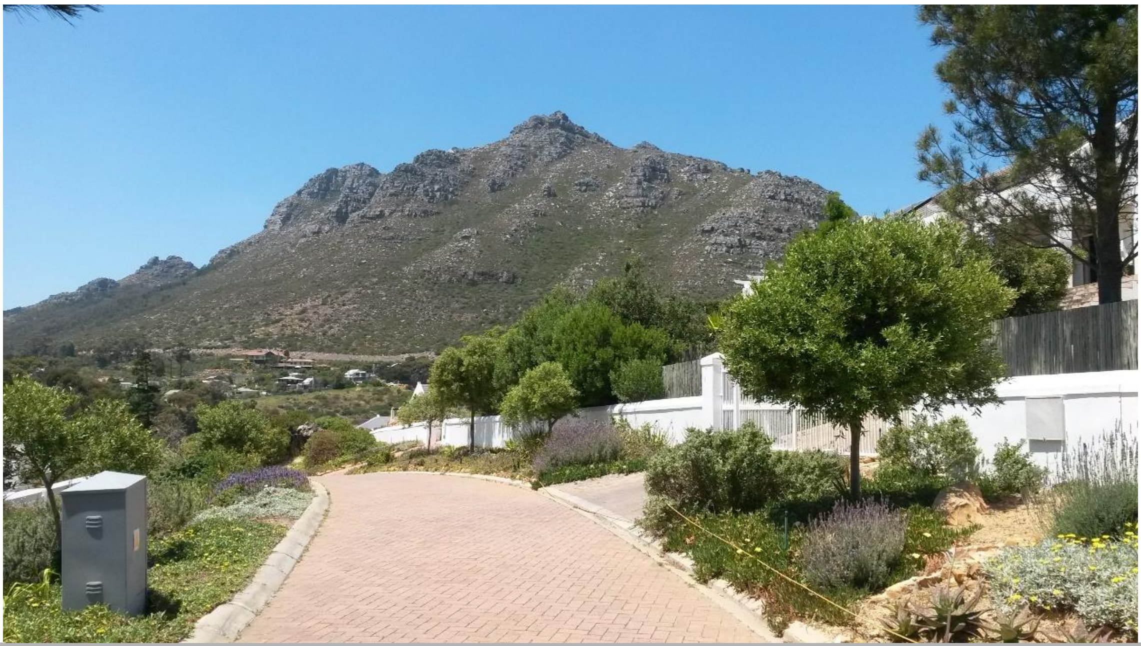

Geohydrological Assessment and Borehole Siting at Oakwood Estate in Hout Bay, Western Cape

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GEOHYDROLOGICAL AND SPATIAL SOLUTIONS INTERNATIONAL (PTY)LTD
GEOSS

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EXECUTIVE SUMMARY

GEOSS – Geohydrological and Spatial Solutions International (Pty) Ltd – was appointed by Christina Giacchetta, Mount Oakhurst Estate, to conduct a geohydrological assessment and borehole siting project for Oakwood Estate housing area in Hout Bay, Cape Town. The aim of this study is to locate optimal targets for the drilling of a borehole for groundwater abstraction. Estimate water requirements are 30 000 L/day.

The study included an initial remote geological and topographical investigation preceding the site visit. Groundwater information of the area was collected from the national database (NGA) concerning boreholes in the area and a geophysical survey was planned, using the electrical resistivity method. A hydrocensus was also conducted in the area, in order to determine typical conditions and expectations from previously drilled boreholes. The geophysics results were then used in conjunction with the hydrocensus, geological map and aerial imagery of the area, in an attempt to understand the groundwater flow in the area and target drill sites. These are detailed below.

Site ID	Latitude (WGS84, DD)	Longitude (WGS84, DD)	Drilling depth (approx.) (m)	Overburden (approx.) (m)
OE_Ds1	-34.023213	18.377506	90	25
OE_Ds2a	-34.022181	18.375579	60	45
OE_Ds2b	-34.023389	18.376594	60	45

It is likely that only one of these sites be necessary to meet the required yield, with OE_Ds2a having the greatest potential, followed by OE_Ds1 and lastly OE_Ds2b (shown in Figure 8, page 10). OE_Ds1 is given a higher priority, due to the convenience of the drill site, however this is a practical consideration, rather than a scientific one. The different drill depths are due to varying geological and topographical conditions. It must also be noted that due to the high cost of drilling in the overburden, OE_Ds1 may be cheaper to drill than the others, despite its greater overall depth, but may not be as preferable for yield as OE_Ds2a.

It is strongly recommended that a hydrogeologist be on site to supervise the drilling process. This is primarily in order to verify the final depth of the borehole, based on the drill chips brought out during drilling, and the geohydrological understanding of the area. It is deemed likely that the overburden will be saturated, the drilling contractor will be required to construct the borehole in such a way as to allow this water into the hole (slotted outer steel casing). Drilling specifications are provided with this report, and diagrammed at the end.

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ABBREVIATIONS

Bh	borehole
CGS	Council for Geoscience
DD	decimal degrees
DWAF	Department of Water Affairs and Forestry, now DWS
DWS	Department Water and Sanitation
EC	electrical conductivity
EM	electromagnetic
HC	horizontal coil
ID	Identification
L/s	litres per second
m	metres
m^3/week	cubic metres per week
mbgl	metres below ground level
mm	millimetre
mS/m	milliSiemens per metre
NGA	National Groundwater Archive
OD	outside diameter
ohm.m	ohm meter, measure of resistivity
SABS	South African Bureau of Standards
VC	Vertical coil
WGS84	Since the 1st January 1999, the official co-ordinate system for South Africa is based on the World Geodetic System 1984 ellipsoid, commonly known as WGS84, with the ITRF91 (epoch 1994.0) co-ordinates of the Hartebeesthoek Radio Astronomy Telescope used as the origin of this system. This new system is known as the Hartebeesthoek94 Datum.
WL	water level.

