DOLOMITE STABILITY INVESTIGATION REPORT: ESKOM ESSELEN SUBSTATION, ESSELEN, TEMBISA, GAUTENG, SOUTH AFRICA

Client: ESKOM

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1. EXECUTIVE SUMMARY

Eskom Esselen Substation has had several occurrences of sinkhole manifestations on the western flank of the site. Efforts have been made to rehabilitate the sinkholes as and when they occur. This approach has seen successful rehabilitation of sinkholes at the site, but due to consistent occurrences of new sinkholes at different localities within the site, Eskom, following the advice from Thoka Geosciences, has decided on conducting a dolomite stability investigation to unveil the extent of the geotechnical dolomite stability within the site to inform the organisation of the problem and expectation for future planning for the Eskom Esselen Substation. Therefore sinkhole rehabilitation was rested whilst a full investigation was initiated at the site.

This report addresses the findings of a dolomite stability investigation requested by Eskom Holdings SOC Limited for the Eskom Esselen Substation located in Esselen Park, Tembisa, Gauteng Province. Thoka Geosciences was appointed by Eskom SOC Limited to conduct a full dolomite stability investigation for Esselen Substation; the request for this investigation is dated 12/05/2017 as per purchase order number 4502641208.

Esselen Substation covers a surface area of about 19 hectare measuring from the outer perimeter fence. This investigation is solely for the area bound by the outer parameter fence and the HV Plant, which covers about 12.5 hectares of the total 19 hectares that makes up Eskom Esselen Substation. The substations servitude extends beyond the outer parameter fence, but did not form part of this investigation as per the instructions from the client. It is however worth noting that some of the rehabilitated sinkholes extended beyond the outer parameter fence including the currently existing sinkhole at the site.

The site is located in Esselen Park, Tembisa bounded by the R21 Highway on the west and the R25 on the south. The central coordinates of the site are Latitude -26.005312° Longitude 28.268662°. The immediate vicinity of Eskom Esselen Substation is occupied by agricultural farms and vacant land. The site is accessible from an unnamed road joining from the M57 road.

On the regional scale, the site is characterised by a slope of 1% sloping towards the eastern direction with a low relief towards the Rietvlei River system located about 3 km east of the site. On a local scale, the site is locally characterised by a generally flat topography gently sloping towards the eastern direction.

The site is currently used as a substation belonging to Eskom. About 5 hectares located at the centre of the substation is used as the HV Plant and the remainder of the periphery is occupied by masonry structures used as offices and parking, open field and transmission networks.

The assessment of the geology within the site boundaries indicated outcropping dolomite at isolated parts of the site interpreted to be panicles of dolomite. Test pits which were excavated for isolation of underground services and the boreholes drilled at the site also indicated occurrence of highly weathered chert breccia in a matrix of ferruginised soil. The typical geological profile at the site is characterised by highly weathered chert breccia in a matrix of reddish brown ferruginsed soil which varies from CLAYEY SILT, SILTY SAND and SANDY GRAVEL. The ferruginsed profile is subsequently typically underlain by highly weathered CHERT which is characterised by occurrence of cavities. The cavities and the highly weathered chert horizon are underlain by moderately; slightly weathered progressing to unweathered DOLOMITE.

The site has had frequent manifestation of sinkholes specifically on the western flank of the site. More than 4 sinkholes have been recorded at the site occurring in a timeframe of 5 years. The sinkholes occur as medium to large sinkholes. Several sinkholes at Esselen Substation were successfully rehabilitated by Thoka Geosciences as a reactionary measure but more sinkholes have manifested at new localities within the site, thus triggering a request to conduct a full dolomite stability investigation at the site. The latest visible sinkhole development at the site may be located by coordinates S26.00678° E28.26650°. It is also worth note that during rehabilitation of the previous sinkholes, Thoka Geosciences discovered some poorly backfilled, re-occurring sinkholes that were supposed to have been rehabilitated by other contractors. As a result, some of these identified sinkholes which were within the working boundary of Thoka Geosciences were properly rehabilitated during the tenure of Thoka Geosciences at the time. A walkover survey outside the outer parameter fence has revealed that there is a number of existing sinkholes which are within the Eskom, Esselen Substation servitude, with some occurring under the Eskom Power lines. Again some of these sinkholes were backfilled with rubble by nearby farmers as an attempt to close off the sinkholes.

Based on the available data, the karst instability in the area is expected to be high considering the number of karst instability events that have already been indicated to be in access of 10 events within vicinity of the site area.

The assessment of the A2N0631 monitoring borehole shows fluctuation of the groundwater level with peak groundwater levels recorded during the year 1997 (7 m from surface) and 2015 (8.7 m from surface). The groundwater levels recorded between 1997 and 2015 shows a drop in the groundwater levels from peak of 7 m from surface to 18 m from surface during the year 2010. The groundwater level begins to drop again from 2015 to the last reading date recording 16.6 m.

Monitoring borehole A2N0627 indicates a steady groundwater level dating back from the year 1999 to date whereby the groundwater remains at about 30 m from surface with fractional fluctuations.

Groundwater borehole A2N0633 only has records up to the year 1998. Recent groundwater data is not available. Records of the groundwater level from 1988 to 1995 show a steady state until a sudden rise in groundwater level between 1995 and 1998 to a depth of about 10 m from surface.

The assessment of the regional groundwater situation within the Sterkfontein Dolomite Compartment shows variable maintenance of the groundwater within the compartment whereby A2N0627 shows sustainable maintenance and A2N0631 shows variable unsteady maintenance of the groundwater level with fluctuations greater than 10 m difference in a 10 year period.

A gravity survey, in support of a dolomite-stability study, was conducted over roughly 12.5 ha surrounding Eskom's Esselen Substation, across the R21 from Tembisa, on 10 October 2017. The area was covered with a 15m grid comprising 622 stations.

The broad gravity high which spans most of the surveyed area is shown to consist of shallow (3 m to 4 m) dolomite bedrock head as intersected by ESN BH20 and ESN BH6. Subtle changes in the residual gravity, within the broader high, correspond with variations in weathering as noted by ESN BH9, ESN BH11, ESN BH13 & ESN BH18 - 19 which intersected competent bedrock formation at between 8 m and 11 m deep. Bedrock deepens toward the northeast, coincident with a broader gravity low, where ESN BH7 - 8, ESN BH15 & 21 intersected bedrock head between 13 m and 18 m deep. In most cases small cavities were intersected which caused sample loss. ESN BH16 & 17, drilled on the gravity gradient, intersected fairly large cavities and were terminated at 19 m and 14 m respectively; both of these locations fall on subtle and small lows originating from the larger gravity low. The gravity low toward the southwest is more irregular and appears to be comprised of two lows, located in the northwest and southwest, connected by narrow, rectilinear lows. This is supported by ESN BH1 & 3 which intersected bedrock at 12 m and 18 m respectively while ESN BH2 & 4 were terminated after intersecting fairly large voids. Although ESN BH5 & 12 showed bedrock to be around 5 m depth, the gravity suggests they may have been drilled on the edge of a slot. Overall the drilling results show the gravity to be a fair reflection of bedrock topography.

A set of two traverse lines were prepared at Eskom Esselen Substation to conduct resistivity surveys using the ABEM LS transmitter plus receiver unit with 61 active field electrodes. The surveys were conducted with minimum electrode spacing of 3 m using the schlumberger and the wenner protocols / electrode array. A maximum distance of 240 m was covered with the setup

and a maximum depth of 52 m was surveyed. The data was assessed and modeled with the RES-2D-INV software.

Traverse line 1 crossing the northeast-southwest direction indicates close to homogenous band of highly resistive material encountered from surface to about 14 m depth. The resistive band also shows pockets of material with even greater resistivity (purple color code). Traverse line 1 passes through vicinity of drilled ESN BH 13, ESN BH 5 and ESN BH 12 which intercept solid dolomite between 4 – 9 m depth inferable as shallow dolomite bedrock.

Traverse line 2 which crosses along a southeast-northwest traverse line for a 240 m distance displays a highly variable geophysical signature which is characterized by isolated pockets of low (dark blue color code) – intermediate (green) resistivity material close to surface. The Traverse line 2 passes within region of the recorded gravity low region northeast of the Esselen Substation characterized by deep dolomite bedrock. On the northern flank of Traverse line 2 from about 180 m to 240 m traverse distance, a resistive material is recorded which coincides the boundary of gravity high zones recorded on the gravity survey.

A total of 19 boreholes were drilled at the site. The boreholes were drilled with a rotary percussion drilling rig (Zeus 5000 rig) at 21 bar air pressure with a capacity of 0.519 m^3 per second using the Reverse Circulation Method. A 208 mm clay cutter was utilized instead of a drilling bit on portions of the area underlain by clay material and a 145 mm reverse circulation drill bit was used on rock material.
Borehole logging results indicated occurrence of two groups of geological profiles, one group which is defined by the gravity high zones and higher apparent resistivity signature and the other group defined by gravity low zones and low resistivity signature. The gravity high zones are characterised by shallow dolomite bedrock conditions which vary based on weathered zones of chert and iron oxides/ferruginous soils and cavities. The gravity low zones are characterised by deeper dolomite bedrock overlain by small persistent cavities and soft clay, clayey silt overburden in upwards succession.

Ferruginous Soils

Occurrences of ferruginous soils in the form of SILTY SAND, CLAYEY SILT and ferricrete nodules are encountered at the site to maximum depths of about 7 m from surface. The ferruginous soils are commonly associated with highly weathered CHERT fragments e.g. ESN BH 1, 3, 4, 5, 12, 13, 16, 18 and 21. The occurrence of ferruginous soil is encountered within the gravity high zones of the site associated with shallow bedrock geology.

Transported Soft Clay, Silty Sand,

Soft clay, silty clay material is encountered within the gravity low zones which are associated with deeper dolomite bedrock. The soft clay, silty clay material is typically reddish brown/dark maroon in colour commonly characterised by rapid penetration rates. The silty clay material is in many cases underlain by persistent cavities until solid dolomite bedrock at depth e.g. ESN BH 15 and ESN BH 8.

Weathered Chert of the Malmani Subgroup

Profiles of moderately to highly weathered CHERT occur commonly within the gravity high zones at the site. The highly weathered CHERT is characterised by rapid penetration rates, and subsequent cavities sometimes in excess of 10 meters e.g. ESN BH 2 and ESN BH 4.

Malmani Subgroup Dolomite

Solid dolomite bedrock is encountered as bluish grey sub-angular chip samples. The solid dolomite bedrock occurs either as shallow bedrock associated with the gravity high zones whereby solid dolomite sometimes rests at 4 meters from the surface. The deep dolomite bedrock is encountered on gravity low zones whereby solid dolomite bedrock can be encountered deeper than 18 m from surface e.g. ESN BH 2 & 3.

The assessment of regional groundwater indicates groundwater levels to be at maximum depth of about 30 m from the surface for monitoring station A2N0627.

None of the 19 investigation boreholes at site encountered groundwater. The deepest borehole drilled at site reached depth of 24 m from the surface. This infers a deeper groundwater table at the site and that sinkhole or subsidence associated with groundwater drawdown is unlikely but rather ingress from ponding / percolating surface water is the main trigger for sinkhole formation at the site.

