Ostrich.
- Taphonomy and pathology of seal remains from the Langebaanweg Early Pliocene fossil site (with R. Govender, Iziko Museums of South Africa) – Paper published.
- Interpreting the environment of human development in eastern Africa (with D.M. Avery, Iziko SA Museum and F.K. Manthi and S. Mucila, National Museums of Kenya. Funding from PAST 2009 – ongoing.
- Spreeuwalle Late Pleistocene Wetland on The Western Cape Coast, South Africa, And its Implications for the Pleistocene History of the Fynbos (with R.G. Klein, Stanford University, USA, C. Cordova, Oklahoma State University, USA, E. Bergh, Iziko South African Museum, Warren Sharp, UC Berkeley, USA and Julie Luyt, University of Cape Town). Funding From Leakey Foundation and PAST. 2003 – Ongoing.
- Uniab brown hyaena den: Taphonomy of a modern hyaena den on the Uniab delta fan, Skeleton Coast Park, Namibia (with P. Fosse, CNRS, Université de Toulouse Mirail, France, J-B. Fourvel, Université de Toulouse Mirail, France, J-F. Tournepiche, Angolême Museum, D.M. Avery, Iziko Museums of South Africa, R. Loutit and S. Braine) –Ongoing.
- Pathologies on Gemsbok at the Uniab brown hyaena den (with R. Govender, Iziko Museums of South Africa) – Ongoing.
- Human behavior, taphonomy, biodiversity and palaeoecology from osteological remains of birds from archaeological and palaeontological sites in the western and Eastern Cape Provinces: Includes a range of Middle and Late Pleistocene ocurrences – Ongoing.
- CNRS/NRF International Co-operation Project on taphonomy of spotted hyaena bone accumulating habits. (with P. Fosse, CNRS, Université de Toulouse Mirail, France, J-F. Tournepiche, Angolême Museum and J-B Fourvel, Université de Toulouse Mirail, France). 2002 – papers published. Ongoing.
- Late Pleistocene Middle Stone Age shell midden at Ysterfontein (with R.G. Klein, Stanford University, T.E. Steele, UC Davis, D. Halkett, University of Cape Town): excavation and study of the bird remains. 2002–2007 – Papers published.

- Records of Middle and Upper Pleistocene birds in fossil and archaeological sites. – Ongoing.
- Palaeo-ecology of the Western Cape Coast. (with Klein, R.G., Stanford University, L. Scott, University of the Free State). Funded initially by NRF grant to A. Chinsamy-Turan, Iziko Museums of Cape Town). 2002 – Ongoing. Papers published.
- Prey of black sparrow hawks in the western Cape (with R. Simmons, Percy FitzPatrick Institute for African Ornithology, University of Cape Town, and O. Curtis, Cape Technikon Nature Conservation MA student).2002 – Ongoing.
- Cercopithecoid and other remains in crowned and black eagle prey assemblages. (with J. P. Kerbis, Field Museum, Chicago, USA; G. Malan, Tshwane University of Technology; A. Armstrong, University of Minnesota, USA). 2001 – Ongoing.
- Co-Director of Duinefontein Project (with R.G. Klein, Stanford University and K. Cruz-Uribe, Northern Arizona University): excavation and overall interpretation; avian remains; palaeo-environment (carbon and oxygen isotopes with J. Lee-Thorp, University of Cape Town); pollens in hyaena coprolites (with L. Scott). NSF and Leakey Foundation funding allocated to RGK. 1997–2002 – Papers published.
- Co-Director of Die Kelders Cave Project (with R.G. Klein Stanford University, F.E. Grine and C. Marean, State University of New York at Stony Brook). NSF funding allocated to RGK. 1992–1995 – Papers published.
- Prey of black, martial and crowned eagles in the Cape Province (with A. Boshoff and G.N. Palmer, Cape Nature Conservation). 1988–1994 – Papers published.
- Late Quaternary palaeoecology of south-western Africa – avian fauna project, taphonomy of modern and archaeological/fossil bone accumulations and an investigation of the Middle Pleistocene hominid and other occurrences at the Elandsfontein fossil site, south-western Cape. Funding through colleagues involved in the project. Now part of Palaeo-ecology of the Western Cape Coast Project 1980 – Papers published. Ongoing.
- Avian fauna, palaeoenvironments and palaeoecology in the Pleistocene/Holocene of the southern and western Cape (PhD). Funding through colleagues involved in excavation projects. 1978–1990 Paper published.
- Monthly surveys of dead seabirds and marine mammals on South African beaches.1977–2006 – Papers published.
- Archaeological salvage of historical material from the Cape Town Station Concourse and Golden Acre Sites. Excavation and preservation of Wagenaar's Reservoir. 1974–1979.
- Systematic investigation of open-station shell midden sites along the south-western Cape coast (MA). CSIR, HSRC, Museum funding to GA. 1970–76 (MA) – Papers published.