GLOSSARY OF TERMS

Aquifer: a geological formation, which has structures or textures that hold water or permit appreciable water movement through them [from National Water Act (Act No. 36 of 1998)].

Borehole: includes a well, excavation, or any other artificially constructed or improved groundwater cavity which can be used for the purpose of intercepting, collecting or storing water from an aquifer; observing or collecting data and information on water in an aquifer; or recharging an aquifer [from National Water Act (Act No. 36 of 1998)].

Groundwater: water found in the subsurface in the saturated zone below the water table or piezometric surface i.e. the water table marks the upper surface of groundwater systems.

Suggested reference for this report:

GEOSS (2017). Geohydrological Assessment and Borehole Siting at Oakwood Estate in Hout Bay, Western Cape. GEOSS Report Number: 2017/12-41. GEOSS - Geohydrological & Spatial Solutions International (Pty) Ltd. Stellenbosch, South Africa.

Cover photo:

Oakwood Estate, River Walk road.

GEOSS project number:

2017_08-2295

1. INTRODUCTION

GEOSS – Geohydrological and Spatial Solutions International (Pty) Ltd – was appointed by Christina Giacchetta, Mount Oakhurst Estate, to conduct a geohydrological assessment and borehole siting project for the Oakwood Estate housing area, Hout Bay, **Figure 1**. The aim of this study was to locate the optimal target for the drilling of a borehole for groundwater abstraction. The estimate required yields are 30 kilolitres per day (0.35 L/s)

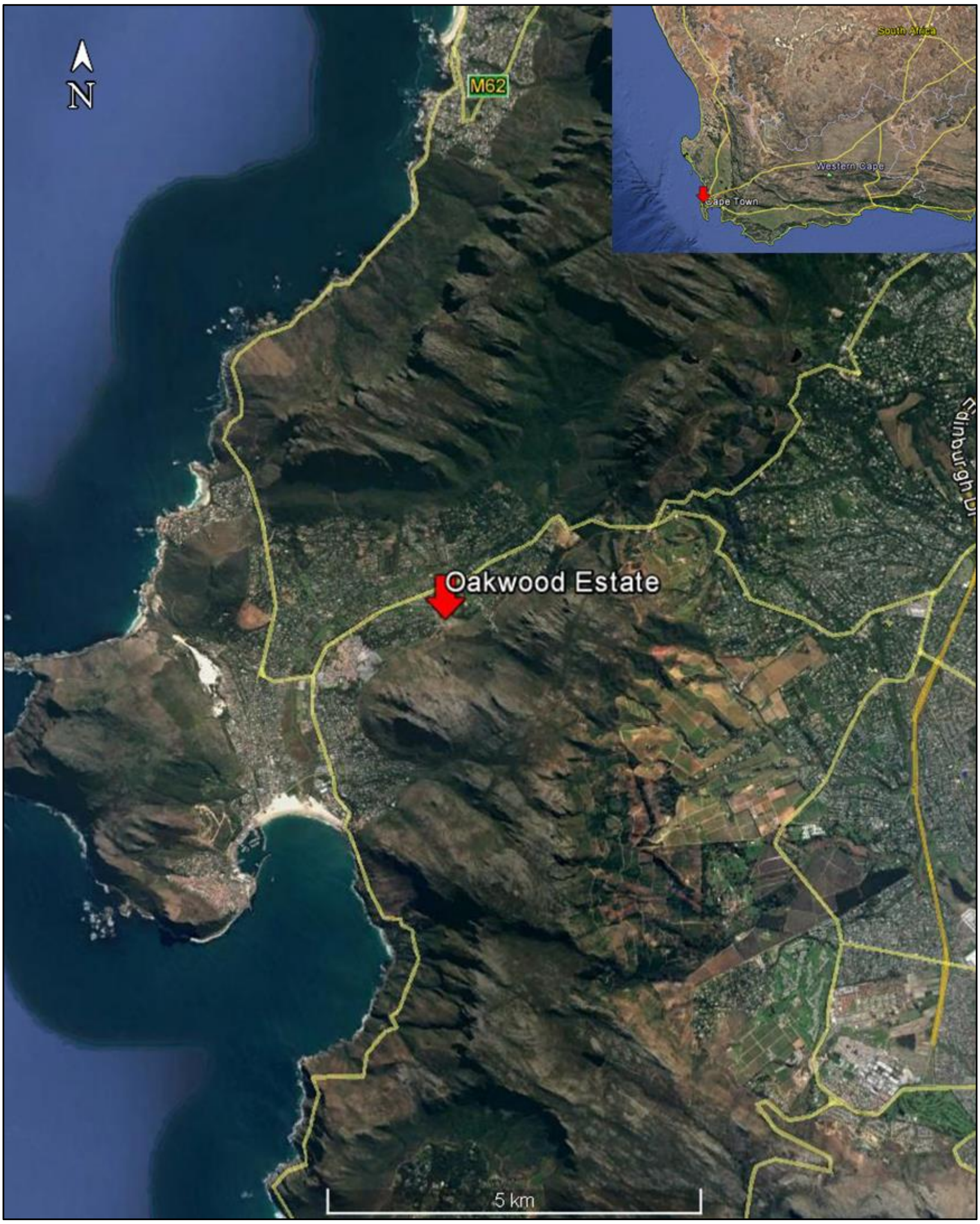

Figure 1: Location of Study Site

The study included an initial remote geological and topographical investigation preceding the site visit. Groundwater information of the area was collected from the national database (NGA) concerning boreholes in the area and a geophysical survey was planned, using the electrical resistivity method. The resistivity method measures the resistivity of the subsurface using direct current coupling; the resistivity of the subsurface is likely to be lower in areas of increased fracturing and water saturation.