Two additional deeper boreholes were drilled on the northeast portion of the site represented by gravity low conditions in preparation for the dolomite risk management strategy requirements. The boreholes were drilled in access of 30 m from the surface and groundwater was intercepted. But, due to instantaneous collapsing during the drilling process, the boreholes had to be prematurely abandoned. The boreholes proved to be too risky to drill with conventional percussion methods, Thoka Geosciences recommends ODEX drilling systems to be implemented specifically for securing groundwater monitoring points at the site.

The purpose of this dolomite stability investigation report is to determine the different engineering geological properties of the surface, subsurface soils and dolomite rocks in

accordance with the SANS 1936 guidelines and assign site classification for the dolomite underlain area.
As required by SANS 1936, stability evaluation of the site included the examination of receptacle development potential, mobilising agents, mobilization potential of blanket layer, bedrock morphology and potential sinkhole development space.

Mobilization is defined as the movement of dolomitic overburden by subsurface erosion. Mobilising agents include ingress water, ground vibrations, water level drawdown or any process that can induce mobilisation of material within the blanketing layer under the force of gravity (Buttrick *et al,* 1995).
The site will be susceptible to water ingress from current and future installation of wet services and water ingress from water ponding or percolation from surface runoff.

As discussed above, only two boreholes intercepted groundwater at depths greater than 24 m from surface, the remainder 19 of the boreholes drilled did not encounter groundwater, thus groundwater is believed to be below the cavity prone dolomite horizons at the site (i.e. >24 m from surface). Thus drawdown of existing groundwater level would have non to little impact on the stability of the dolomitic land as it is not within highly leached / weathered CHERT and DOLOMITE horizons characterised by cavities. This assertion is also reinforced by the fact that groundwater monitoring was conducted within the January – February 2018 period which is expected to be the high rainfall season for the geographical area. Although this is the case, there should be a groundwater management system in place as a precautionary measure to manage the usage/fluctuation of the groundwater particularly focusing on possible rise and fall of the groundwater table that could increase the inherent hazard for ground movement.

According to SANS 1936 - 2, the positive contribution towards dolomite stability of shallow groundwater levels should only be taken into account where:

- The compartmentalization of dolomite groundwater and aerial extent of the compartments have been determined.
- All groundwater users are identified and the maximum quantities abstracted are known.
- There is evidence to show licensed pumping does not exceed normal natural replenishment.
- There are data showing the groundwater level behaviour patterns during periods of drought and recovery.
- The groundwater level is not located within the dolomite residuum.
- The local authority or relevant national department has regularly monitored the groundwater level in the past and continues to do so.

More groundwater monitoring stations must be developed to ascertain the above requirements for groundwater. **Thus a groundwater monitoring station at the site is recommended as part of a risk management facility.**

The method adopted in sinkhole size determination followed the criteria by Buttrick *et al* 2001, whereby bedrock depth shallower than 3 m is expected to be more prone to develop a small (<2 m) sinkhole and bedrock depth >3 m<15 m is more prone to develop a medium sinkhole and bedrock depth deeper 15 m more prone to develop a large sinkhole (5 - 15 m Wide Sinkholes).

Due to the variable depth to dolomite bedrock, the site is inferred to be more prone to develop medium to large sinkholes respective to the borehole results. Medium sinkholes are sinkholes expected to have a nominal diameter of 2 – 5 m and large sinkhole expected to have 5 – 15 m diameter. Based on the assessment of the geophysics, gravity low zones have deeper bedrock and more prone to develop large sinkholes and gravity high zones are more prone to develop medium to large sinkholes.

The blanketing material at the site may be summed up as ferrugenised SILTY SAND, SILT and SOFT CLAY with fragments of highly weathered CHERT. The geological profiles of the blanketing material at the site although sometimes as thick as 8 m from surface is easily permeable due to the nature and characteristics of the material. Drilling penetration rates recorded to be less 1 minute per meter drilled over the blanketing material suggest easily permeable material susceptible to collapse/movements. **Thus instability triggered by water ingress from the surface is highly likely in situations whereby surface water is not drained at sufficient rate.**

The occurrence of highly weathered chert/dolomite horizons and cavity at shallow and deeper depths as per gravity high and gravity low zones throughout the site suggests typical high inherent hazard for karst formation as voids and cavities form part of receptacles for material of the overlaying strata. Recorded historic sinkhole and subsidence on the western flank of the site further imply high risk zones and caution. The vast area on the western flank of the Eskom Esselen Substation has been zoned of as a high risk area as a whole due to evident sinkhole formation within that area. The triggering mechanism for sinkhole formation is by assessment due to sudden loss of support accelerated by surface water ingress.

Considering all the discussed attributes of mobilization /blanketing material agency, cavities, sinkhole size and nature of blanketing material, dolomite bedrock topography and geohydrology, the site is regarded to have variable hazard classes. Boreholes representing high inherent hazard (IHC 6 – 8) dominate by about 70 % of the drilled borehole classifying either as IHC

6/7/8. Most of the high inherent hazard areas are characterised by either gravity low zones/deep bedrock or contact zones between gravity high and gravity low zones e.g. ESN BH 13. This assessment suggests platforms of shallow dolomite adjacent to troughs of weathered zones covered by soil sediment deposits (FERRUGENISED CLAYEY SILT). The platforms of shallow dolomite in most instances represent intermediate inherent hazard classified as IHC 2/3/4.

The Dolomite Land Classification for the site will be pre-determined by the type of development to be pursued at the site. SANS 1936-1, Table 2 shows the permissible land usage per inherent hazard class for dolomite land. Any proposed development will thus be guided by the permissible land usage guidelines. **The site falls under C3 type development, thus developable with footprint requirements up until IHC 6.** Therefore any future development at the site should be prioritised on the gravity high zones of the site **but with care to avoid the contact zones of gravity high platforms and gravity low troughs. No future development at the site should be conducted or permitted without a detailed footprint investigation.**

Portions of the site are thus regarded to be conditionally developable under D3 + Footprint Investigation conditions as a C3 Development Type. Should any future footprint investigations proof worse conditions, the respective area must be regarded as a D4 area with high inherent hazard.

A crucial requirement of development on dolomitic lands, as stipulated in SANS 1936-1, is the establishment and implementation of a dolomite risk management strategy (DRMS) by the developer, which must tie in with that in place and controlled by the relevant local authority which in this regard the relevant authority would be the Ekurhuleni Municipality. SANS 1936-4 describes this in detail.

It is therefore highly recommended that Thoka Geosciences be appointed to develop a dolomite risk management strategy so as to minimize further development of sinkholes within the station. The dolomite risk management strategy will entail amongst others, monitoring regional groundwater, monitoring local groundwater fluctuations, monitoring of surface flow on site and emergency preparedness plan in cases where sinkholes develop.

The risk management strategy will be tied with local municipalities risk management strategy in place also providing reporting strategies of sinkhole and subsidence events. The training of local personnel occupying the Esselen Substation will be part and parcel of the risk management strategy. Training will include amongst other aspects, training of personnel on identification of sinkholes, subsidence, tension cracks leading to sinkholes, and management of surface water ponding and reporting strategies.

Urgency to rehabilitate existing sinkholes must be placed and further assessment of the dolomite stability beyond the outer parameter fence onto the boundary of Eskom Esselen Substation servitude needs to be prioritised as a matter of urgency.

Areas deduced to be IHC 8 from this investigation are recommended for proactive rehabilitation in the form of overburden strip, expose cavity throat and rehabilitation to prevent highly likely sinkhole occurrences.

2. INTRODUCTION

2.1. BACKGROUND

Eskom Esselen Substation has had several occurrences of sinkhole manifestations on the western flank of the site. Efforts have been made to rehabilitate the sinkholes as and when they occur. This approach has seen successful rehabilitation of sinkholes at the site, but due to consistent occurrences of new sinkholes at different localities within the site, Eskom, following the advice from Thoka Geosciences, has decided on conducting a dolomite stability investigation to unveil the extent of the geotechnical dolomite stability within the site to inform the organisation of the problem and expectation for future planning for the Eskom Esselen Substation. Therefore sinkhole rehabilitation was rested whilst a full investigation was initiated at the site.

2.2. GENERAL

This report addresses the findings of a dolomite stability investigation requested by Eskom Holdings SOC Limited for the Eskom Esselen Substation located in Esselen Park, Tembisa, Gauteng Province. Thoka Geosciences was appointed by Eskom SOC Limited to conduct a full dolomite stability investigation for Esselen Substation; the request for this investigation is dated 12/05/2017 as per purchase order number 4502641208.

2.3. OBJECTIVES

The objectives of the investigation were to:

- Assess the exposure and vulnerability of the site to dolomite geo-hazards which have historically manifest into sinkholes and surface subsidence.
- Characterize the suitability of the site for any future development
- Highlight any discrepancies noted on the site in aspects of geotechnical stability risk
- **By default, the following form part of the investigations:**
- Determination of the site specific geological conditions
- Determination of all potentially restraining dolomite stability factors including the hydrogeological characteristics and soils
- Establish the presence and proximity of groundwater to the surface including historic groundwater data
- Classification of the site according to SANS 1936 in respect of dolomitic land
- Provide recommendations for future utilization of the site, risk management solutions

2.4. SCOPE

The scope of the work conducted to achieve the objectives of the investigations involved:

- A site visit which involved touring the vicinity of the site boundaries and capturing of information such as rock outcrops, geology, sinkholes, subsidence, tension cracks, installed services, vegetation, soils, topographic properties and access routes.
- Desktop investigation of all available information and previous work in the vicinity of the area
- Preparation of a gravity survey of the site
- Preparation of borehole positions integrated with gravity survey results
- Preparation for rotary percussion borehole drilling using reverse circulation methods
- Drilling of 19 boreholes at selected positions within the site using the most efficient methods
- Capturing of drilling information including groundwater strikes and groundwater levels after 24 period lapse
- Interpretation of information gathered from all methodologies employed
- Recommending precautionary and risk mitigation measures to be implemented
- reparation of a comprehensive report

2.5. SOURCES OF INFORMATION

- The 1:250 000 2628 East Rand Sheet as published by the Council for Geoscience
- Council for Geoscience Sinkhole Database, Borehole and Dolomite Stability Investigation Reports
- South Africa National Standards (SANS-1:2012, -2:2012 and -3:2012)
- Satellite imagery available from Google Earth
- National Groundwater Achieves
- Published online literature relating to the site geology, geo-hydrology and physiographic information of the site

3. SITE LOCATION AND DESCRIPTION

3.1. GEOGRAPHIC DESCRIPTION

Esselen Substation covers a surface area of about 19 hectare measuring from the outer perimeter fence. This investigation is solely for the area bound by the outer parameter fence and the HV Plant, which covers about 12.5 hectares of the total 19 hectares that makes up Eskom Esselen Substation. The substations servitude extends beyond the outer parameter fence, but did not form part of this investigation as per the instructions from the client. It is however worth noting that some of the rehabilitated sinkholes extended beyond the outer parameter fence including the currently existing sinkhole at the site.

The site is located in Esselen Park, Tembisa bounded by the R21 Highway on the west and the R25 on the south. The central coordinates of the site are Latitude -26.005312° Longitude 28.268662°. The immediate vicinity of Eskom Esselen Substation is occupied by agricultural farms and vacant land. The site is accessible from an unnamed road joining from the M57 road.

3.2. TOPOGRAPHY

On the regional scale, the site is characterised by a slope of 1% sloping towards the eastern direction with a low relief towards the Rietvlei River system located about 3 km east of the site. On a local scale, the site is locally characterised by a generally flat topography gently sloping towards the eastern direction.

