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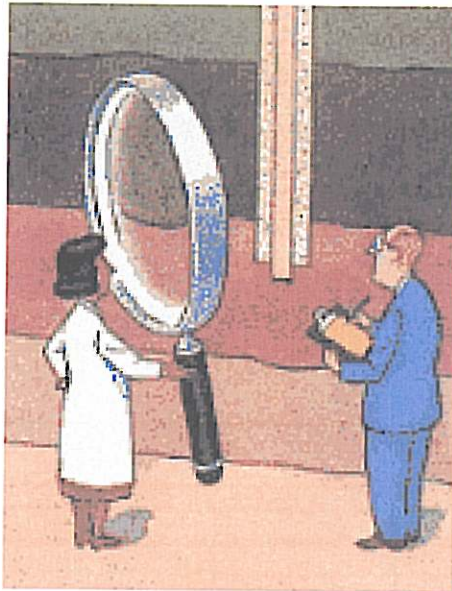
water & forestry

Department:
Water Affairs & Forestry
REPUBLIC OF SOUTH AFRICA

OUTENIQUA WATER SITUATION ASSESSMENT STUDY:

MOSSEL BAY GROUNDWATER EXPLORATION

PHASE 1: SITE SELECTION AND DRILLING RESULTS



Conducted by

THE DIRECTORATE: WATER RESOURCE PLANNING SYSTEMS

SUB-DIRECTORATE: INTEGRATED HYDROLOGICAL PLANNING

On behalf of

MOSSEL BAY MUNICIPALITY

Author: Dr FS Botha and Mrs S Veltman

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1 INTRODUCTION

The Outeniqua Coast Water Situation Study (OCWSS), commissioned by the Department of Water Affairs and Forestry, was done to address a shortfall in yield in the general area between Stilbaai and Noetzie. Various groundwater exploration targets were identified by Parsons and Associates Specialist Groundwater Consultants cc, as possible options to pursue further groundwater resource development.

It was concluded that groundwater resources can play a meaningful role in addressing many of the water supply challenges, especially peak demands. To determine the extent of groundwater resources in the area, Parsons & Veltman (2006) also recommended a comprehensive groundwater assessment for the whole area.

1.1 Project background

As part of the OCWSS the Mossel Bay Municipal area was one of the six priority areas and the Municipality approached the Department to assist them in exploring newly identified groundwater targets.

The Municipality requested specialist hydrogeological support and they will be responsible for funding exploration boreholes. The Directorate Water Resource Planning Systems (WRPS) made two specialists available to identify possible drilling sites and assist the Municipality during the drilling programme. Geophysical surveys were performed by the Council for Geosciences

1.2 Methodology

After discussion with the Municipality and Regional DWAF personnel it was decided to view this investigation as a first step to a comprehensive groundwater assessment. The methodology agreed on included the following:

- Desk top assessment of possible target areas
- On-site verification of access and geological conditions
- Ground geophysical assessment at identified positions
 - Resistivity, Magnetic and Electro-magnetic(EM34) methods
- Drilling supervision
- Report writing

As a result this report focuses on the geophysical and hydrogeological identification of exploration boreholes, and also report on initial drilling results.

1.3 Locality

The exploration target areas included the *De Hoek Fault* in the general area between Vleesbaai and Danabaai, as well as the *Vleesbaai Fault* in the vicinity of Vleesbaai. The Mossel Bay municipality also requested assistance in providing water to a small community situated at *Kleinberg*. All the target areas are located in quaternary catchment K10A on the 1:50 000 topocadastral maps 3421BB, 3421BD and 3422AA (Figure 1).

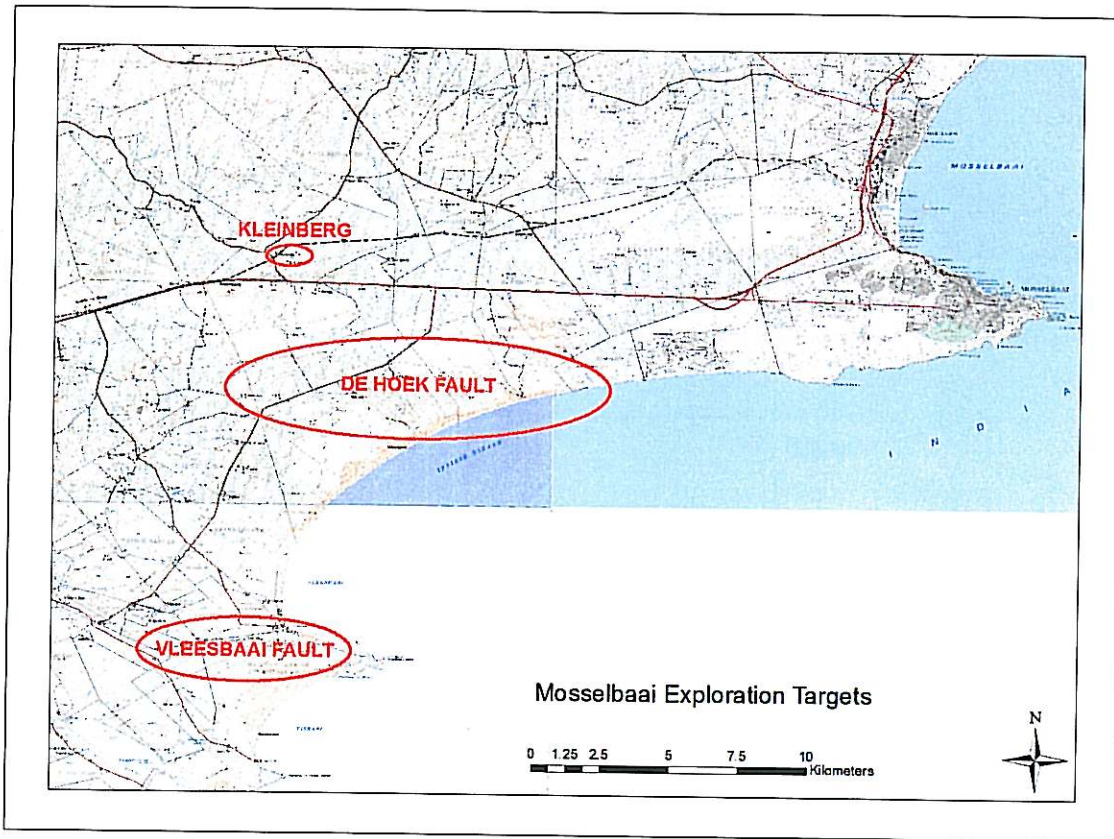


Figure 1: Location of the three exploration target areas

2 GENERAL GEOLOGY

The Table Mountain and Bokkeveld Groups of the Cape Supergroup are found in the study area. These rocks were deposited between 500 and 340 Ma ago in the Agulhas Sea and underwent deformation during the Cape Orogeny some 280 to 220 Ma ago, and during the breakup of Gondwana 170 to 130 Ma ago (Parsons & Veltman, 2006).

The geological sequences relevant to this investigation are described briefly in the following sections and illustrated in Figure 2, Figure 3 and Figure 4.

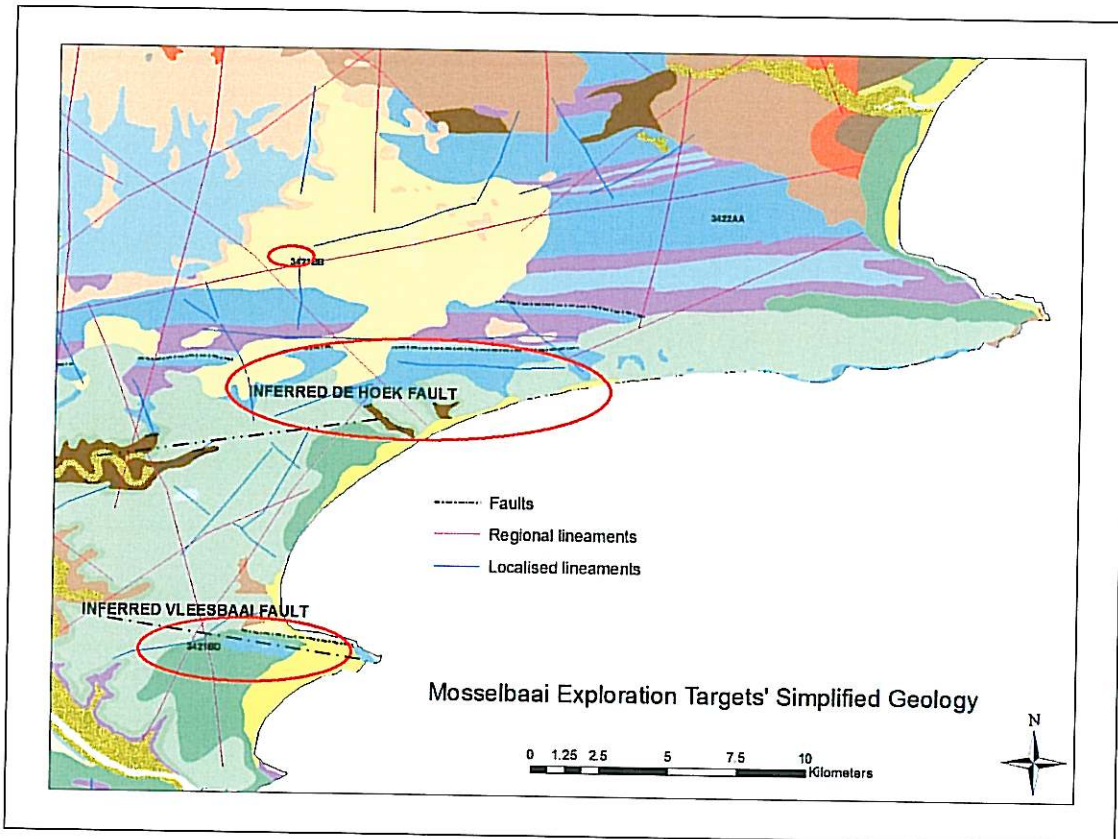


Figure 2: Simplified geology of Mossel Bay exploration targets

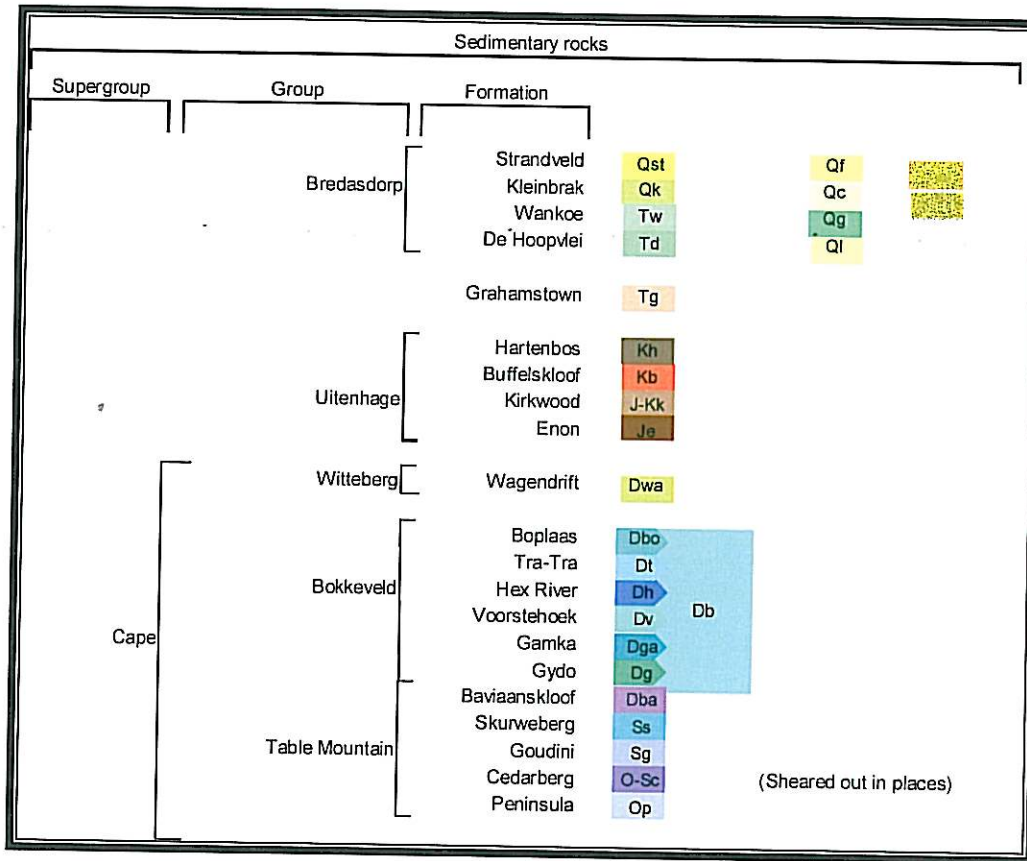


Figure 3: Geological map legend

| ERA | PERIOD | AGE (Ma) | SUPER GROUP | GROUP | SUB GROUP | FORMATION | LITHOLOGY | AQUIFER |
|------------|--------|----------|-------------|----------------|------------------|---|------------------------------|------------------|
| Cenozoic | Q | 0 | Cape | Quaternary | | | semi to unconsolidated sands | Bredasdorp |
| | | | | Bredasdorp | Strandveld | dune sand | | |
| | | | | | Waenhuiskraal | calcified dune sand | | |
| | | | | | Klein Brak | shelly sand, pebbles | | |
| | | | | | Wankoe | calcaranites, aeolian sandstone, calcrete | | |
| | | | | | De Hoopvlei | shelly limestone, calcaranites, conglomerates | | |
| Mesozoic | Ct | 65-120 | Cape | Unconformity | | | Uitenhage | |
| | | | | Grahamstown | Grahamstown | silcrete, ferricrete | | |
| | | | | Uitenhage | Hartenbos | silt and mudstones | | |
| | | | | | Buffelskloof | conglomerate, sandstone | | |
| | | | | | Kirkwood | sand, silt and mudstone | | |
| | | | | | Enon | conglomerate, sandstone | | |
| Palaeozoic | Cape | 140-500 | Cape | Unconformity | | | Bokkeveld | |
| | | | | Witteberg | Wagendrift | shale, quartzite | | |
| | | | | Bokkeveld | Ceres | alternating shale and sandstone | | |
| | | | | | | Baviaanskloof | | shale, sandstone |
| | | | | Table Mountain | Kouga | sandstone | | |
| | | | | | Goudini | sandstone | | |
| | | | | | Cedarberg | shale | | |
| | | | | | Peninsula | quartzite, sandstone | | |
| | | | | Cape Granite | George pluton | granite and gneissic granite | | Cape Granite |
| | | | | | Woodville pluton | biotite-rich granite | | |

Figure 4: Geological sequence of the study area (Parsons & Veltman, 2006)

2.1.1 Table Mountain Group

The Table Mountain Group was deposited directly on granites of the Cape Granite Suite. The Group comprises 5 principal units in the southern and eastern Cape, namely the Peninsula, Cedarberg, Goudini, Skurweberg and Baviaanskloof Formations. Rocks of the Table Mountain Group are competent and resistant to weathering. Because of this, they form the Langeberg and Outeniqua mountains in the northern parts of the study area. Limited outcrop occurs between Albertinia and Mossel Bay (Parsons & Veltman, 2006).

2.1.2 Bokkeveld Group

The Bokkeveld Group comprises the basal Ceres Subgroup and the Tarka Subgroup. Only the Ceres Subgroup outcrops in the study area. The Bokkeveld Group is more easily eroded than the underlying Table Mountain Group, and consequently forms valleys rather than mountains. Shales and mudstones of the Bokkeveld Group underlie much of the area between the N2 national road and the Langeberg Mountains between Riversdal and Mossel Bay (Parsons & Veltman, 2006).

2.1.3 Uitenhage Group

The Uitenhage Group comprises the Enon, Kirkwood, Buffelskloof and Hartenbos Formations, with the Enon Formation being dominant in the study area. This formation was deposited in high energy environments directly adjacent to major faults that formed between 140 and 120 Ma ago. Consequently, the Enon Formation comprises conglomerates (predominantly Table Mountain or Bokkeveld Group clasts in a sandy matrix) and coarse-grained sandstones. Outcrops are limited to those parts of the study between Riversdal and Mossel Bay directly south of the Langeberg Mountains (Parsons & Veltman, 2006).

2.1.4 Grahamstown Formation

The Grahamstown Formation comprises silcretes and ferricretes; and scattered outcrops are found north of the N2 national road between Riversdal and Mossel Bay. The formation occurs at an elevation of between 210 – 240 m and is only about 8 m thick. Because of its limited thickness, this formation is not considered an aquifer. However, its hard, impervious character may influence recharge on a local scale (Parsons & Veltman, 2006).

2.1.5 Bredasdorp Group

The Bredasdorp Group comprises of sediments that were generally deposited on wave-cut platforms under marine transgression and regression conditions and outcrops on the coastal plains west of Mossel Bay. The group comprises the basal De Hoopvlei Formation and the Wankoe, Klein Brak and Strandveld Formations (Parsons & Veltman, 2006).

The Wankoe Formation comprises calcarenite with aeolian cross-bedding and calcrete lenses. Extensive outcrops are found on the coastal plains west of Mossel Bay. In place, this unit is capped by a calcrete cover or covered by light grey to pale red sandy soil (Parsons & Veltman, 2006).

2.1.6 Quaternary Deposits

A variety of younger deposits (sand) are found in river valleys and on the coastal plains west of Mossel Bay. During the last 10 000 years, climatic changes and sea level movements gave rise to dune fields along the coast. Most of these deposits are unconsolidated, but may be

semi-consolidated in places. Because little is known about the thickness of these deposits, they have been grouped with the Bredasdorp Group as the Bredasdorp Group aquifer. (Parsons & Veltman, 2006)

2.2 Aquifers types

An extensive layer of sediments of the Bredasdorp Group covers much of the area. As a result aquifers within the area are not well known. It is however known that aquifers from the Table Mountain Group (TMG), Bokkeveld, Uitenhage and Bredasdorp Group are all present in the area and major aquifer types identified are described in more detail in the following sections and illustrated in Figure 5 (Parsons & Veltman, 2006).

The Grahamstown Formation was not considered as an aquifer because of its limited thickness and extent (Parsons & Veltman, 2006).

2.2.1 Table Mountain Group Aquifers

A narrow sheet-like outcrop of TMG lies west of Mossel Bay. Aquifers comprising of fractured and faulted rocks of the TMG are recognised as major aquifer systems capable of yielding large quantities of good quality groundwater. The TMG tends to produce high yielding boreholes with almost 25% of the boreholes yielding more than 5 l/s.

Groundwater quality is generally good, ranging between 10 and 100 mS/m. However, high iron and manganese concentrations are recorded in places and iron bacteria can cause clogging of borehole equipment. The rough terrain and hard, brittle rock can make these aquifers difficult to exploit and develop (Parsons & Veltman, 2006).

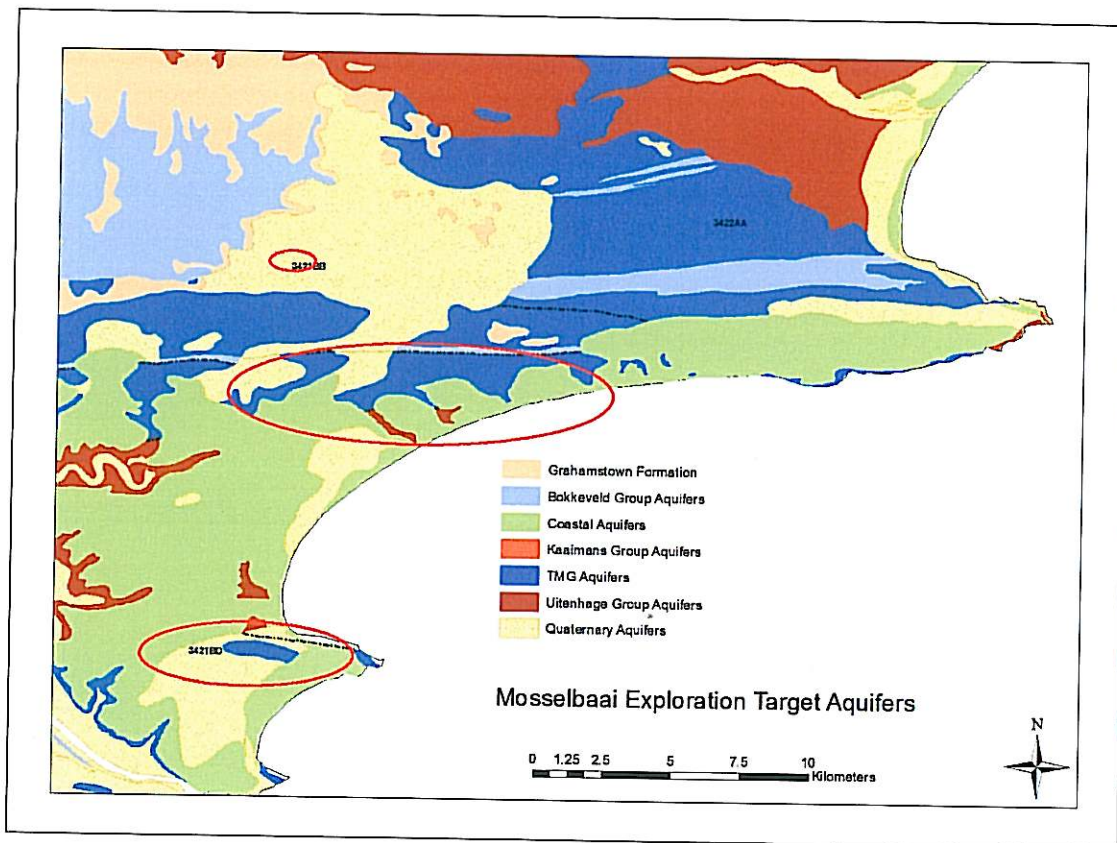


Figure 5: Aquifers present at the exploration targets

2.2.2 Bokkeveld Group Aquifers

As shown in Figure 5 the Bokkeveld Group is prominent north of the N2 highway. The Bokkeveld Group consists of both sandstone-poor and sandstone-rich formations, with boreholes in the sandstone-rich formations, Ceres Subgroup, often yielding more than 5 l/s. Bokkeveld Group aquifers are classified as minor aquifer types and can be developed for local water supply purposes (Parsons & Veltman, 2006).

Groundwater quality ranges between 30 and 400 mS/m in the sandstone-rich formations, with the electrical conductivity usually above 400 mS/m in the shale-rich horizons. From time to time these aquifers are found to form integrated aquifer system with TMG aquifers and as a result may yield large quantities of good quality groundwater (Parsons & Veltman, 2006).

2.2.3 Uitenhage Group Aquifers

The Uitenhage Group outcrops west of Mossel Bay. The Group consists of layers of sandstone, conglomerate, breccia, mudstone, siltstone and tuff, and tends to produce boreholes that yield less than 1 l/s. Uitenhage Group aquifers are either classified as minor or poor aquifer systems and may provide sufficient groundwater for local-scale use (Parsons & Veltman, 2006).

EC values usually exceed 300 mS/m and some elements exceed maximum recommended limits for drinking water. Moderate quality groundwater is yielded from the Enon Formation, but drilling into these conglomerates is technically difficult because of continual collapse during drilling (Parsons & Veltman, 2006).

2.2.4 Bredasdorp Group Aquifers

The Bredasdorp Group outcrops mostly south of the N2 highway. The Group consists of five relatively thin coarse-grained formations, ranging from calcarenite, conglomerate, sandstone and calcareous sand overlying the Bokkeveld Group. Groundwater flow occurs as the contact of the basal De Hoop Conglomerates and the underlying impervious Bokkeveld Group. It has good groundwater potential with almost 20% of the boreholes yielding more than 5 l/s and of the 63 springs identified in the area, more than 10% yield more than 15 l/s. In places these aquifers can be developed to yield large quantities of water.

Little information is available regarding alluvial aquifers in the study area, but they may be important local sources of groundwater (Parsons & Veltman, 2006).

The electrical conductivity of the groundwater seldom exceeds 100 mS/m. Bredasdorp Group aquifers are classified as either major or minor aquifer systems (Parsons & Veltman, 2006).

3 RESULTS

Based on the existing hydrogeology, and requirements from the Municipality several exploration sites were identified and include the following:

- Kleinberg (Request by the Municipality)
- De Hoek Fault
- Vleesbaai
- Nautilus Bay Fault

Results from the investigation are reported per exploration site. A detailed geophysical report is in Appendix 1 and a detailed drilling report in Appendix 2.

3.1 Kleinberg

The Kleinberg community is situated 20 km west of Mossel Bay next to the Kleinberg railway station (Figure 7). The Mossel Bay Municipality has to cart water to the community and is therefore opting for on-site water supply. As a result the site was identified as a priority area by the Municipality.

3.1.1 Exploration Targets

The Kleinberg community is underlain by Grahamstown Formation silcrete and covered by sandy loam soil (Raath, 2007). The exploration target identified at the Kleinberg community was the contact between a thin layer (10 – 20 m thick) of the Grahamstown Formation overlying the Bokkeveld Group. The contact might yield some water for small scale water supply (Figure 6).

It is suspected that the Bokkeveld Group was subjected to huge stress at the time of folding, and thrust faulting might occurred on the sedimentary planes of the Bokkeveld, between the Bokkeveld and the TMG (Figure 6). If correct the fault planes might be moderately permeable and targeted as a second group of deep seated exploration targets.

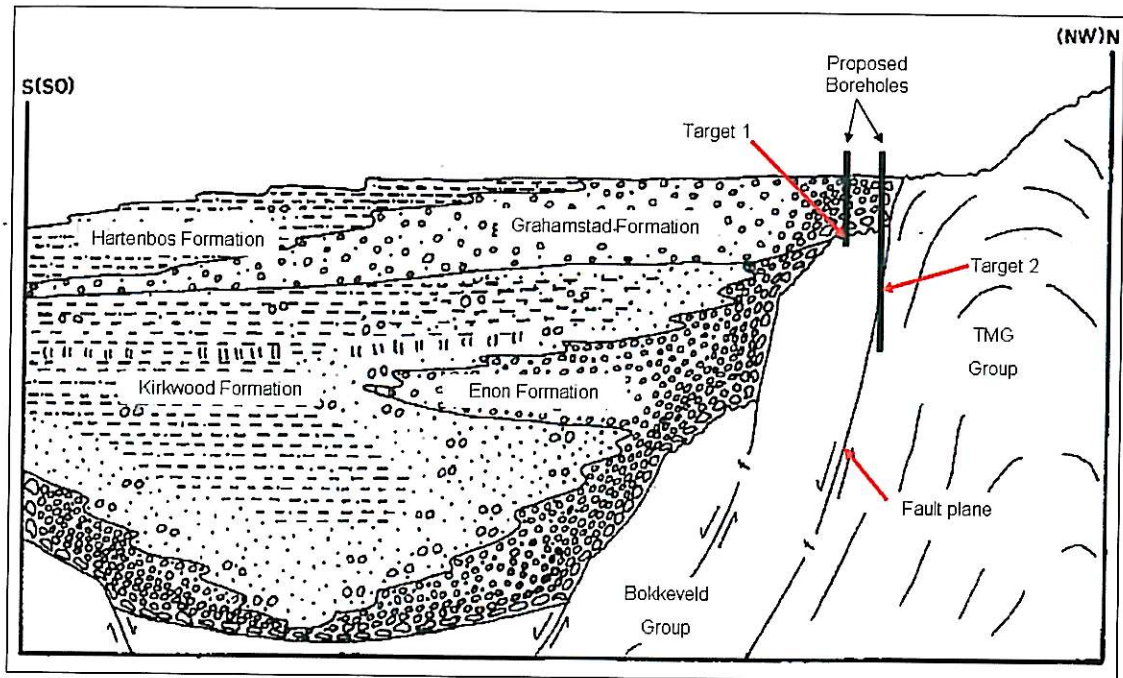


Figure 6: A schematic cross-section of the geology in the Herbertsdale/Mossel Bay area, showing identified targets at Kleinberg (after Viljoen and Malan, 1993).