2. SITE GEOLOGY AND GEOHYDROLOGY

The Geological Survey of South Africa (now the Council for Geoscience (CGS)) has mapped the area at a 1:50 000 scale (3318AB Cape Peninsula). The geological setting is shown in **Figure 2** and the main geology of the area is listed in **Table 1**.

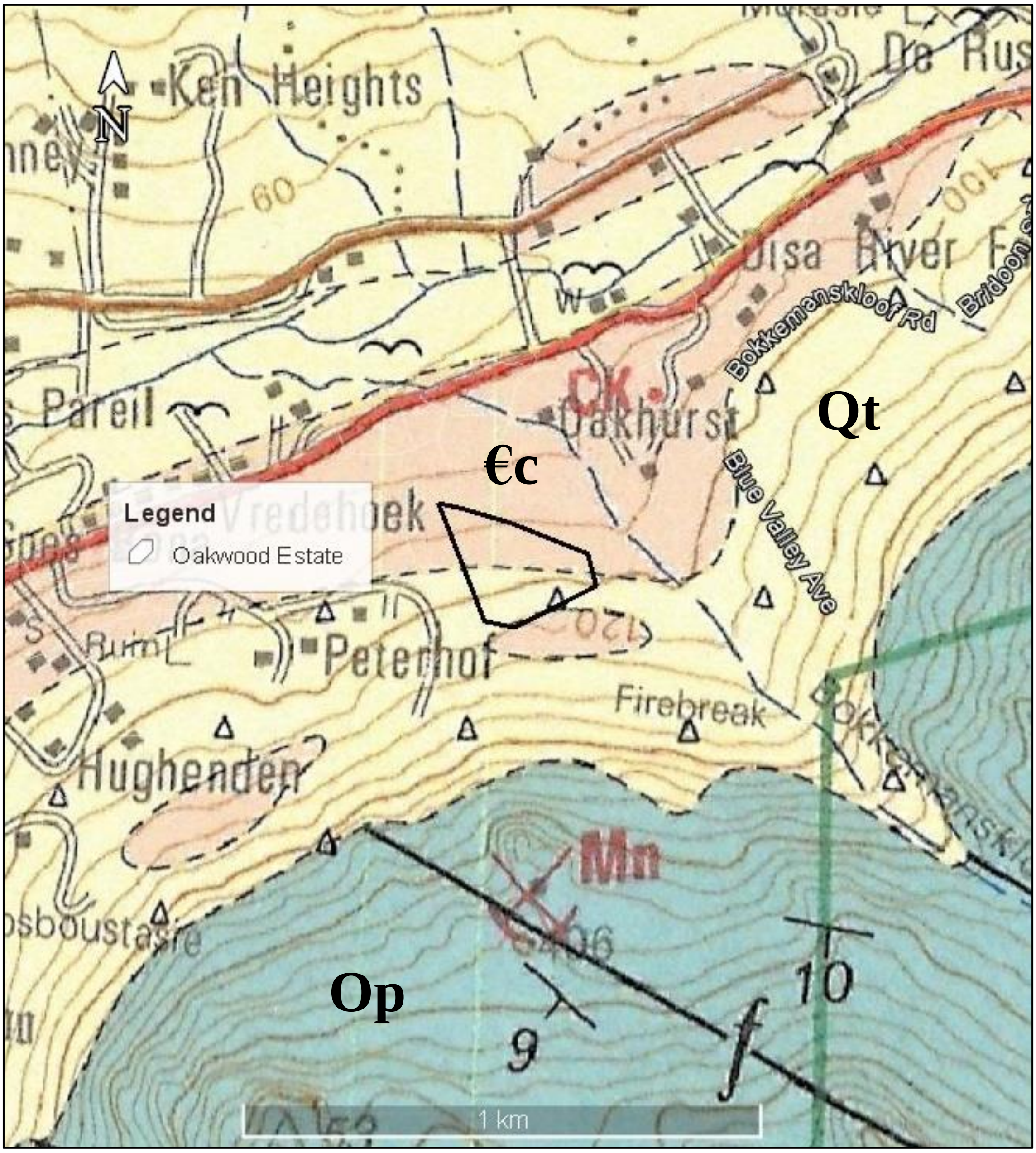

Figure 2: 1:50 000 Geological Setting of the Study Area (CGS, 1984).

Table 1: Geological formations within the study area

Code	Formation/Pluton	Group/Suite	Description
⁀⁀	-	-	River alluvium
Qt	-	-	Scree and gritty sand
Op	Peninsula Formation	Table Mountain Group	Quartzitic sandstones.
€c	Cape Peninsula Pluton	Cape Granite Suite	Coarse porphyritic, biotite rich granite.
--- *f* ---			Fault

The estate is underlain by scree from the mountain slope and the underlying Cape Peninsular Pluton granite. Towards the south (up slope) the quartzitic sandstones of the Table Mountain Group form Constantia Mountain, in which several faults (*f*) are clearly visible in aerial imagery. The faulting of the Table Mountain Group sandstones is what lends this formation into being such a high yielding fractured aquifer, however it is expecting that some of these faults and the associated fracturing, may extend into the underlying granites. The main target fault assessed in this study is visible from Donkerboskloof on the Klein Constantia side, across the Contantia Mountain, to the Bokkemanskloof, above the Oakwood Estate. This has been inferred to continue to the estate, by the large scale erosional weathering, left by the outflow from this fault, shown below.