Curatorial and Museology

Collections Management

Planning, management, curation and co-ordination of the archaeological, physical anthropology and Quaternary collections of Iziko SA Museum, as well as the Archaeological Data Recording Centre. Using databases of different types. Writing contracts for collections, external loans and impact assessments. Overseeing the input of the archaeological, physical anthropology caste and Quaternary mollusc collections on Excel spreadsheets to make them more accessible and contributing to the improvement and upgrading of the LogosFlow Humanities Database, used by the African Studies section. Assisting in the development of a LogosFlow Archaeology/Quaternary Database to capture data for individual cultural items, fossils and

assemblages with a view to simplifying transfer of data already on spreadsheets to an Access relational database.

Collections Policy Development
Assisting in the development of Archaeology, Human Remains and Palaeontology collection policies.

Sensitive Collections

- Best practices for sensitive collections (human remains). Organized a workshop on sensitive collections, the results of which led to greater understanding of museum and social issues, which have significantly changed the way in which many museums in South Africa treat human remains in particular. Contributed to public forums on the issues of museums and human remains and a member of the Iziko Reference Group on Human Remains, which developed Iziko's current Policy on Human Remains.

Contributions to Development and Training

- Heritage training for Construction staff Elandsfontein Phosphate Mine.
- Lectures to university and technikon students and courses on the curation and conservation of collections and collection management. Provided in-service training and mentoring for young museum research and collections staff, university students, postdocs and interns. Participated in training programmes for tour guides, museum volunteers and construction t project staff.
- Public Programmes, Public Understanding of Archaeology and Palaeontology and Communication
- Application of the results of my archaeozoological and palaeontological research to training, education and tourism/recreation. I have lectured extensively to adult and learner audiences, tertiary level students and conferees, and conducted behind-the-scenes activities and excursions.
- Initiating and assisting in the planning, co-ordination and leadership of a number of exhibitions (archaeology, rock art, Robben Island, indigenous knowledge, Blombos Cave artefacts, Search for Our Early Ancestors, Natural Selection, Darwin and the Cape and Australopithecus sediba) and exhibition planning for Origins, New Cenozoic, Human Journey, San Diorama and Links between natural history and culture).
- Outreach projects, including exhibits at Cape Town's Golden Acre (17th century Wagenaar's Reservoir and 19th century Maclear's Beacon), the Elandsfontein fossil site at the Hopefield Information Centre and the development of information boards for the Klipgat Cave (Die Kelders) and the Ysterfontein 1 archaeological site.
- Compiling, with A. Galla (Australia), and coordinating the publication of Changing the Paradigm: a Plan for Diversifying Heritage Practice in South Africa, a discussion document on the transformation of South African museums, for the Southern African Museums Association (SAMA).

Membership of Professionally-Related Societies

- Royal Society of South Africa (Council Member and Editor of Newsletter).
- Association of Southern African Professional Archaeologists (ASAPA). Professional Member #008 with Cultural Resource Management (CRM) accreditation.
- South African Society for Quaternary Research (SASQUA).
- International Council for Archaeozoology (ICAZ).
- South African Archaeological Society.

- Southern African Museums Association (SAMA) (Life Member).