3.1.2 Geophysical survey

The community is situated next to a railway line and the only open space to do a geophysical survey was in the road leading to and between the houses, next to a fence. Therefore the multi-electrode resistivity (CVES) profile was done (Figure 7) and the results are displayed in Figure 8. The proposed exploration targets were sited at station 125, 170 and 220.

- T1 - interpreted as deep weathering (Raath, 2007)
- T2 - Highly resistant part of the profile, due to the possibility of Skurweberg Formation sandstone present below the Grahamstown Formation.
- Fault Plane (T3) - Most resistant part of the profile, also due to the possibility of Skurweberg Formation Sandstone present below the Grahamstown Formation.

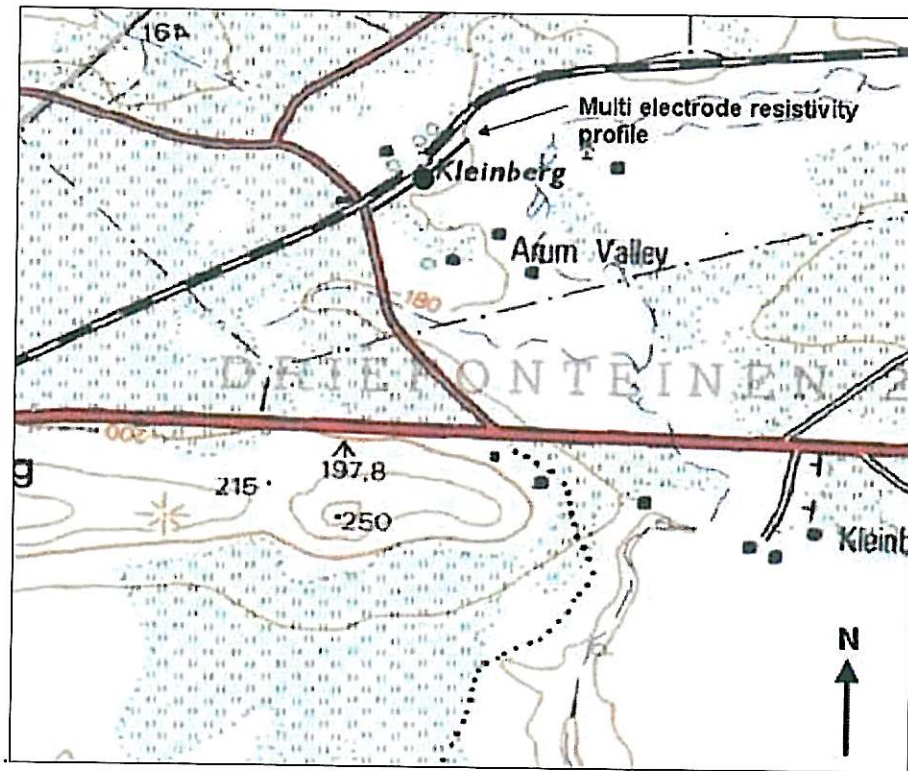


Figure 7: Topo sheet showing position of geophysical profile at Kleinberg (map to scale)

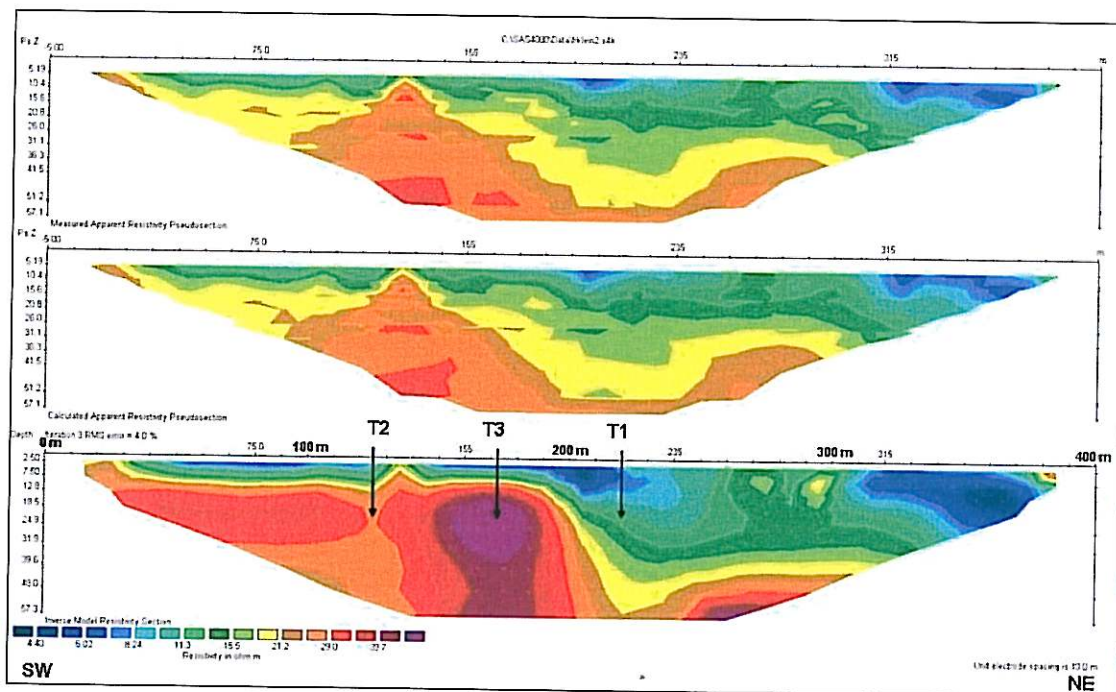


Figure 8: Resistivity profile at Kleinberg and proposed drilling sites marked T1, T2 and T3

3.1.3 Drilling

All three targets were drilled at Kleinberg and results are shown in Table 1.

Table 1 Drilling results at Kleinberg community

| Regional Borehole nr. | Village Name | Latitude Deg | Longitude Deg | Altitude (masl) | Depth (m) | Yield info | | Geology | Boreholes use |
|-----------------------|--------------|--------------|---------------|-----------------|-----------|----------------|-----------|----------|---------------|
| | | | | | | Air lift (l/s) | Test bore | | |
| GZ353 ✓ | Kleinberg | -34.169136 | 21.909270 | 180 | 91.00 | 0.00 | No | Bk | Exploration |
| GZ354 ✓ | Kleinberg | -34.169732 | 21.908533 | 175 | 60.00 | 0.00 | No | Bk | Exploration |
| GZ360 ✓ | Kleinberg | -34.169214 | 21.909171 | 179 | 117.00 | 0.00 | No | Bk | Incomplete |
| GZ361 ✓ | Kleinberg | -34.169400 | 21.908948 | 177 | 240.00 | 0.50 | Yes | Bk/ Frac | Testing |

Bk- Bokkeveld shale; S - Standveld sand; Frac - Fractured quartzite; Ss - Quartzitic sandstone from Skurweberg Group Formation; En - soft mudstone and unconsolidate material from the Enon Formation

- GZ353 - The first borehole was successful (T1), but did not show a significant water strike
- GZ354 - The second borehole was not successful and was terminated at 61 m. It did not encounter the Skurweberg Formation (T2) and did not show a significant water strike
- GZ360 - The contractor started the third borehole at the wrong position and it was terminated at 117 m. It showed the same result as GZ353
- GZ360 – The fourth borehole was successful (T3) and was terminated at 240 m. At 167 m fractured quartzite was encountered (suspected fault plane) and a blow yield of 0.5 l/s was estimated.

3.2 De Hoek Fault

The De Hoek Fault was targeted on the farm Klipfontein, approximately 7 km north of the Vleesbaai community. It is accessible on the Springerbaai nature estate. It can be developed as a water source for either Vleesbaai or Danabaaai.

3.2.1 Exploration targets

The De Hoek Fault is covered by calcified dune sand and sand of the Bredasdorp Group, which is underlain by Uitenhage Group conglomerate and Skurweberg Formation quartzitic sandstone (Raath, 2007). The sandstone is possibly overlain by the Enon Formation, which consists of the weathering fault breccia. It was expected that fault breccia typically consists of angular fragments of shattered TMG or Bokkeveld Group rocks in a sandy silt material. The fault breccia was targeted as the first exploration target (T1). The resulting fault surfaces from the De Hoek Fault in the Skurweberg Formation were also identified as an exploration target (T2).

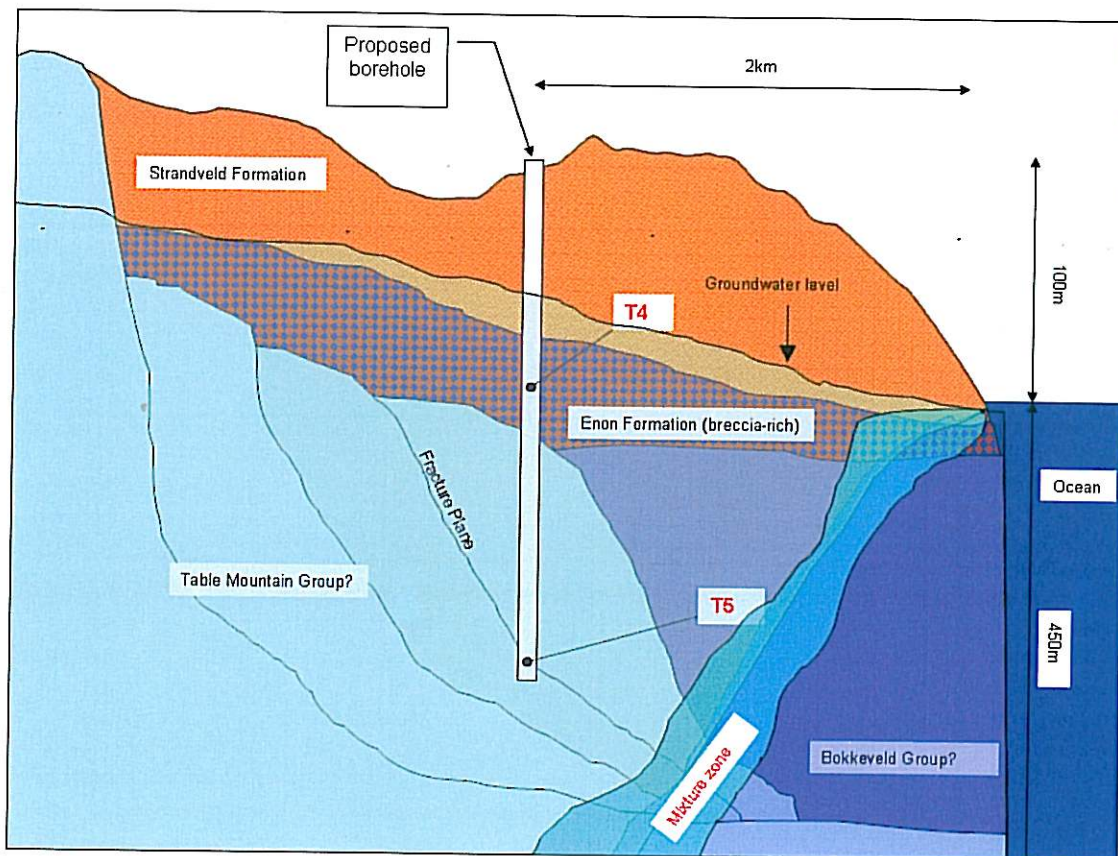


Figure 9: Schematic cross-section at Springerbaai showing breccia-rich Enon Formation (T4) and fracture planes in the TMG (T5), and proposed borehole.

3.2.2 Geophysical survey

Three traverses were conducted (Figure 10) and both electromagnetic (EM) and magnetic measurements were taken. Traverse 5 showed a step in the EM data between stations 100 and 200 and magnetic data also show a minor step. This was interpreted as the most favourable position to intersect both exploration targets. One borehole position (T4) was sited at station 120 (Raath, 2007).

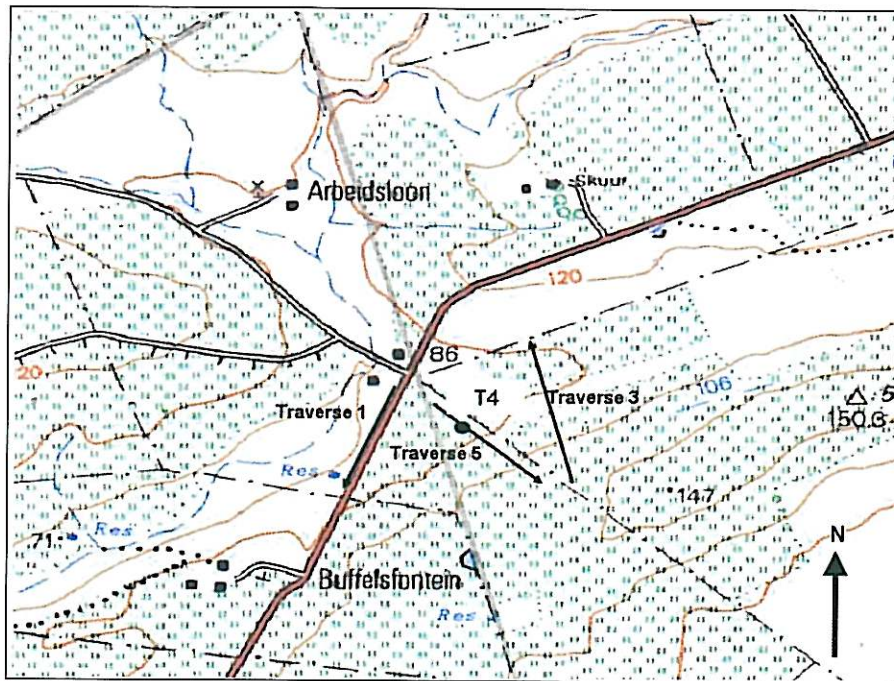


Figure 10: Locality map, geophysical traverses and exploration target T4 on the farm Klipfontein (map not to scale)

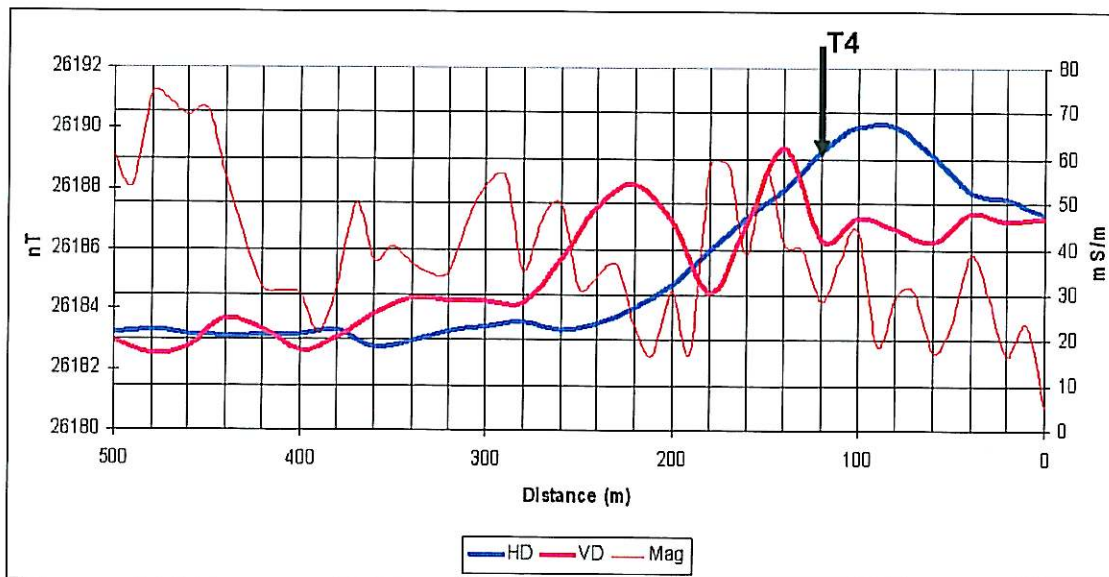


Figure 11: Geophysical profile results from Traverse 5 (magnetic and EM-34)

3.2.3 Drilling results

One borehole was drilled at Klipfontein and results are shown in Table 2.

Table 2 Drilling results at Klipfontein

| Regional Borehole nr. | Village Name | Latitude Deg | Longitude Deg | Altitude (masl) | Depth (m) | Yield info | | Geology | Boreholes use |
|-----------------------|--------------|--------------|---------------|-----------------|-----------|----------------|-----------|---------|---------------|
| | | | | | | Air lift (l/s) | Test bore | | |
| GZ355 ✓ | Springerbaai | 34.224488 | 21.905996 | 120 | 204.00 | 2.50 | Yes | S/ Ss | Testing |

GZ355 - The borehole was successful and intersected both the breccia-rich Enon Formation (T4) and fracture planes within the Skurweberg Group (T5). Significant water strikes were recorded at 120, 133, 153 and 164 m. The water strikes made the borehole side wall unstable and the drilling was stopped at 204 m.

3.3 Vleesbaai Fault

The Vleesbaai Fault was targeted on the farm Vleesch Baai 256, 3 km west of the Vleesbaai community. Previous boreholes drilled on the fault for water supply were situated much closer to the sea and due to poor management the water quality deteriorated and cannot be used for domestic water supply.

3.3.1 Exploration targets

At the target area the Vleesbaai Fault is covered by calcified dune sand of the Bredasdorp group (Raath, 2007). The target is similar to the target described at the De Hoek Fault aquifer site and the primary aquifer targeted in the Vleesbaai Fault is the Skurweberg formation of the TMG. This fault may also have remnants of the Enon formation in the fault. On of the farmers, Mr Ricky Van Rensberg (pers. comm., 2007), mentioned that researched done in the area indicated the Enon deposits to be as deep as 600 m and the need to be taken into account considered during the drilling programme.

3.3.2 Geophysical survey

As is shown in Figure 12 traverse 2 was conducted from south to north perpendicular to the expected position of the Vleesbaai fault and across another lineament identified from satellite imagery (Raath, 2007).

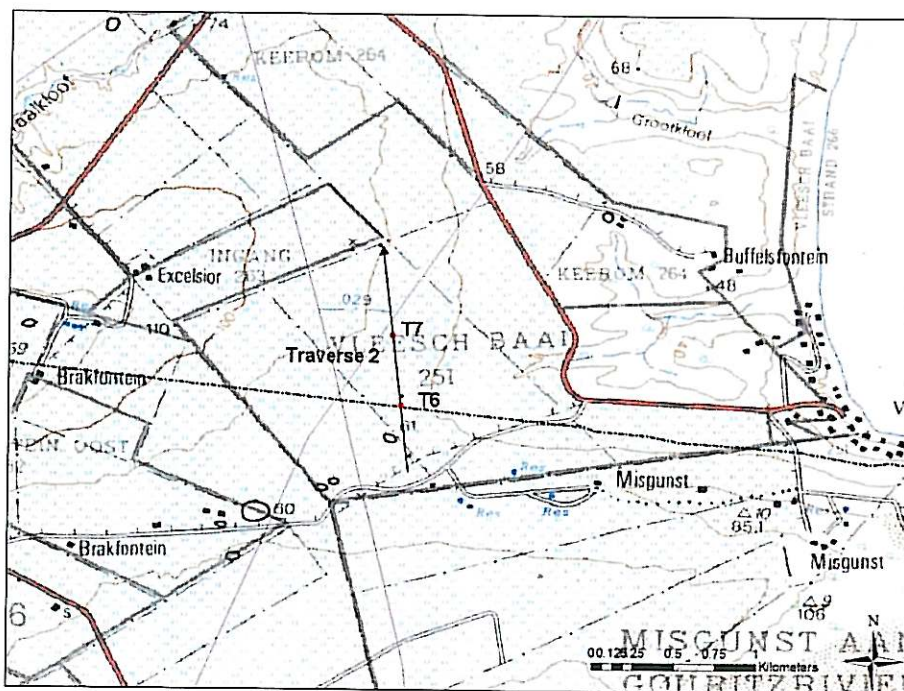


Figure 12: Locality map and geophysical traverse on the farm Vleeschbaai

The EM-34 profile, Figure 13, is dominated by the large positive anomaly from station 20 to 260. A possible borehole position (T6) was sited on the edge of the horizontal dipole high at

station 260. There is no distinct anomaly on the magnetic data that can be associated with the fault. A second possible borehole position (T7) was sited at station 600 where there is a step of approximately 40 mS/m in the horizontal and vertical dipole EM 34 data (Raath, 2007).

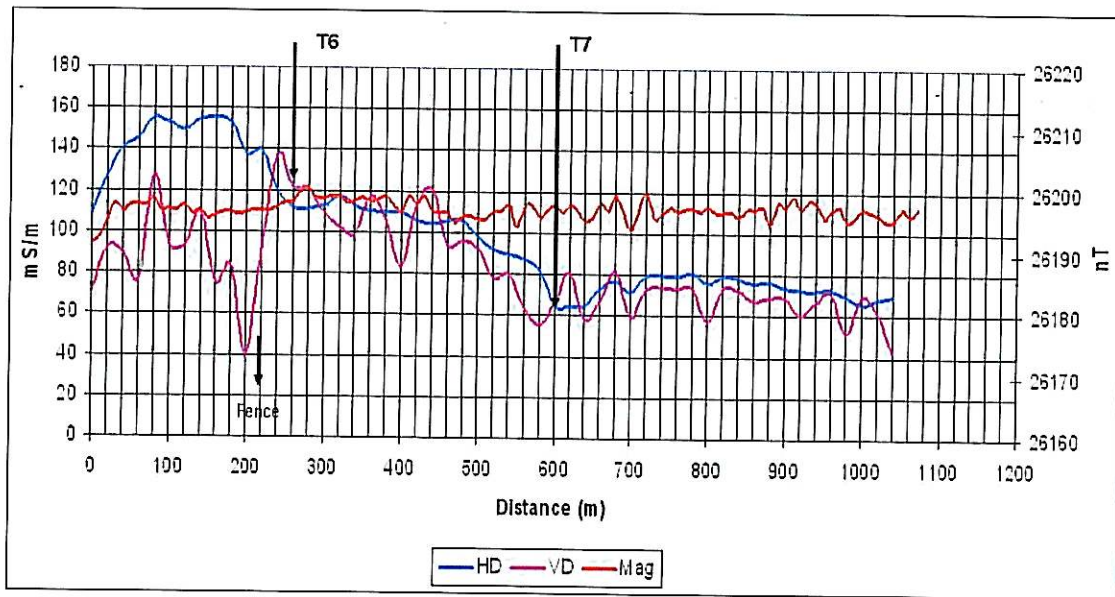


Figure 13: Geophysical profile of the magnetic and EM data on the farm Vleeschbaai

3.3.3 Drilling results

Both targets were drilled and results are shown in Table 3.

Table 3 Drilling results at Vleeschbaai

| Regional Borehole nr. | Village Name | Latitude Deg | Longitude Deg | Altitude (masl) | Depth (m) | Yield info | | Geology | Boreholes use |
|-----------------------|--------------|--------------|---------------|-----------------|-----------|----------------|-----------|---------|---------------|
| | | | | | | Air lift (l/s) | Test bore | | |
| GZ357 ✓ | Vleeschbaai | -34.290147 | 21.888938 | 80 | 151.00 | 28.00 | Yes | En/ Ss | Testing |
| GZ358 ✓ | Vleeschbaai | -34.285731 | 21.888468 | 90 | 223.00 | 3.40 | Yes | En | Testing |

GZ357 - The borehole was successful and intersected both the breccia-rich Enon Formation and fracture planes within the Skurweberg Group. Significant water strikes were recorded at 125, 131, 142 and 147 m. The water strikes made the borehole side wall unstable and drilling was stopped at 151 m.

GZ358 - The borehole intersected only breccia-rich Enon Formation (T7) and significant water strikes were recorded at 223 m. The water strike made the borehole side wall unstable and drilling was stopped at 223 m.

3.4 Nautilus Bay Fault

The site on the Nautilus Bay Fault is located on the farm Oude Duinzigt 248, approximately 1 km south of the N2, on the Vleeschbaai. It is not an official name for the fault but for the purpose of this investigation it is referred to as the Nautilus Bay Fault.

3.4.1 Exploration targets

The Nautilus Bay Fault is mapped as a thrust fault, with the Skurweberg Formation forming the hanging wall and the Bokkeveld Group the foot wall. The fault plane was targeted as a high permeable zone.

3.4.2 Geophysical results

SRK did the geophysical survey and only an EM-34 profile was conducted. Based on the EM-34 results two sites were selected (data is available from SRK).

3.4.3 Drilling

Both targets were drilled and results are show in Table 4.

Table 4 Drilling results at Nautilus Bay

| Regional Borehole nr. | Village Name | Latitude Deg | Longitude Deg | Altitude (masl) | Depth (m) | Yield info | | Geology | Boreholes use |
|-----------------------|--------------|--------------|---------------|-----------------|-----------|----------------|-----------|---------|---------------|
| | | | | | | Air lift (l/s) | Test bore | | |
| GZ356 ✓ | Nautilus | -34.196460 | 21.980130 | 120 | 250.00 | 0.10 | No | Shale | Monitoring |
| GZ359 ✓ | Nautilus | -34.197276 | 21.980351 | 135 | 151.00 | 0.00 | No | Ss/Bk | Exploration |

GZ356 - The borehole only intersected the Bokkeveld Shale and no significant water strikes were recorded and drilling was stopped at 250 m

GZ359 - The borehole started in the Quartzitic sandstone and intersected the Bokkeveld shale at 78 m and no significant water strikes were recorded. Drilling was stopped at 151 m

4 CONCLUSIONS

Nine boreholes were drilled and four were successful. The following conclusions were drawn:

- Exploration targets identified at the Kleinberg community, the contact between a thin layer (10 – 20 m thick) of the Grahamstown Formation and overlying the Bokkeveld Group, were not successful and based on the available information it should not be considered as a possible groundwater target.
- Suspected thrust faulting planes in the Bokkeveld Group was intersected and show blow yields of ~0.5 l/s. It has a marginal groundwater development potential and can only be used for domestic and small urban development scenarios.
- Fault-breccia resulting from the De Hoek Fault was intersected, with blow yields of 1 – 2.5 l/s and fault surfaces from the De Hoek Fault in the Skurweberg Formation were also intersected with blow yields of up to 28 l/s. These targets have great groundwater development potential and can potentially be used for bulk water supply water resources.
- The thrust fault between the Bokkeveld and the Skurweberg (Nautilus Bay Fault) was intersect but no water strikes were recorded and based on the available information it should not be considered as a possible groundwater target.

5 RECOMMENDATIONS

The following recommendations are made:

- Borehole GZ357 and GZ358 need to be re-drilled to at least 450 mbgl.
- The in-situ material is unstable and a different drilling method, for example symmetric drilling or tri-cone mud-rotary, needs to be employed. Cost per borehole will be in the order of ~R450 000 per borehole.
- After completion boreholes need to be developed with a developing tool.
- After development boreholes need to be tested for 72 hours and recovery measured for 144 hours.
- Chemical samples need to be taken every 8 hours during testing and analysed.
- Report the development potential of GZ357 and GZ358.