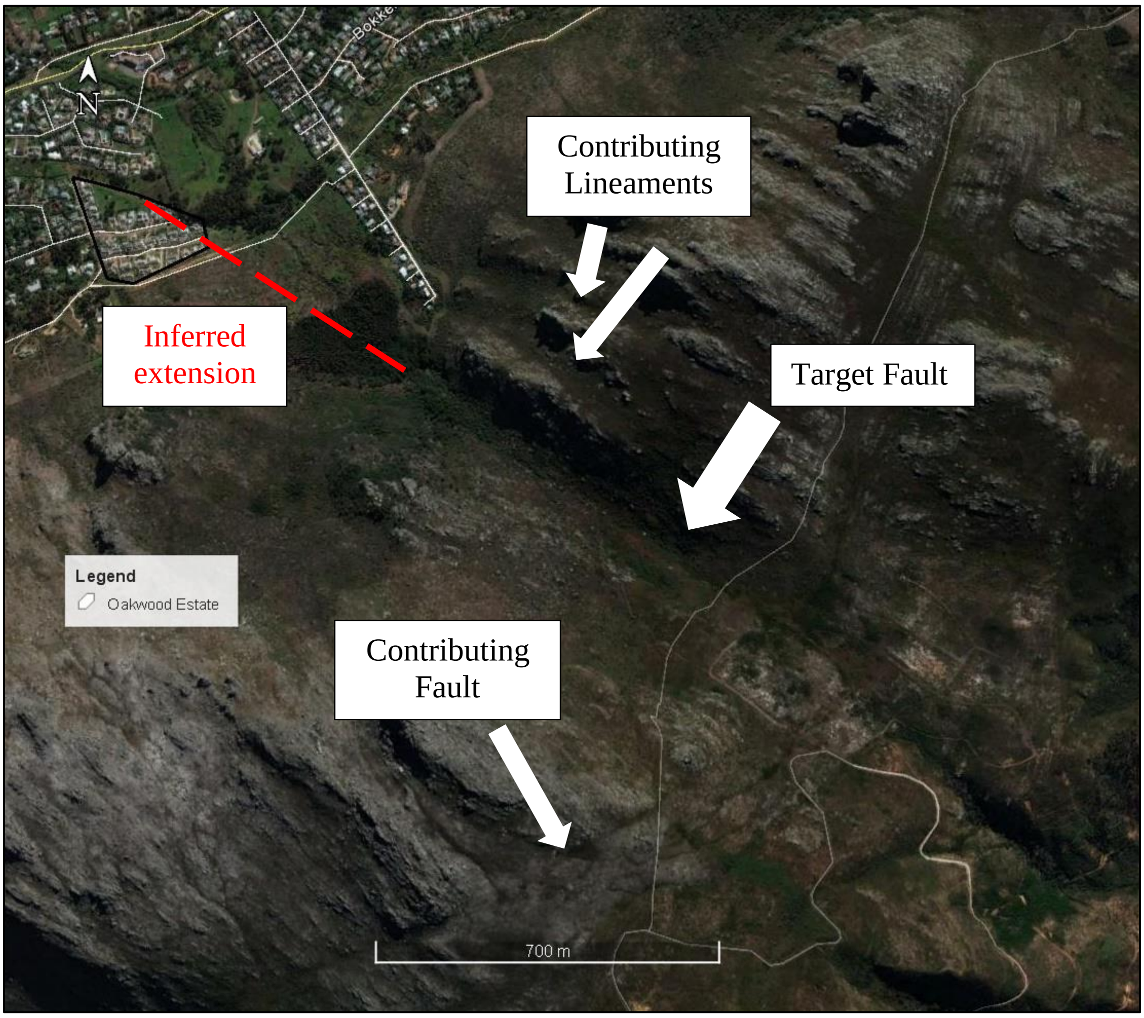

Figure 3: Target Fault and Surrounding Contributing Lineaments

The regional aquifer underlying the site is classified by the Department of Water Affairs and Forestry (DWAF, 2000) as an intergranular and fractured aquifer with an average yield potential of < 0.1 L/s (up to 360 L/hour) associated with the granite pluton. To the east, the aquifer is classified as 0.5 – 2 L/s (1800 – 7200 L/hour) which is associated with the quartzitic sandstones of the Table Mountain Group (**Figure 4**). This coarsely mapped and appears to show the estate within the incorrect aquifer.

The groundwater quality is classified as good with an associated electrical conductivity (EC) of up to 70 mS/m (DWAF, 2000) (**Figure 5**).

Both these classifications are based on regional (1:500 000) datasets, and therefore only provide an indication of conditions to be expected.

