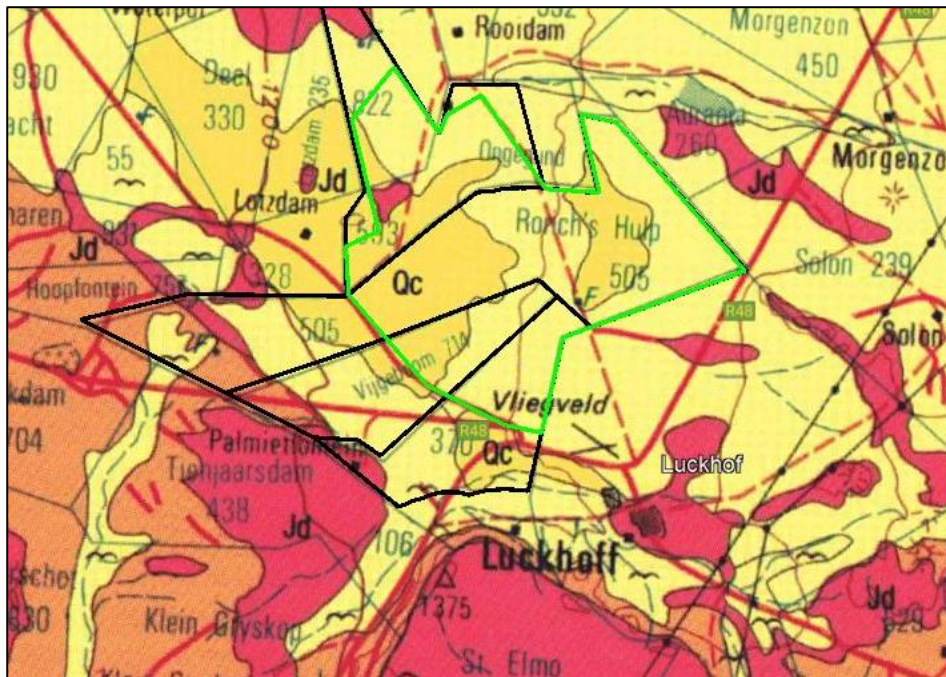


Geotechnical Desktop Study Report to Environamics for the proposed Luckhoff Solar 2 Photovoltaic Solar Energy Facility

Reference: 22-748

Dated: November 2022



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1. INTRODUCTION AND TERMS OF REFERENCE

On the 6th September 2022, Mrs. Marélie Botha of Environamics requested Delta Geotech (Pty) Ltd provide a quotation to undertake a desktop study assessment report for three PV Solar Energy Facilities and one power line corridor near Luckhoff in the Free State Province. Delta's quotation was successful and appointed for the work. This desktop study report covers the development Area 2 portion as per the supplied KMZ. While the other two PV Solar sites and the power line corridor will be assessed in separate individual reports.

2. SCOPE OF REPORT

The objectives of the study were as follows:

- Assess topographical maps which may provide historical data relevant to the proposed site;
- Assess geological maps to determine the site stratigraphy and anticipated bedrock conditions;
- Review literature to identify potential problematic soil conditions.
- Identify potential geotechnical fatal flaws with regards to trench sidewall and slope stability and groundwater;
- Determine likely geotechnical issues that may be encountered during construction;
- Determine any other matter of geotechnical relevance;

3. INFORMATION SUPPLIED

The following information was utilized during the investigation:

- Remote Colour Imagery – Google (2020).
- Locality maps and KMZs provided by Environamics indicating the three proposed PV solar Facilities and 5km long power line corridor.
- The 1:250 000 geological map – 2924 – Koffiefontein (Council for Geoscience).

- The 1:500 000 hydrological map series – Bloemfontein – Department of Water Affairs and Forestry.
- Brink A.B.A (1985). Engineering Geology of South Africa - Post Gondwana Deposits. Volume 4. Building Publications. South Africa. 332pp.