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Appendix A: Geophysical survey at Kleinberg and Vleesbaai

(Copy of original report @ the Council of Geoscience)

GEOPHYSICAL SURVEY AT KLEINBERG COMMUNITY AND VLEESBAAI

BY:

C. J. De W. RAATH

© DEPARTMENT OF WATER AFFAIRS AND FORESTRY

REPORT NO. 2007-0052

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GEOPHYSICAL SURVEY AT KLEINBERG COMMUNITY AND VLEESBAAI

1. Introduction

The Geophysics Unit at the Council for Geoscience was appointed by the Department of Water Affairs and Forestry, refer to letter of appointment 4/8/3/1/4(W8885) received on 2007-02-14, to conduct a multi electrode survey at the Kleinberg community and an electromagnetic (EM) and magnetic survey in the Vleesbaai area. The purpose of the survey at Kleinberg was to delineate possible weathered zones or geological structures associated with groundwater occurrences that could be drilled for water for domestic use. The purpose of the surveys at Klipfontein and Vleesbaai were to determine the possible positions of the De Hoek and Vleesbaai faults.

2. Localities and Geological Background

The areas that were investigated are the Kleinberg community, situated 20km west of Mosselbaai, the farm Klipfontein, approximately 7km north of the Vleesbaai community and the farm Vleesch baai 3 km west of the Vleesbaai community (Figure 1).

Three additional traverses were conducted at three sites not in the original planning. Traverse 4 north-west of Klein Brakrivier (Figure 2) was done in an attempt to delineate an area of deeper weathering or sand cover to drill a high yielding saline borehole to be used for desalination. Traverse 6 was done west of the Vleesch baai site to confirm the possible position of the Vleesbaai fault (Figure 1). Traverse 7 south west of the Vleesch baai site was done in an attempt to delineate a possible contact between Table Mountain and Bokkeveld sandstone as seen on the original geological field maps (Figure 1).

The Kleinberg site is mainly underlain by Grahamstown formation silcrete and covered by sandy loam soil (Figure 3).

The Klipfontein site is covered by calcified dune sand and sand of the Bredasdorp group which is underlain by Uitenhage group conglomerate and Skurweberg formation quartzitic sandstone (Figure 3).

The Vleesch baai site is underlain by calcified dune sand of the Bredasdorp group (Figure 3).

3 Theoretical Aspects

In line with the survey objective to detect zones of weathering and possible faults, it was decided to utilise the magnetic, frequency domain EM and multi electrode resistivity (Continuous Vertical Electrical Soundings, CVES) methods. The multi electrode resistivity method is used to detect areas of deeper weathering or faults and fracture zones associated with groundwater occurrences. This method is ideal in areas of high cultural noise caused by power lines, railway lines, fences and houses. The magnetic survey aimed at detecting changes in the magnetic field caused by dykes and faults. The EM on the other hand is most appropriate for detecting weathering and fracturing of the bedrock as the presence of clay minerals associated with weathering and fault zones are usually fairly conductive.

3.1 Magnetic Method

Magnetic surveys make use of the variation in magnetization of rocks. In igneous and metamorphic rocks the main carriers of the magnetization are the mixed oxides of iron and titanium, of which the iron rich member magnetite is the best known.

Magnetite can occur as large concentration such as in massive iron ores, in thin or thick bands as in banded iron stones, in varying degrees of concentration in igneous and metamorphic rocks and can occur finely distributed through some sedimentary rocks.

The local total magnetic field strength of the earth is measured by means of a proton magnetometer. Magnetic features such as magnetic dykes and sills, ferruginous layers, magnetite-rich ore bodies etc. behave like large magnets within the earth's crust, which add local magnetic fields to the earth's main field. Ground magnetic surveys are useful for reconnaissance purposes for detecting features like dykes, sills, and faults under soil cover, and defining positions of structures deduced from geological maps more accurately in the field. Furthermore the magnetic method is quick, cheap and easy to apply.

Limitations of the method

The ability for the magnetic method to detect targets can be impeded in regions where either:

- There is not enough magnetic contrast between the target and the country rock.
- The country rock has such large quantities of magnetite, that the huge magnetic signals resulting from the country rock masks the target's own signature.

- There is man made structures such as power lines, fences or any metal structures

3.2 The Electromagnetic Method

The electromagnetic technique uses alternating current, flowing in a coil, to induce a secondary current in the subsurface of the earth. The strength of these induced or secondary currents and the phase difference between the induced and primary current provides an indication of the conductivity of the earth. These secondary currents generate a secondary magnetic field that is detected by the receiver of the electromagnetic instrument. The secondary magnetic field is a function of the conductivity, size and geometry of the conductor (geological structure). Electromagnetic exploration techniques make use of the ratio of the secondary magnetic field (from the induced current) to the primary magnetic field in order to calculate the apparent conductivity of the subsurface.

Equipment Description and Related Theory

The specific electromagnetic equipment, which was used in this survey, is the Geonics EM34-3, which is a controlled-source frequency-domain EM system. In controlled-source systems (like the EM34-3) the source of the above mentioned primary magnetic field is an artificial source generated by the transmitter of the instrument, which can be a current carrying loop (EM34-3) or a grounded wire. This instrument is fast, simple to operate and cost-effective. The EM34-3 uses 3 intercoil spacing's to investigate variable depths of exploration up to 60 metres.

In the horizontal coplanar dipole mode (HD) the EM34-3 is very sensitive to vertical geological structures and is widely used for detecting fractured, faulted and weathered bedrock zones. The EM profiling mode is used to detect lateral changes in conductivity.

The EM34-3 is a moving-source, moving-receiver system where both the transmitter and receiver are moved along the survey lines with a constant coil separation. The survey lines or profiles have to be approximately perpendicular to the strike of the zone of interest. Discounting the conductivity of the medium, the frequency of the Tx (transmitter) current and coil separation determines the survey depth. The smaller the coil separation, the higher the frequency and the smaller the survey depth will be. For the same coil separation, different depths of exploration (survey depths) can be obtained by using the two different dipole modes (horizontal coplanar and vertical coplanar).

For horizontal coplanar dipoles (coils are vertical) the survey depth is about 0.75 times the coil separation and for the vertical coplanar (coils are horizontal or lying flat) the survey depth is about 1.50 times the coil separation. For example for a 40 m coil separation the survey depth in horizontal coplanar mode will be 40×0.75 i.e. 30 m and for the vertical coplanar mode the survey depth will be 40×1.5 , i.e. 60 m.

The conductivity of the sub-surface as well as the nature and composition of the conductive material influence the survey depth. The more conductive (e.g. horizontal clay-rich layer) the sub-surface the shallower the survey depth becomes.

The resolution of the EM 34 is of such a nature that very thin layers with a slightly different conductivity than the surrounding host rock will be seen as part of the host rock since the EM 34 samples a volume of the sub surface from coil to coil and from the surface to the respective depth for that coil separation, and give an average value for this volume of earth and not a value at a single point at a specific depth. For example for a 40m coil separation, horizontal dipole mode, the EM 34 samples a volume of earth from coil to coil and from the surface to 30 m depth.

The units in which the EM34-3 are measuring is milli Siemens per metre (= millimhos per metre).

Factors Affecting Terrain Conductivity

Most dry soil and rock minerals are electrical insulators of very high resistivity. However conductive minerals such as magnetite, specular hematite, carbon, graphite, pyrite and pyrrhotite occur in sufficient quantities in rocks to greatly increase their overall conductivity.

In the absence of above mentioned conditions, the conductivity is generally electrolytic and takes place through the moisture filled pores and passages (e.g. moisture filled clay) which are contained within the insulating matrix. The conductivity is therefore determined for both rocks and soils by

- Porosity: shape and size of pores, number, size and shape of interconnecting passages
- The extent to which pores are filled by water i.e. water content
- Concentration of dissolved electrolytes in the contained moisture

- Temperature and phase state of the pore water
- Amount and composition of colloids

As can be seen above the composition, structure (solid or porous) and included moisture of soil or rock are of great importance in determining the conductivity.

Values obtained with an EM System change with different geological settings. It is also unlikely that two sites with the similar underlying geology will have the same conductivity values. Rather, a conductivity range for a specific type of geology should be anticipated. In broad terms the conductivity values across solid granite, quartzite and sandstone are relatively low, on the condition that there is no weathering, faults and fracture zones. Clayey and wet areas such as marshes or river beds, dykes with associated fracture zones, faults with mineralised zones etc. will have relatively high values.

Electric power lines, fences with metal posts, railway lines, houses with tin roofs etc. will have an influence on the values obtained with an EM 34-3.

As mentioned above the survey lines have to be approximately perpendicular to the strike of the suspected target features for maximum coupling of the electromagnetic field with these bodies.

3.3 Explanation of multi electrode resistivity (Continuous Vertical Electrical Soundings (CVES))

The resistivity method requires the measurement of resistance of the ground. This is usually done by injecting a current into the ground using two electrodes and measuring the resulting potential across another two electrodes. The exploration depth that the measurement applies to depend on the electrode separation, thus a picture of resistance with depth can be derived by systematically increasing the electrode separation. This process is known as a vertical electrode sounding. A series of such soundings adjacent to each other provides a continuous vertical electrical sounding or CVES.

Purpose-built instruments are available for automatically collecting CVES data. Depending on the requirement different electrode configurations and separations can be programmed.

The resistivity data sets were processed using RES2DINV. RES2DINV automatically interprets the resistivity variations of the ground by fitting internally-generated model data to the field data through several iterations. Prior to inverting, obviously noisy or spurious data points are manually eliminated from the data sets. After the first interpretation pass of up to five iterations, further editing is carried out to remove data that were outliers compared with the computer-generated model readings. A final cycle of modelling then followed.

Anomalies are recognised in the model by virtue of a higher or lower resistance relative to the surrounding material. Where deeper weathering is present the data may appear as a less resistive area relative to the surrounding host rock.

4. Geophysical Fieldwork

In the case of the magnetic method, the magnetic contrast between the target and the surrounding host rock were very small and the original objective of obtaining anomalies associated with possible weathering and faults dykes was not successful using this technique.

4.1 Kleinberg Community Survey

Since the area is situated next to a railway line and the only possible open space to do a geophysical survey was in the road leading to and between the houses next to a fence it was decided to do a multi electrode resistivity (CVES) profile.

An ABEM Lund system was used to collect CVES (continuous vertical electrical soundings) data using a Wenner electrode configuration with a basic electrode separation of ten metres. The data were processed using the program RES2DINV. The location of the traverse line is shown in Figure 4 and the resistivity model is reproduced in Figure 5. A Garmin GPS map76S was used to record start and end co-ordinates whilst stations every 100m were marked in the field with barrier tape.

The line was 400m in length. A resistivity high was recorded between 130m and 195 m, terminating in a vertical contact at 200 metres (Figure 5). From 200 m to 240m conductivity high was recorded indicating an area of deeper weathering and from 240m to 310 m an area with a slightly higher resistivity again.

The proposed borehole (PBH1) was sited at station 220 where the weathering seemed to be the deepest.

4.2 Klipfontein

At the Klipfontein site three traverses were conducted. Traverse 1 consists of a magnetic profile and the other two traverses 3 and 5 consist of an EM 34 and a magnetic profile (Figure 6). The EM was done with a 40m coil separation in the horizontal and vertical dipole modes with a station spacing of 20 m. The magnetic data was collected at 10 m intervals along the same traverses as the EM 34. The profiles and traverse co-ordinates are attached in Appendix A and B. The thick black line represents the magnetic data, the solid thin line represents the horizontal dipole EM 34 data and the dotted line represents the vertical dipole EM 34 data.

Traverse 1 a magnetic profile was done in the road from the Springer baai offices in an attempt to determine the De Hoek fault position. The small magnetic high of 8 nT between stations 160 and 280 could be an indication of the fault.

On traverse 3 there is a definite step in the EM data between stations 280 and 380 that is a good indication of a geological structure. The magnetic data were not of much value and seem to be very erratic; the range of magnetic values from minimum to maximum was only 9 nT.

Traverse 5 was done to correlate the data on traverse 3, as can be seen on the profile there is a step in the EM data on traverse 5 between stations 100 and 200. Again the magnetic data were not of much value and seem to be very erratic and the range of magnetic values from minimum to maximum was also only 9 nT. A proposed borehole position (PBH 4) was sited at station 120 (Figure 6).

4.3 Vleesch baai

One traverse (traverse 2) was done on this site (Figure 7). The EM was done with a 40m coil separation in the horizontal and vertical dipole modes with a station spacing of 20 m. The magnetic data was collected at 10 m intervals along the same traverses as the EM 34 and the data can be seen in Appendix A.

Traverse 2 was done from south to north across the approximate position of the Vleesch baai fault. The EM 34 profile is dominated by the large positive anomaly from station 20 to 260. As can be seen on the profile the large negative value at station 200 on the vertical dipole data was caused by the proximity of the fence to the receiver coil and the large positive value at station 240 was caused by the proximity of the fence to the transmitter coil. A possible borehole position (PBH 2) was sited on the edge of the horizontal dipole high at station 260

(Figure 7). There is no distinct anomaly on the magnetic data that can be associated with the fault.

A second possible borehole position (PBH 3) was sited at station 540 where there is a step of approximately 20 mS/m in the horizontal and vertical dipole EM 34 data.

Traverse 6 was done to confirm the possible position of the Vleesbaai fault (Figure 7) but the data was very erratic and no anomaly was identified.

Traverse 7 (Figure 7) was done in an attempt to delineate a possible contact between Table Mountain and Bokkeveld sandstone, no anomaly was identified on this traverse, a power line running parallel to the road as indicated on the profile could have been at the position where the traverse intersected the contact .

The profiles and traverse co-ordinates are attached in Appendix A and B.

4.4 Klein Brakrivier

Traverse 4 close to Klein Brakrivier (Figure 2) was done from north-east to south-west parallel to the road approximately 60m from the road on the north western side. The horizontal dipole data was relatively featureless. A possible borehole position (PBH 4) was sited on the highest conductivity on the vertical dipole data at station 440 which could be an indication of an area with deeper weathering. The conductivity high at the beginning of the traverse was most probably caused by a fence and can not be attributed to any geological structures.

The profile and traverse co-ordinates are attached in Appendix A and B.

5 Conclusions

Five proposed borehole positions were sited on the different traverses. GPS co-ordinates (WGS 84) were recorded at all the proposed borehole positions. The different proposed borehole co-ordinates are attached in Table 1. Photos of the proposed borehole positions were taken where possible and are attached as figures 8 to 13.

Table1: Proposed borehole co-ordinates

| St. no. | Lat | Long | |
|---------|-----------|-----------|-------------------|
| PBH1 | S34.16918 | E21.90932 | Figure 8 |
| PBH2 | S34.28997 | E21.88900 | Figure 9 |
| PBH3 | S34.28621 | E21.88848 | |
| PBH4 | S34.07656 | E22.13915 | Figures 10 and 11 |
| PBH5 | S34.22448 | E21.90599 | Figures 12 and 13 |

The EM 34 method is more effective than the magnetic method in areas where there is no significant difference in the magnetization of the different rock types as was the case in the Vlees baai area. Future geophysical surveys should rather make use of the Electromagnetic and resistivity methods and even the gravity method can be used to detect large faults.

FIGURES

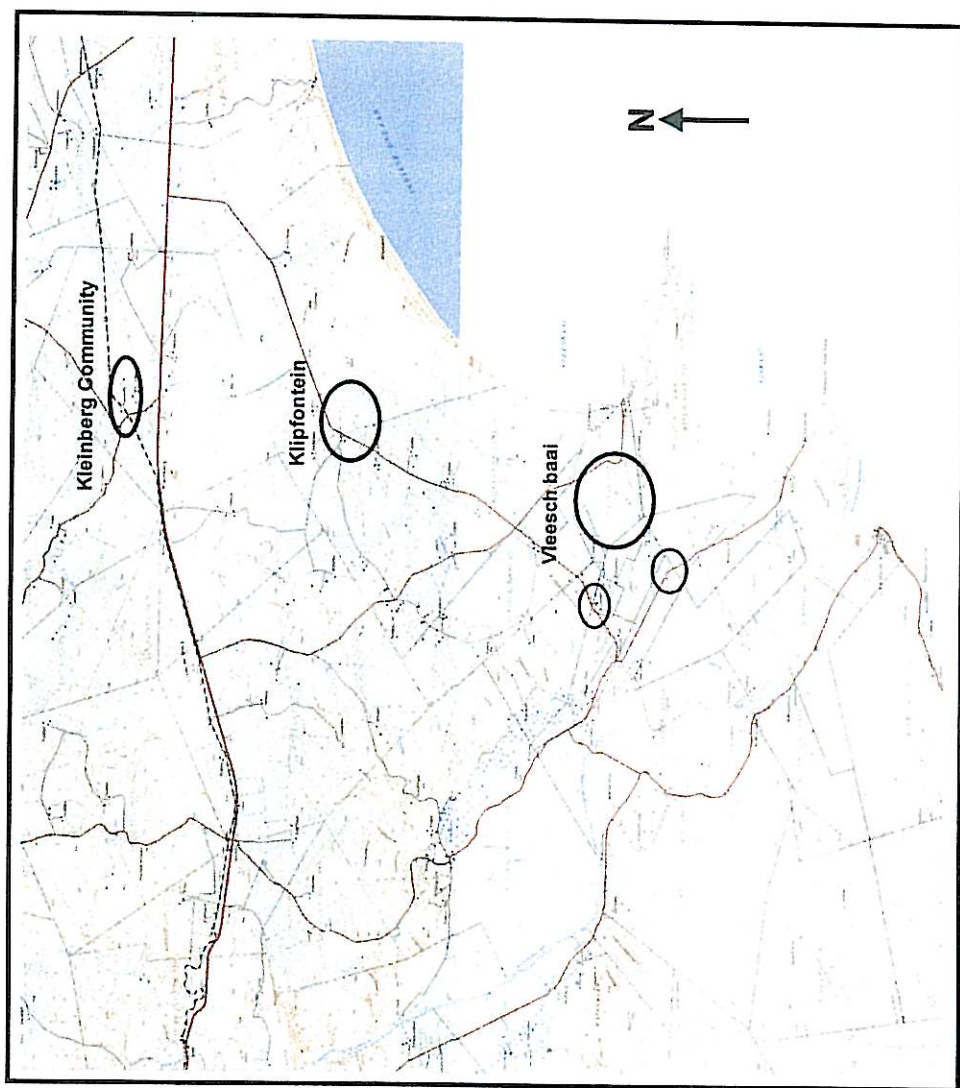


Figure 1: Locality map (not to scale)

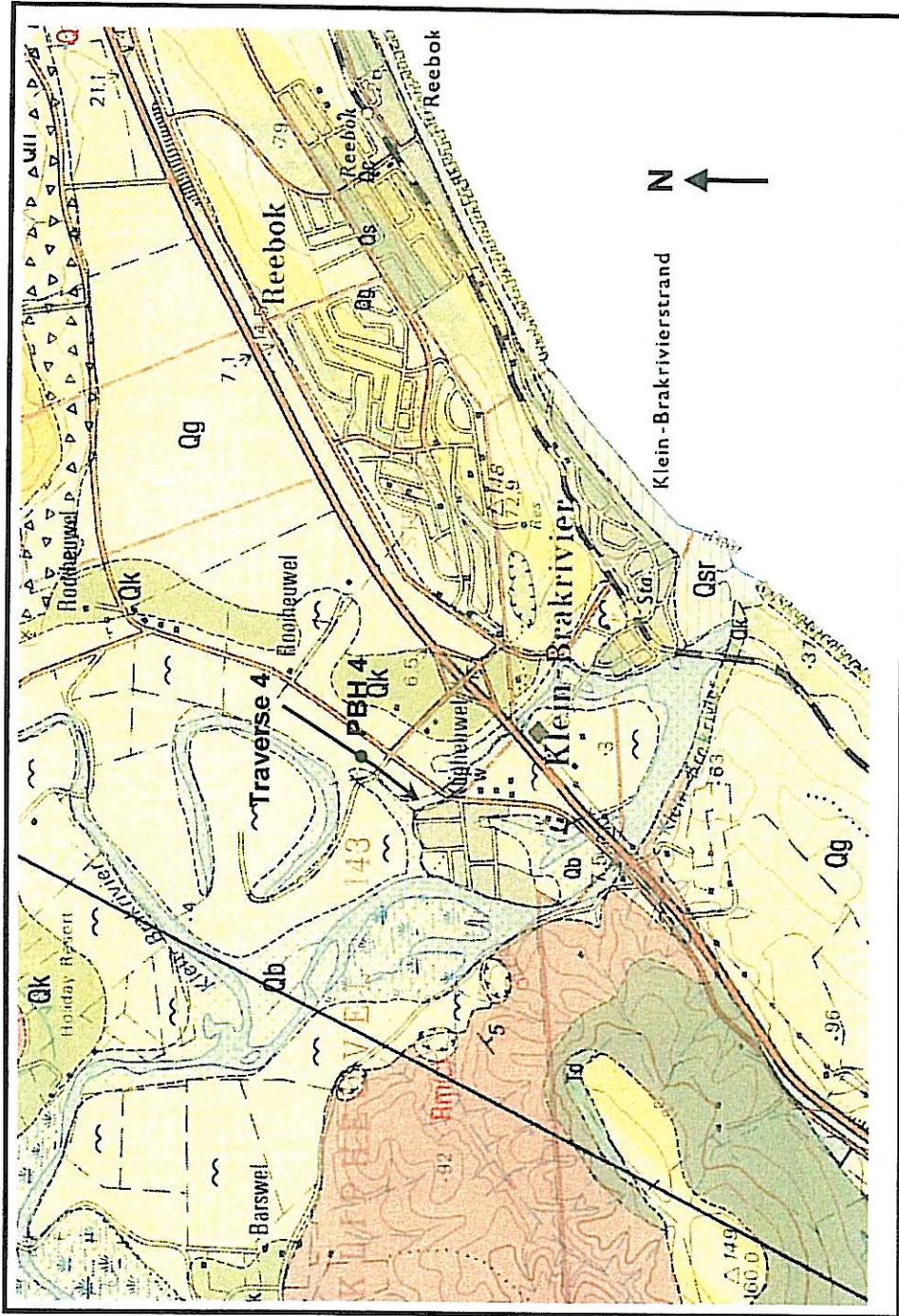


Figure 2: Klein Brakrivier geological map and locality of traverse 4

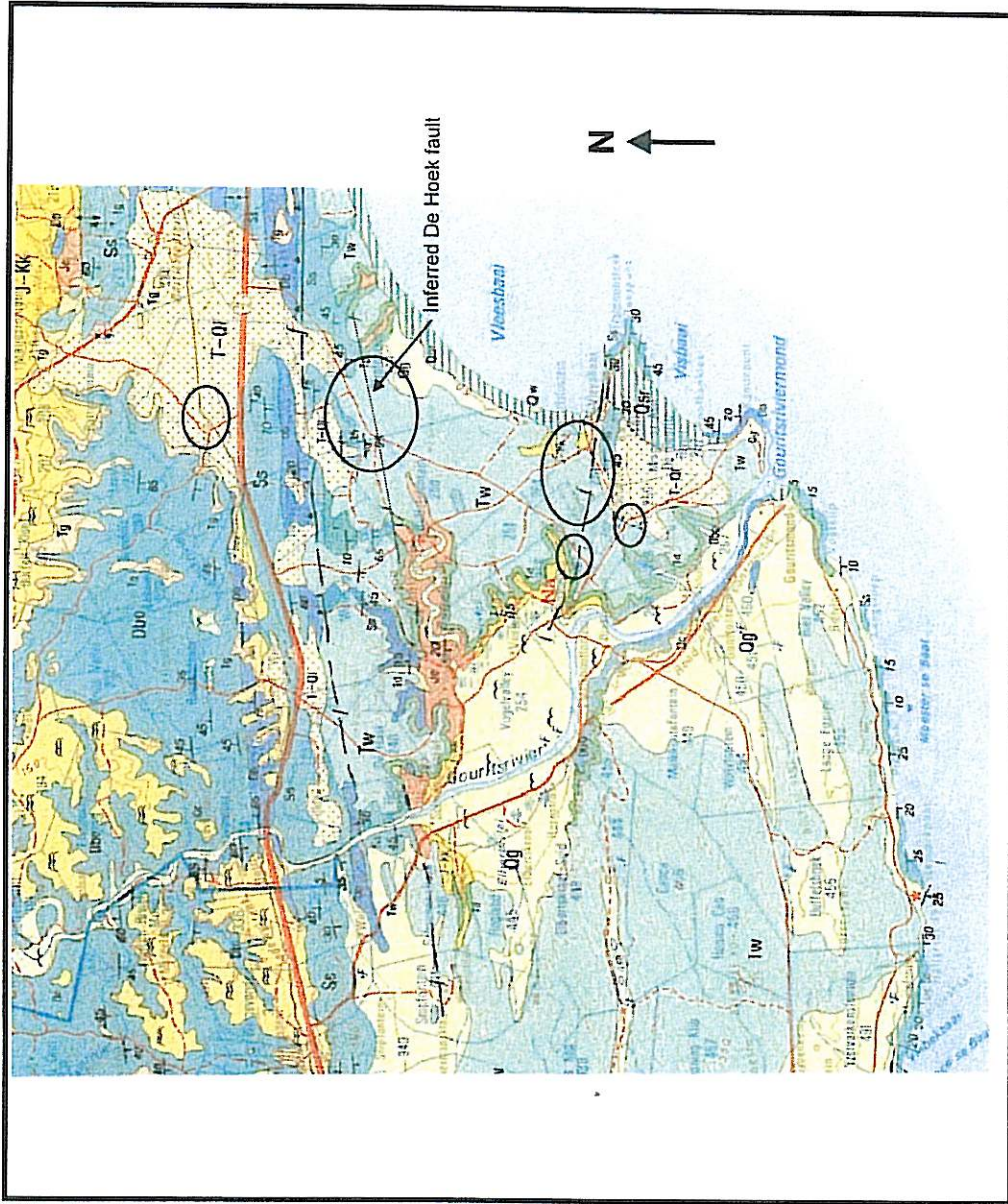


Figure 3: Geological map with study areas (not to scale)

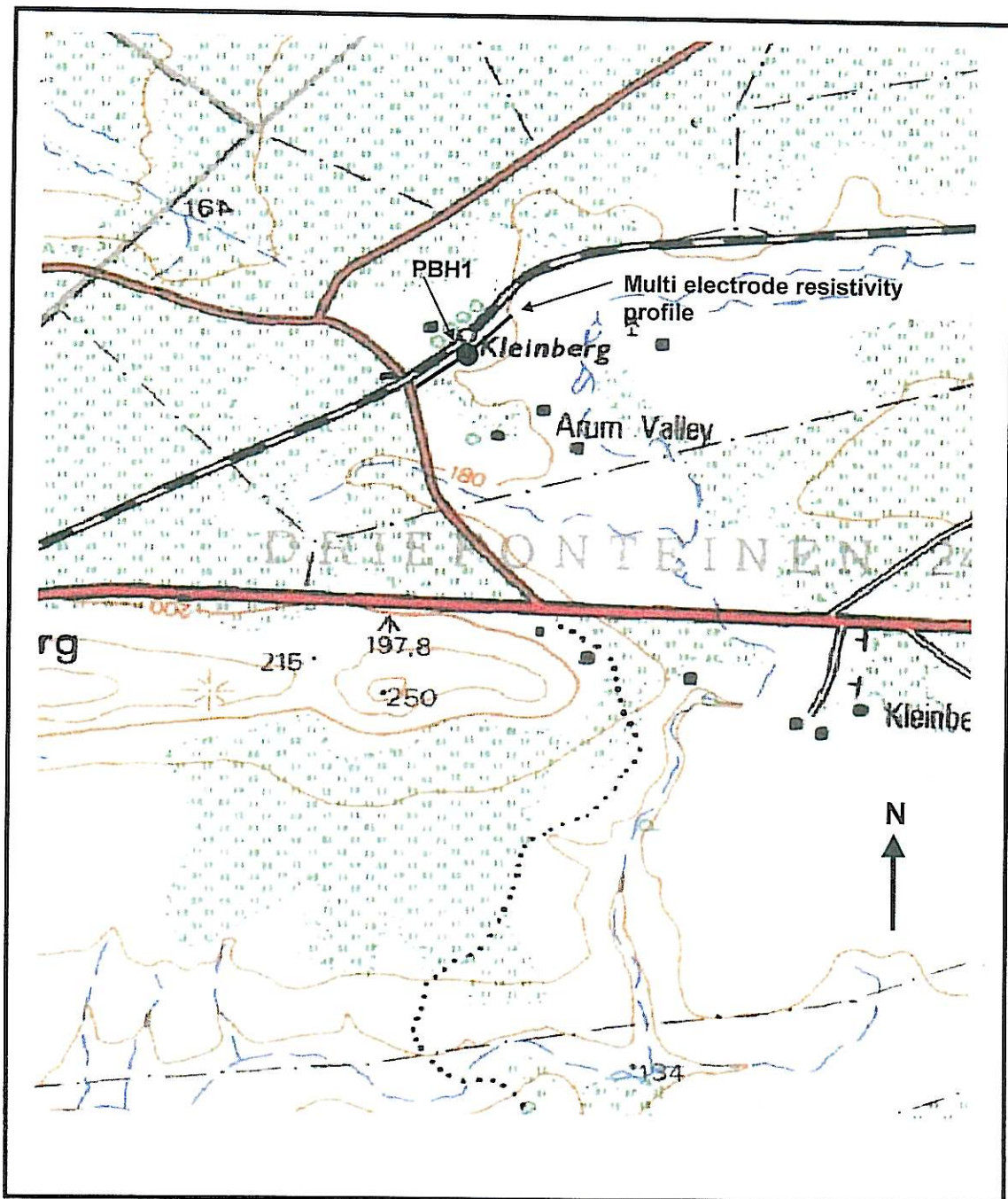


Figure 4: Kleinberg multi electrode resistivity profile and proposed borehole position