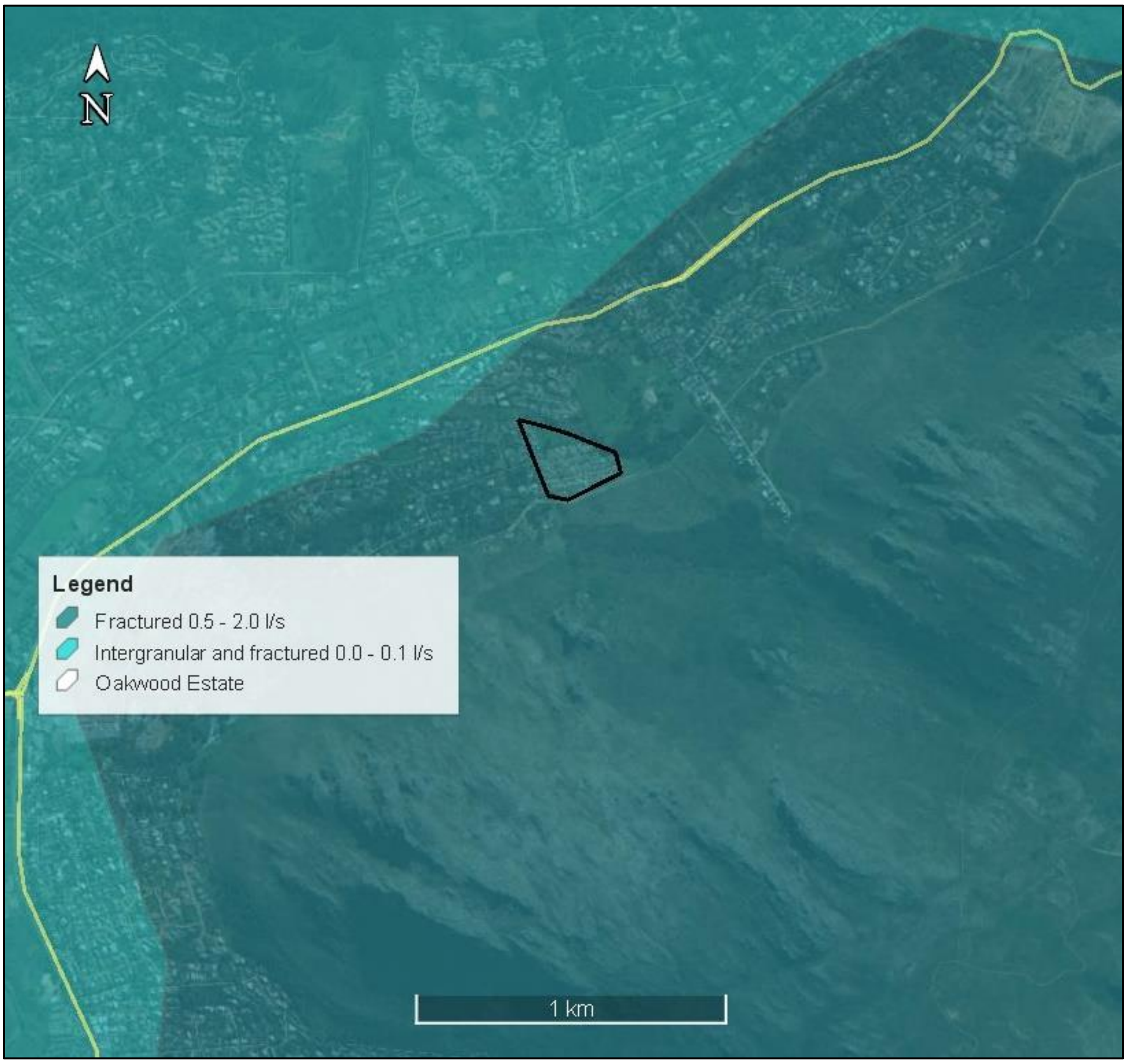

Figure 4: Aquifer Type and Yield within the Study Area (DWS, 2000)