Honorary Positions

- South African Archaeological Society Vice-President (2016-2018).
- Iziko South African Museum Honorary Research Associate (2012–).
- Archaeology Department, University of Cape Town Research Associate (2012–).
- Hon. Editor *RSSAfNews* (2012–).
- Hon. Editor *Piscator* (2012–2015).
- Royal Society of South Africa (RSSAf) Council Member (2010–2016).
- Cape Town Science Centre Scientific Advisory Board (2008–).
- Cape Nature Klipgat Development Group (2004–2007).
- Member Wildlife and Environment Society of South Africa (WESSA) Past President (1997—2003) and Honorary Life (2004–).
- Amafa aKwaZulu-Natali (Heritage KwaZulu-Natal) Permit Review Committee (2001–2016).
- Southern African Association of Archaeologists (now ASAPA) Chairperson (2000–2004).
- South African Heritage Resources Agency (SAHRA) Archaeology, Palaeontology & Meteorite Permit Committee Specialist Advisor (2000–2003).
- University of Cape Town (UCT/Iziko MOU) Research Associate (1999-2011).
- Percy FitzPatrick Institute for African Ornithology Advisory Board (Representing WESSA) (1999–).
- World Wildlife Fund South Africa (WWF SA) Trustee (1999–).
- Klipgat Trust: coastline and heritage between Die Kelders Cave (Klipgat) and Gansbaai Trustee
- (1998–).

Awards (other than grants)

- WESSA Lifetime Conservation Achiever Award (2016).
- Honorary Life Membership of the Wildlife and Environment Society of South Africa (WESSA) (2004).
- Heritage Award Amafa Akwazulu Natali (conservation of heritage in KwaZulu Natal).

Appendix A: Cultural Resource Management Reports (CRM)

Avery, G. 2016. Awareness Training: Draft procedures for the mitigation of Potential Excavation/Construction Impacts on Palaeontological Resources at the WHBO OTMS Crude Oil Tank Farm Construction, Saldanha Bay (Project C00610). For WBHO. 9 pp.

Avery, G. In Prep. Palaeontological Assessment and Monitoring of Access Road and Infrastructure for Proposed Phosphate Mine, Elandsfontein, Hopefield.

Avery, G. In Prep. Palaeontological Assessment: Proposed Development of Erf 1960, Killarney Gardens, Cape Town (1:50000 3318DC Bellville). For Doug Jeffrey Environmental Consultants (Pty) LTD.

Avery, G. In Prep. Palaeontological Assessment: Proposed development, Trekossenkraal, Vredenburg, Western Cape Province (1:50000 3218 CA and CC Velddrif). For Rancho Al Paraiso (Pty) Ltd (Registration No: 73/13437) and Houtfield Cattle Ranch (Pty) Ltd (Registration No: 21843/84).

Avery, G. 2016. Palaeontological Assessment: Proposed Establishment of a Calcrete/Calc-sand Borrow Pit, Farm Langeberg 188, Vredenburg, Western Cape Province (1:50 000 3218 CA and CC Velddrif). For ACRM. 45 pp.

Orton J. and Avery, G. 2016. Heritage Impact Assessment for the Proposed Extension of a Car Park at the Koeberg Nuclear Power Station, Farm 1552, Cape Town Magisterial District, Western Cape. For Advisian.