4. SITE DESCRIPTION

The proposed Luckhoff Solar 2 site is located on Farm Mooidoorns No. 1224, covering an area of 570 hectares and occurs to the north of the three sites and northwest of Luckhoff (See Figure 1 below). The proposed solar development overlies relatively young unconsolidated quaternary soils on fairly flat ground. A gravel road heading north out of Luckhoff and extending from Voortrekker Street forms the sites eastern boundary. The vegetation generally appears to be sparse karoo bushes and grasses while a relatively large patch of trees (approximately 400m across) occurs in the south-central part of the site (Figure 1). A roughly N-S striking gravel road bisects the site and meets up with some buildings near the forest. To the south-west of the site near the western site boundary a small dam wall (dry dam) can be seen along a sandy drainage line (Figure 1).

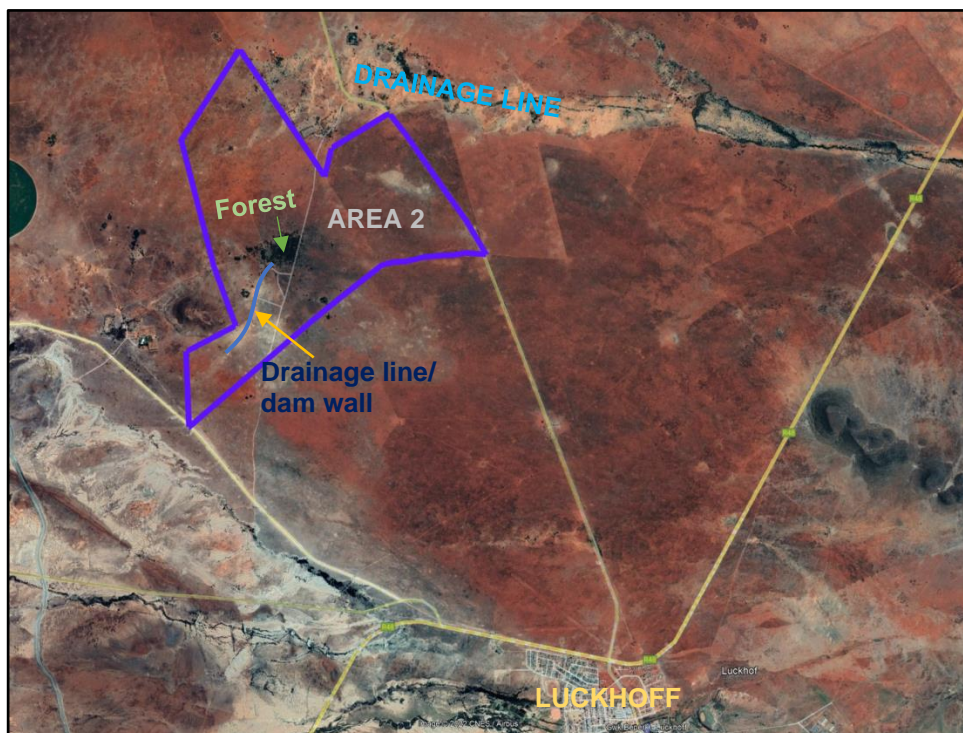


Figure 1: Site plan indicating site boundary of the development Luckhoff Solar 2 Facility, the minor rise in topography towards the south-east.

Google elevation profiles indicate ~1.0 to 1.5% average slopes in the north-south and west-east direction respectively with maximum slopes of between 5.9 and 8.5%. In other words, the topography gently falls with minor undulations from the southeast corner towards the northern site boundary (See Figure 1 – Site Plan).