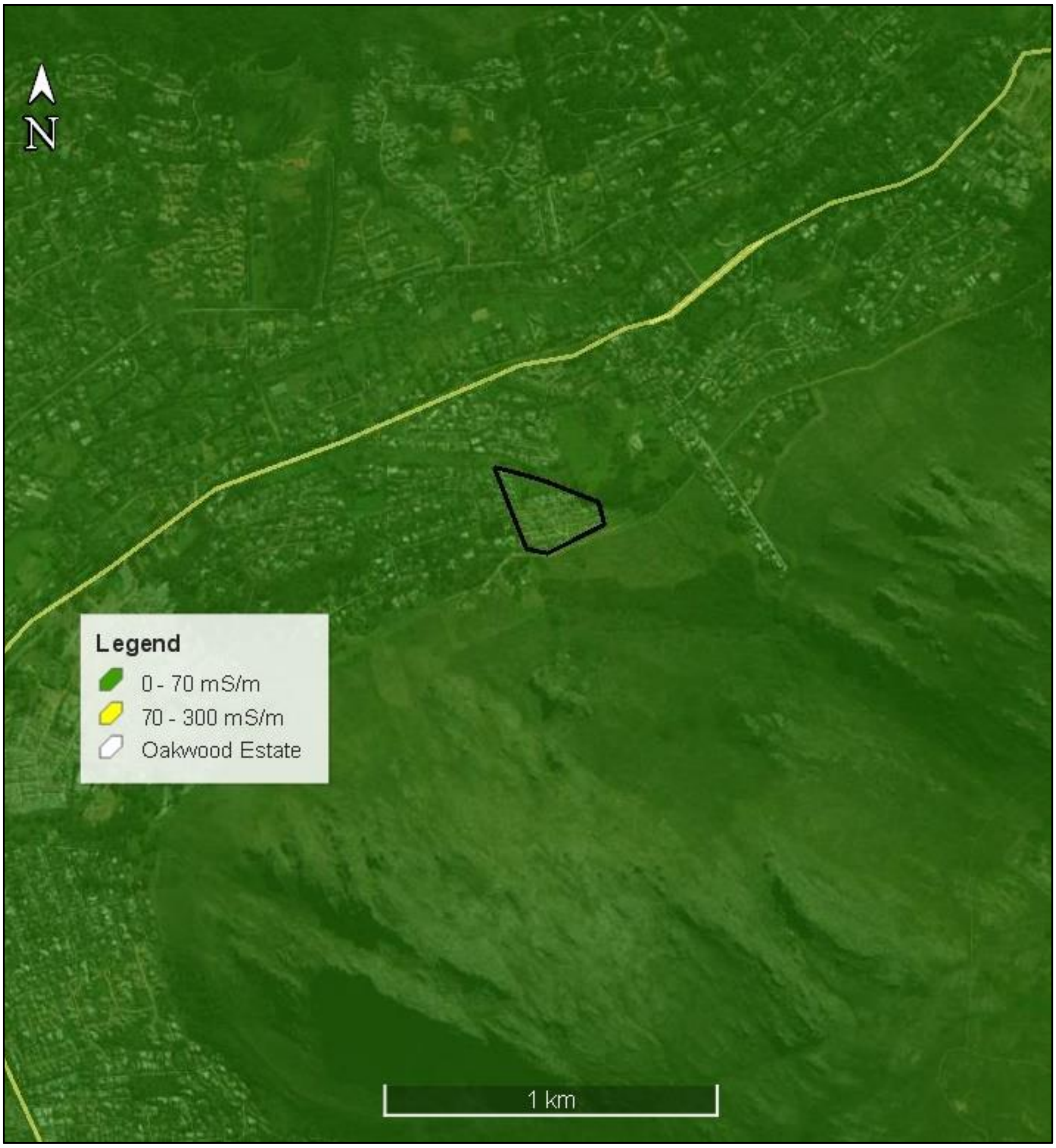

Figure 5: Groundwater Quality as indicated by Electrical Conductivity (DWS, 2000)

Prior to the field visit, information was obtained from the National Groundwater Archive (NGA). Data was obtained for a number of NGA sites within a 1 km radius of the study site. Only one site was located, which is indicated on the study area map in **Figure 6**. The information available is summarised in **Table 2**.

Table 2: Summary of NGA borehole details.

NGA ID	Latitude (WGS84, DD)	Longitude (WGS84, DD)	Depth	Geology	Yield (L/s)
3418AB0003	-34.01658	18.38152	35	Granite	0.4

3. SITE VISIT

A site visit was carried out on 10 November 2017 to conduct an onsite assessment of geological conditions, as well as to conduct a hydrocensus and geophysical survey. The survey was completed using the electrical electromagnetic method.

3.1 Hydrocensus

The results of the hydrocensus are listed in **Table 3** and shown in **Figure 6** along with the NGA site. The NGA site was not visible in the field, and is likely lost, or incorrectly captured data. The hydrocensus data indicates that there is groundwater in the area, which is very good quality.

Table 3: Hydrocensus of the Study Area

Site ID	Latitude (WGS84, DD)	Longitude (WGS84, DD)	Yield	Quality
Spring Flow	-34.024940	18.375473	"Trickle"	EC = 27.4 mS/m
HBh1	-34.020797	18.375796	10 000 L Overnight (float switch top up)	pH = 6.45 EC = 53 mS/m Alkalinity = 22.4 Iron <0.024 mg/L
HBh2	-34.020087	18.374849	"Garden Irrigation"	Unknown
HBh3	-34.020739	18.374452	"Garden Irrigation"	Unknown

Figure 6: NGA and Hydrocensus Sites

3.2 Geophysics

The resistivity method was used to locate lateral and vertical changes in electrical properties that may be related to changes in the formation properties of the subsurface. The data for the resistivity profile was acquired from west to east, along the River Walk pathway.

Resistivity is a non-invasive geophysical tool that can provide cost-effective solutions to geological questions. The bulk resistivity of different geological units varies mostly because of changes in water saturation or porosity and/or salinity of the pore fluid (Telford et al, 1990). The Lund imaging system is a completely automated resistivity tomography data acquisition system. The resistivity tomography method provides a pseudo-section of change in electrical properties in the subsurface along a specified line. Two multi-core cables with 16 electrode take-outs every 10 m were used. These cables were laid out in a straight line (as much as possible) on the ground end to end. An electrode (metal stake) is inserted into the ground next to every electrode take-out on the cable. The electrode take-out is then connected to the electrode with a short cable jumper. The multi core cables are connected to the ABEM electrode selector ES464 that controls the measurement sequence. The electrode selector is connected to the ABEM Terrameter SAS1000 that takes the apparent resistivity measurements. The data were collected using a standard protocol with the Wenner array. All data were acquired for n = 1 to 8 and 10, 12, 14, 16, 18 and 20 where "n" is the electrode separation multiplication factor. The apparent resistivity data acquired in the field were inverted using the RES2DINV software (Loke and Barker, 1996) to provide a true-depth resistivity section. The only pre-processing required is to erase obviously erratic data points. The resulting true resistivity pseudo-section is used for the interpretation. The inverted resistivity data profile is shown in **Figure 7**.