Figure 1 shows a delineation of the topography and the slope of the site.

3.3. CLIMATE

The climate data is based on a 30 year historical weather data for Tembisa, Gauteng. The mean low temperatures range between 3 to 15 degree Celsius and the mean high temperatures range between 18 to 28 degrees Celsius. The rainfall in the area is seasonal with the highest rainfall occurring during the October to March period ranging from about 71 mm to about 127 mm. The high rainfall period is within the summer months (https://www.meteoblue.com/en/weather/forecast/modelclimate/tembisa_south-africa_949880, March 2017).

3.4. VEGETATION

The site vegetation is characterised by the Carletonville Dolomite Grassland which forms part of the Dry Highveld Grassland Bioregion.

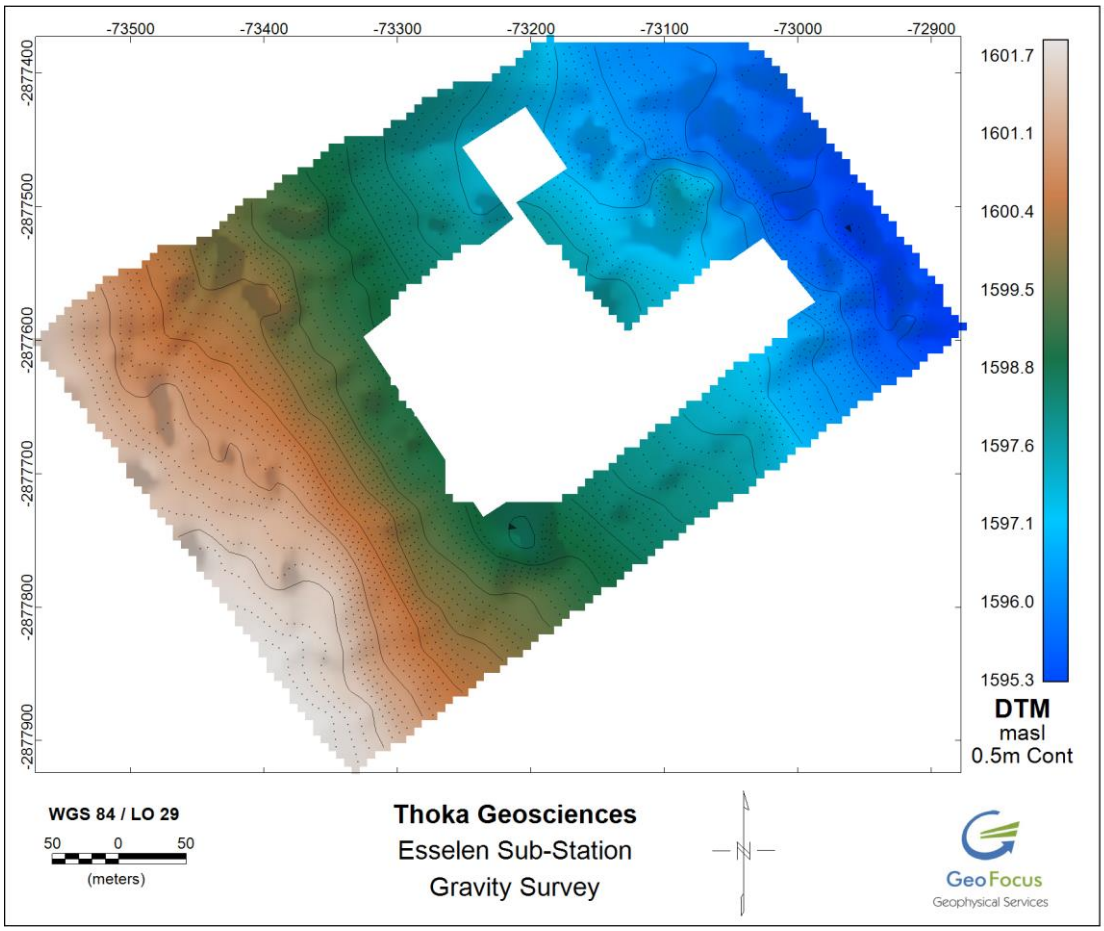


Figure 1 shows the topographic delineation of the site

3.5. PREVIOUS AND CURRENT LAND USE

The site is currently used as a substation belonging to Eskom. About 5 hectares located at the centre of the substation is used as the HV Plant and the remainder of the periphery is occupied by masonry structures used as offices and parking, open field and transmission networks.

3.6. DRAINAGE

The natural drainage within vicinity of the site is towards the east into the Rietvlei River System. The drainage is controlled by a gentle slope of about 1%. The locality of the site is engineered with concrete surface V-channels drainage systems that induce control and channelling of storm water towards the eastern flank of the site (Figure 2).

Figure 2 shows engineered storm water drainage systems developed at the site.

3.7. REGIONAL GEOLOGY

The regional geology of the area is underlain by the Malmani Subgroup dolomitic rocks of the Chuniespoort Group (1: 250 000 Geological Series, 2628 East Rand). The Malmani Subgroup is comprised of the Oaktree Formation as the oldest formation followed by the Monte Christo, Lyttelton, Eccles and Frisco Formation in chronological order from oldest to youngest of age. The subdivision of the Malmani Subgroup is based on the differences in chert content, stromatolite morphology, intercalated shales and erionsion surfaces (Button, 1973b). Due to the composition of dolomite rock, slightly acid fluids such as rain water can cause dissolution of dolomite. The dissolution process of dolomite can be represented as follows:

$$CaMg(CO3)2 + 2\ H2CO3 \rightarrow Ca(HCO3)2 + Mg(HCO3)2 \qquad \text{Equation 1}$$

Due to the solubility of dolomite, vertical zonation of residual products may be of result. The vertical zonation is typically in the form of solid unweathered dolomite bedrock overlain by slightly weathered and jointed bedrock and thereafter a sudden highly weathered dolomite horizon characterised by low strength insoluble manganese oxides, chert an iron oxides. The Council for Geosciences has a dedicated database for sinkholes recorded and all dolomite stability investigations within the regional area. An abundance of dolomite stability investigations is evident within the regional geographical area. Figure 3 illustrates existing boreholes drilled as part of dolomite stability investigations for other properties and occurrences of sinkholes within the area. It is evident that the sinkholes that have occurred within the Esselen Substation have not been recorded under the Council for Geosciences database. This is a concern that must be addressed by a dolomite risk management strategy for Eskom Esselen Substation.

3.8. LOCAL GEO LOGY

The assessment of the geology within the site boundaries indicated outcropping dolomite at isolated parts of the site interpreted to be panicles of dolomite. Test pits which were excavated for isolation of underground services and the boreholes drilled at the site also indicated occurrence of highly weathered chert breccia in a matrix of ferruginised soil. The typical geological profile at the site is characterised by highly weathered chert breccia in a matrix of reddish brown ferruginsed soil which varies from CLAYEY SILT, SILTY SAND and SANDY GRAVEL. The ferruginsed profile is subsequently typically underlain by highly weathered CHERT which is characterised by occurrence of cavities. The cavities and the highly weathered chert horizon are underlain by moderately; slightly weathered progressing to unweathered DOLOMITE.

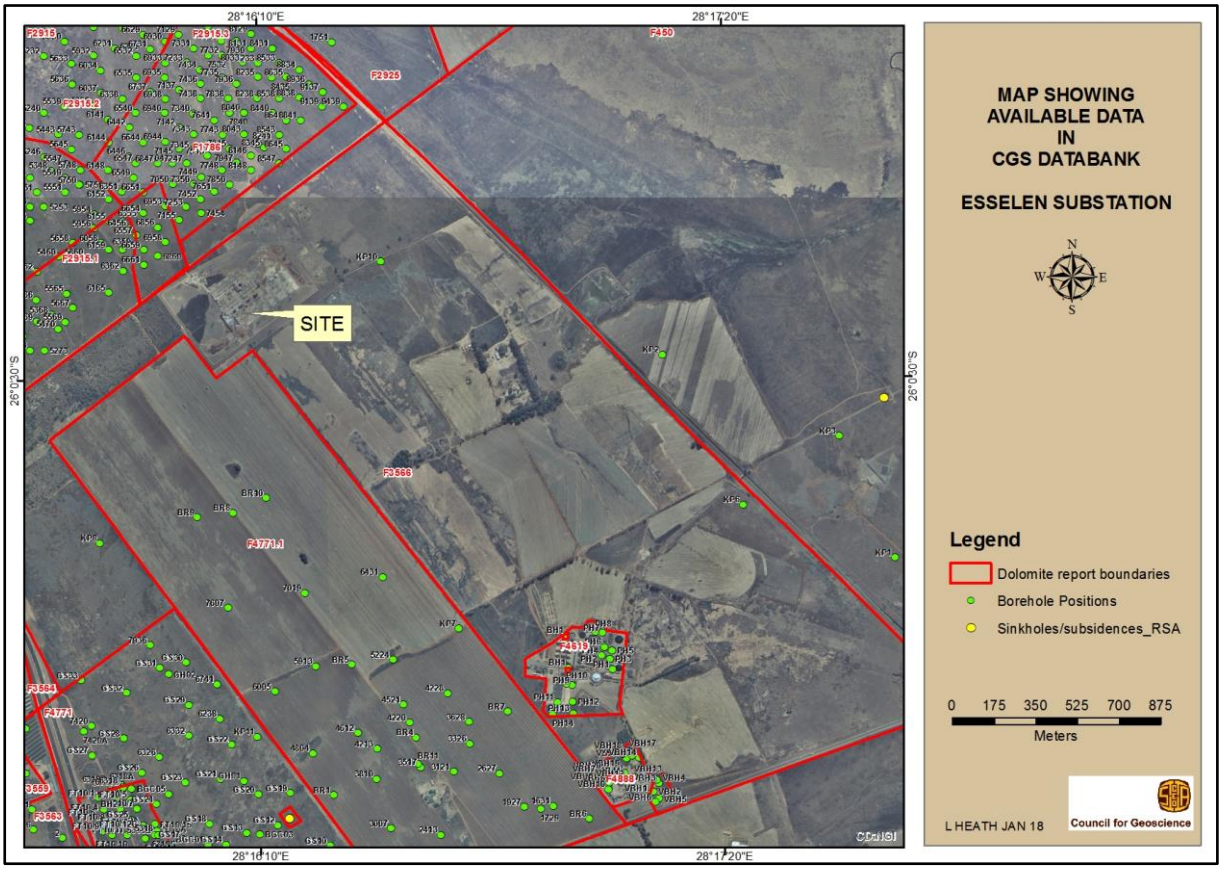


Figure 3: Shows the locality of previous dolomite stability investigation reports and previously drilled boreholes within the vicinity of the investigation area.

3.9. HISTORIC KARST INSTABILITY

The site has had frequent manifestation of sinkholes specifically on the western flank of the site. More than 4 sinkholes have been recorded at the site occurring in a timeframe of 5 years. The sinkholes occur as medium to large sinkholes. Several sinkholes at Esselen Substation were

successfully rehabilitated by Thoka Geosciences as a reactionary measure but more sinkholes have manifested at new localities within the site, thus triggering a request to conduct a full dolomite stability investigation at the site. The latest visible sinkhole development at the site may be located by coordinates S26.00678° E28.26650° (
Figure 4). It is also worth note that during rehabilitation of the previous sinkholes, Thoka Geosciences discovered some poorly backfilled, re-occurring sinkholes that were supposed to have been rehabilitated by other contractors. As a result, some of these identified sinkholes which were within the working boundary of Thoka Geosciences, were properly rehabilitated during the tenure of Thoka Geosciences at the time. A walkover survey outside the outer parameter fence has revealed that there is a number of existing sinkholes which are within the Eskom, Esselen Substation servitude, with some occurring under the Eskom Power lines. Again some of these sinkholes were backfilled with rubble by nearby farmers as an attempt to close off the sinkholes.