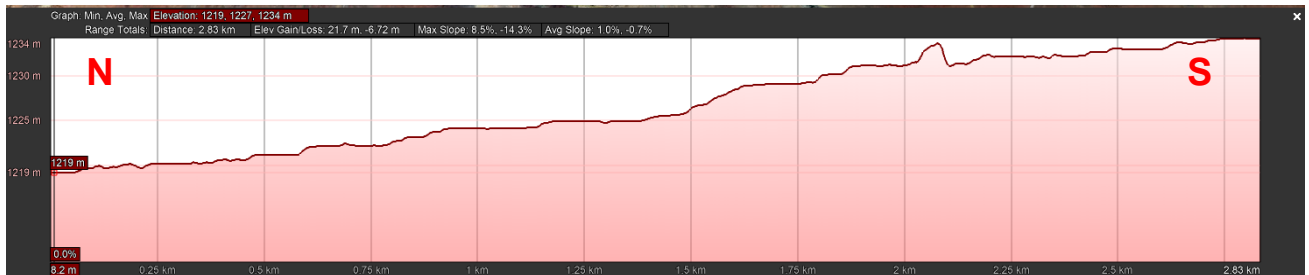


Figure 2: N-S elevation profile indicating a rise in elevation from the north to the south at an average slope of 1.0% and maximum slope of 8.5%.

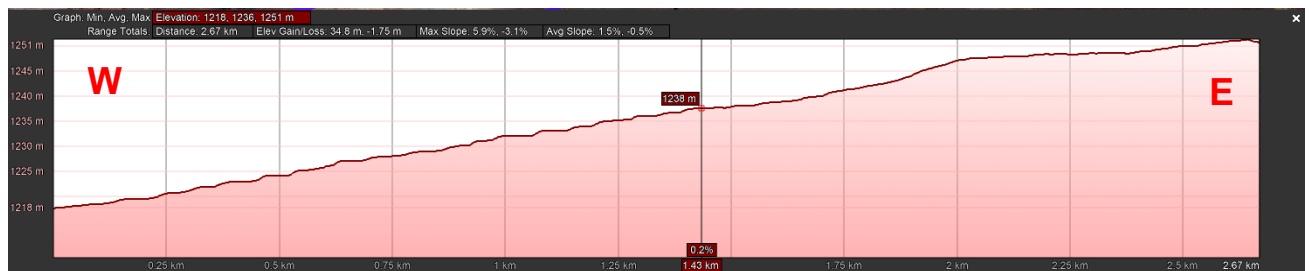
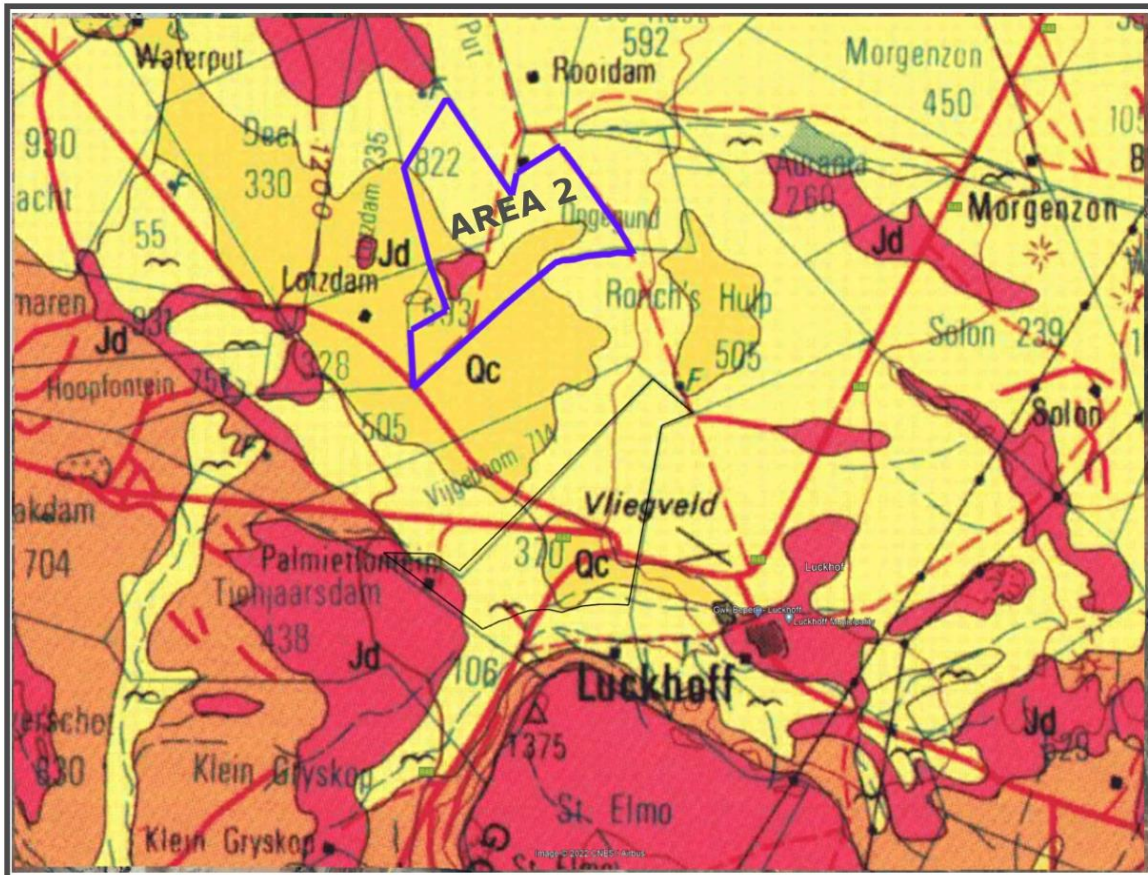