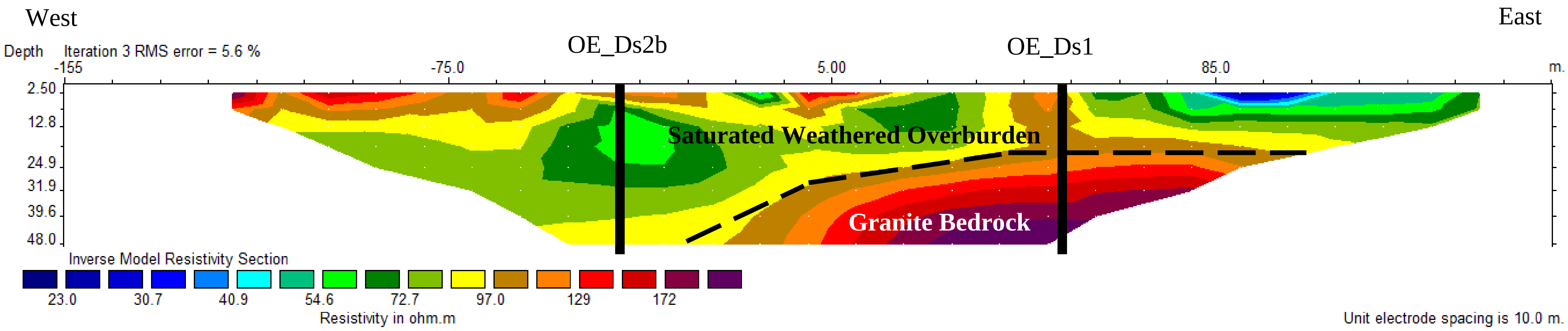

Figure 7: Inverted resistivity data profile with interpretation and the drilling targets.

The resistivity profile indicates that the fault is likely extending through the estate on the eastern side, approximately 30 m from the boundary. It is also shown that deeper weathering in the granitic bedrock is found in the central to western area of the property.

From this profile, borehole target locations have been identified, targeting a fault structure, as well as the deeper saturated overburden found to the west and north of the property. From these three targets, it is recommended that the sites be carefully assessed by the client in order to understand the risks and potential involved.

3.3 Borehole Siting

From the geophysical survey and a geological conceptualisation of the site, three drilling targets are provided, one being a 90 m borehole, the other two 60 m depths, due to the geological target conditions. Details for the drill site are summarised in **Table 5** and shown spatially in **Figure 8**, following.

Table 4: Details of drilling targets – Oakwood Estate.

Site ID	Latitude (WGS84, DD)	Longitude (WGS84, DD)	Drilling depth (approx.) (m)	Overburden (approx.) (m)
OE_Ds1	-34.023213	18.377506	90	25
OE_Ds2a	-34.022181	18.375579	60	45
OE_Ds2b	-34.023389	18.376594	60	45

OE_Ds1 and OE_Ds2a both target the same fault structure, however due to elevation differences and overburden depths, it is unlikely that OE_Ds2a will need to be drilled deeper than 60 m. It is also likely that OE_Ds2a may be higher yielding, due to overburden supplementation of the bedrock fracturing, as well as receiving more contribution from lineaments crossing the fault. OE_Ds2b is only targeting the deeper weathering, however due to its generally higher elevation, will also likely require drilling to 90 m.

The borehole should be installed by conducting Odex drilling with 203 mm steel casing through the overburden (**Table 5**), either with slotted casing or with provision for slotting the casing after installation. The borehole can then be drilled with a 165 mm diameter into bedrock, to be equipped with a 140 mm uPVC casing, screened (1 mm slots) at each water strike and a gravel pack installed in the annulus between the uPVC and the rock wall.

Should the drilling be successful, the borehole should be properly developed with compressed air from the bottom of the hole, from all water strikes, and especially at the slotted steel casing interval. It is recommended that a hydrogeologist be on site to help define the depth and design of the borehole. If successful, abstraction from the borehole will also need to be carefully managed to ensure sustainable use.

Figure 8: Geophysical profiles overlain on aerial imagery, showing drill targets.

4. RECOMMENDATIONS

The following recommendations are made for the drilling and development of the borehole for groundwater utilisation:

- The borehole can be drilled up to a maximum depth of about 90 m in the case of OE_Ds1 and 60 m for OE_Ds2a and OE_Ds2b. Should sufficient water be intersected before these depths, the drilling should continue for 10 m beyond the latest water strike. Should the formation be favourable, the drilling may continue beyond these depths.
- During the borehole drilling, geological samples must be collected for every 1 m drilled and the depth of fractures and water strikes noted. A hydrogeologist must then log the borehole details. Ideally a hydrogeologist should be on site when the borehole is drilled. When drilling a borehole, the main issue is "when is the borehole deep enough" and this issue is best addressed by a hydrogeologist.
- The borehole should be developed with compressed air for four hours upon completion of the borehole (if successful). Following this an airlift yield must be supplied by the driller. As sustainable yields are often between 20 – 50 % of the airlift yield (although both higher and lower sustainable yields are not uncommon), the decision to stop drilling should be carefully assessed between the driller, the client and the geohydrological consultant.
- The borehole, once drilled, should be tested to determine the sustainable groundwater yield available. This is to be done according to scientifically acceptable standards (as outlined by the SABS) and may form part of the groundwater use license application process. **Please note that non-SABS yield tests are not accepted by Department of Water and Sanitation (DWS) as part of a license application.**
- A sample of the groundwater should be submitted to an accredited laboratory for analysis to determine if the quality is suitable for its intended use.
- Licensing of the water use should be addressed upon successful completion of the borehole.

The borehole, if successful, should also be equipped with monitoring infrastructure:

- Installation of a 40 mm OD (class 10) observation pipe from the pump depth to the surface, closed at the bottom and slotted for the bottom 10 - 20 m. This enables manual or automated water level monitoring.
- Installation of a timer switch set to pump according to recommendations made from the yield test.
- Installation of a sampling tap.
- Installation of a flow volume meter.