Based on Table 3-Inherent hazard categories, SANS 1936-2; the inherent hazard must also be determined by considering the amount of anticipated events per hectare per 20 years. High Inherent Hazard is implicated by karst associated events occurring in an area of 1 hectare in less than 20 years. Based on the available data, the karst instability in the area is expected to be high considering the number of karst instability events that have already been indicated to be in access of 10 events within vicinity of the site area.

Figure 4 shows the latest sinkhole development at the site

3.10. REGIONAL HYDROGEOLOGY

The site is located within the Sterkfontein Dolomite Compartment in the A21A Groundwater Management Unit in the Crocodile West and Marico Water Management Area. The hydrogeological properties of the compartment are characterised by the karst nature of dolomite aquifers.

Three of the nearest available groundwater monitoring points within a 3 km radius from the Esselen Substation have been selected for assessment of the regional groundwater situation. The groundwater monitoring boreholes are available from the National Groundwater Achieve identifiable as A2N0633, A2N0627 and A2N0631 as depicted by Figure 5, Figure 6 and Figure 7.

The assessment of the A2N0631 monitoring borehole shows fluctuation of the groundwater level with peak groundwater levels recorded during the year 1997 (7 m from surface) and 2015 (8.7 m from surface). The groundwater levels recorded between 1997 and 2015 shows a drop in the groundwater levels from peak of 7 m from surface to 18 m from surface during the year 2010. The groundwater level begins to drop again from 2015 to the last reading date recording 16.6 m.

Monitoring borehole A2N0627 shown in Figure 6 indicates a steady groundwater level dating back from the year 1999 to date whereby the groundwater remains at about 30 m from surface with fractional fluctuations.

Groundwater borehole A2N0633 only has records up to the year 1998. Recent groundwater data is not available. Records of the groundwater level from 1988 to 1995 show a steady state until a sudden rise in groundwater level between 1995 and 1998 to a depth of about 10 m from surface (Figure 7).

The assessment of the regional groundwater situation within the Sterkfontein Dolomite Compartment shows variable maintenance of the groundwater within the compartment whereby A2N0627 shows sustainable maintenance and A2N0631 shows variable unsteady maintenance of the groundwater level with fluctuations greater than 10 m difference in a 10 year period.

Ground stability is an important consideration in establishing large scale water abstraction in dolomite underlain areas. The extent of water level drawdown is one of the critical factors in the development of ground subsidence and sinkhole formation. The risk of development of ground subsidence and sinkholes is greatest in areas where the groundwater level occurs closer to surface (<30 m) and where the groundwater fluctuates more than 6 m in response to pumping (HC Barnard, 2000).

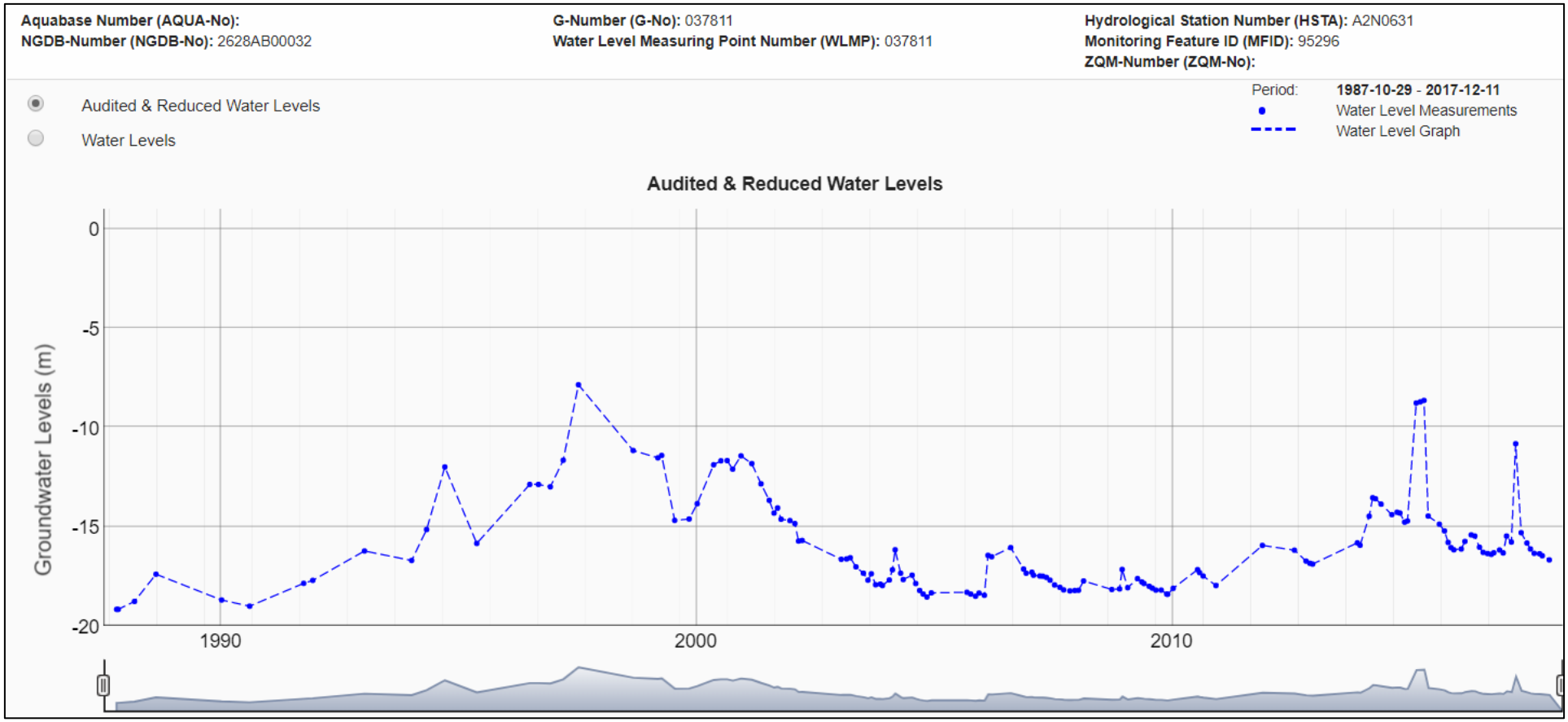


Figure 5 shows the groundwater monitoring graph for monitoring station A2N0631 from the year 1987 – 2017 (National Groundwater Achieve, 2018)

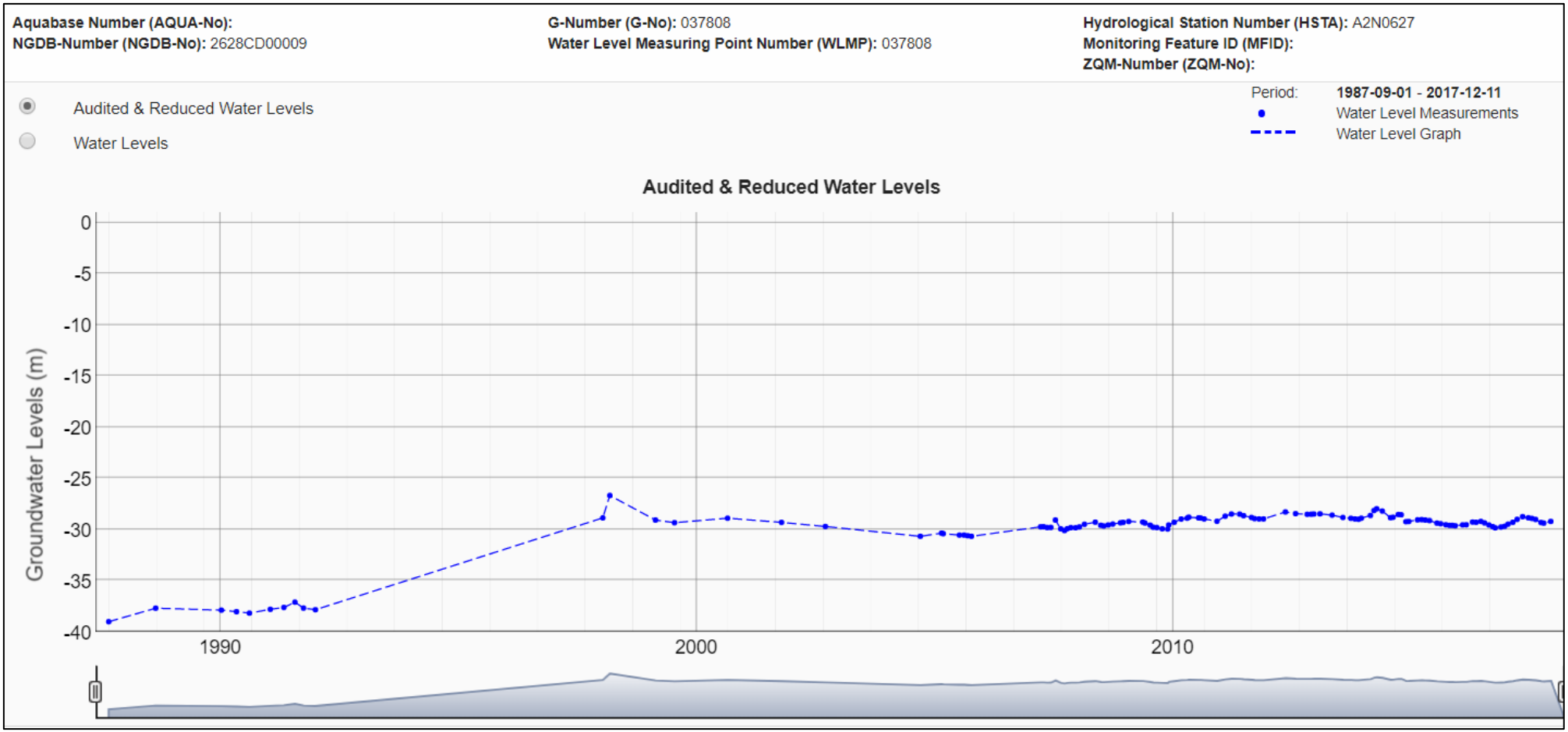


Figure 6 shows the groundwater monitoring graph for monitoring station A2N0627 from the year 1987 – 2017 (National Groundwater Achieve, 2018)