Figure 3: W-E elevation profile indicating a rise in elevation from the west to the east at an average slope of 1.5% and maximum slope of 5.9%.

5. GEOLOGY AND GROUNDWATER CONDITIONS

5.1 General Geology of the Area

The general geology of the area comprises relatively young quaternary deposits with large areas of the region underlain by calcrete and wind-blown sands (aeolian) as well as more localised alluvial deposits adjacent to river courses or more widespread alluvial variants as sheet-wash deposits. In lower lying areas these soils are underlain by Permian aged Tierberg Formation blue-grey to dark grey shale with carbonate concretions and subordinate sandstone in the upper parts of the formation which form part of the Ecca Group, Karoo Supergroup. These Karoo sediments are intensely intruded by Jurassic hypabyssal igneous dolerite dykes and sills which outcrop and are generally associated with the surrounding high ground koppies and hills see (Figure 4 – Geological plan over page).



Geological Legend

Supergroup	Group	Formation	Description
QUATERNARY			<p>Aeolian sand Qs</p> <p>Calcrete Qc</p>
JURASSIC			<p>Dolerite Jd</p>
Karoo Supergroup	PERMIAN ECCA	Tierberg	<p>Blue-grey to dark-grey shale with carbonate concretions; subordinate sandstone and siltstone in upper part Pt</p>

FIGURE 4 - GEOLOGICAL PLAN INDICATING REGIONAL GEOLOGY AND APPROXIMATE SITE BOUNDARY

5.2 Site Geology

According to the geological map, the predominate formations overlying the site are quaternary aged aeolian sands and calcrete, however, localised deposits of colluvium, alluvium and residual soils followed by sedimentary and/or igneous doleritic bed rock could be expected as well. A summary of each soil/rock type is as follows:

a) Colluvial

A veneer of colluvial soils could be expected, this horizon deposited via debris flow and sheet wash comprising metastable low density silty sands and gravels. Problems associated with colluvial deposits may be collapse upon wetting and compressibility/ consolidation. Deposits can be identified by assessing the debris flow morphology, but these soils would most likely be thinly developed and should not directly affect the proposed developments.

b) Aeolian

According to the geological explanation sheet for the Koffiefontein Geological Map, aeolian sands occur over large parts of the area. These may be deposited as either seif-like dunes with amplitudes of up to 40cm or as a thin veneer of sand varying in thickness of between 0.02m to 1.50m. These soils will generally be sandy in nature but may contain larger rounded cobble and boulder size fragments on the margins of hills and drainage lines. Problems associated with these soils include liquefaction and erodibility. However, where sufficiently dense, the aeolian sands could possibly form suitable *in-situ* subgrade and possibly selected subgrades as well as founding substrates.