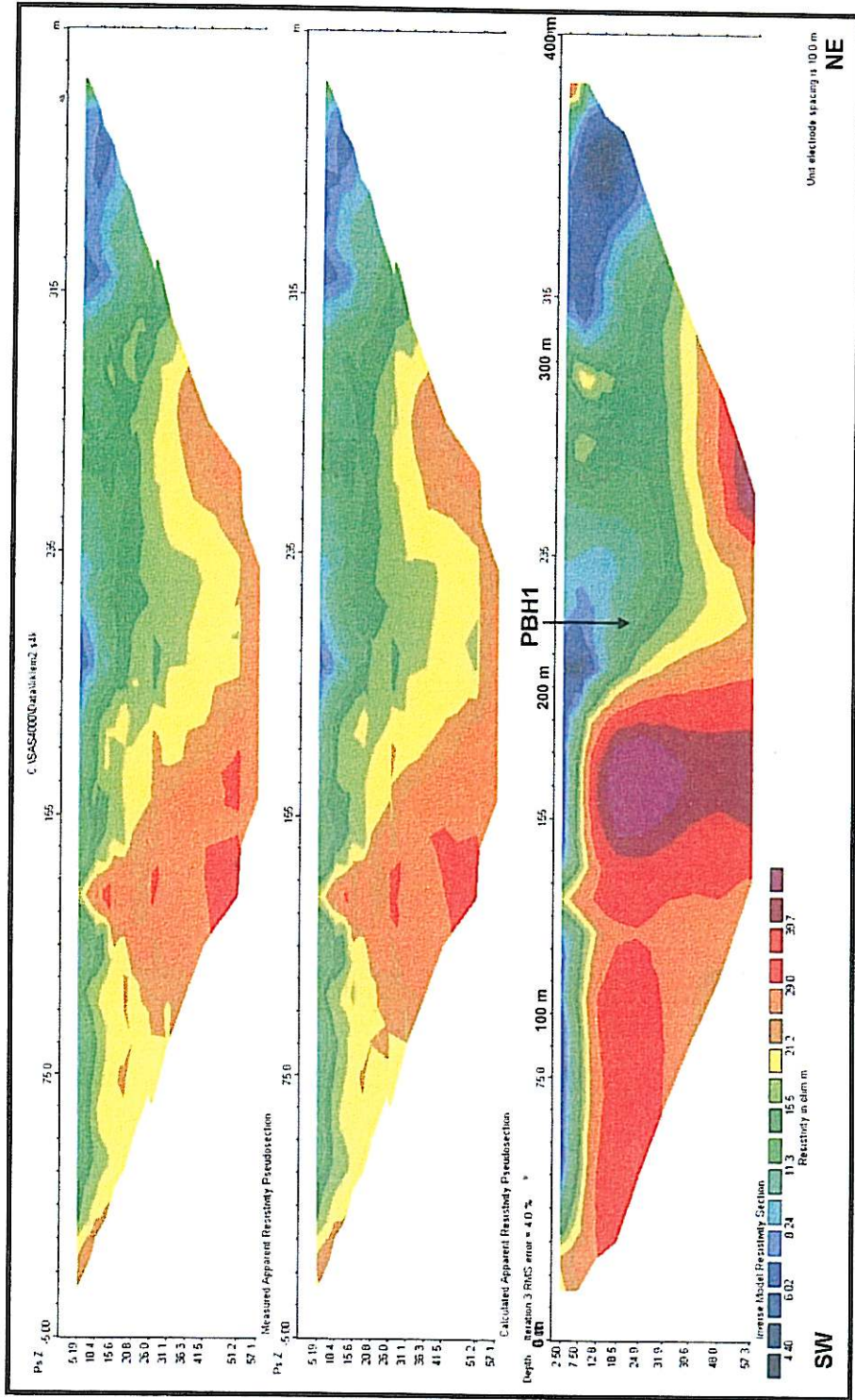


Figure 5: Kleinberg resistivity model with proposed borehole position

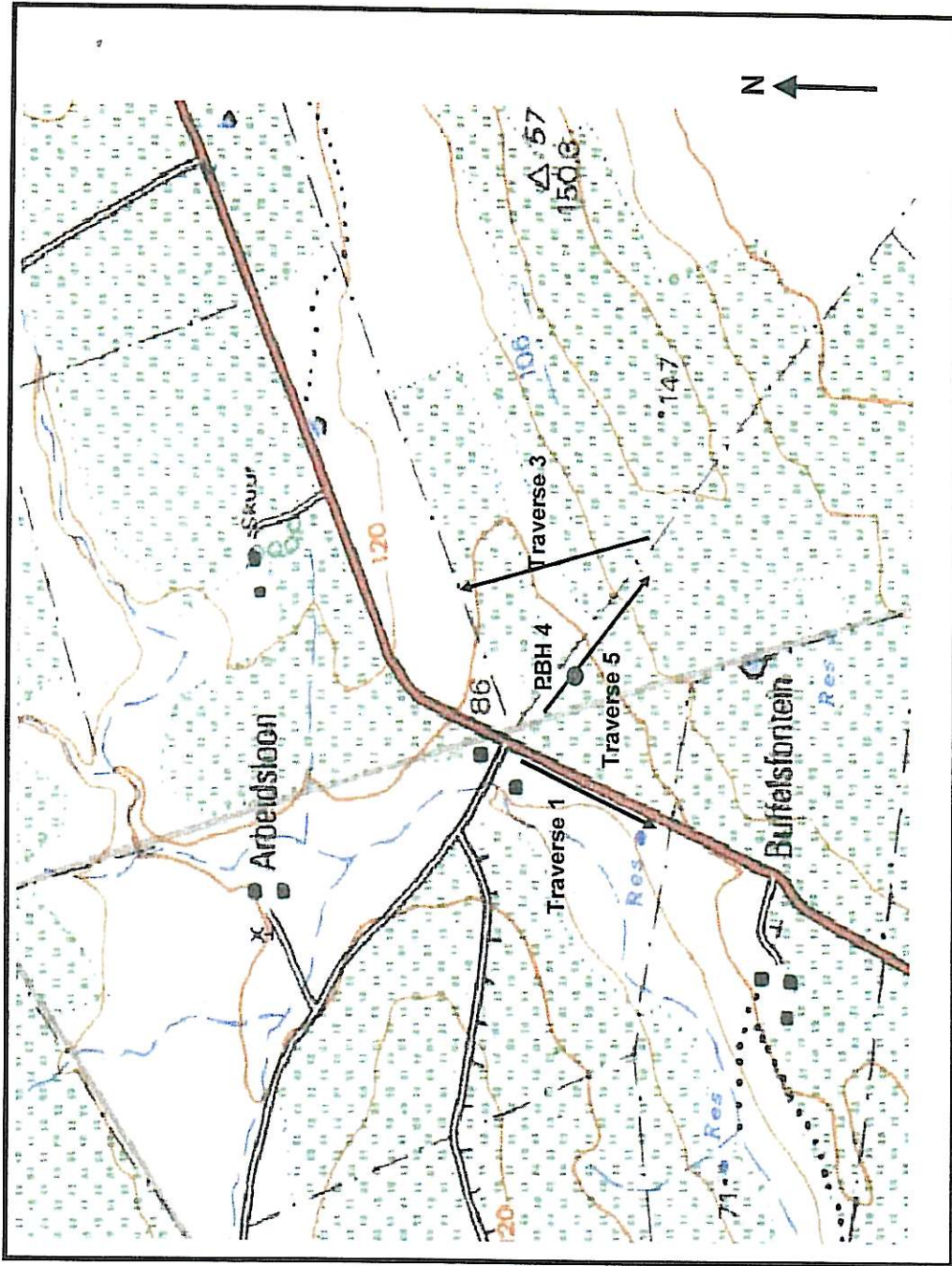


Figure 6: Klipfontein traverse and proposed borehole positions

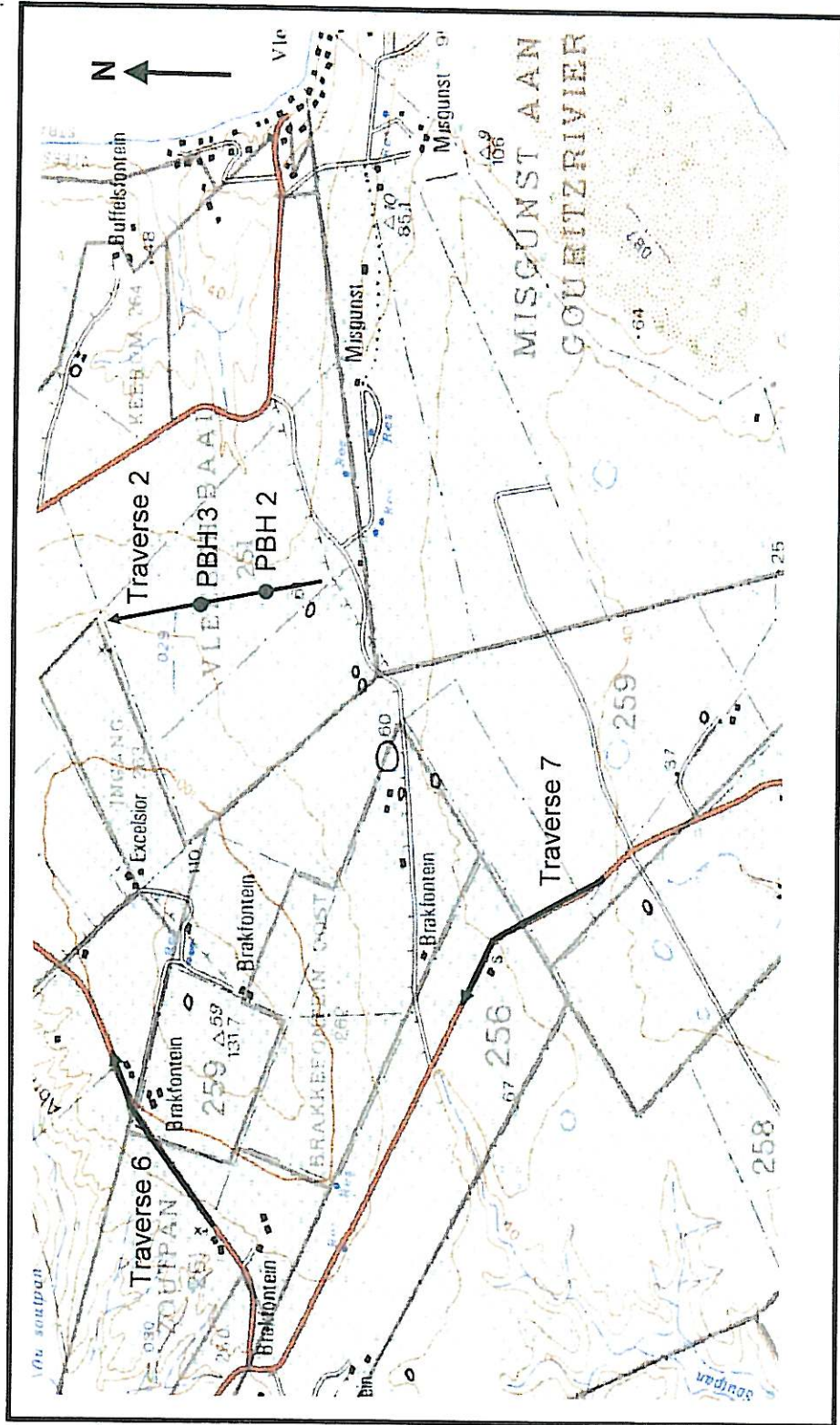


Figure 7: Vleeschbaai traverse and proposed borehole positions

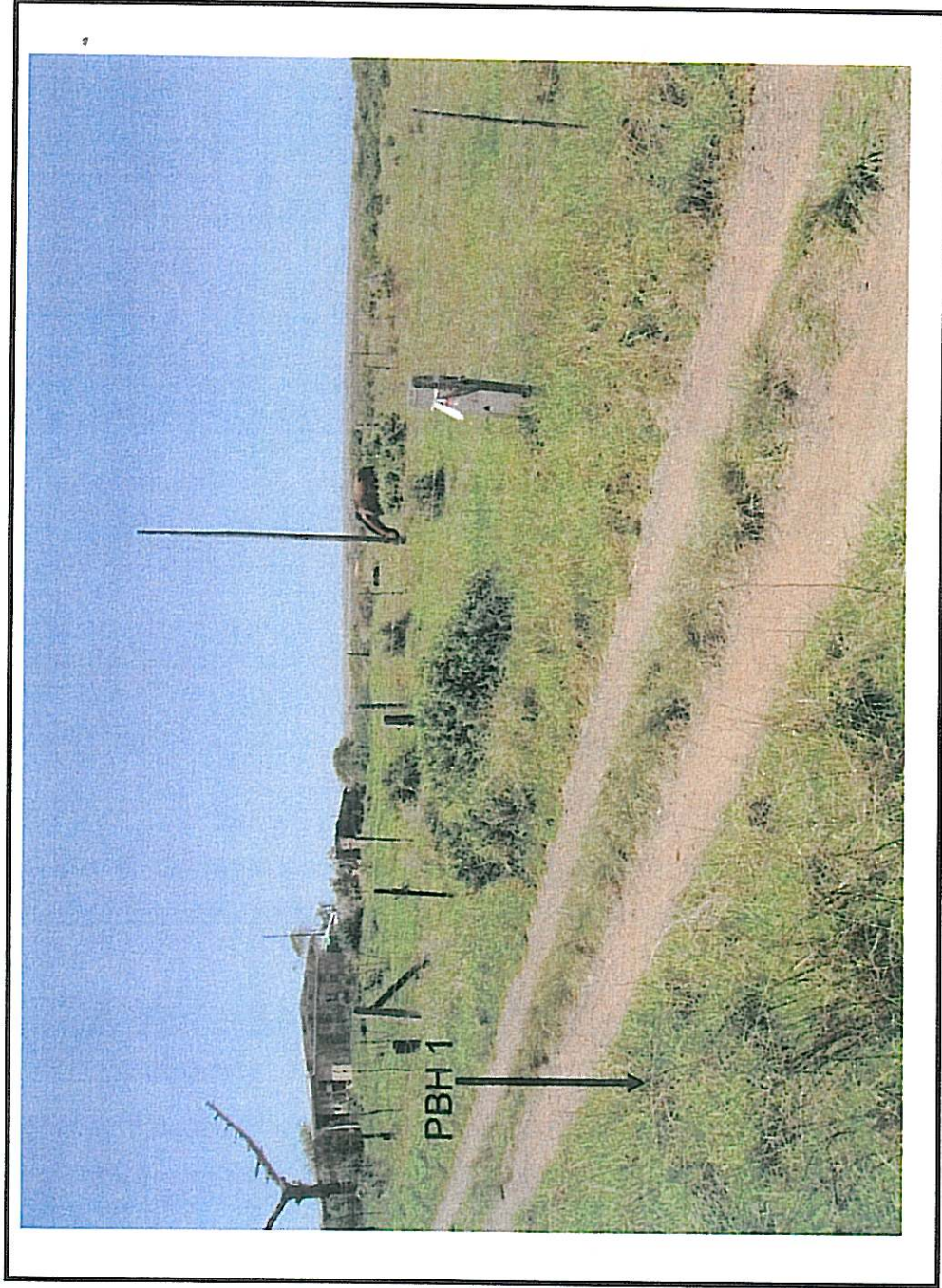


Figure 8: Kleinberg Community Possible borehole position (PBH 1)

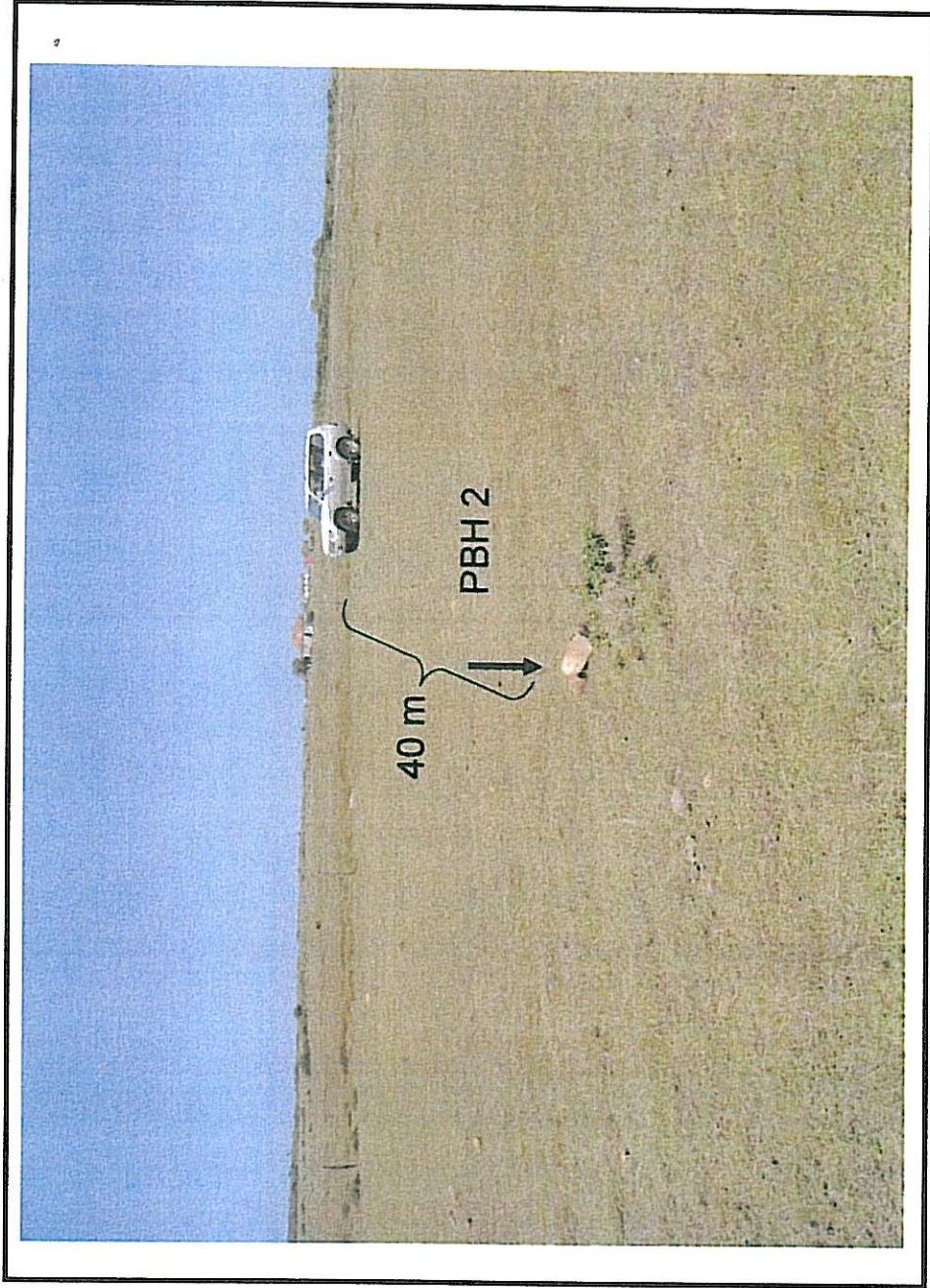


Figure 9: Vleesch baai Possible borehole position (PBH 2)

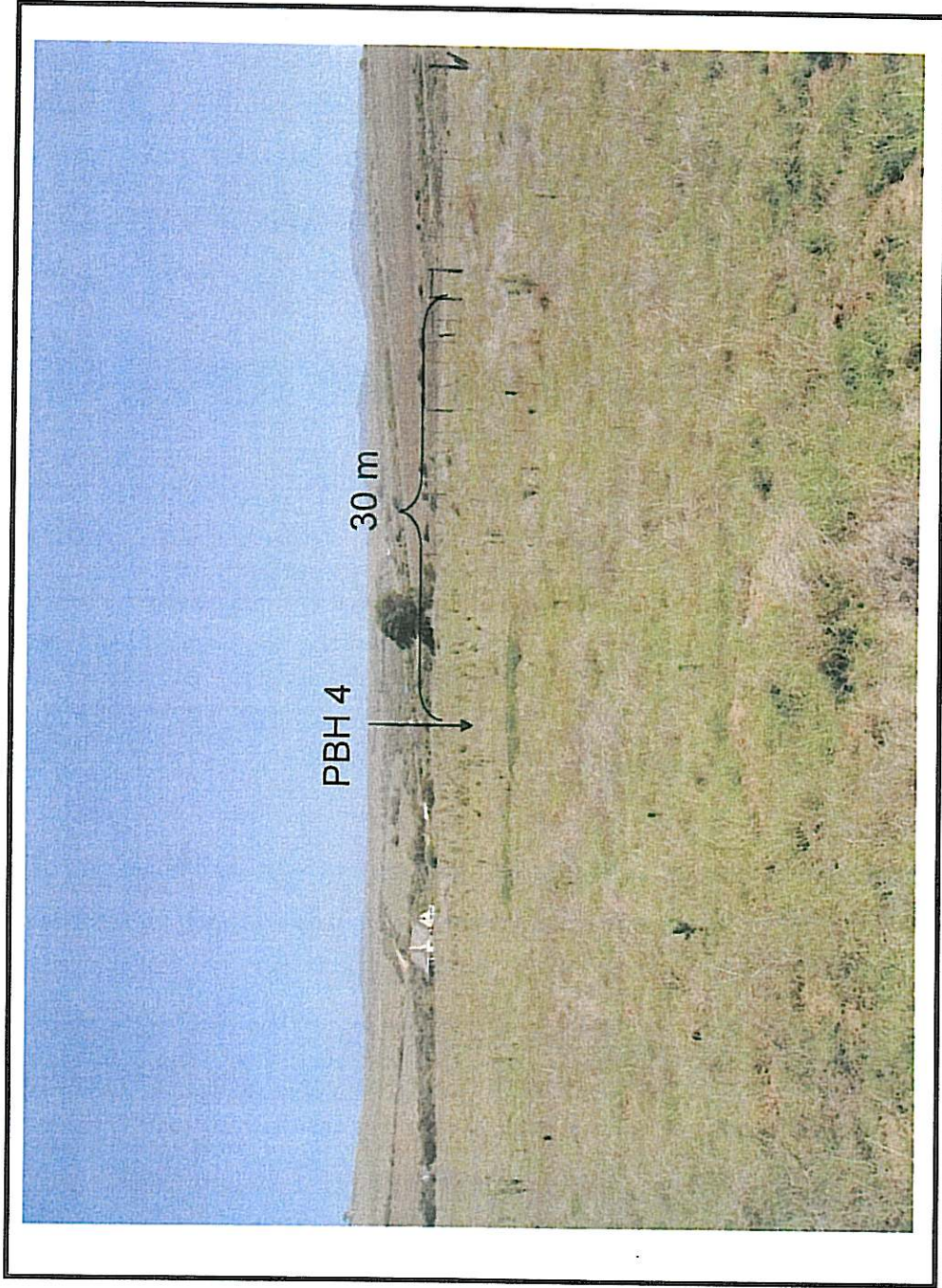


Figure 10: Klipfontein Possible borehole position (PBH 4)



Figure 11: Klipfontein Possible borehole position (PBH 4)

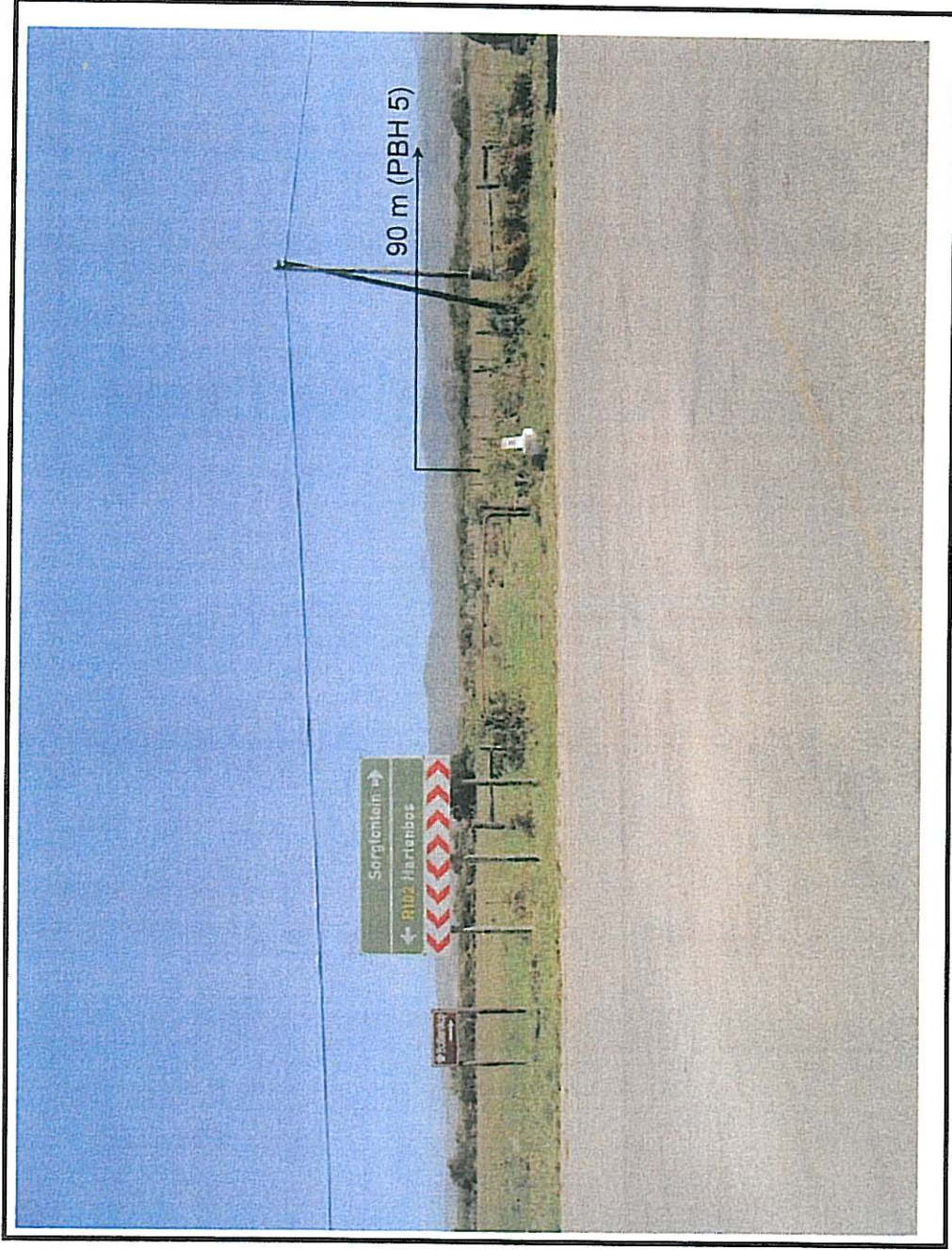


Figure 12: Klein Brakrivier Possible borehole position (PBH 5)