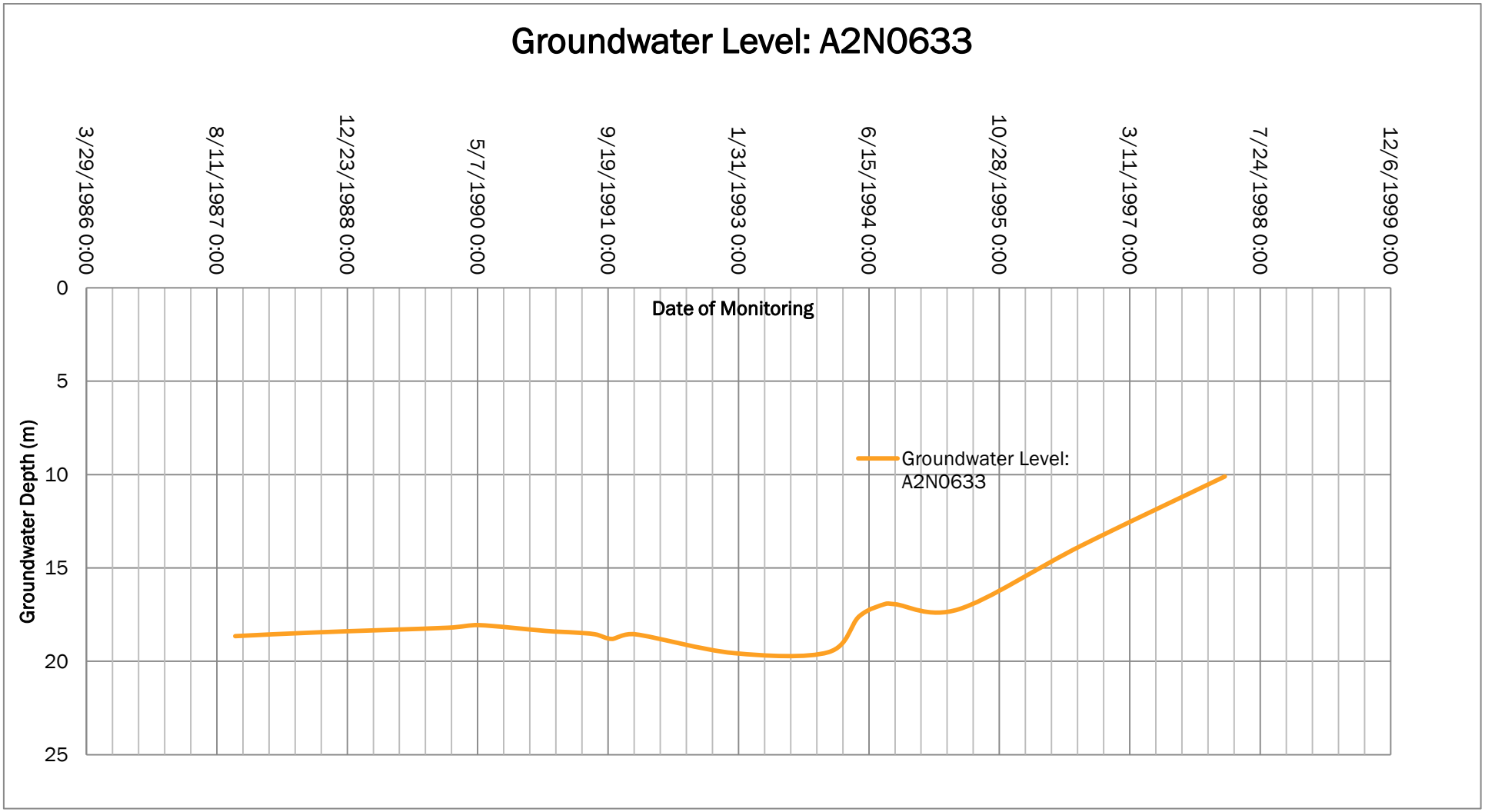


Figure 7 shows the groundwater monitoring graph for monitoring station A2N0633 from the year 1986 – 1999 (National Groundwater Achieve, 2018)

4. GEOPHYSICAL SURVEY RESULTS

4.1. GRAVITY SURVEY

A gravity survey, in support of a dolomite-stability study, was conducted over roughly 12.5 ha surrounding Eskom's Esselen Substation, across the R21 from Tembisa, on 10 October 2017. The area was covered with a 15m grid comprising 622 stations.

Gravity was observed with a Scintrex CG5 gravimeter whilst a Javad DGPS recorded station locations. Gravity data processing procedures commonly used for dolomite studies were applied, firstly reducing the data to relative Bouguer values by applying elevation, terrain and Bouguer corrections. Secondly, an estimation of the regional gravity field (slope), calculated either through linear regression or a grid trend, is removed from the relative Bouguer gravity to produce an uncorrected or provisional residual gravity map emphasizing local changes. The final residual gravity map is produced by correcting for bedrock head intersections acquired during outcrop mapping, pitting and/or drilling. This usually entails a base shift (adjustment by a constant) so that the residual gravity values agree on average with bedrock depths. This is done by shifting the residual Bouguer highs to represent outcrop, where present, as zero (0) mGal. Otherwise drill locations where bedrock was intersected are adjusted so that the corresponding residual Bouguer value approximates the ratio of -1mGal = 48m. In some cases, notably small surveys, bedrock head intersections can provide the necessary spatial correlation needed to recalculate the regional gravity field in order to achieve a better fit.

The median elevation of the survey area is approximately 1,599 masl (relative) sloping southwest to northeast by roughly 7 m. A 1st-order approximation of the regional gravity field was removed from the Bouguer anomaly data resulting in a residual gravity dataset with peak-to-peak distribution of approximately 0.4 mGal. Corrections were applied to the residual gravity data based on a set of nineteen (19) boreholes drilled across the site.

The broad gravity high which spans most of the surveyed area is shown to consist of shallow (3 m to 4 m) dolomite bedrock head as intersected by ESN BH20 and ESN BH6. Subtle changes in the residual gravity, within the broader high, correspond with variations in weathering as noted by ESN BH9, ESN BH11, ESN BH13 & ESN BH18 - 19 which intersected competent bedrock formation at between 8 m and 11 m deep. Bedrock deepens toward the northeast, coincident with a broader gravity low, where ESN BH7 - 8, ESN BH15 & 21 intersected bedrock head between 13 m and 18 m deep. In most cases small cavities were intersected which caused sample loss. ESN BH16 & 17, drilled on the gravity gradient, intersected fairly large cavities and were terminated at 19 m and 14 m respectively; both of these locations fall on subtle and small lows originating from the larger gravity low. The gravity low toward the southwest is more irregular and

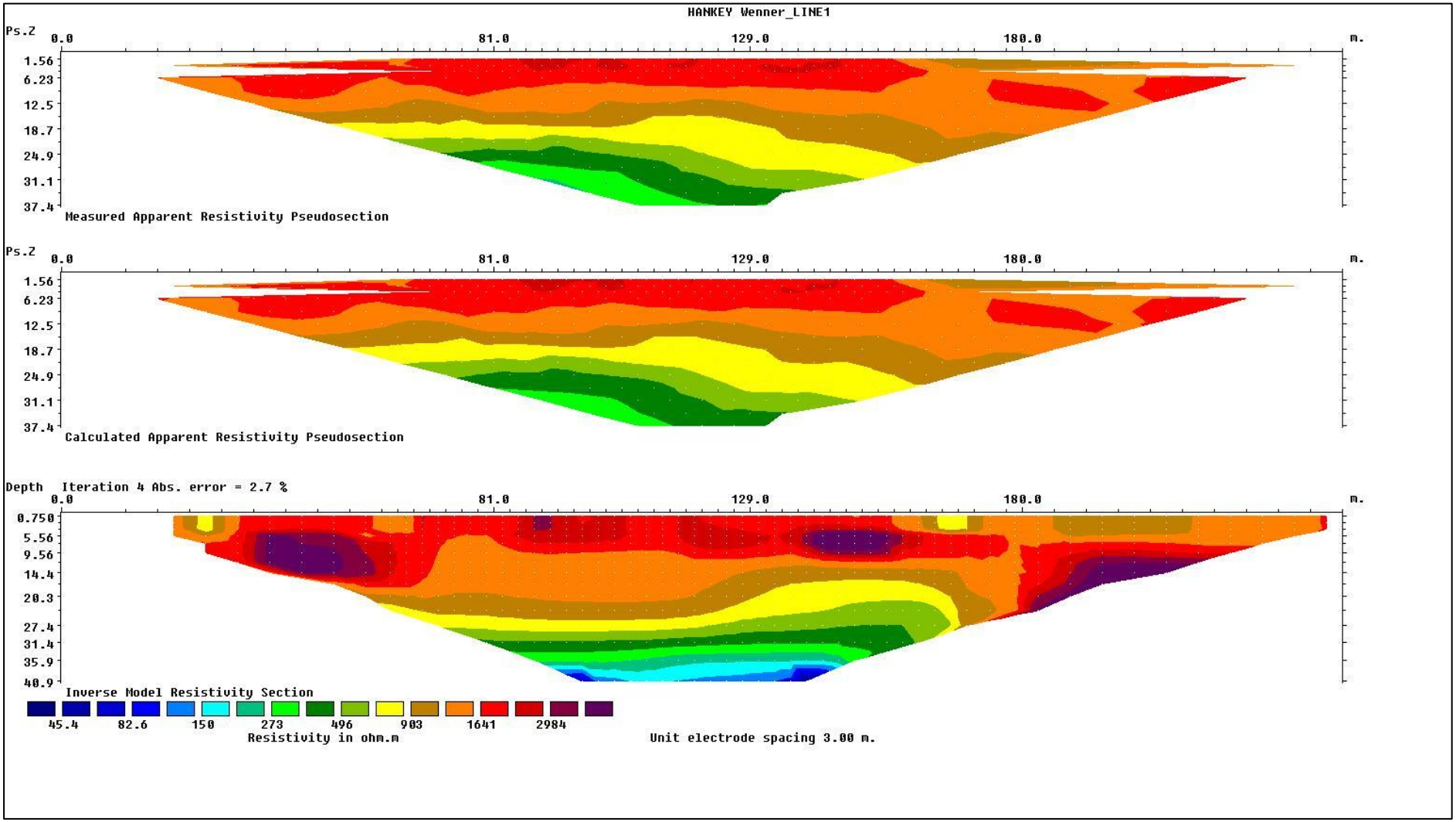
appears to be comprised of two lows, located in the northwest and southwest, connected by narrow, rectilinear lows. This is supported by ESN BH1 & 3 which intersected bedrock at 12 m and 18 m respectively while ESN BH2 & 4 were terminated after intersecting fairly large voids. Although ESN BH5 & 12 showed bedrock to be around 5 m depth, the gravity suggests they may have been drilled on the edge of a slot. Overall the drilling results show the gravity to be a fair reflection of bedrock topography.

4.2. RESISTIVITY SURVEY

A set of two traverse lines were prepared at Eskom Esselen Substation to conduct resistivity surveys using the ABEM LS transmitter plus receiver unit with 61 active field electrodes. The surveys were conducted with minimum electrode spacing of 3 m using the schlumberger and the wenner protocols / electrode array. A maximum distance of 240 m was covered with the setup and a maximum depth of 52 m was surveyed. The data was assessed and modeled with the RES-2D-INV software.

Traverse line 1 crossing the northeast-southwest direction (Figure 8) indicates close to homogenous band of highly resistive material encountered from surface to about 14 m depth. The resistive band also shows pockets of material with even greater resistivity (purple color code). Traverse line 1 passes through vicinity of drilled ESN BH 13, ESN BH 5 and ESN BH 12 which intercept solid dolomite between 4 – 9 m depth inferable as shallow dolomite bedrock.

Traverse line 2 which crosses along a southeast-northwest traverse line for a 240 m distance (Figure 9) displays a highly variable geophysical signature which is characterized by isolated pockets of low (dark blue color code) – intermediate (green) resistivity material close to surface. The Traverse line 2 passes within region of the recorded gravity low region northeast of the Esselen Substation characterized by deep dolomite bedrock. On the northern flank of Traverse line 2 from about 180 m to 240 m traverse distance, a resistive material is recorded which coincides the boundary of gravity high zones recorded on the gravity survey.