c) Alluvial

Alluvial soils are deposited in drainage lines and can be highly variable in composition from clay to gravelly sandy soils with rounded to sub rounded cobble and boulder clasts where higher energy environments occur. However, with the lower gradients anticipated on site the alluvium confined to river courses are expected to be mainly fine grained (silt and very fine grained sand) whereas the sheet wash deposits are likely to be coarser grained sands with frequent scattered cobble sized rock fragments. Problems associated with these soils include liquefaction, compressibility, expansive characteristics, dispersive characteristics, erodibility and difficulty associated with compaction and boulder class B excavations. As the site appears to occur outside of the alluvial zone it is unlikely that these soils occur but on site confirmation will be required as flood zones can extend outside of alluvial zones.

d) Pedogenic Calcrete

According to the geological explanation sheet for the area, large areas of the site are anticipated to be underlain by calcrete as this horizon is associated with circulating calcium carbonate rich groundwater sourced from or introduced to the upper beds of the shale underlying surficial soils. Evaporation of the water near surface has led to the precipitation of calcrete as well as acute folding in the upper most shale beds due to lateral stresses formed from CaCO_3 crystallization. The calcrete as noted by Potgieter (1974) in the area is classified as three main formations as follows:

1. First intermediate calcretes, mainly found to occur in calcified alluvial gravels
2. Second intermediate calcretes containing Middle Stone age tools (the most common)
3. Recent hard-pan calcrete found adjacent pans.

Problems associated with calcrete include lateral variability in subgrade and excavation difficulties in hardpan formations. Calcrete generally forms suitable selected and *in-situ* subgrades as well as a competent founding substrate.

e) Residual

Residual soils are a weathering product, through decomposition, of the underlying parent rock. These soils are generally clayey in nature and where associated with finer grained parent rocks, may be expansive. However, due to the climate zone (Weinert's N Value = ~10) the residual soils are expected to be very thinly developed through mainly disintegration or physical weathering. The residual is thus not expected to have any major geotechnical significance on site.

f) Rock

According to the geological map the site is likely underlain by sedimentary rocks of the Tierberg Formation comprised by blue grey to dark grey shales with carbonate concretions and subordinate sandstone and siltstone in the upper parts of the formations. Dolerite may also be present within the site boundary. The rock on site is likely to occur at shallow depths owing to the high Weinert's N value of the area with difficulties associated with excavations. All the rock encountered on site will form suitable selected (where excess material is available during construction) and *in-situ* subgrades as well as a competent founding substrate for the envisioned structures.

5.3 Groundwater

Perched groundwater in the general area will rely mainly on recharge from direct infiltration of rainfall, as well as, from upslope recharge of the groundwater via horizontal flow. As such, this water table will be best developed during the fairly short wet /rainy seasons at soil rock interfaces with the shallow highly saturated soils expected to occur following heavy rainfall episodes.

As per the *1:500 000 Hydrological map series of Bloemfontein*, Luckhoff predominately exhibits a b3 mode or fractured principal groundwater occurrence within argillaceous rocks. Borehole yield class range between 0.5 to 2.0 litres/second for fractured b3 mode of groundwater occurrence.