5. REFERENCES

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6. APPENDIX A – DRILLING SPECIFICATIONS

Borehole Specifications	**Drill**
Bhole ID	OE_Ds2a
Elevation (mamls)	
Borehole Type (production/monitoring/windpump)	Production
Sand / Rock Borehole?	Scree (0 - 45 m) and Rock (45 m - EOH)
BOREHOLE:	
Borehole diameter (mm) / (inches)	219 mm and 165 mm
Casing diameter (OD - mm) / (inches)	203 mm (Steel - slotted for 3 m above bedrock)
Screen diameter (OD - mm) / (inches)	140 mm (uPVC)
Casing interval (from-to in metres)	0 - 45 m
Screen interval (from-to in metres)	0 - 60 m
Gravel pack (Y/N)	Y
Gravel pack size (in mm)	7/16
Approximate borehole yield (litres/s)	1.0
Approximate borehole water level (m)	5
Length of development time (hours)	4 hrs
Geological description:	Granite
ODEX / Normal drilling?	ODEX in overburden, air percussion in bedrock
To bottom of Borehole diameter (mm) / (inches)	165 mm
Borehole depth (m)	60 m
Drilling mud required?	Optional - method dependent

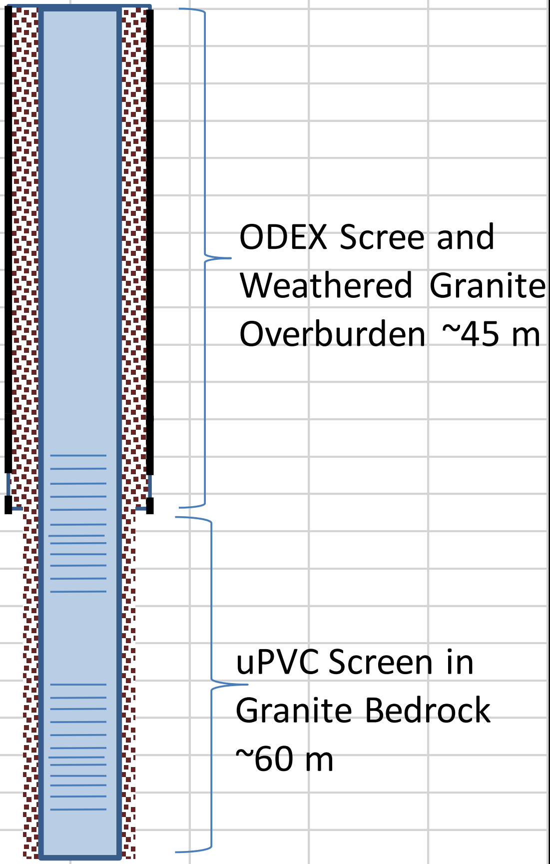

Figure 9: OE_Ds2a Drilling Specifications

Borehole Specifications	Drill
Bhole ID	OE_Ds1
Elevation (mamls)	
Borehole Type (production/monitoring/windpump)	Production
Sand / Rock Borehole?	Scree (0 - 25 m) and Rock (25 m - EOH)
BOREHOLE:	
Borehole diameter (mm) / (inches)	219 mm and 165 mm
Casing diameter (OD - mm) / (inches)	203 mm (Steel - slotted for 3 m above bedrock)
Screen diameter (OD - mm) / (inches)	140 mm (uPVC)
Casing interval (from-to in metres)	0 - 25 m
Screen interval (from-to in metres)	0 - 90 m
Centralizers (Y/N)	Y
Gravel pack (Y/N)	Y
Gravel pack size (in mm)	7/16
Approximate borehole yield (litres/s)	0.5 - 1
Approximate borehole water level (m)	5
Length of development time (hours)	4 hrs
Geological description:	Granite
ODEX / Normal drilling?	ODEX in overburden, air percussion in bedrock
To bottom of Borehole diameter (mm) / (inches)	165 mm
Borehole depth (m)	90 m
Drilling mud required?	Optional - method dependent

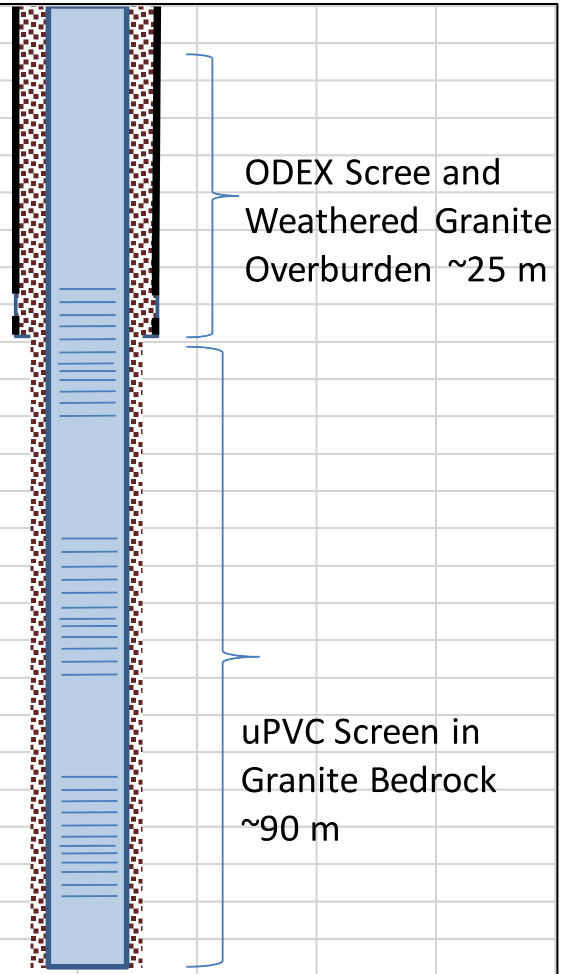

Figure 10: OE_Ds1 Drilling Specifications