HANKEY Wenner_LINE1
Ps.Z
0.0
81.0
129.0
180.0
m.
1.56
6.23
12.5
18.7
24.9
31.1
37.4
Measured Apparent Resistivity Pseudosection
Ps.Z
0.0
81.0
129.0
180.0
m.
1.56
6.23
12.5
18.7
24.9
31.1
37.4
Calculated Apparent Resistivity Pseudosection
Depth
Iteration 4 Abs. error = 2.7 %
0.0
81.0
129.0
180.0
m.
0.750
5.56
9.56
14.4
20.3
27.4
31.4
35.9
40.9
Inverse Model Resistivity Section
45.4
82.6
150
273
496
903
1641
2984
Resistivity in ohm.m
Unit electrode spacing 3.00 m.

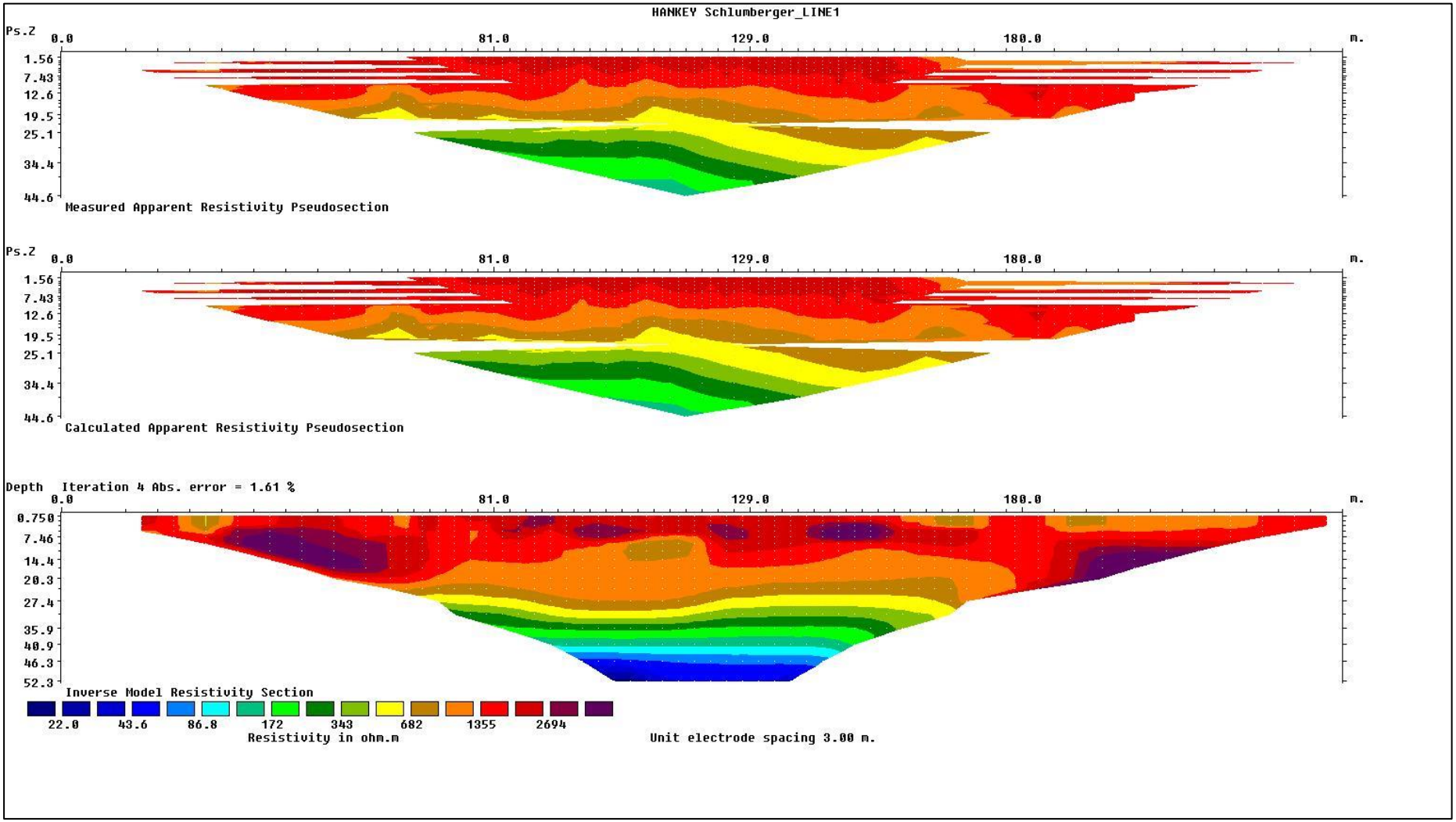
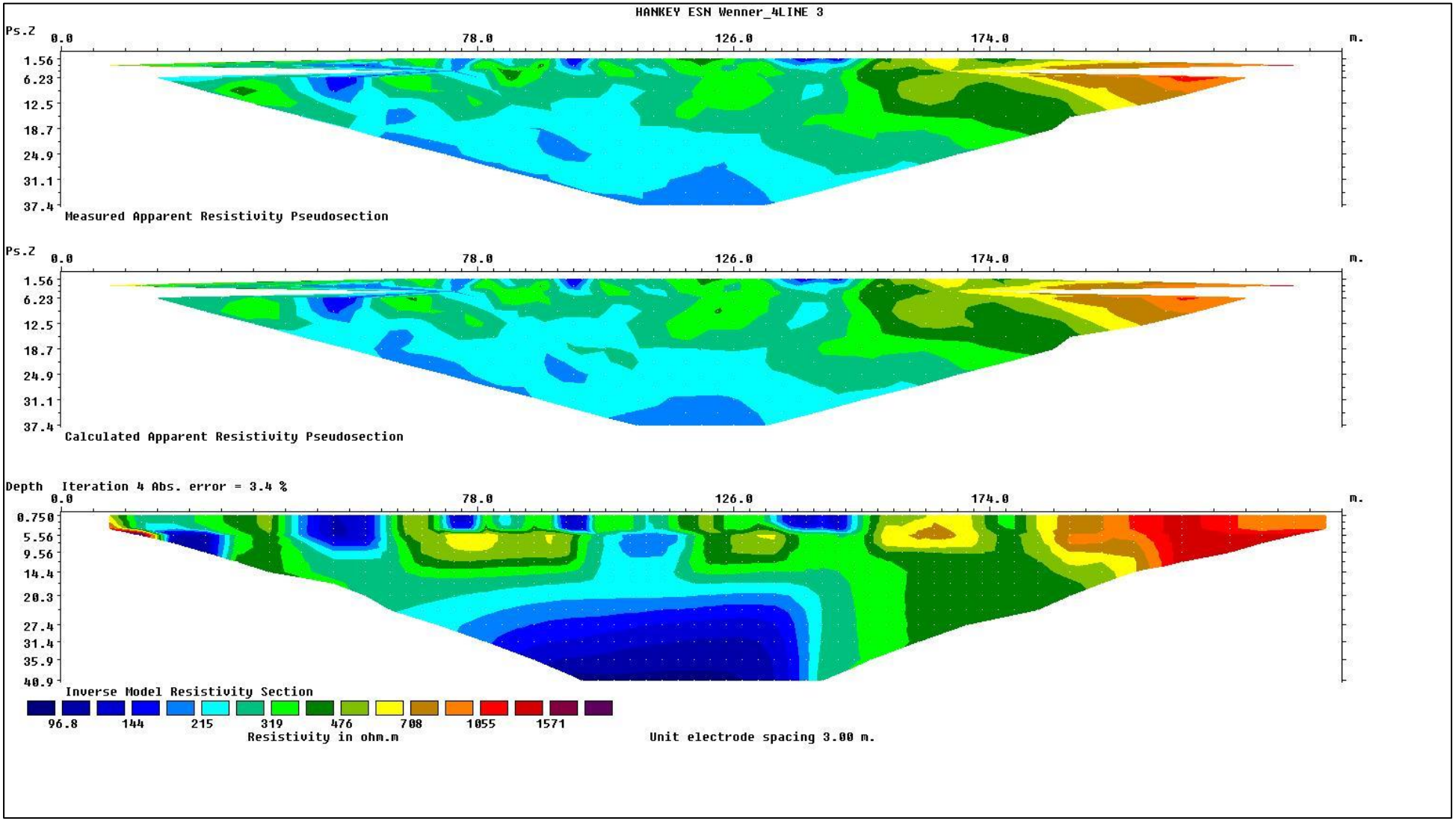


Figure 8 shows the resistivity survey line 1 conducted along a northeast-southwest direction over a 240 m traverse line


HANKEY ESN Wenner_4LINE 3
Ps.Z
0.0
78.0
126.0
174.0
m.
1.56
6.23
12.5
18.7
24.9
31.1
37.4
Measured Apparent Resistivity Pseudosection
Ps.Z
0.0
78.0
126.0
174.0
m.
1.56
6.23
12.5
18.7
24.9
31.1
37.4
Calculated Apparent Resistivity Pseudosection
Depth
Iteration 4 Abs. error = 3.4 %
0.0
78.0
126.0
174.0
m.
0.750
5.56
9.56
14.4
20.3
27.4
31.4
35.9
40.9
Inverse Model Resistivity Section
96.8
144
215
319
476
708
1055
1571
Resistivity in ohm.m
Unit electrode spacing 3.00 m.