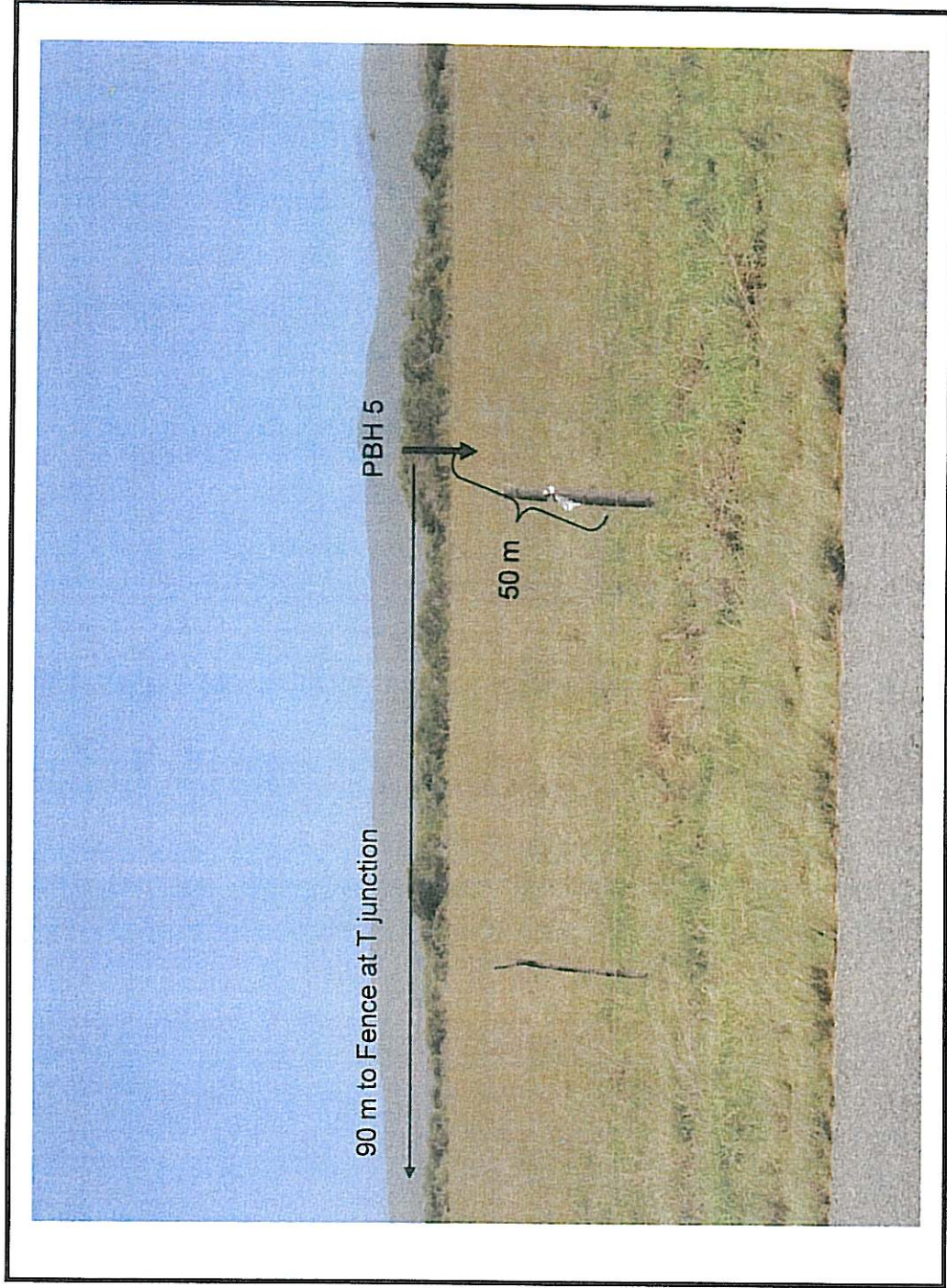
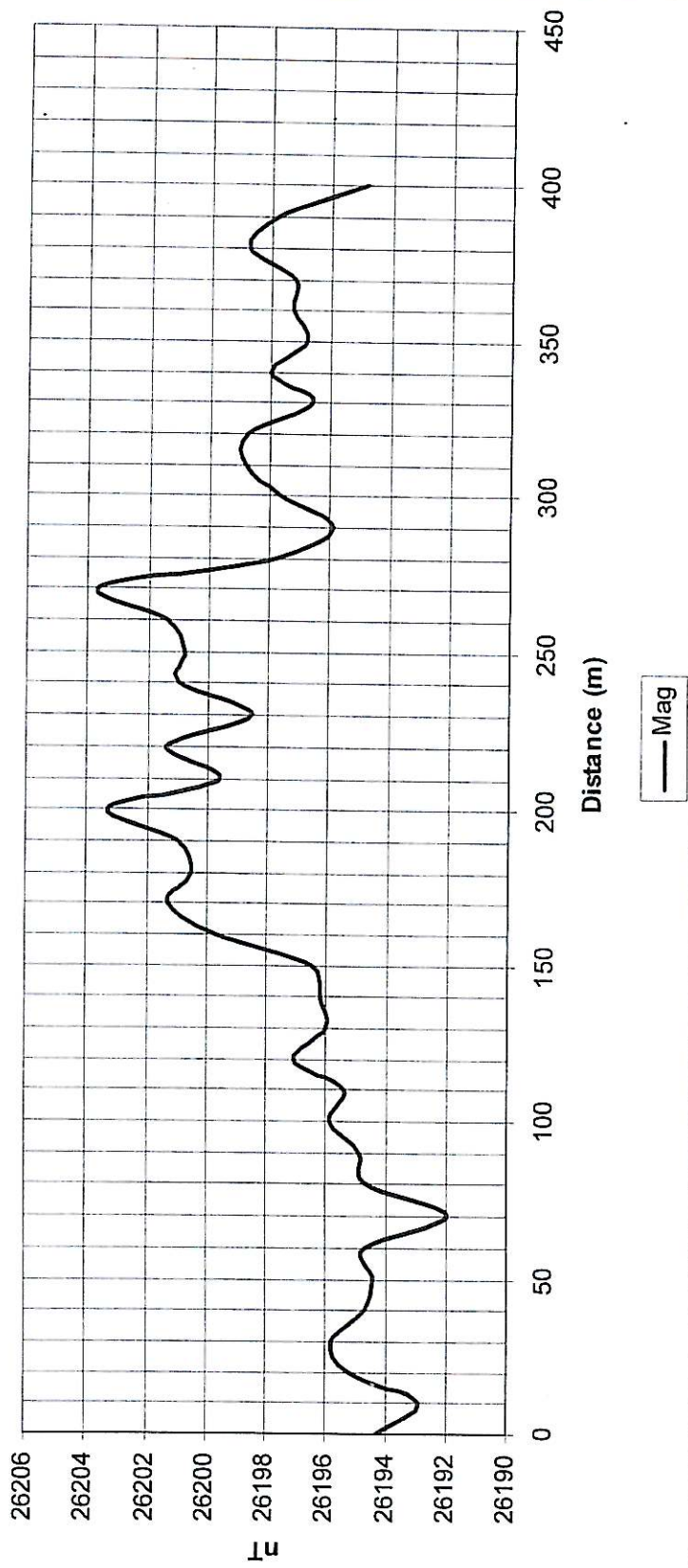


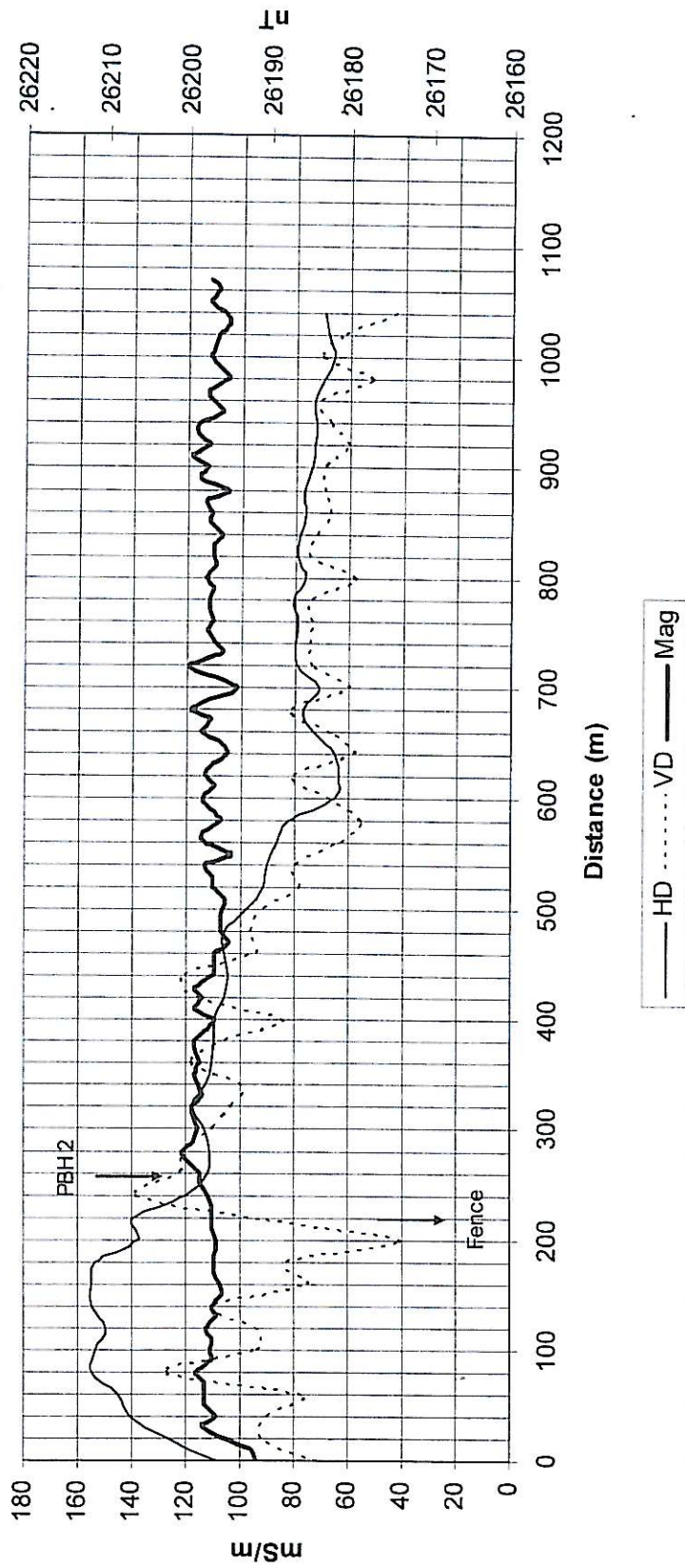
Figure 13: Klein Brakrivier Possible borehole position (PBH 5)

APPENDIX A

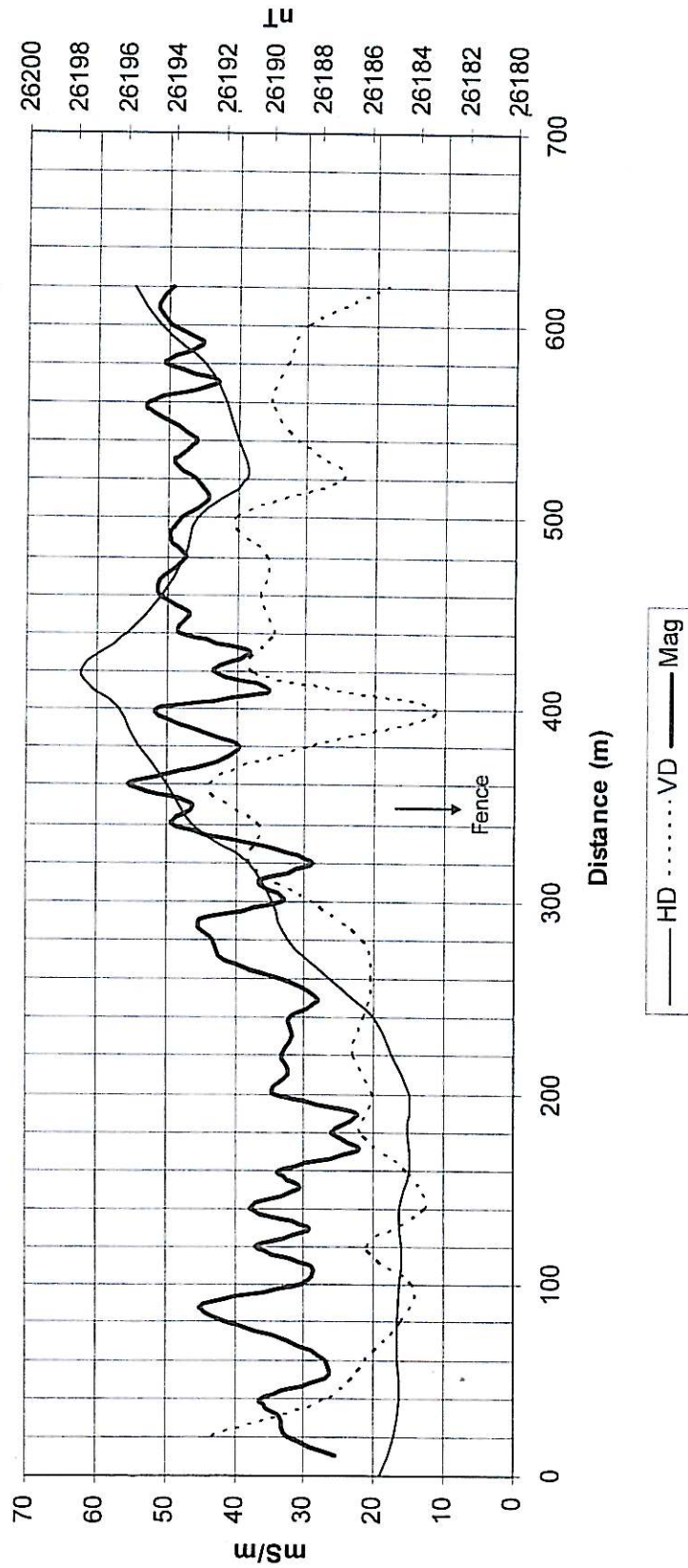
Traverse 1 Klipfontein Magnetics NNE-SSW



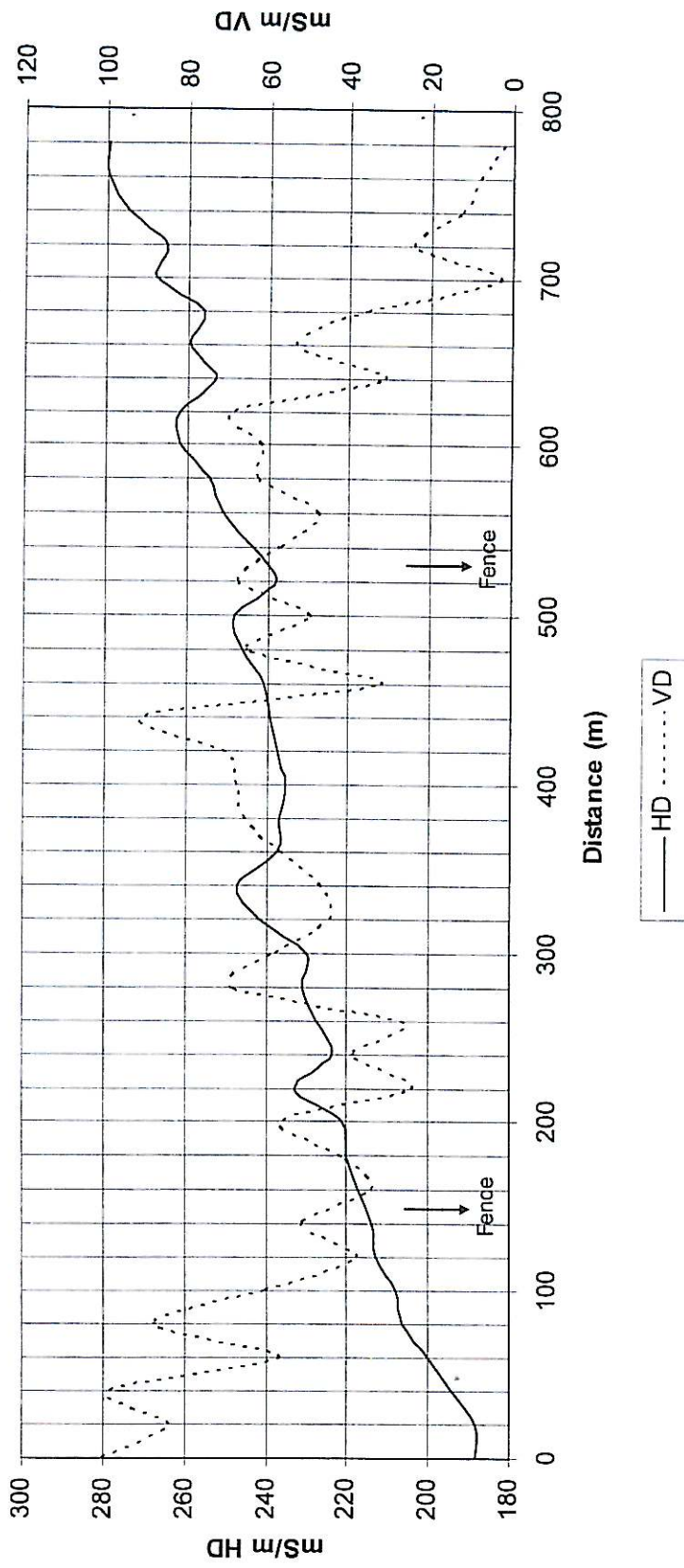
Traverse 2 Vleesbaai EM 34 and Magnetics S-N



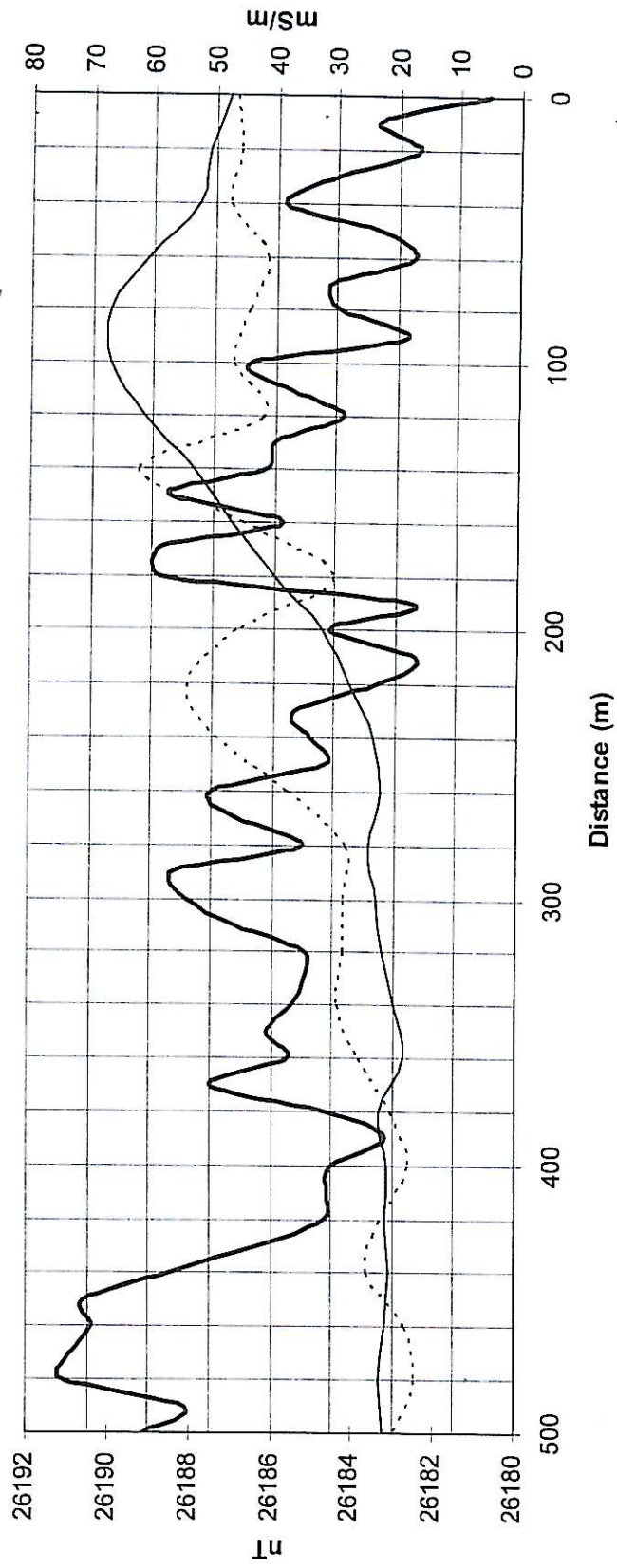
Traverse 3 Klipfontein EM 34 and Magnetics S-N



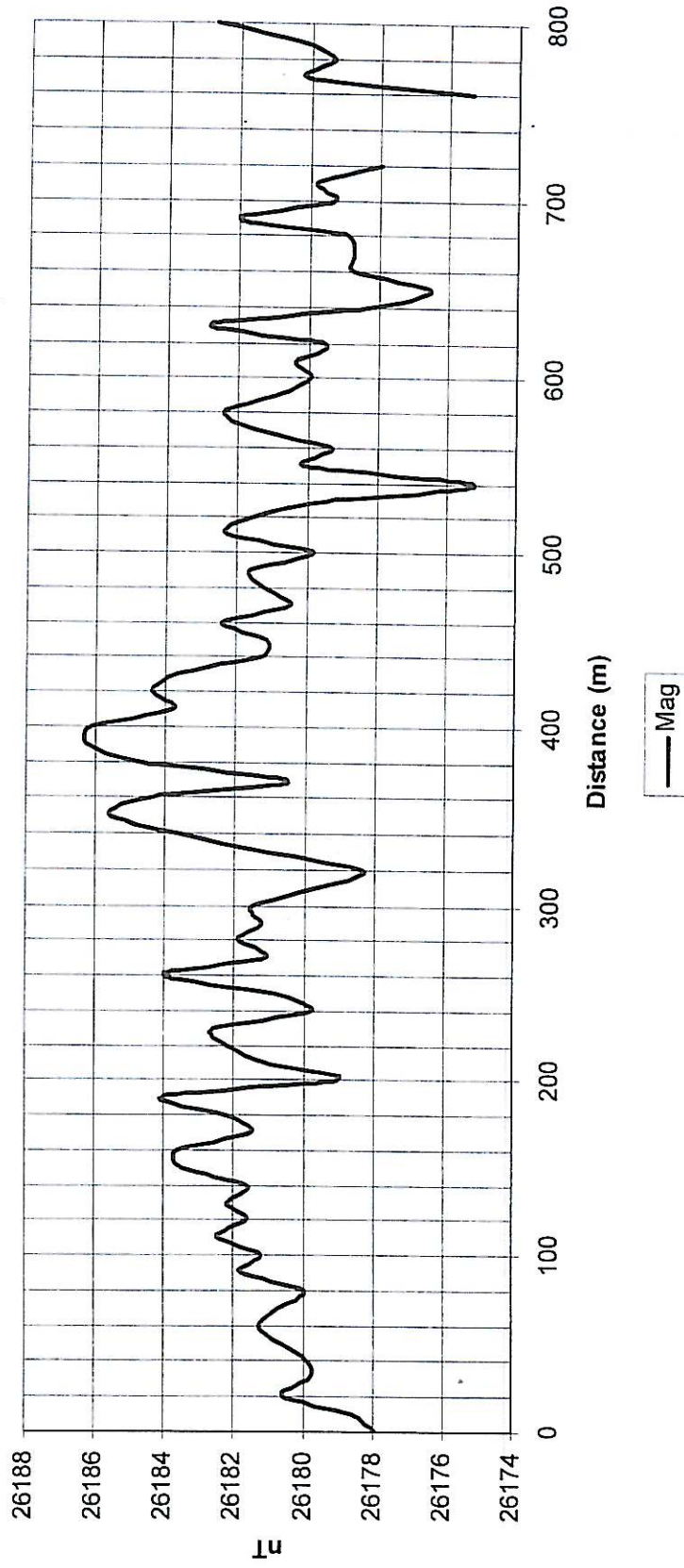
Traverse 4 Klein Brak rivier EM 34 NE-SW



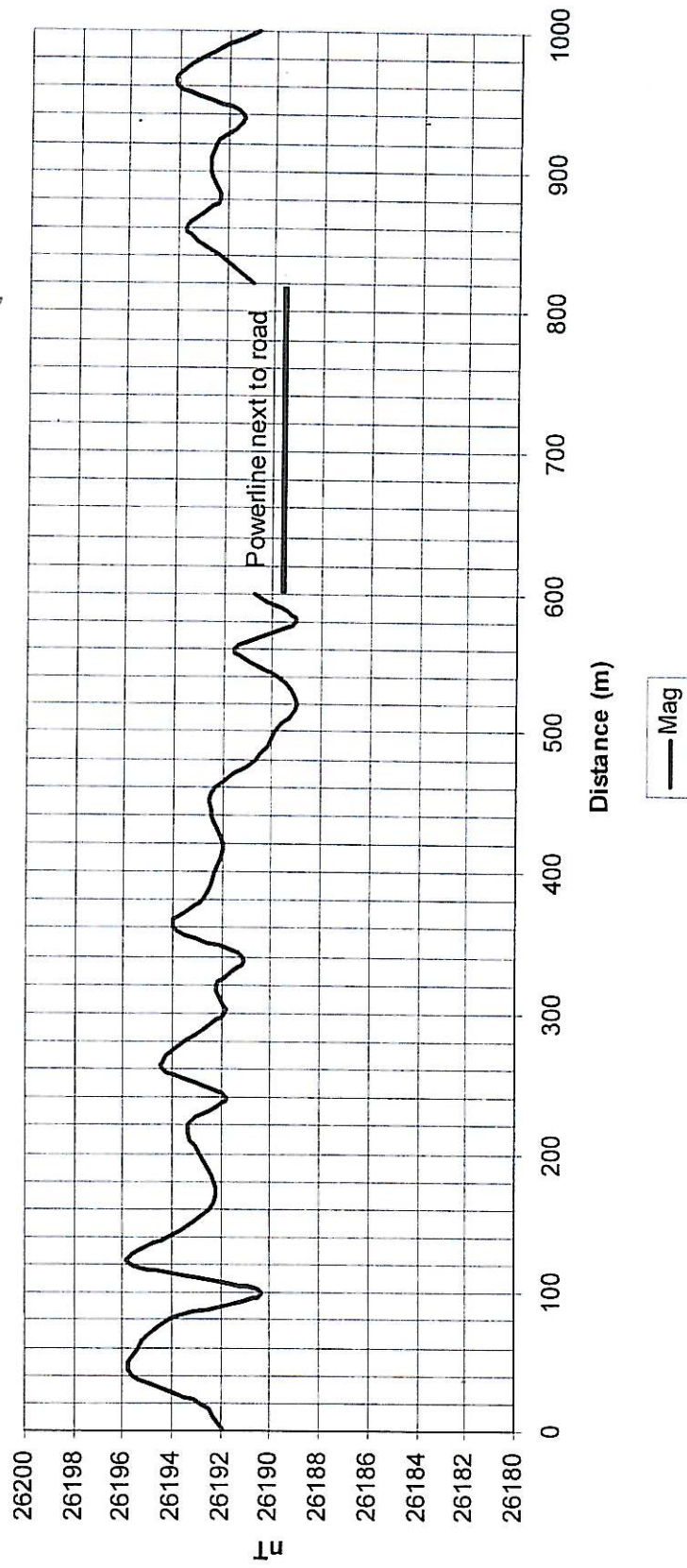
Traverse 5 Klipfontein EM 34 and Magnetics SE-NW