Orton, J. and Avery, G. 2016. Heritage Impact Assessment for Proposed Power Lines and Substations near Saldanha Bay, Hopefield and Vredenburg Magisterial Districts, Western Cape. For Savannah Environmental (Pty) Ltd.
Avery, G. 2016. Palaeontological Impact Assessment: Proposed Gas-Fired Independent Power Plant To Support Saldanha Steel And Other Industries In Saldanha Bay, Western Cape (1:50000 3218CA & CC Velddrif; 3317BB &3318AA Saldanha). 29 pp.
Avery, G. May 2016. Palaeontological Assessment: Rectification Application for the Unlawful Upgrading and Realignment of an Existing Unsurfaced Access Road on Portions 4 and 7 of Farm No. 264 and Infilling of the Road within 100 Meters of the High Water Mark Arniston, Western Cape Province (1:50000 3420 CA & CC). 15 pp.
Avery, G. 2016. Palaeontology and Pleistocene Archaeology in the Saldanha Municipal Region. 39 pp.
Avery, G. 2016. Palaeontological Assessment: proposed calcrete mine extension, Farm 1043 (Rem), Vredenburg, Western Cape Province (1:50000 3218 CA and CC Velddrif). 27 pp.
Avery, G., 2016. Baseline Palaeontological Assessment: Proposed Saldanha – Ankerlig Natural Gas (SANG) Import Project, Western Cape Province (1:50000 3317BB & 3318AA Saldanha, 3318AD Darling and 3318CB Melkbosstrand). 16 pp.
Avery, G., Kaplan, J., 2016a. Heritage Western Cape Work Plan Application for Mitigation of Archaeological and Palaeontological Sites Weskusfleur Proposed Sub-station Alternative 4. For Eskom. 6 pp.
Avery, G., Kaplan, J., 2016b. Report on Sub-surface Investigation of Palaeontological and Archaeological Potential, Weskusfleur Substation Alternative 4 (1:50 000 3318CB Melkbosstrand). For Eskom. 20 pp.
Avery, G., 2015. Palaeontological Assessment Proposed Power Line from the Rheboksfontein Wind Energy Facility to the Aurora Substation, Western Cape Province (1:50000 between 3318AD Darling and 3317BB & 3318AA Saldanha), p. 20.
Avery, G. 2015. Archaeological and Palaeontological Assessment Proposed Dallas Sand Mine, Farm 711/30 Klip Fontyn, Gansbaai, Western Cape Province (1:50000 3419CB Gansbaai). 17 pp.
Avery, G. 2015. Palaeontological Assessment Proposed Icon, Cape Agulhas, Western Cape Province (1:50000 3420CC Bredasdorp). 12 pp.
Avery, G. 2015. Palaeontological Assessment Proposed Ibhubesi Gas Pipe line, Western Cape Province (1:50000 3218AD & 3218 CC Velddrif and 3318CB Melkbosstrand). 28 pp.
Avery, G. 2015. Palaeontological Assessment Proposed Power Line from the Rheboksfontein Wind Energy Facility to the Aurora Substation, Western Cape Province (1:50000 between 3318AD Darling and 3317BB & 3318AA Saldanha). 20 pp.
Avery, G., 2014. Palaeontological Assessment Weskusfleur Substation Alternatives 1 and 4 (1:50000 3318CB Melkbosstrand). For Eskom. 31 pp.
Avery, G. 2014. Palaeontological Assessment Saldanha Bay and Pepper Bay: Stabilization of Eroded Embankments (3317BB & 3318AA Saldanha), Vredenburg Magisterial District. 13 pp.
Avery, G. 2014. Palaeontological Assessment Wellington Industrial Park, Remainder Erf 34 (1:50 000 3318DB Paarl). 10 pp.
Avery, G. 2013. Palaeontological Assessment Upgrade of Abalone Hatchery (3017AD Hondeklipbaai). 13 pp.
Avery, G. 2013. Palaeontological Assessment: Proposed Development Farms CA1183 (Portions 1&4) and CA 4 (Portion 93), (3318CB Melkbosstrand). 9 pp.
Avery, G. 2013. Palaeontological Assessment Upgrade of R 43 Hermanus to Stanford (3419AD Stanford). 10 pp.

Avery, G. 2013. Palaeontological Assessment Sand Mining on Portion of Rondevlei 586 (3318BC Malmesbury), Malmesbury District. 11 pp.
Avery, G. 2013. Palaeontological Assessment Sand Mining on Portion of Rondevlei 586 (3318BC Malmesbury), Malmesbury District. 22 pp.
Avery, G. 2012. Palaeontological Assessment proposed CoCT Biosolids Beneficiation Project (Cape Farm 140, Cape Farm 153 portion 2 and 3, portion of Cape Farm 153 and portion 1 of Cape farm 957, Vissershok, 3318DC Bellville). 12 pp.
Avery, G. 2012. Palaeontological Assessment proposed upgrade Total South Africa Paarden Island Bulk Storage Depot, (3318CD Cape Town). 10 pp.
Avery, G. 2012. Palaeontological Assessment N7 Upgrade Trawal to Van Rhynsdorp, (3118DC Klawer; 3118DA Van Rhynsdorp). 9 pp.
Avery, G. 2012. Palaeontological Assessment: Proposed Development Farms CA1183 (Portions 1&4) and CA 4 (Portion 93), 3318CB Melkbosstrand. 10 pp.
Avery, G. 2012. Palaeontological Assessment proposed new Eskom Line between Beaufort West and Aberdeen. 7 pp.
Avery, G. 2012. Palaeontological Assessment Proposed sites for 66kV Substation, Calitzdorp (3321DA Calitzdorp). 8 pp.
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