6. GEOTECHNICAL ASSESSMENT

Table 1: Geotechnical assessment based on the desktop study

Site	Generalized Geology Summary	Estimated Excavatability (SANS 1200D)	Groundwater	Possible geotechnical constraints	Likely source of material for construction purposes	Preliminary Recommendations
Luckhoff Solar 2 Facility	<ul style="list-style-type: none"> - Fine granular colluvial soils - Sandy aeolian soils - Possibly localised fine granular alluvium - Nodular/ or hardpan calcrete - Limited and thin residual soils - Shale with carbonate concretions and subordinate upper sandstone and siltstone. - Dolerite - All soils expected to be loose in the uppermost horizons (100mm) and rapidly becoming medium dense to dense with depth. 	<p>To depths of 150mm. Excavation natural soils would classify as "Soft" and possibly limited boulder class B excavations.</p> <p>Excavations in excess of approximately 150 to 200mm beneath these depths would likely be in at least moderately weathered rock and would require a minimum "intermediate" excavation technique achievable using tracked excavators with rock buckets.</p> <p>The rock is expected to become rapidly less weathered at depths of between 0.50m to 1.20m begl and would possibly require "Hard Rock" excavation techniques with the use of</p>	<p>Shallow perched groundwater briefly following heavy rainfall episodes which are likely to saturate the soil profile.</p> <p>Intermittent difficulties associated with moving machinery and vehicles across a saturated site.</p>	<ul style="list-style-type: none"> - Compressible aeolian and colluvial sands. - Hard rock excavation requiring tracked excavator with rock bucket and pneumatic hammers, possibly blasting of sandstone beds or dolerite are encountered. 	<p>Excess granular aeolian sands and calcrete soils as well as excavated weathered rock from the site should form suitable selected subgrade for use as a construction material. Testing of these materials would be required to determine quality.</p> <p>Due to the widespread presence of dolerite and sedimentary rocks in the surrounding areas, existing or Greenfields borrow sites/quarries are likely to be available.</p>	<p>The at least medium dense aeolian sands or calcrete soils as well as all rock formations would from suitable <i>in-situ</i> subgrades for any pavements and surface beds</p> <p>In terms of foundations, the calcrete and rock should form a competent founding substrate for the structures. While the aeolian sands could be considered where at least medium dense with only minor precautions to account for any variability in density that is likely to occur.</p>



		tracked excavators with rock buckets and pneumatic hammers, as well as, controlled blasting (in dolerites and sandstone).				
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7. GEOTECHNICAL RECOMMENDATIONS SUMMARY

With reference to items discussed above this section provides a summary of recommendations.

Recommendations are based solely on the perceived site conditions and a detailed geotechnical investigation will be required to confirm site conditions.

7.1 Subgrade and Foundations

Though confirmation will be required through detailed investigations, it is anticipated that the granular transported soils will be loose from surface to approximately 0.10m below and rapidly become medium dense to dense. Calcrete soils would be very dense in consistency. Where at least medium dense the soils and rock should form a suitable *in-situ* subgrade for proposed roadways. While expect shallow foundations for all structures. Depending on the thickness of the aeolian sands precautions such as compaction and modified construction techniques may be required to account for variability in density.

7.2 Excavatability

Excavation in fill and soils would classify as "Soft" and possibly "Boulder Class B" in places, excavation in terms of the SANS 1200DM Earthworks Specification. Whilst excavation in the highly weathered medium hard rock would classify as "Intermediate" excavation. Any moderately to unweathered hard rock would classify as "Hard Rock" excavation and may require the use of tracked excavators with rock buckets and pneumatic hammers, as well as controlled blasting (dolerites and sandstone)

7.3 Possible Geotechnical Problems

The following restraints could potentially occur:

- Compressible soils associated with deeper aeolian and colluvial soils.
- Saturated soils during peak rainfall episodes may result in difficulties associated with access around the site.
- Potential sporadic boulder class B excavation requirements associated with alluvial soils.
- Intermediate and Hard rock excavation likely to occur at shallow depths.

These restraints can be overcome through allowance of effective construction procedures and equipment as well as effective engineering designs informed from actual geotechnical parameters obtained in the field.

8. CONCLUSIONS

In summary the conditions according to the desktop study appear favourable for the proposed Luckhoff Solar 2 Facility. Good quality *in-situ* soils for selected and *in-situ* subgrades for pavements and surface beds as well as shallow competent founding on calcrete and rock. Excavations in soils in the upper approximately 250mm begl which classify as "soft excavation" but rapidly grade towards hard excavation in the underlying calcrete and rock.

As indicated all of the above will require confirmation through site walkover and a detailed geotechnical investigation.

We trust that the information provided meets with your requirements. Should you have any queries do not hesitate to contact us.