Traverse 6 Vleesbaai Magnetics SW-NE



Traverse 7 Vleesbaai Magnetics SE-NW



APPENDIX B

WGS 84

| St. no. | LO | Lat (Dec. deg.) | Long (Dec. deg.) |
|---------|----|-----------------|------------------|
| 1 0 | 21 | S34.22296 | E21.90307 |
| 1-400 | 21 | S34.22644 | E21.90116 |
| 2 0 | 21 | S34.29268 | E21.88950 |
| 2 300 | 21 | S34.28950 | E21.88902 |
| 2 1070 | 21 | S34.28142 | E21.88780 |
| 3 0 | 21 | S34.22665 | E21.90964 |
| 3-600 | 21 | S34.22137 | E21.90830 |
| 4 0 | 23 | S34.07304 | E22.14184 |
| 4-780 | 23 | S34.07882 | E22.13659 |
| 5 0 | 21 | S34.22358 | E21.90493 |
| 5-500 | 21 | S34.22670 | E21.90869 |
| 6 0 | 21 | S34.28683 | E21.85778 |
| 6-850 | 21 | S34.28202 | E21.86583 |
| 7 0 | 21 | S34.30611 | E21.87453 |
| 7-1050 | 21 | S34.29953 | E21.86814 |
| PBH1 | 21 | S34.16918 | E21.90932 |
| PBH2 | 21 | S34.28997 | E21.88900 |
| PBH3 | 21 | S34.28621 | E21.88848 |
| PBH4 | 23 | S34.07656 | E22.13915 |
| PBH5 | 21 | S34.22448 | E21.90599 |

Appendix B: Drilling results

34-21-86

34-21-86 120
 34-21-86 121
 34-21-86 122
 34-21-86 123
 34-21-86 119
 34-21-86 120
 34-21-86 124
 34-21-86 125
 34-21-86 126

34 10 09 / 21 54 33
 34 10 11 / 21 54 34
 34 13 28 / 21 54 27
 34 11 47 / 21 58 49
 34 17 25 / 21 53 20-80
 34 17 08 / 21 53 18 80
 34 11 50 / 21 58 49 86
 34 10 09 / 21 54 33 86
 34 10 09 / 21 54 32 86

| Regional Borehole nr. | Village Name | Latitude Deg | Longitude Deg | Altitude (masl) | Depth (m) | Yield info | | Boreholes use |
|-----------------------|--------------|--------------|---------------|-----------------|-----------|----------------|-----------|---------------|
| | | | | | | Air lift (l/s) | Test bore | |
| GZ353 | Kleinberg | -34.169136 | 21.909270 | 180 | 91.00 | 0.00 | No | Exploration |
| GZ354 | Kleinberg | -34.169732 | 21.908533 | 175 | 60.00 | 0.00 | No | Exploration |
| GZ355 ✓ | Springerbaai | -34.224488 | 21.905996 | 120 | 204.00 | 2.50 | Yes | Testing |
| GZ356 | Nautilus | -34.196460 | 21.980130 | 120 | 250.00 | 0.10 | No | Monitoring |
| GZ357 | Vleesbaai | -34.290147 | 21.888938 | 80 | 151.00 | 28.00 | Yes | Testing |
| GZ358 | Vleesbaai | -34.285731 | 21.888468 | 90 | 223.00 | 3.40 | Yes | Testing |
| GZ359 | Nautilus | -34.197276 | 21.980351 | 135 | 151.00 | 0.00 | No | Exploration |
| GZ360 | Kleinberg | -34.169214 | 21.909171 | 179 | 117.00 | 0.00 | No | Incomplete |
| GZ361 | Kleinberg | -34.169400 | 21.908946 | 177 | 240.00 | 2.00 | Yes | Testing |

Bk- Bokkeveld shale

S - Standveld sand

Frac - Fractured quartzite

Ss - Quartzitic sandstone from Skunweberg Group Formation

En - soft mudstone and unconsolidate material from the Enon Formation

Borehole Construction and Geological Log

Date compiled: 2007/10/18

BASIC SITE INFORMATION:

Site Identifier: 3421BBV0001 Number: GZ00353 Site type: Borehole

Distr./Farm No.: Site Name/Des.: KLEINBERG

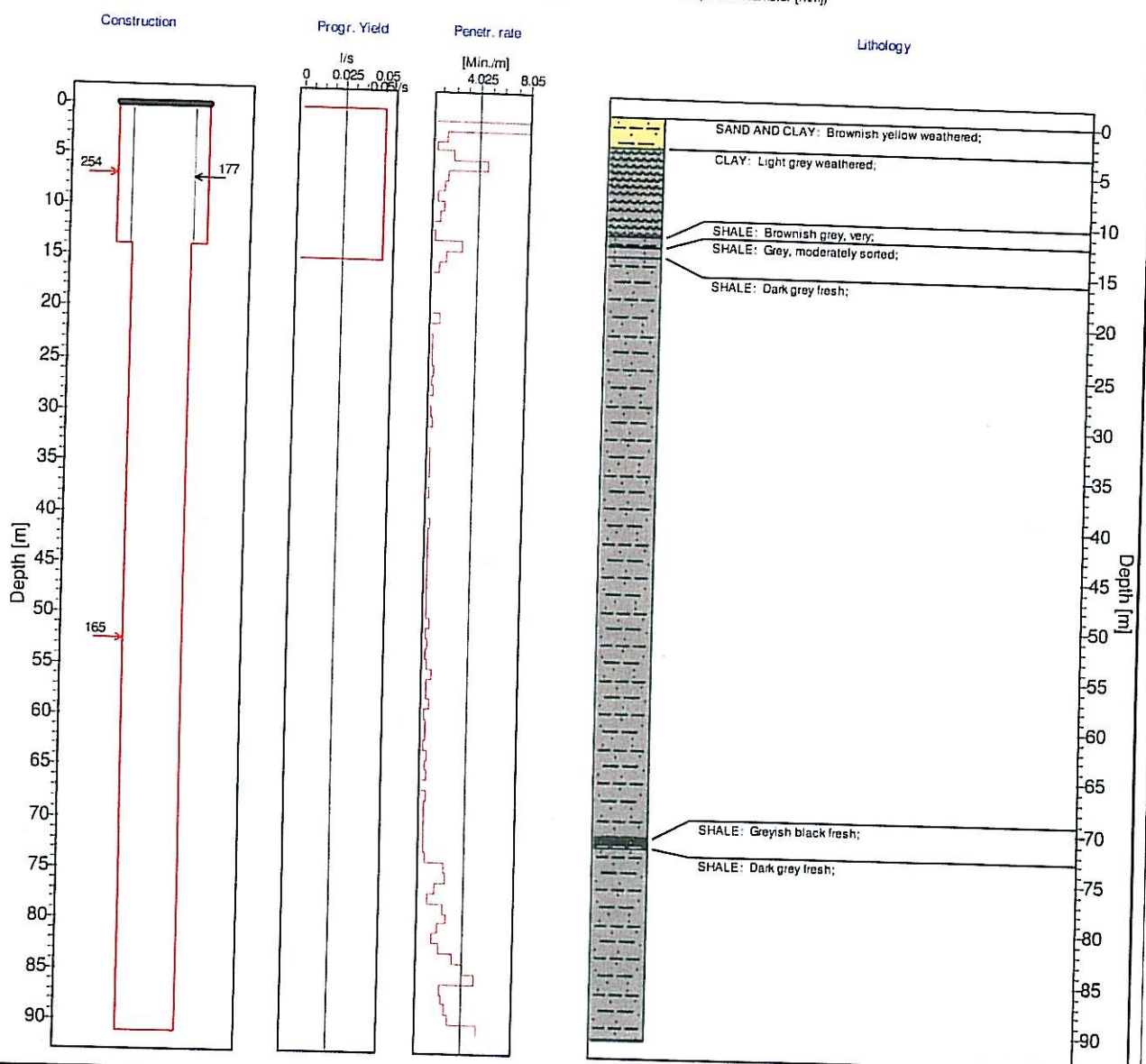
Region Type: Region Descr.: MOSSEL BAY MUNICIPALITY

| | | | |
|--|-----------|--------------|------------------|
| Latitude [°]: 34.169136 | Reg./BB.: | Topo-set.: | Depth [m]: 91.00 |
| Longitude [°]: 21.909270 | G-Nr.: | Site status: | Col. ht. [m]: |
| Altitude [m]: | | Site purp.: | Diam. [mm]: 177 |
| Coord. acc.: Accurate to within 10 units | | Use applic.: | Drain. reg.: |
| Coord. meth.: Global Positioning System | | Equipment: | Rep. inst.: |

Coordinate System: Geographic Decimal Degrees (Longitude/Latitude), WGS 1984

Construction and Geohydrological Legend

- Hole
- Casing (plain / perforated, stoted)
- Screen / Mesh Screen
- Piezometer
- Hole diameter [mm]
- Casing diameter [mm]
- Waterlevel with date meas.
- Piezometer (Nr. & Diameter [mm])



COMMENT:



VSA Leboa Consulting (Pty) Ltd.
 P.O. Box 222, Pietersburg, 0700
 Tel: (015) 298 8847/298 8702
 Fax: (015) 298 8082
 E-mail: vsaleboanels@mweb.co.za

3421 BB120

Borehole Construction and Geological Log

Date compiled: 2007/10/18

CONSTRUCTION:

| Date const. | Contractor | Constr. meth. | Type finish | Develop. Method | Durat. | Special treatment |
|-------------|-----------------------|---------------|-------------|-----------------|--------|-------------------|
| 20070626 | STEYNS DRILLING TRUST | | | | | |

HOLE DIAMETER:

| Date constr. | Depth to Top [m] | Depth to Bot. [m] | Diam. [mm] | Comment |
|--------------|------------------|-------------------|------------|---------|
| 20070626 | 0 | 14 | 254 | |
| 20070626 | 14 | 91 | 165 | |

CASING DETAILS:

| Date inst. | Depth to Top [m] | Depth to Bot. [m] | Diam. [mm] | Material | Type of Openings | Openings [mm] | | |
|------------|------------------|-------------------|------------|----------|------------------|---------------|-------------|-------------|
| | | | | | | Thickn. [mm] | Hori. dist. | Vert. dist. |
| 20070626 | 0.5 | 14 | 177 | S | | | | |

AQUIFER:

| AQUIFER type | Depth to Top [m] | Depth to Bot. [m] | Yield [l/s] | Method meas. | Comment |
|--------------|------------------|-------------------|-------------|--------------|---------|
| | 0 | 15 | 0.05 | N | |

GEOLOGY: Lithology colour, texture & feature

| Depth to Top [m] | Depth to Bot. [m] | Lithology | Colour | | | Texture | Feature | |
|------------------|-------------------|-----------|---------|-----------|--|---------|---------|-----------|
| | | | Primary | Secondary | | | Primary | Secondary |
| 0 | 3 | SDCL | Y | C | | | WT | |
| 3 | 12 | CLAY | H | L | | | WT | |
| 12 | 13 | SHLE | H | C | | | | |
| 13 | 14 | SHLE | H | | | | | |
| 14 | 71 | SHLE | H | D | | | FR | |
| 71 | 72 | SHLE | S | H | | | FR | |
| 72 | 91 | SHLE | H | D | | | FR | |

GEOLOGY: Sorting, Roundness & Notes

| Depth to Top [m] | Depth to Bot. [m] | Sorting | Roundness | Notes |
|------------------|-------------------|---------|-----------|-------|
| 0 | 3 | | | |
| 3 | 12 | | | |
| 12 | 13 | | | |
| 13 | 14 | 33 | | |
| 14 | 71 | | | |
| 71 | 72 | | | |
| 72 | 91 | | | |

GEOLOGY: Grain Distribution

| Depth to Top [m] | Depth to Bot. [m] | Silt | | | Sand | | | Gran-ular | | |
|------------------|-------------------|------|------|--------|--------|------|--------|-----------|--------|--------|
| | | Clay | Fine | Medium | Coarse | Fine | Medium | Coarse | Pebbly | Cobbly |
| 0 | 3 | | | | | | | | | |
| 3 | 12 | | | | | | | | | |
| 12 | 13 | | | | | | | | | |
| 13 | 14 | | | | | | | | | |
| 14 | 71 | | | | | | | | | |
| 71 | 72 | | | | | | | | | |
| 72 | 91 | | | | | | | | | |

COMMENT:



VSA Leboa Consulting (Pty) Ltd.
P.O. Box 222, Pietersburg, 0700
Tel: (015) 298 8847/298 8702
Fax: (015) 298 8082
E-mail: vsaleboanels@mweb.co.za

3421BB121

Borehole Construction and Geological Log

Date compiled: 2007/10/18

BASIC SITE INFORMATION:

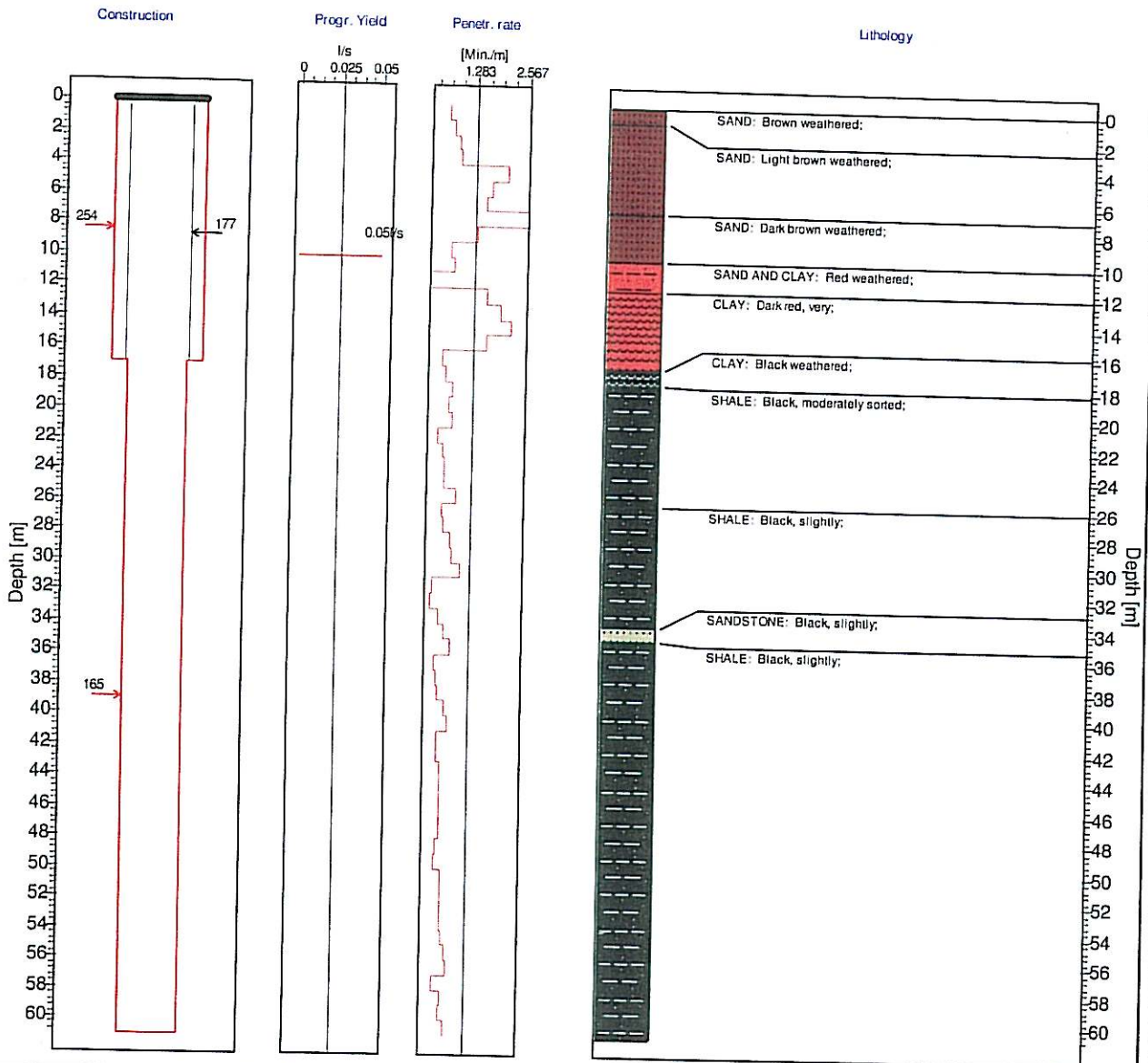
Site Identifier: 3421BBV0004 *Number:* GZ00354 *Site type:* Borehole
Distr./Farm No.: *Site Name/Des.:* KLEINBERG
Region Type: *Region Descr.:* MOSSEL BAY MUNICIPALITY

| | | | |
|---|------------------|---------------------|-------------------------|
| <i>Latitude [°]:</i> 34.169732 | <i>Reg./BB.:</i> | <i>Topo-set.:</i> | <i>Depth [m]:</i> 61.00 |
| <i>Longitude [°]:</i> 21.908533 | <i>G-Nr.:</i> | <i>Site status:</i> | <i>Col. ht. [m]:</i> |
| <i>Altitude [m]:</i> | | <i>Site purp.:</i> | <i>Diam. [mm]:</i> 165 |
| <i>Coord. acc.:</i> Accurate to within 10 000 units | | <i>Use applic.:</i> | <i>Drain. reg.:</i> |
| <i>Coord. meth.:</i> Global Positioning System | | <i>Equipment:</i> | <i>Rep. inst.:</i> DWAF |

Coordinate System: Geographic Decimal Degrees (Longitude/Latitude), WGS 1984

Construction and Geohydrological Legend

- Hole
- Casing (plain / perforated, slotted)
- Screen / Mesh Screen
- Piezometer
- Hole diameter [mm]
- Casing diameter [mm]
- Waterlevel with dato meas.
- Piezometer (Nr. & Diameter [mm])



COMMENT:



VSA Leboa Consulting (Pty) Ltd.
 P.O. Box 222, Pietersburg, 0700
 Tel: (015) 298 8847/298 8702
 Fax: (015) 298 8082
 E-mail: vsaleboanels@mweb.co.za

3421BB 121

Borehole Construction and Geological Log

Date compiled: 2007/10/18

CONSTRUCTION:

| Date const. | Contractor | Constr. meth. | Type finish | Develop. Method | Durat. | Special treatment |
|-------------|-----------------------|---------------|-------------|-----------------|--------|-------------------|
| 20070626 | STEYNS DRILLING TRUST | P | | | | |

HOLE DIAMETER:

| Date constr. | Depth to Top [m] | Depth to Bot. [m] | Diam. [mm] | Comment |
|--------------|------------------|-------------------|------------|---------|
| 20070626 | 0 | 17 | 254 | |
| 20070626 | 17 | 61 | 165 | |

CASING DETAILS:

| Date inst. | Depth to Top [m] | Depth to Bot. [m] | Diam. [mm] | Material | Type of Openings | Openings [mm] | | |
|------------|------------------|-------------------|------------|----------|------------------|---------------|-------------|-------------|
| | | | | | | Thickn. [mm] | Hori. dist. | Vert. dist. |
| 20070626 | 0.5 | 17 | 177 | S | N | 4 | | |

AQUIFER:

| AQUIFER type | Depth to Top [m] | Depth to Bot. [m] | Yield [l/s] | Method meas. | Comment |
|--------------|------------------|-------------------|-------------|--------------|---------|
| W | 10 | 10 | 0.05 | N | |

GEOLOGY: Lithology colour, texture & feature

| Depth to Top [m] | Depth to Bot. [m] | Lithology | Colour | | | Texture | | Feature | |
|------------------|-------------------|-----------|---------|-----------|---------|-----------|---------|-----------|--|
| | | | Primary | Secondary | Primary | Secondary | Primary | Secondary | |
| 0 | 1 | SAND | C | | | | | WT | |
| 1 | 7 | SAND | C | L | | | | WT | |
| 7 | 10 | SAND | C | D | | | | WT | |
| 10 | 12 | SDCL | R | | | | | WT | |
| 12 | 17 | CLAY | R | D | | | | | |
| 17 | 18 | CLAY | S | | | | | WT | |
| 18 | 26 | SHLE | S | | | | | | |
| 26 | 34 | SHLE | S | | | | | | |
| 34 | 35 | SNDS | S | | | | | | |
| 35 | 61 | SHLE | S | | | | | | |

GEOLOGY: Sorting, Roundness & Notes

| Depth to Top [m] | Depth to Bot. [m] | Sorting | Roundness | Notes |
|------------------|-------------------|---------|-----------|-------|
| 0 | 1 | | | |
| 1 | 7 | | | |
| 7 | 10 | | | |
| 10 | 12 | | | |
| 12 | 17 | | | |
| 17 | 18 | | | |
| 18 | 26 | 33 | | |
| 26 | 34 | | | |
| 34 | 35 | | | |
| 35 | 61 | | | |

GEOLOGY: Grain Distribution

| Depth to Top [m] | Depth to Bot. [m] | Clay | Silt | | | Sand | | | Gran-ular | | |
|------------------|-------------------|------|------|--------|--------|------|--------|--------|-----------|--------|----------|
| | | | Fine | Medium | Coarse | Fine | Medium | Coarse | Pebbly | Cobbly | Boulders |
| 0 | 1 | | | | | | | | | | |
| 1 | 7 | | | | | | | | | | |
| 7 | 10 | | | | | | | | | | |
| 10 | 12 | | | | | | | | | | |
| 12 | 17 | | | | | | | | | | |
| 17 | 18 | | | | | | | | | | |
| 18 | 26 | | | | | | | | | | |
| 26 | 34 | | | | | | | | | | |

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VSA Leboa Consulting (Pty) Ltd.
 P.O. Box 222, Pietersburg, 0700
 Tel: (015) 298 8847/298 8702
 Fax: (015) 298 8082
 E-mail: vsaleboanels@mweb.co.za

Borehole Construction and Geological Log

Date compiled: 2007/10/18

| | |
|----|----|
| 34 | 35 |
| 35 | 61 |

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P.O. Box 222, Pietersburg, 0700
Tel: (015) 298 8847/298 8702
Fax: (015) 298 8082
E-mail: vsaleboanels@mweb.co.za

Borehole Construction and Geological Log

Date compiled: 2007/10/18

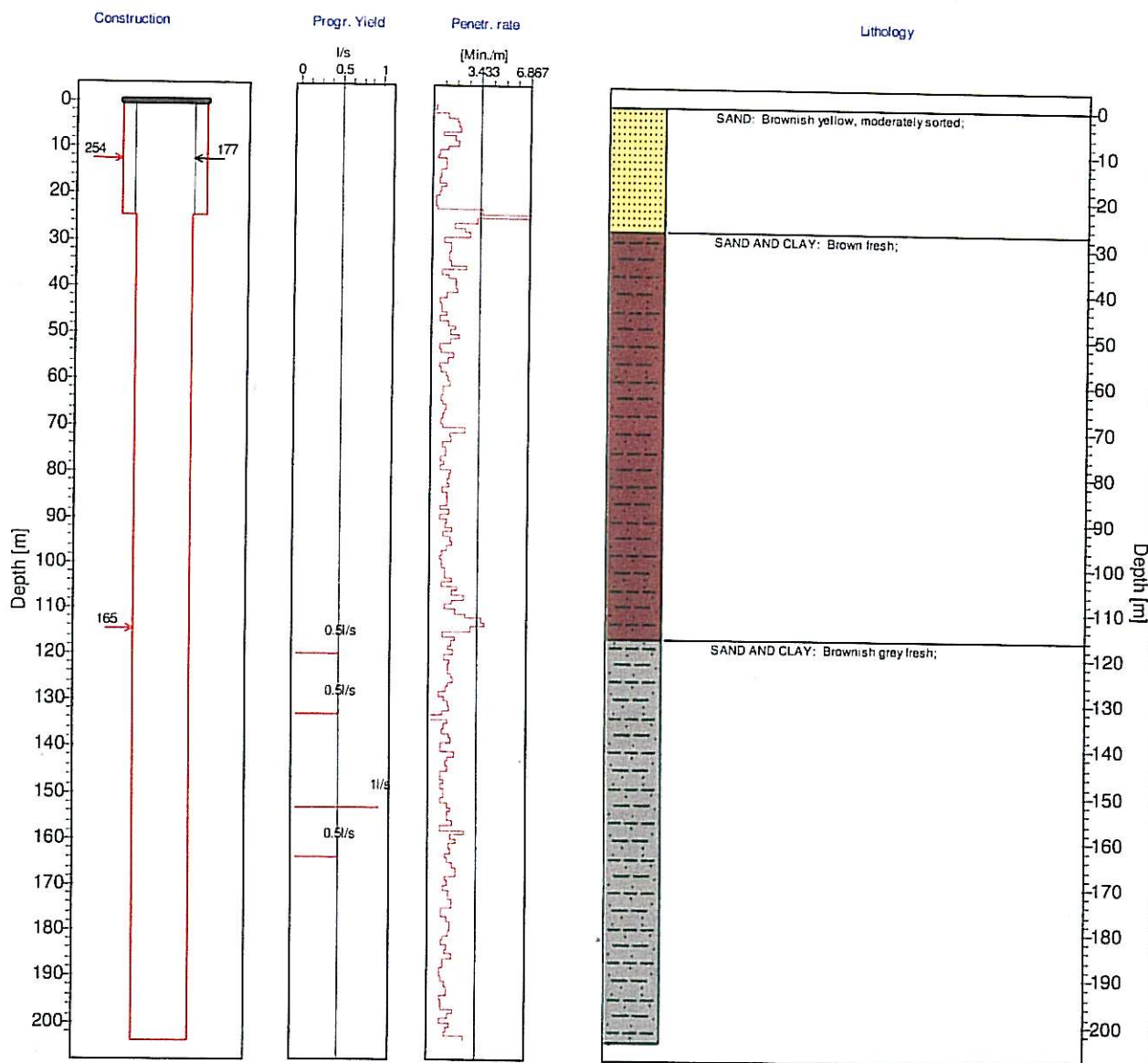
BASIC SITE INFORMATION: Site Identifier: 3421BBV0002 Number: GZ00355 Site type: Borehole
 Distr./Farm No.: Site Name/Des.: SPRINGER BAY
 Region Type: Region Descr.: MOSSEL BAY MUNICIPALITY

| | | | |
|--|-----------|--------------|-------------------|
| Latitude [°]: 34.224488 | Reg./BB.: | Topo-set.: | Depth [m]: 204.00 |
| Longitude [°]: 21.905996 | G-Nr.: | Site status: | Col. ht. [m]: |
| Altitude [m]: | | Site purp.: | Diam. [mm]: 165 |
| Coord. acc.: Accurate to within 10 units | | Use applic.: | Drain. reg.: |
| Coord. meth.: Global Positioning System | | Equipment: | Rep. inst.: DWAF |