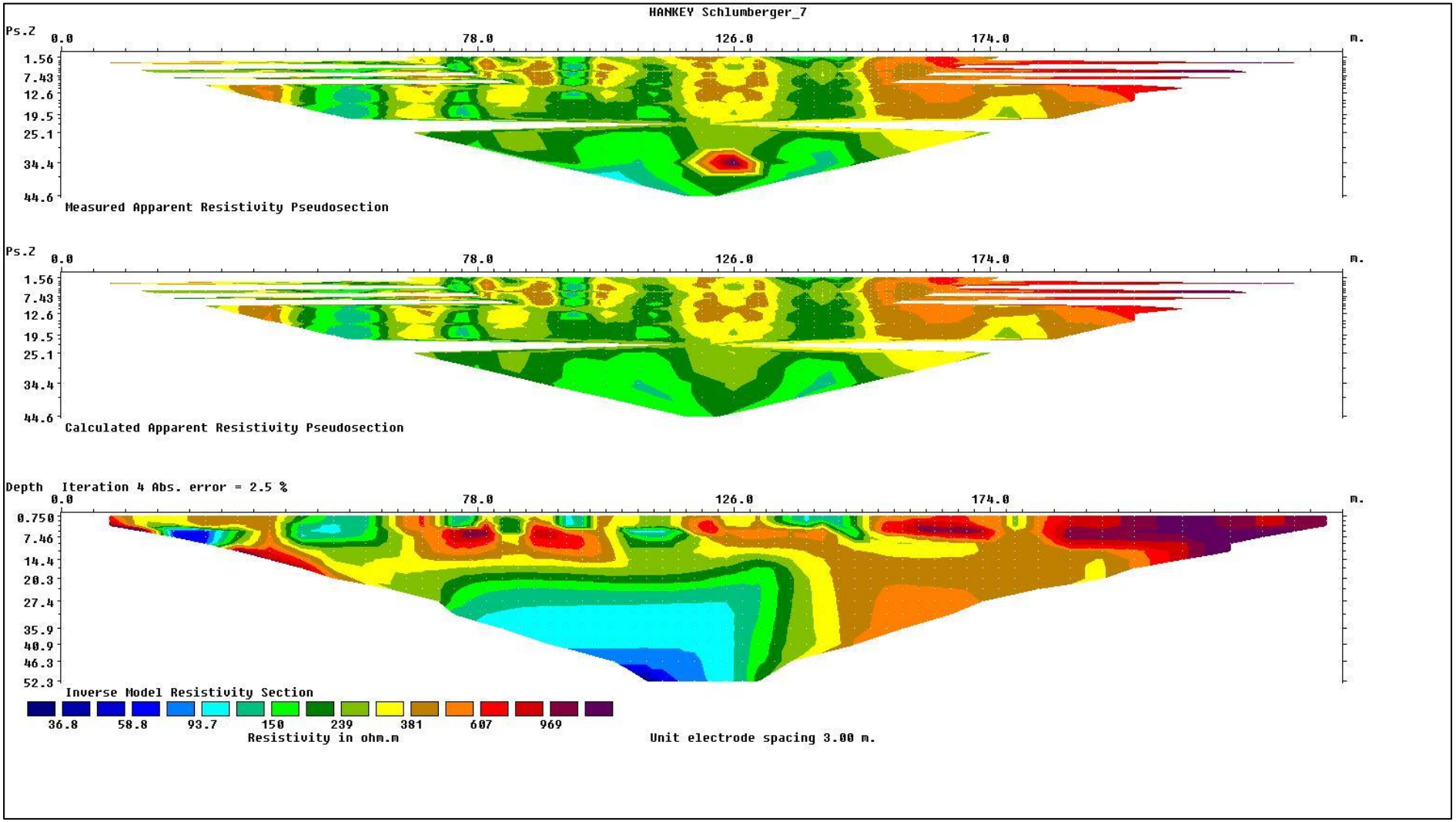


Figure 9 shows the resistivity survey line 2 conducted along a southeast-northwest direction over a 240 m traverse line

5. BOREHOLE DRILLING AND LOGGING RESULTS

5.1. GENERAL

A total of 19 boreholes were drilled at the site (Figure 10). The boreholes were drilled with a rotary percussion drilling rig (Zeus 5000 rig) at 21 bar air pressure with a capacity of 0.519 m^3 per second using the Reverse Circulation Method. A 208 mm clay cutter was utilized instead of a drilling bit on portions of the area underlain by clay material and a 145 mm reverse circulation drill bit was used on rock material.

The layout of the drilled boreholes is shown in Figure 10. It should be noted that all boreholes were backfilled with the extracted access sample and sealed with concrete for 1 m.

Chip logging of the boreholes was carried out to identify and to characterise the soil and rock horizons of the site as required by SANS 1936. Appendix III presents the details of the chip logs for the boreholes drilled together with the water levels recorded at least 24 hours after drilling was completed.

5.2. DRILLING SPECIFICATIONS

Drilling was conducted to various depths considering aspects of 60 m maximum depth or until at least 6 m of competent dolomite/solid bedrock was penetrated, whichever comes first and the drilling conditions in instances such as where sample was no longer recoverable or deep cavities. Information such as penetration rate per meter, depth of groundwater strikes, hammer rate, sample loss per meter and air loss per meter was recorded during the drilling of the boreholes.
For a detailed view of the information captured during drilling please see drillers logs attached under Appendix IV.

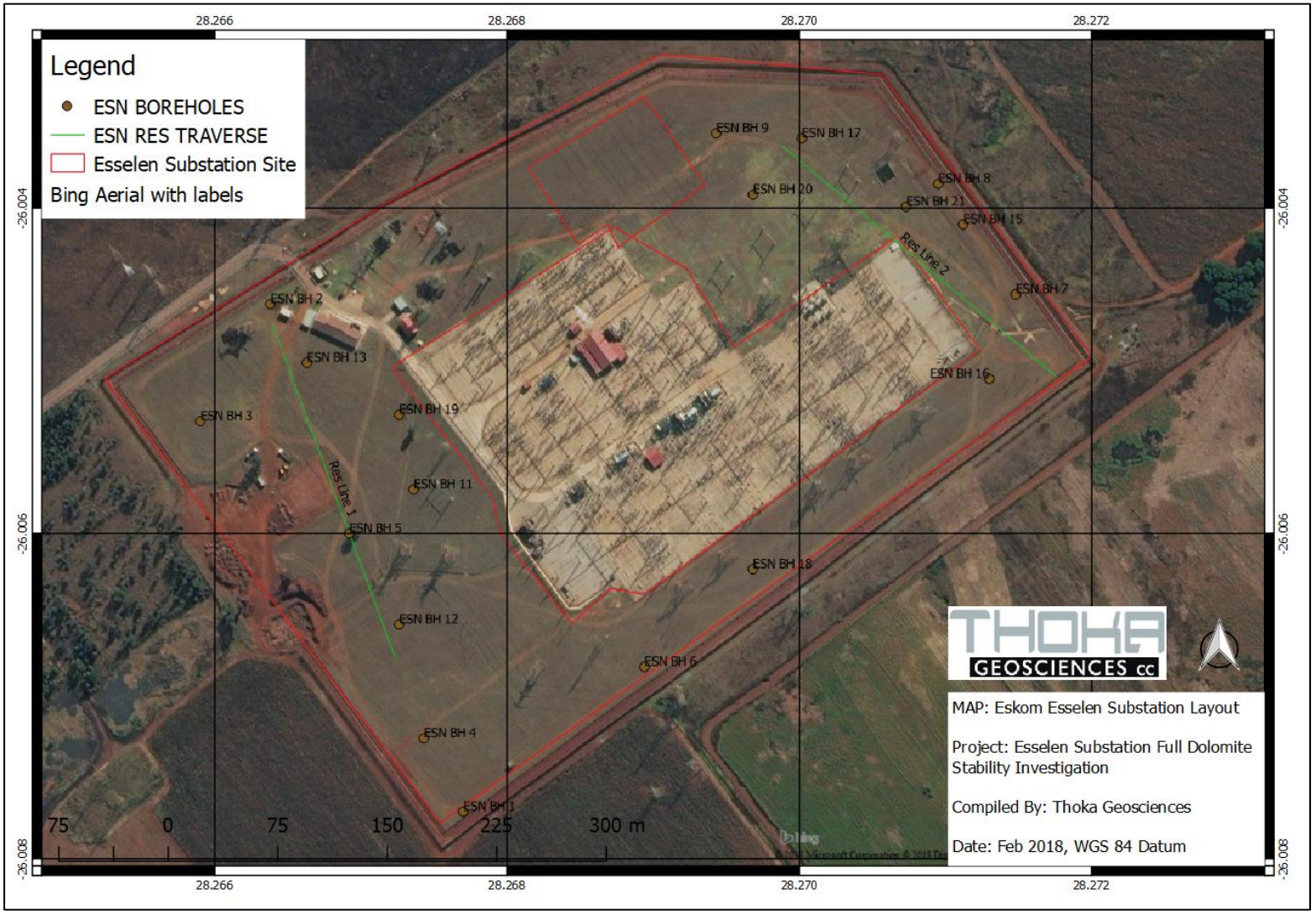


Figure 10 shows the locality of the site, resistivity traverse lines and the drilled boreholes

5.3. SAMPLING AND CHIP LOGGING

Chip samples were collected per meter drilled on site and described according to the current industry standards described in SANS 633. All the samples were put sequentially in plastic sleeves with tags describing the borehole number, penetration rate, and sample depth.
Soil and rock horizons in each of the boreholes were identified and described comprehensively applying the percussion chip logging techniques as required by SANS 1936 and 633. The key sample information recorded for each profile included: Moisture condition, colour, soil texture, origin of soils, rock types, weathering of the rocks and their origin. Appendix III illustrates the results and interpretation of the chip logging conducted and Appendix II shows the Percussion borehole drilling results summary of the boreholes drilled on the site.

A typical logging process would begin with the description of the bulk sample which comments on the bulk moisture, colour and texture of the sample. This is then followed by sieve washed description which includes texture description, colour, rock type and the degree of weathering. The last part of the logging process is the interpretation of the bulk sample description and sieve washed sample description (Appendix III).

5.4. SUMMARY OF PERCUSSION BOREHOLE LOGGING

Borehole logging results indicated occurrence of two groups of geological profiles, one group which is defined by the gravity high zones and higher apparent resistivity signature and the other group defined by gravity low zones and low resistivity signature. The gravity high zones are characterised by shallow dolomite bedrock conditions which vary based on weathered zones of chert and iron oxides/ferruginous soils and cavities. The gravity low zones are characterised by deeper dolomite bedrock overlain by small persistent cavities and soft clay, clayey silt overburden in upwards succession.

Ferruginous Soils

Occurrences of ferruginous soils in the form of SILTY SAND, CLAYEY SILT and ferricrete nodules are encountered at the site to maximum depths of about 7 m from surface. The ferruginous soils are commonly associated with highly weathered CHERT fragments e.g. ESN BH 1, 3, 4, 5, 12, 13, 16, 18 and 21. The occurrence of ferruginous soil is encountered within the gravity high zones of the site associated with shallow bedrock geology.

Transported Soft Clay, Silty Sand,

Soft clay, silty clay material is encountered within the gravity low zones which are associated with deeper dolomite bedrock. The soft clay, silty clay material is typically reddish brown/dark maroon

in colour commonly characterised by rapid penetration rates. The silty clay material is in many cases underlain by persistent cavities until solid dolomite bedrock at depth e.g. ESN BH 15 and ESN BH 8.

Weathered Chert of the Malmani Subgroup

Profiles of moderately to highly weathered CHERT occur commonly within the gravity high zones at the site. The highly weathered CHERT is characterised by rapid penetration rates, and subsequent cavities sometimes in excess of 10 meters e.g. ESN BH 2 and ESN BH 4.

Malmani Subgroup Dolomite

Solid dolomite bedrock is encountered as bluish grey sub-angular chip samples. The solid dolomite bedrock occurs either as shallow bedrock associated with the gravity high zones whereby solid dolomite sometimes rests at 4 meters from the surface. The deep dolomite bedrock is encountered on gravity low zones whereby solid dolomite bedrock can be encountered deeper than 18 m from surface e.g. ESN BH 2 & 3.

5.5. HYDROGEOLOGY OF THE SITE

The assessment of regional groundwater indicates groundwater levels to be at maximum depth of about 30 m from the surface for monitoring station A2N0627.

None of the 19 investigation boreholes at site encountered groundwater. The deepest borehole drilled at site reached depth of 24 m from the surface. This infers a deeper groundwater table at the site and that sinkhole or subsidence associated with groundwater drawdown is unlikely but rather ingress from ponding / percolating surface water is the main trigger for sinkhole formation at the site.

Two additional deeper boreholes were drilled on the northeast portion of the site represented by gravity low conditions in preparation for the dolomite risk management strategy requirements. The boreholes were drilled in access of 30 m from the surface and groundwater was intercepted. But, due to instantaneous collapsing during the drilling process, the boreholes had to be prematurely abandoned. The boreholes proved to be too risky to drill with conventional percussion methods, Thoka Geosciences recommends ODEX drilling systems to be implemented specifically for securing groundwater monitoring points at the site.