Yours faithfully,

DELTA GEOTECH (PTY) LTD

Prepared by:

Daniel Miller

Engineering Geologist

Approved by:



Matthew Jones Pr.Sci.Nat MEng MSAIEG



environmental affairs

Department:
Environmental Affairs
REPUBLIC OF SOUTH AFRICA

DETAILS OF THE SPECIALIST, DECLARATION OF INTEREST AND UNDERTAKING UNDER OATH

File Reference Number:	(For official use only)
NEAS Reference Number:	DEA/EIA/
Date Received:	

Application for authorisation in terms of the National Environmental Management Act, Act No. 107 of 1998, as amended and the Environmental Impact Assessment (EIA) Regulations, 2014, as amended (the Regulations)

PROJECT TITLE

Kindly note the following:

1. This form must always be used for applications that must be subjected to Basic Assessment or Scoping & Environmental Impact Reporting where this Department is the Competent Authority.
2. This form is current as of 01 September 2018. It is the responsibility of the Applicant / Environmental Assessment Practitioner (EAP) to ascertain whether subsequent versions of the form have been published or produced by the Competent Authority. The latest available Departmental templates are available at <https://www.environment.gov.za/documents/forms>.
3. A copy of this form containing original signatures must be appended to all Draft and Final Reports submitted to the department for consideration.
4. All documentation delivered to the physical address contained in this form must be delivered during the official Departmental Officer Hours which is visible on the Departmental gate.
5. All EIA related documents (includes application forms, reports or any EIA related submissions) that are faxed; emailed; delivered to Security or placed in the Departmental Tender Box will not be accepted, only hardcopy submissions are accepted.

Departmental Details

Postal address:

Department of Environmental Affairs
Attention: Chief Director: Integrated Environmental Authorisations
Private Bag X447
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0001

Physical address:

Department of Environmental Affairs
Attention: Chief Director: Integrated Environmental Authorisations
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Arcadia

Queries must be directed to the Directorate: Coordination, Strategic Planning and Support at:
Email: EIAAdmin@environment.gov.za

1. SPECIALIST INFORMATION

Specialist Company Name:	DELTA GEOTECH PTY LTD		
B-BBEE	Contribution level (indicate 1 to 8 or non-compliant)	4	Percentage Procurement recognition
Specialist name:	MATTHEW JONES		
Specialist Qualifications:	ENGINEERING GEOLOGIST		
Professional affiliation/registration:	400118/14		
Physical address:	5 Villa Road Naloon East London		
Postal address:	" " "		
Postal code:	5241	Cell:	0815867378
Telephone:		Fax:	
E-mail:	mattjonesel@gmail.com		

2. DECLARATION BY THE SPECIALIST

I, MATTHEW JONES, declare that -

- I act as the independent specialist in this application;
- I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have expertise in conducting the specialist report relevant to this application, including knowledge of the Act, Regulations and any guidelines that have relevance to the proposed activity;
- I will comply with the Act, Regulations and all other applicable legislation;
- I have no, and will not engage in, conflicting interests in the undertaking of the activity;
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
- all the particulars furnished by me in this form are true and correct; and
- I realise that a false declaration is an offence in terms of regulation 48 and is punishable in terms of section 24F of the Act.



 Signature of the Specialist

DELTA GEOTECH PTY LTD

 Name of Company:

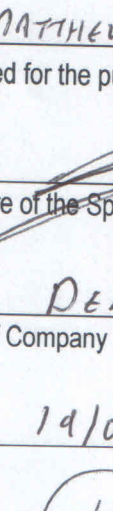
19/01/2023

 Date



3. UNDERTAKING UNDER OATH/ AFFIRMATION

I, MATTHEW JOWEL, swear under oath / affirm that all the information submitted or to be submitted for the purposes of this application is true and correct.


Signature of the Specialist

DELTA GEOTECH - Pty LTD
Name of Company

14/01/2023
Date


Signature of the Commissioner of Oaths

2023-01-19
Date