Coordinate System: Geographic Decimal Degrees (Longitude/Latitude), WGS 1984

Construction and Geohydrological Legend

- Hole
- Casing (plain / perforated, slotted)
- Screen / Mesh Screen
- Piezometer
- 165 Hole diameter [mm]
- 152 Casing diameter [mm]
- Waterlevel with date meas.
- 0.50 Piezometer (Nr. & Diameter [mm])



COMMENT:



VSA Leboa Consulting (Pty) Ltd.
 P.O. Box 222, Pietersburg, 0700
 Tel: (015) 298 8847/298 8702
 Fax: (015) 298 8082
 E-mail: vsaleboanels@mweb.co.za

3421 BB 122

Borehole Construction and Geological Log

Date compiled: 2007/10/18

CONSTRUCTION:

| Date const. | Contractor | Constr. meth. | Type finish | Develop. Method | Durat. | Special treatment |
|-------------|-----------------------|---------------|-------------|-----------------|--------|-------------------|
| 20070630 | STEYNS DRILLING TRUST | P | | | | |

HOLE DIAMETER:

| Date constr. | Depth to Top [m] | Depth to Bot. [m] | Diam. [mm] | Comment |
|--------------|------------------|-------------------|------------|---------|
| 20070630 | 0 | 25 | 254 | |
| 20070630 | 25 | 204 | 165 | |

CASING DETAILS:

| Date inst. | Depth to Top [m] | Depth to Bot. [m] | Diam. [mm] | Material | Type of Openings | Openings [mm] | | |
|------------|------------------|-------------------|------------|----------|------------------|---------------|-------------|-------------|
| | | | | | | Thickn. [mm] | Hori. dist. | Vert. dist. |
| 20070630 | 0 | 25 | 177 | S | | | | 4 |

AQUIFER:

| Aquifer type | Depth to Top [m] | Depth to Bot. [m] | Yield [l/s] | Method meas. | Comment |
|--------------|------------------|-------------------|-------------|--------------|---------|
| | 120 | 120 | 0.5 | N | |
| | 133 | 133 | 0.5 | N | |
| | 153 | 153 | 1 | N | |
| | 164 | 164 | 0.5 | N | |

GEOLOGY: Lithology colour, texture & feature

| Depth to Top [m] | Depth to Bot. [m] | Lithology | Colour | | | Texture | Feature | |
|------------------|-------------------|-----------|---------|-----------|--|---------|---------|-----------|
| | | | Primary | Secondary | | | Primary | Secondary |
| 0 | 27 | SAND | Y | C | | | | |
| 27 | 116 | SDCL | C | | | FR | | |
| 116 | 204 | SDCL | H | C | | FR | | |

GEOLOGY: Sorting, Roundness & Notes

| Depth to Top [m] | Depth to Bot. [m] | Sorting | Roundness | Notes |
|------------------|-------------------|---------|-----------|-------|
| 0 | 27 | 33 | | |
| 27 | 116 | | | |
| 116 | 204 | | | |

GEOLOGY: Grain Distribution

| Depth to Top [m] | Depth to Bot. [m] | Clay | Silt | | | Sand | | | Gran-ular | Pebbly | Cobbly | Boulders |
|------------------|-------------------|------|------|--------|--------|------|--------|--------|-----------|--------|--------|----------|
| | | | Fine | Medium | Coarse | Fine | Medium | Coarse | | | | |
| 0 | 27 | | | | | | | | | | | |
| 27 | 116 | | | | | | | | | | | |
| 116 | 204 | | | | | | | | | | | |

COMMENT:



VSA Leboa Consulting (Pty) Ltd.
 P.O. Box 222, Pietersburg, 0700
 Tel: (015) 298 8847/298 8702
 Fax: (015) 298 8082
 E-mail: vsaleboanels@mweb.co.za

Borehole Construction and Geological Log

Date compiled: 2007/10/18

BASIC SITE INFORMATION:

Distr./Farm No.:

Site Identifier: 3421BBV0006 Number: GZ00356

Site type: Borehole

Region Type:





Site Name/Des.: SPRINGER BAY NAUTILUS

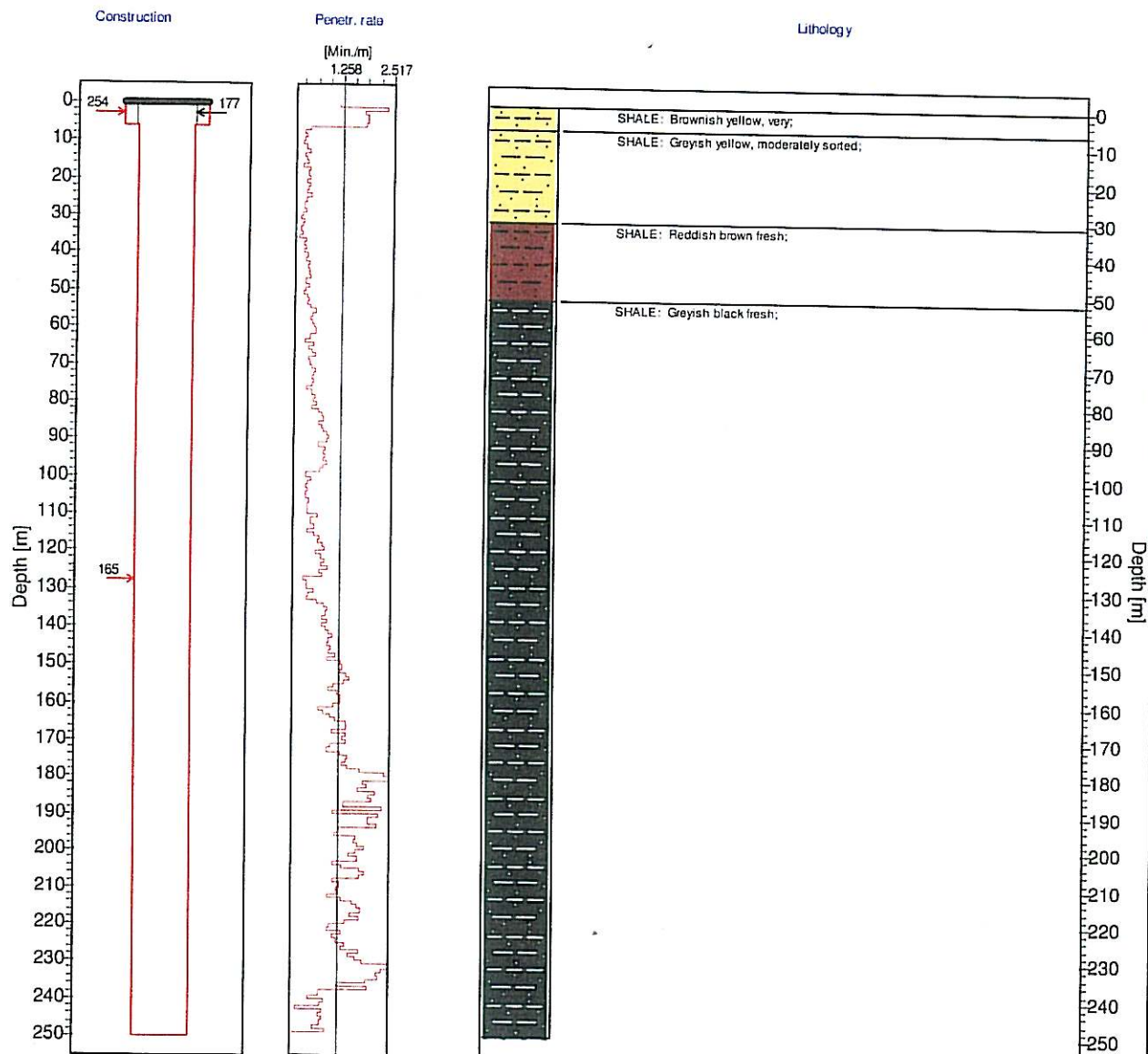
Region Descr.: MOSSEL BAY MUNICIPALITY

| | | | | | |
|----------------|---------------------------------|-----------|--------------|---------------|--------|
| Latitude [°]: | 34.196460 | Reg./BB.: | Topo-set.: | Depth [m]: | 250.00 |
| Longitude [°]: | 21.980130 | G-Nr.: | Site status: | Col. ht. [m]: | |
| Altitude [m]: | | | Site purp.: | Diam. [mm]: | 165 |
| Coord. acc.: | Accurate to within 10 000 units | | Use applic.: | Drain. reg.: | |
| Coord. meth.: | Global Positioning System | | Equipment: | Rep. inst.: | DWAF |

Coordinate System: Geographic Decimal Degrees (Longitude/Latitude), WGS 1984

Construction and Geohydrological Legend

| | | | |
|---|--------------------------------------|--------|----------------------------------|
|  | Hole | 165 → | Hole diameter [mm] |
|  | Casing (plain / perforated, slotted) | ← 152 | Casing diameter [mm] |
|  | Screen / Mesh Screen | ▼ | Waterlevel with date meas. |
|  | Piezometer | 0.50 → | Piezometer (Nr. & Diameter [mm]) |



COMMENT:



VSA Leboa Consulting (Pty) Ltd.
 P.O. Box 222, Pietersburg, 0700
 Tel: (015) 298 8847/298 8702
 Fax: (015) 298 8082
 E-mail: vsaleboanels@mweb.co.za

3421 BB 123

Borehole Construction and Geological Log

Date compiled: 2007/10/18

CONSTRUCTION:

| Date const. | Contractor | Constr. meth. | Type finish | Develop. Method | Durat. | Special treatment |
|-------------|-----------------------|---------------|-------------|-----------------|--------|-------------------|
| 20070704 | STEYNS DRILLING TRUST | P | | | | |

HOLE DIAMETER:

| Date constr. | Depth to Top [m] | Depth to Bot. [m] | Diam. [mm] | Comment |
|--------------|------------------|-------------------|------------|---------|
| 20070704 | 0 | 6 | 254 | |
| 20070704 | 6 | 250 | 165 | |

CASING DETAILS:

| Date inst. | Depth to Top [m] | Depth to Bot. [m] | Diam. [mm] | Material | Type of Openings | Openings [mm] | | |
|------------|------------------|-------------------|------------|----------|------------------|---------------|--------|-------------------------|
| | | | | | | Thickn. [mm] | Length | Hori. Vert. dist. dist. |
| 20070704 | 0 | 6 | 177 | S | N | 4.5 | | |

GEOLOGY: Lithology colour, texture & feature

| Depth to Top [m] | Depth to Bot. [m] | Lithology | Colour | | Texture | Feature | |
|------------------|-------------------|-----------|---------|-----------|---------|---------|-----------|
| | | | Primary | Secondary | | Primary | Secondary |
| 0 | 6 | SHLE | Y | C | | | |
| 6 | 31 | SHLE | Y | H | | | |
| 31 | 52 | SHLE | C | R | | | FR |
| 52 | 250 | SHLE | S | H | | | FR |

GEOLOGY: Sorting, Roundness & Notes

| Depth to Top [m] | Depth to Bot. [m] | Sorting | Roundness | Notes |
|------------------|-------------------|---------|-----------|-------|
| 0 | 6 | | | |
| 6 | 31 | 33 | | |
| 31 | 52 | | | |
| 52 | 250 | | | |

GEOLOGY: Grain Distribution

| Depth to Top [m] | Depth to Bot. [m] | Clay | Silt | | | Sand | | | Granular | Pebbly | Cobbly | Boulders |
|------------------|-------------------|------|------|--------|--------|------|--------|--------|----------|--------|--------|----------|
| | | | Fine | Medium | Coarse | Fine | Medium | Coarse | | | | |
| 0 | 6 | | | | | | | | | | | |
| 6 | 31 | | | | | | | | | | | |
| 31 | 52 | | | | | | | | | | | |
| 52 | 250 | | | | | | | | | | | |

COMMENT:



VSA Leboa Consulting (Pty) Ltd.
P.O. Box 222, Pietersburg, 0700
Tel: (015) 298 8847/298 8702
Fax: (015) 298 8082
E-mail: vsaleboanels@mweb.co.za

Borehole Construction and Geological Log

Date compiled: 2007/10/18

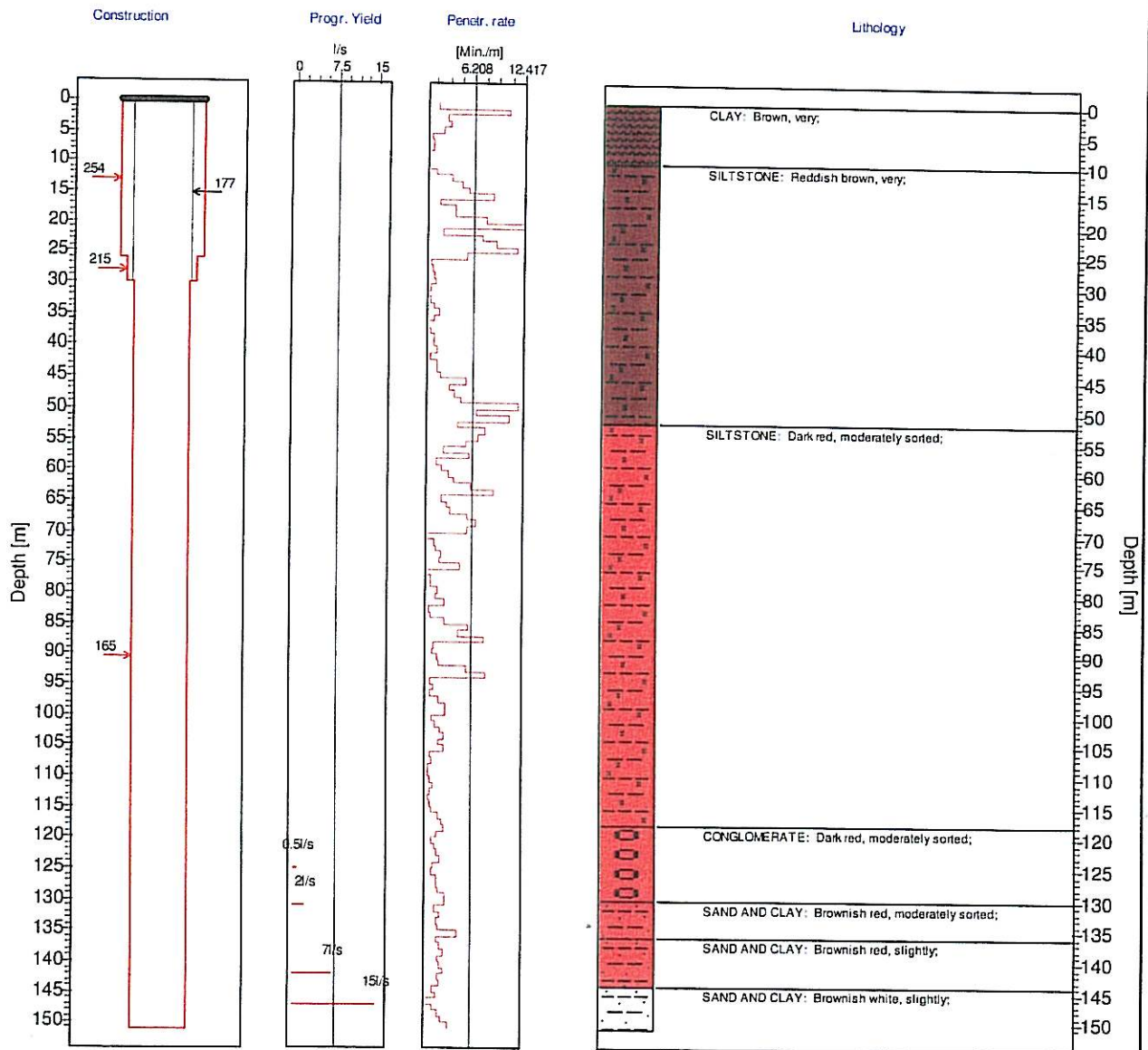
BASIC SITE INFORMATION: Site Identifier: 3421BDV0001 Number: GZ00357 Site type: Borehole
 Distr./Farm No.: Site Name/Des.: SPRINGER-BAY-VLEESBAAI
 Region Type: Region Descr.: MOSSEL BAY MUNICIPALITY

| | | | |
|--|-----------|--------------|-------------------|
| Latitude [°]: 34.290147 | Reg./BB.: | Topo-set.: | Depth [m]: 151.00 |
| Longitude [°]: 21.888938 | G-Nr.: | Site status: | Col. ht. [m]: |
| Altitude [m]: | | Site purp.: | Diam. [mm]: 165 |
| Coord. acc.: Accurate to within 10 units | | Use applic.: | Drain. reg.: |
| Coord. meth.: Global Positioning System | | Equipment: | Rep. inst.: DWAF |

Coordinate System: Geographic Decimal Degrees (Longitude/Latitude), WGS 1984

Construction and Geohydrological Legend

- Hole
- Casing (plain / perforated, slotted)
- Screen / Mesh Screen
- Piezometer
- Hole diameter [mm]
- Casing diameter [mm]
- Waterlevel with date meas.
- Piezometer (Nr. & Diameter [mm])



COMMENT:



VSA Leboa Consulting (Pty) Ltd.
 P.O. Box 222, Pietersburg, 0700
 Tel: (015) 298 8847/298 8702
 Fax: (015) 298 8082
 E-mail: vsaleboanels@mweb.co.za

Borehole Construction and Geological Log

Date compiled: 2007/10/18

CONSTRUCTION:

| Date const. | Contractor | Constr. meth. | Type finish | Develop. Method | Durat. | Special treatment |
|-------------|-----------------------|---------------|-------------|-----------------|--------|-------------------|
| 20070706 | STEYNS DRILLING TRUST | P | | | | |

HOLE DIAMETER:

| Date constr. | Depth to Top [m] | Depth to Bot. [m] | Diam. [mm] | Comment |
|--------------|------------------|-------------------|------------|---------|
| 20070706 | 0 | 26 | 254 | |
| 20070706 | 26 | 30 | 215 | |
| 20070706 | 30 | 151 | 165 | |

CASING DETAILS:

| Date inst. | Depth to Top [m] | Depth to Bot. [m] | Diam. [mm] | Material | Type of Openings | Openings [mm] | | | |
|------------|------------------|-------------------|------------|----------|------------------|---------------|--------|-------|-------------------------|
| | | | | | | Thickn. [mm] | Length | Width | Hori. Vert. dist. dist. |
| 20070706 | 0.5 | 30 | 177 | S | N | | | | 4 |

AQUIFER:

| Aquifer type | Depth to Top [m] | Depth to Bot. [m] | Yield [l/s] | Method meas. | Comment |
|--------------|------------------|-------------------|-------------|--------------|---------|
| | 125 | 125 | 0.5 | N | |
| | 131 | 131 | 2 | N | |
| | 142 | 142 | 7 | N | |
| | 147 | 147 | 15 | N | |

GEOLOGY: Lithology colour, texture & feature

| Depth to Top [m] | Depth to Bot. [m] | Lithology | Colour | | | Feature | | |
|------------------|-------------------|-----------|---------|-----------|---------|---------|-----------|--|
| | | | Primary | Secondary | Texture | Primary | Secondary | |
| 0 | 10 | CLAY | C | | | | | |
| 10 | 52 | SLSN | C | R | | | | |
| 52 | 118 | SLSN | R | D | | | | |
| 118 | 130 | CLGM | R | D | | | | |
| 130 | 136 | SDCL | R | C | | | | |
| 136 | 144 | SDCL | R | C | | | | |
| 144 | 151 | SDCL | W | C | | | | |

GEOLOGY: Sorting, Roundness & Notes

| Depth to Top [m] | Depth to Bot. [m] | Sorting | Roundness | Notes |
|------------------|-------------------|---------|-----------|-------|
| 0 | 10 | | | |
| 10 | 52 | | | |
| 52 | 118 | 33 | | |
| 118 | 130 | 33 | | |
| 130 | 136 | 33 | | |
| 136 | 144 | | | |
| 144 | 151 | | | |

GEOLOGY: Grain Distribution

| Depth to Top [m] | Depth to Bot. [m] | Clay | Silt | | | Sand | | | Gran-ular | | | Cobbly | Boulders |
|------------------|-------------------|------|------|--------|--------|------|--------|--------|-----------|--|--|--------|----------|
| | | | Fine | Medium | Coarse | Fine | Medium | Coarse | | | | | |
| 0 | 10 | | | | | | | | | | | | |
| 10 | 52 | | | | | | | | | | | | |
| 52 | 118 | | | | | | | | | | | | |
| 118 | 130 | | | | | | | | | | | | |
| 130 | 136 | | | | | | | | | | | | |
| 136 | 144 | | | | | | | | | | | | |
| 144 | 151 | | | | | | | | | | | | |

COMMENT:



VSA Leboa Consulting (Pty) Ltd.
P.O. Box 222, Pietersburg, 0700
Tel: (015) 298 8847/298 8702
Fax: (015) 298 8082
E-mail: vsaleboanels@mweb.co.za

Borehole Construction and Geological Log

Date compiled: 2007/10/18

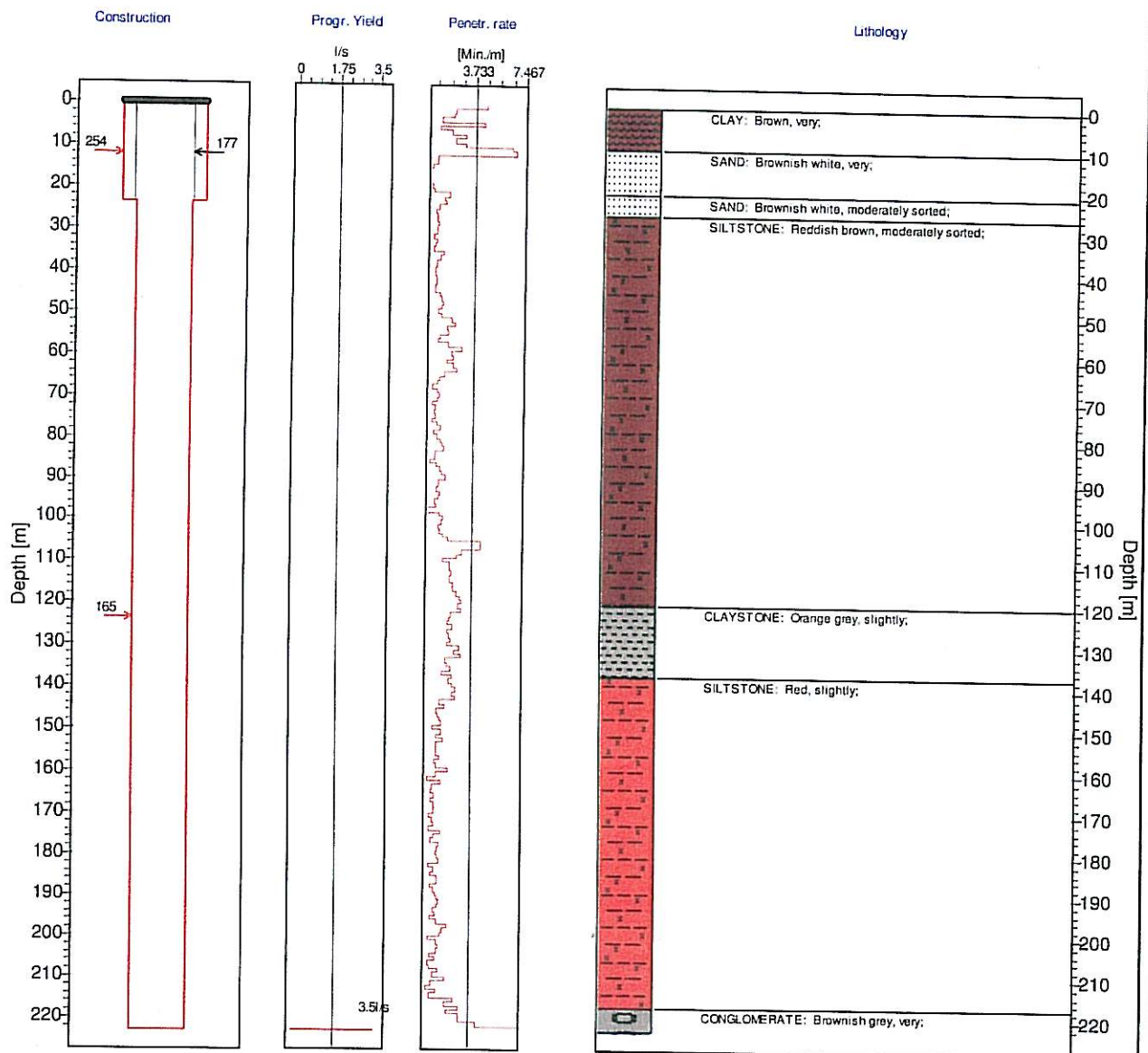
BASIC SITE INFORMATION: Site Identifier: 3421BDV0002 Number: GZ00358 Site type: Borehole
 Distr./Farm No.: Site Name/Des.: SPRINGER BAY Moss Baaie
 Region Type: Region Descr.: MOSSEL BAY MINICIPALITY

| | | | |
|--|-----------|--------------|-------------------|
| Latitude [°]: 34.285731 | Reg./BB.: | Topo-set.: | Depth [m]: 223.00 |
| Longitude [°]: 21.888468 | G-Nr.: | Site status: | Col. ht. [m]: |
| Altitude [m]: | | Site purp.: | Diam. [mm]: 165 |
| Coord. acc.: Accurate to within 10 units | | Use applic.: | Drain. reg.: |
| Coord. meth.: Global Positioning System | | Equipment: | Rep. inst.: DWAF |

Coordinate System: Geographic Decimal Degrees (Longitude/Latitude), WGS 1984

Construction and Geohydrological Legend

- Hole
- Casing (plain / perforated, slotted)
- Screen / Mesh Screen
- Piezometer
- 165 Hole diameter [mm]
- 152 Casing diameter [mm]
- Waterlevel with date meas.
- 0:50 Piezometer (Nr. & Diameter [mm])



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 Fax: (015) 298 8082
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Borehole Construction and Geological Log

Date compiled: 2007/10/18

CONSTRUCTION:

| Date const. | Contractor | Constr. meth. | Type finish | Develop. Method | Durat. | Special treatment |
|-------------|-----------------------|---------------|-------------|-----------------|--------|-------------------|
| 20070706 | STEYNS DRILLING TRUST | P | | | | |

HOLE DIAMETER:

| Date constr. | Depth to Top [m] | Depth to Bot. [m] | Diam. [mm] | Comment |
|--------------|------------------|-------------------|------------|---------|
| 20070706 | 0 | 24 | 254 | |
| 20070706 | 24 | 223 | 165 | |

CASING DETAILS:

| Date inst. | Depth to Top [m] | Depth to Bot. [m] | Diam. [mm] | Material | Type of Openings | Openings [mm] | | |
|------------|------------------|-------------------|------------|----------|------------------|---------------|-------------|-------------|
| | | | | | | Thickn. [mm] | Hori. dist. | Vert. dist. |
| 20070706 | 0 | 24 | 177 | S | N | 4.5 | | |

AQUIFER:

| Aquifer type | Depth to Top [m] | Depth to Bot. [m] | Yield [l/s] | Method meas. | Comment |
|--------------|------------------|-------------------|-------------|--------------|---------|
| | 223 | 223 | 3.5 | N | |

GEOLOGY: Lithology colour, texture & feature

| Depth to Top [m] | Depth to Bot. [m] | Lithology | Colour | | Texture | Feature | |
|------------------|-------------------|-----------|---------|-----------|---------|---------|-----------|
| | | | Primary | Secondary | | Primary | Secondary |
| 0 | 10 | CLAY | C | | | | |
| 10 | 21 | SAND | W | C | | | |
| 21 | 26 | SAND | W | C | | | |
| 26 | 120 | SLSN | C | R | | | |
| 120 | 137 | CLSN | H | O | | | |
| 137 | 217 | SLSN | R | | | | |
| 217 | 223 | CLGM | H | C | | | |

GEOLOGY: Sorting, Roundness & Notes

| Depth to Top [m] | Depth to Bot. [m] | Sorting | Roundness | Notes |
|------------------|-------------------|---------|-----------|-------|
| 0 | 10 | | | |
| 10 | 21 | | | |
| 21 | 26 | 33 | | |
| 26 | 120 | 33 | | |
| 120 | 137 | | | |
| 137 | 217 | | | |
| 217 | 223 | | | |

GEOLOGY: Grain Distribution

| Depth to Top [m] | Depth to Bot. [m] | Clay | | | Silt | | | Sand | | | Granular | | | Pebbly | Cobbly | Boulders |
|------------------|-------------------|------|--------|--------|------|--------|--------|------|--------|--------|----------|--|--|--------|--------|----------|
| | | Fine | Medium | Coarse | Fine | Medium | Coarse | Fine | Medium | Coarse | | | | | | |
| 0 | 10 | | | | | | | | | | | | | | | |
| 10 | 21 | | | | | | | | | | | | | | | |
| 21 | 26 | | | | | | | | | | | | | | | |
| 26 | 120 | | | | | | | | | | | | | | | |
| 120 | 137 | | | | | | | | | | | | | | | |
| 137 | 217 | | | | | | | | | | | | | | | |
| 217 | 223 | | | | | | | | | | | | | | | |

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VSA Leboa Consulting (Pty) Ltd.
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 E-mail: vsaleboanels@mweb.co.za

Borehole Construction and Geological Log

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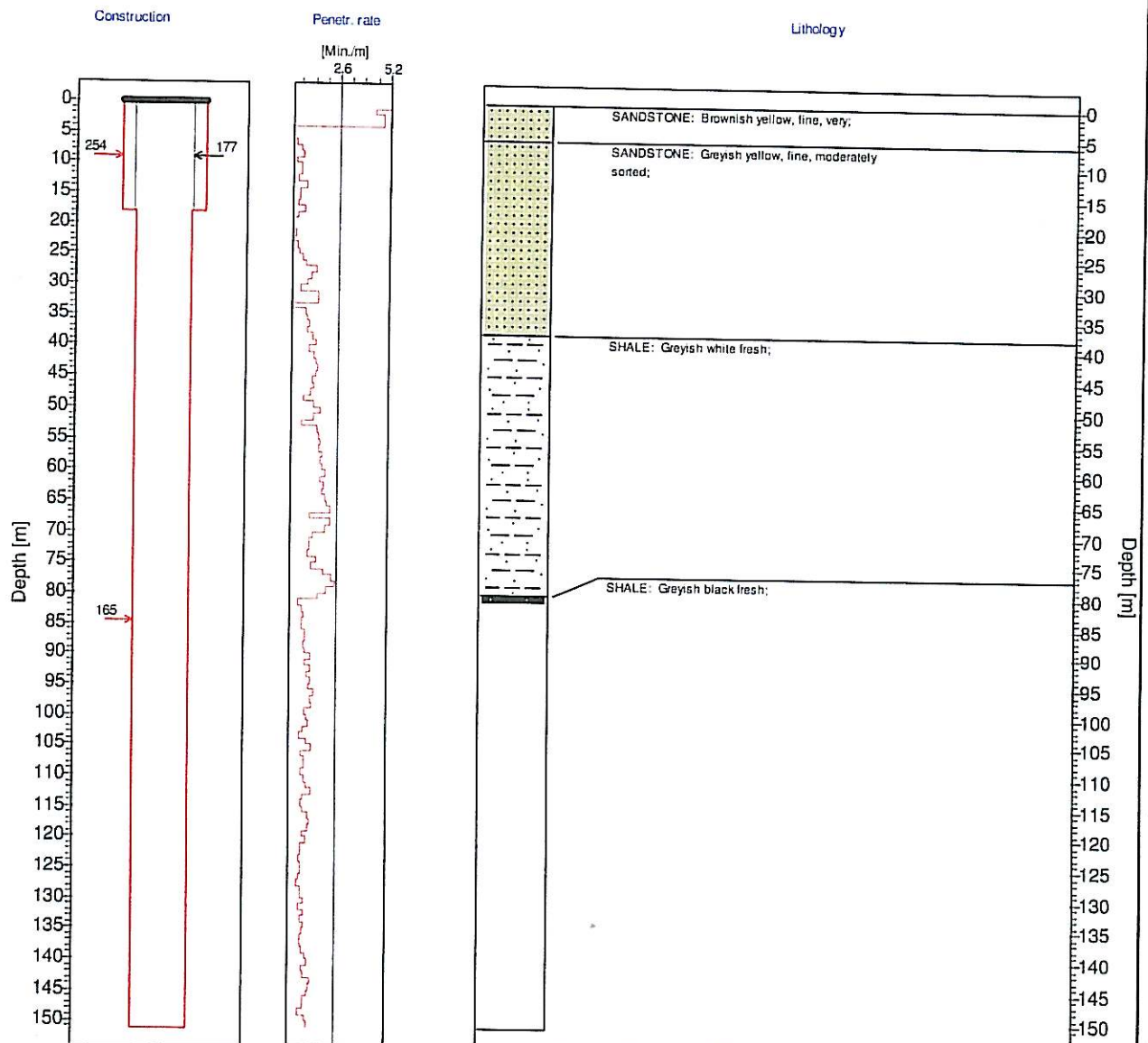
BASIC SITE INFORMATION: Site Identifier: 3421BBV0007 Number: GZ00359 Site type: Borehole
 Distr./Farm No.: Site Name/Des.: SPRINGER BAY
 Region Type: Region Descr.: MOSSEL BAY MUNICIPALITY

| | | | |
|--|-----------|--------------|-------------------|
| Latitude [°]: 34.197276 | Reg./BB.: | Topo-set.: | Depth [m]: 151.00 |
| Longitude [°]: 21.980351 | G-Nr.: | Site status: | Col. ht. [m]: |
| Altitude [m]: | | Site purp.: | Diam. [mm]: 165 |
| Coord. acc.: Accurate to within 10 units | | Use applic.: | Drain. reg.: |
| Coord. meth.: Global Positioning System | | Equipment: | Rep. inst.: DWAF |

Coordinate System: Geographic Decimal Degrees (Longitude/Latitude), WGS 1984

Construction and Geohydrological Legend

- Hole
- Casing (plain / perforated, slotted)
- Screen / Mesh Screen
- Piezometer
- Hole diameter [mm]
- Casing diameter [mm]
- Waterlevel with date meas.
- Piezometer (Nr. & Diameter [mm])



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VSA Leboa Consulting (Pty) Ltd.
 P.O. Box 222, Pietersburg, 0700
 Tel: (015) 298 8847/298 8702
 Fax: (015) 298 8082
 E-mail: vsaleboanels@mweb.co.za

3421 66 124

Borehole Construction and Geological Log

Date compiled: 2007/10/18

CONSTRUCTION:

| Date const. | Contractor | Constr. meth. | Type finish | Develop. Method | Durat. | Special treatment |
|-------------|-----------------------|---------------|-------------|-----------------|--------|-------------------|
| 20070708 | STEYNS DRILLING TRUST | P | | | | |

HOLE DIAMETER:

| Date constr. | Depth to Top [m] | Depth to Bot. [m] | Diam. [mm] | Comment |
|--------------|------------------|-------------------|------------|---------|
| 20070708 | 0 | 18 | 254 | |
| 20070708 | 18 | 151 | 165 | |

CASING DETAILS:

| Date inst. | Depth to Top [m] | Depth to Bot. [m] | Diam. [mm] | Material | Type of Openings | Openings [mm] | | |
|------------|------------------|-------------------|------------|----------|------------------|---------------|--------------|-------------|
| | | | | | | Thickn. [mm] | Hori. Length | Vert. dist. |
| 20070708 | 0 | 18 | 177 | S | N | 4.5 | | |

GEOLOGY: Lithology colour, texture & feature

| Depth to Top [m] | Depth to Bot. [m] | Lithology | Colour | | | Texture | | Feature | |
|------------------|-------------------|-----------|---------|-----------|----|---------|-----------|---------|-----------|
| | | | Primary | Secondary | | Primary | Secondary | Primary | Secondary |
| 0 | 6 | SNDS | Y | C | 22 | | | | |
| 6 | 38 | SNDS | Y | H | 22 | | | | |
| 38 | 80 | SHLE | W | H | | | FR | | |
| 80 | 81 | SHLE | S | H | | | FR | | |

GEOLOGY: Sorting, Roundness & Notes

| Depth to Top [m] | Depth to Bot. [m] | Sorting | Roundness | Notes |
|------------------|-------------------|---------|-----------|-------|
| 0 | 6 | | | |
| 6 | 38 | 33 | | |
| 38 | 80 | | | |
| 80 | 81 | | | |

GEOLOGY: Grain Distribution

| Depth to Top [m] | Depth to Bot. [m] | Clay | Silt | | | Sand | | | Granular | Pebbly | Cobbly | Boulders |
|------------------|-------------------|------|------|--------|--------|------|--------|--------|----------|--------|--------|----------|
| | | | Fine | Medium | Coarse | Fine | Medium | Coarse | | | | |
| 0 | 6 | | | | | | | | | | | |
| 6 | 38 | | | | | | | | | | | |
| 38 | 80 | | | | | | | | | | | |
| 80 | 81 | | | | | | | | | | | |

COMMENT:



VSA Leboa Consulting (Pty) Ltd.
P.O. Box 222, Pietersburg, 0700
Tel: (015) 298 8847/298 8702
Fax: (015) 298 8082
E-mail: vsaleboanels@mweb.co.za

Borehole Construction and Geological Log

Date compiled: 2007/10/18

BASIC SITE INFORMATION: Site Identifier: 3421BBV0005 Number: GZ00360 Site type: Borehole

Distr./Farm No.: Site Name/Des.: KLEINBERG

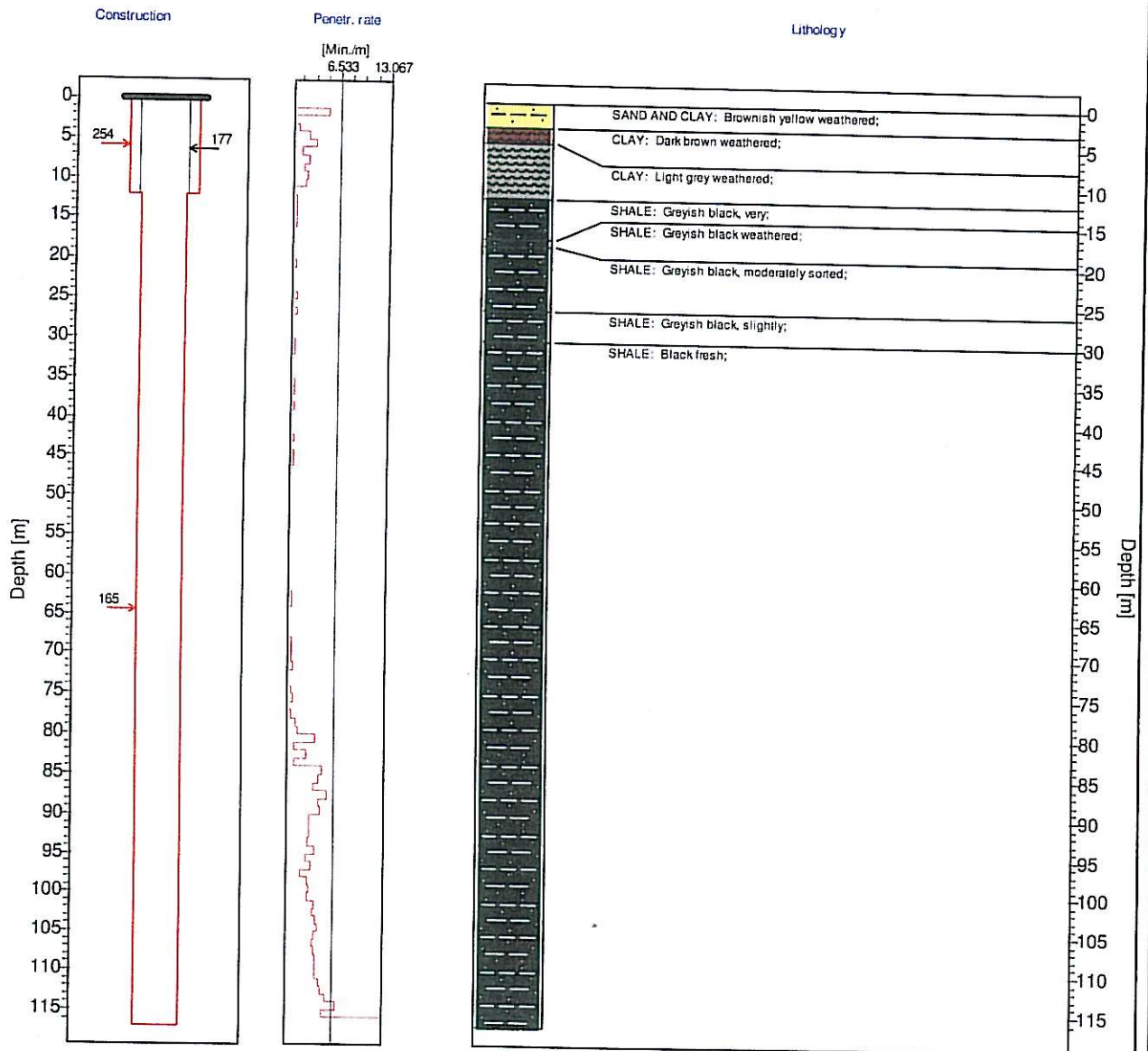
Region Type: Region Descr.: MOSSEL BAY MUNICIPALITY

| | | | |
|--|-----------|--------------|-------------------|
| Latitude [°]: 34.169214 | Reg./BB.: | Topo-set.: | Depth [m]: 117.00 |
| Longitude [°]: 21.909171 | G-Nr.: | Site status: | Col. ht. [m]: |
| Altitude [m]: | | Site purp.: | Diam. [mm]: 165 |
| Coord. acc.: Accurate to within 10 000 units | | Use applic.: | Drain. reg.: |
| Coord. meth.: Global Positioning System | | Equipment: | Rep. inst.: DWAF |

Coordinate System: Geographic Decimal Degrees (Longitude/Latitude), WGS 1984

Construction and Geohydrological Legend

| | | | |
|--|--------------------------------------|--------|----------------------------------|
| | Hole | 165 → | Hole diameter [mm] |
| | Casing (plain / perforated, slotted) | ← 152 | Casing diameter [mm] |
| | Screen / Mesh Screen | ▼ | Water level with date meas. |
| | Piezometer | 0.50 → | Piezometer (Nr. & Diameter [mm]) |



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VSA Leboa Consulting (Pty) Ltd.
 P.O. Box 222, Pietersburg, 0700
 Tel: (015) 298 8847/298 8702
 Fax: (015) 298 8082
 E-mail: vsaleboanels@mweb.co.za

34216B 125

Borehole Construction and Geological Log

Date compiled: 2007/10/18

CONSTRUCTION:

| Date const. | Contractor | Constr. meth. | Type finish | Develop. Method | Durat. | Special treatment |
|-------------|-----------------------|---------------|-------------|-----------------|--------|-------------------|
| 20070709 | STEYNS DRILLING TRUST | P | | | | |

HOLE DIAMETER:

| Date constr. | Depth to Top [m] | Depth to Bot. [m] | Diam. [mm] | Comment |
|--------------|------------------|-------------------|------------|---------|
| 20070709 | 0 | 12 | 254 | |
| 20070709 | 12 | 117 | 165 | |

CASING DETAILS:

| Date inst. | Depth to Top [m] | Depth to Bot. [m] | Diam. [mm] | Material | Type of Openings | Openings [mm] | | |
|------------|------------------|-------------------|------------|----------|------------------|---------------|--------|-------------------------|
| | | | | | | Thickn. [mm] | Length | Hori. Vert. dist. dist. |
| 20070709 | 0.5 | 12 | 177 | S | N | 4 | | |

GEOLOGY: Lithology colour, texture & feature

| Depth to Top [m] | Depth to Bot. [m] | Lithology | Colour | | | Feature | | |
|------------------|-------------------|-----------|---------|-----------|---------|---------|-----------|----|
| | | | Primary | Secondary | Texture | Primary | Secondary | |
| 0 | 3 | SDCL | Y | C | | | | WT |
| 3 | 5 | CLAY | C | D | | | | WT |
| 5 | 12 | CLAY | H | L | | | | WT |
| 12 | 17 | SHLE | S | H | | | | WT |
| 17 | 18 | SHLE | S | H | | | | WT |
| 18 | 26 | SHLE | S | H | | | | WT |
| 26 | 30 | SHLE | S | H | | | | |
| 30 | 117 | SHLE | S | H | | | | FR |

GEOLOGY: Sorting, Roundness & Notes

| Depth to Top [m] | Depth to Bot. [m] | Sorting | Roundness | Notes |
|------------------|-------------------|---------|-----------|-------|
| 0 | 3 | | | |
| 3 | 5 | | | |
| 5 | 12 | | | |
| 12 | 17 | | | |
| 17 | 18 | | | |
| 18 | 26 | 33 | | |
| 26 | 30 | | | |
| 30 | 117 | | | |

GEOLOGY: Grain Distribution

| Depth to Top [m] | Depth to Bot. [m] | Clay | Silt | | | Sand | | | Granular | Pebbly | Cobbly | Boulders |
|------------------|-------------------|------|------|--------|--------|------|--------|--------|----------|--------|--------|----------|
| | | | Fine | Medium | Coarse | Fine | Medium | Coarse | | | | |
| 0 | 3 | | | | | | | | | | | |
| 3 | 5 | | | | | | | | | | | |
| 5 | 12 | | | | | | | | | | | |
| 12 | 17 | | | | | | | | | | | |
| 17 | 18 | | | | | | | | | | | |
| 18 | 26 | | | | | | | | | | | |
| 26 | 30 | | | | | | | | | | | |
| 30 | 117 | | | | | | | | | | | |

COMMENT:



VSA Leboa Consulting (Pty) Ltd.
 P.O. Box 222, Pietersburg, 0700
 Tel: (015) 298 8847/298 8702
 Fax: (015) 298 8082
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Borehole Construction and Geological Log

Date compiled: 2007/10/18

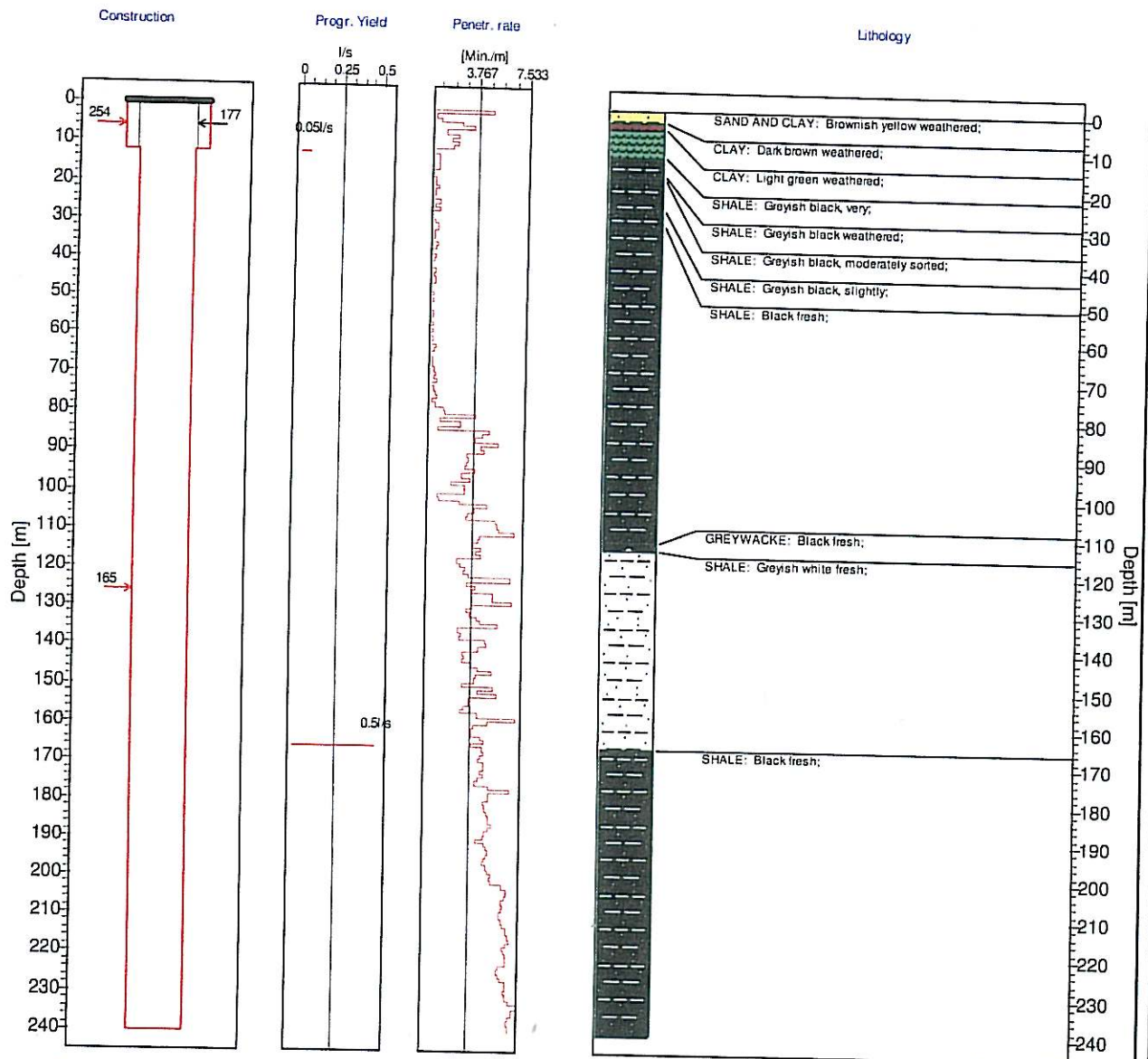
BASIC SITE INFORMATION: Site Identifier: 3421BBV0003 Number: GZ00361 Site type: Borehole
 Distr./Farm No.: Site Name/Des.: KLEINBERG
 Region Type: Region Descr.: MOSSEL BAY MUNICIPALITY

| | | | |
|--|-----------|--------------|-------------------|
| Latitude [°]: 34.169400 | Reg./BB.: | Topo-set.: | Depth [m]: 240.00 |
| Longitude [°]: 21.908946 | G-Nr.: | Site status: | Col. ht. [m]: |
| Altitude [m]: | | Site purp.: | Diam. [mm]: 165 |
| Coord. acc.: Accurate to within 10 units | | Use applic.: | Drain. reg.: |
| Coord. meth.: Global Positioning System | | Equipment: | Rep. inst.: DWAF |

Coordinate System: Geographic Decimal Degrees (Longitude/Latitude), WGS 1984

Construction and Geohydrological Legend

| | | | |
|--|--------------------------------------|--------|----------------------------------|
| | Hole | 165 → | Hole diameter [mm] |
| | Casing (plain / perforated, slotted) | ← 152 | Casing diameter [mm] |
| | Screen / Mesh Screen | ▼ | Waterlevel with date meas. |
| | Piezometer | 0:50 → | Piezometer (Nr. & Diameter [mm]) |



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VSA Leboa Consulting (Pty) Ltd.
 P.O. Box 222, Pietersburg, 0700
 Tel: (015) 298 8847/298 8702
 Fax: (015) 298 8082
 E-mail: vsaleboanels@mweb.co.za

3421 BB 126

Borehole Construction and Geological Log

Date compiled: 2007/10/18

CONSTRUCTION:

| Date const. | Contractor | Constr. meth. | Type finish | Develop. Method | Durat. | Special treatment |
|-------------|-----------------------|---------------|-------------|-----------------|--------|-------------------|
| 20070710 | STEYNS DRILLING TRUST | P | | | | |

HOLE DIAMETER:

| Date constr. | Depth to Top [m] | Depth to Bot. [m] | Diam. [mm] | Comment |
|--------------|------------------|-------------------|------------|---------|
| 20070710 | 0 | 12 | 254 | |
| 20070710 | 12 | 240 | 165 | |

CASING DETAILS:

| Date inst. | Depth to Top [m] | Depth to Bot. [m] | Diam. [mm] | Material | Type of Openings | Openings [mm] | | |
|------------|------------------|-------------------|------------|----------|------------------|---------------|--------|-------------------------|
| | | | | | | Thickn. [mm] | Length | Hori. Vert. dist. dist. |
| 20070710 | 0 | 12 | 177 | S | N | 4 | | |

AQUIFER:

| Aquifer type | Depth to Top [m] | Depth to Bot. [m] | Yield [l/s] | Method meas. | Comment |
|--------------|------------------|-------------------|-------------|--------------|---------|
| W | 12 | 12 | 0.05 | N | |
| | 166 | 166 | 0.5 | N | |

GEOLOGY: Lithology colour, texture & feature

| Depth to Top [m] | Depth to Bot. [m] | Lithology | Colour | | | Texture | Feature | |
|------------------|-------------------|-----------|---------|-----------|--|---------|---------|-----------|
| | | | Primary | Secondary | | | Primary | Secondary |
| 0 | 3 | SDCL | Y | C | | | WT | |
| 3 | 5 | CLAY | C | D | | | WT | |
| 5 | 12 | CLAY | G | L | | | WT | |
| 12 | 17 | SHLE | S | H | | | | |
| 17 | 18 | SHLE | S | H | | | WT | |
| 18 | 26 | SHLE | S | H | | | | |
| 26 | 30 | SHLE | S | H | | | | |
| 30 | 112 | SHLE | S | | | | FR | |
| 112 | 114 | GRCK | S | | | | FR | |
| 114 | 166 | SHLE | W | H | | | FR | |
| 166 | 240 | SHLE | S | | | | FR | |

GEOLOGY: Sorting, Roundness & Notes

| Depth to Top [m] | Depth to Bot. [m] | Sorting | Roundness | Notes |
|------------------|-------------------|---------|-----------|-------|
| 0 | 3 | | | |
| 3 | 5 | | | |
| 5 | 12 | | | |
| 12 | 17 | | | |
| 17 | 18 | | | |
| 18 | 26 | 33 | | |
| 26 | 30 | | | |
| 30 | 112 | | | |
| 112 | 114 | | | |
| 114 | 166 | | | |
| 166 | 240 | | | |

GEOLOGY: Grain Distribution

| Depth to Top [m] | Depth to Bot. [m] | Clay | Silt | | | Sand | | | Granular | | | Cobbly | Boulders |
|------------------|-------------------|------|------|--------|--------|------|--------|--------|----------|--------|--|--------|----------|
| | | | Fine | Medium | Coarse | Fine | Medium | Coarse | ular | Pebbly | | | |
| 0 | 3 | | | | | | | | | | | | |
| 3 | 5 | | | | | | | | | | | | |
| 5 | 12 | | | | | | | | | | | | |
| 12 | 17 | | | | | | | | | | | | |
| 17 | 18 | | | | | | | | | | | | |

COMMENT:



VSA Leboa Consulting (Pty) Ltd.
P.O. Box 222, Pietersburg, 0700
Tel: (015) 298 8847/298 8702
Fax: (015) 298 8082
E-mail: vsaleboanels@mweb.co.za

Borehole Construction and Geological Log

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| | |
|-----|-----|
| 18 | 26 |
| 26 | 30 |
| 30 | 112 |
| 112 | 114 |
| 114 | 166 |
| 166 | 240 |

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P.O. Box 222, Pietersburg, 0700
Tel: (015) 298 8847/298 8702
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