6. GEOTECHNICAL SITE APPRAISAL

6.1. GEOTECHNICAL PROVISIONS & LIMITATIONS

A 15 m grid gravity survey was conducted for Esselen Substation prior to commencement of drilling of boreholes.

A total of 21 boreholes were planned as part of Dolomite Stability Investigation with at least 1 or two borehole used for groundwater monitoring purposes. A total of 19 boreholes were drilled at the site for this investigation and two reserved for deeper drilling into identified aquifer zones within the site for monitoring purposes as part of the risk management strategy for the site. The boreholes drilled were to satisfy the requirements for a dolomite stability investigation at Eskom Esselen Substation.

Post drilling of boreholes, a resistivity investigation survey was conducted across parts of the site specifically targeting gravity low and gravity high zones with the aim of mapping the subsurface differences between gravity low and gravity high zones.

6.2. SITE CLASSIFICATION AND DEVELOPMENT POTENTIAL

6.2.1. General IHC Considerations

The purpose of this dolomite stability investigation report is to determine the different engineering geological properties of the surface, subsurface soils and dolomite rocks in accordance with the SANS 1936 guidelines and assign site classification for the dolomite underlain area.

As required by SANS 1936, stability evaluation of the site included the examination of receptacle development potential, mobilising agent, mobilization potential of blanket layer, bedrock morphology and potential sinkhole development space.

Mobilization is defined as the movement of dolomitic overburden by subsurface erosion. Mobilising agents include ingress water, ground vibrations, water level drawdown or any process that can induce mobilisation of material within the blanketing layer under the force of gravity including periodic rise and fall of groundwater level (Buttrick *et al,* 1995).

6.2.2. Groundwater Impact analysis

The site will be susceptible to water ingress from current and future installation of wet services and water ingress from water ponding or percolation from surface runoff.

As discussed above, only two boreholes intercepted groundwater at depths greater than 24 m from surface, the remainder 19 of the boreholes drilled did not encounter groundwater, thus groundwater is believed to be below the cavity prone dolomite horizons at the site (i.e. >24 m

from surface). Thus drawdown of existing groundwater level would have non to little impact on the stability of the dolomitic land as it is not within highly leached / weathered CHERT and DOLOMITE horizons characterised by cavities. This assertion is also reinforced by the fact that groundwater monitoring was conducted within the January – February 2018 period which is expected to be the high rainfall season for the geographical area. Although this is the case, there should be a groundwater management system in place as a precautionary measure to manage the usage/fluctuation of the groundwater particularly focusing on possible rise and fall of the groundwater table that could increase the inherent hazard for ground movement.

According to SANS 1936 - 2, the positive contribution towards dolomite stability of shallow groundwater levels should only be taken into account where:

- The compartmentalization of dolomite groundwater and aerial extent of the compartments have been determined.
- All groundwater users are identified and the maximum quantities abstracted are known.
- There is evidence to show licensed pumping does not exceed normal natural replenishment.
- There are data showing the groundwater level behaviour patterns during periods of drought and recovery.
- The groundwater level is not located within the dolomite residuum.
- The local authority or relevant national department has regularly monitored the groundwater level in the past and continues to do so.

More groundwater monitoring stations must be developed to ascertain the above requirements for groundwater. **Thus a groundwater monitoring station at the site is recommended as part of a risk management strategy.**

6.2.3. Sinkhole Size Analysis

The method adopted in sinkhole size determination followed the criteria by Buttrick *et al* 2001, whereby bedrock depth shallower than 3 m is expected to be more prone to develop a small (<2 m) sinkhole and bedrock depth >3 m < 15 m is more prone to develop a medium sinkhole and bedrock depth deeper 15 m more prone to develop a large sinkhole (5 - 15 m Wide Sinkholes).

Due to the variable depth to dolomite bedrock, the site is inferred to be more prone to develop medium to large sinkholes respective to the borehole results. Medium sinkholes are sinkholes expected to have a nominal diameter of 2 – 5 m and large sinkhole expected to have 5 – 15 m diameter. Based on the assessment of the geophysics, gravity low zones have deeper bedrock

and more prone to develop large sinkholes and gravity high zones are more prone to develop medium to large sinkholes.

6.2.4. Blanketing Material/layer Analysis

The blanketing material at the site may be summed up as ferrugenised SILTY SAND, SILT and SOFT CLAY with fragments of highly weathered CHERT. The geological profiles of the blanketing material at the site although sometimes as thick as 8 m from surface is easily permeable due to the nature and characteristics of the material. Drilling penetration rates recorded to be less 1 minute per meter drilled over the blanketing material suggest moderate to highly permeable material susceptible to collapse/movements. **Thus instability triggered by water ingress from the surface is highly likely in situations whereby surface water is not drained at sufficient rate.**

6.2.5. Cavities, Voids and Historic Sinkholes/subsidence's

The occurrence of highly weathered chert/dolomite horizons and cavity at shallow and deeper depths as per gravity high and gravity low zones throughout the site suggests typical high inherent hazard for karst formation as voids and cavities form part of receptacles for material of the overlaying strata. Recorded historic sinkhole and subsidence on the western flank of the site further imply high risk zones and caution. The vast area on the western flank of the Eskom Esselen Substation has been zoned of as a high risk area as a whole due to evident sinkhole formation within that area. The triggering mechanism for sinkhole formation is by assessment due to sudden loss of support accelerated by surface water ingress.

6.2.6. Site Classification

Considering all the discussed attributes of mobilization /blanketing material agency, cavities, sinkhole size and nature of blanketing material, dolomite bedrock topography and geohydrology, the site is regarded to have variable hazard classes. Boreholes representing high inherent hazard (IHC 6 – 8) dominate by about 70 % of the drilled borehole classifying either as IHC 6/7/8. Most of the high inherent hazard areas are characterised by either gravity low zones/deep bedrock or contact zones between gravity high and gravity low zones e.g. ESN BH 13. This assessment suggests platforms of shallow dolomite adjacent to troughs of weathered zones covered by soil sediment deposits (FERRUGENISED CLAYEY SILT). The platforms of shallow dolomite in most instances represent intermediate inherent hazard classified as IHC 2/3/4.

Table 1 shows the summary of all the boreholes drilled on site and their inherent hazard classifications.

Chart 3 shows the location of all the boreholes drilled at the site and Chart 3 also shows the inherent hazard classification(s) of the site.

The Dolomite Land Classification for the site is pre-determined by the type of development to be pursued at the site. SANS 1936-1, Table 2 shows the permissible land usage per inherent hazard class for dolomite land. Any other proposed development will thus be guided by the permissible land usage guidelines. **The site falls under C3 type development (Electrical Substations, please see**
Figure 11**) thus developable with footprint requirements up until IHC 6.** Therefore any future development at the site should be prioritised on the gravity high zones of the site **but with care to avoid the contact zones of gravity high platforms and gravity low troughs. No future development at the site should be conducted or permitted without a detailed footprint investigation.**

Portions of the site are thus regarded to be conditionally developable under D3 + Footprint Investigation conditions as a C3 Development Type. Should any future footprint investigations prove worse conditions, the respective area must be regarded as a D4 area with high inherent hazard.

1	2	3	4	5	6	7	8	9	10
Land usage		**Inherent hazard class determined in accordance with the requirements of SANS 1936-2**							
Designation	**Description**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
		Dolomite area designation and footprint investigation requirement							
Commercial and miscellaneous non-residential usage									
C1	Places of detention, police stations, and institutional homes for the handicapped or aged	D3 + FPI					D4		
C2	Hospitals (including clinics), hostels, hotels	D3 + FPI						D4	
C3	Commercial developments ≤ 3 storeys, including railway stations, shops, wholesale stores, offices, places of worship, theatrical, indoor sports or public assembly venues, other institutional land uses such as universities, schools, colleges, libraries, exhibition halls and museums, light (dry) industrial developments, dry manufacturing, commercial uses such as warehousing, packaging, and electrical substations, filling stations	D2 + FPI	D3 + FPI					D4	
C4	Commercial developments > 3 storeys, including railway stations, shops, wholesale stores, offices, places of worship, theatrical, indoor sports or public assembly venues, other institutional land uses such as universities, schools, colleges, libraries, exhibition halls and museums, light (dry) industrial developments, dry manufacturing, commercial uses such as warehousing, packaging, and electrical substations	D2 + FPI	D3 +FPI	D4					
C5	Fuel depots, processing plants or any other areas for the storage of liquids, waste sites.	D2 + DLI	D3 + DLI				D4		
C6	Outdoor storage facilities, stock yards, container depots	D2 + DLI	D3 + DLI						D4
C7	Parking garages	D2	D3 + FPI					D4	
C8	Parking areas	D2	D3						D4
DLI = Design level investigation in accordance with the requirements of SANS 1936-2, as deemed appropriate by the competent person. FPI = Design level investigation specifically below the footprint of the structure.									
NOTE 1 D1, D2, D3 and D4 have the meanings assigned in table 1. NOTE 2 Residential coverage ratio = footprint area/site area.									

Figure 11 Extracted from Table 2 of SANS 1936-1; page 11 shows the permissible infrastructure and social facilities per inherent hazard class.

NOTE: Development of any future C3 type development will require a footprint investigation of the proposed development.

Table 1: Summary of Inherent Hazard Class Classifications

Borehole Number	Wad	Voids	Air Loss	Sample Loss	Sinkhole Size Class	Average Mobilization Potential	Sinkhole Hazard	Subsidence Depression. Hazard	Inherent Hazard Class (IHC) for Water ingress Scenario/None Dewatering	Inherent Hazard Class (IHC) for Dewatering Scenario
ESN BH 1	None	-	4 - 8	4 - 8	Medium	High	High	High	6	6
ESN BH 2	None	8-19	6 – 19	6 – 19	Large	High	High	High	8	8
ESN BH 3	None	7 – 10 13 - 16	6 – 19	6 - 19	Large	High	High	High	8	8
ESN BH 4	None	6 – 13	3 – 13	6 – 13	Large	High	High	High	8	8
ESN BH 5	None	-	-	-	Small – Medium	Low - Medium	Low - Medium	Medium	2	2
ESN BH 6	None	-	-	-	Small – Medium	Low - Medium	Medium	Medium	3	3
ESN BH 7	None	7 – 10	7 – 11	7 – 12	Medium	High	High	High	6	6
ESN BH 8	None	8-14	8 – 19	8 – 14	Medium	High	High	High	6	6
ESN BH 9	None	6-8	6 – 14	6 – 8	Medium	High	High	High	6	6
ESN BH 10	None									

Borehole Number	Wad	Voids	Air Loss	Sample Loss	Sinkhole Size Class	Average Mobilization Potential	Sinkhole Hazard	Subsidence Depression. Hazard	Inherent Hazard Class (IHC) for Water ingress Scenario/None Dewatering	Inherent Hazard Class (IHC) for Dewatering Scenario
ESN BH 11	None	3-5	3 – 7	3 - 5	Medium	Medium	High	High	6	6
ESN BH 12	None	-	-	-	Medium	Medium	Small to Medium	Medium	3	3
ESN BH 13	None	-	2 – 10	-	Medium	High	High	High	6	6
ESN BH 14	None									
ESN BH 15	None	8-18	8 – 24	8 – 18	Large	High	High	High	7	7
ESN BH 16	None	9-19	7 – 19	9 – 19	Large	High	High	High	8	8
ESN BH 17	None	6-14	6 – 14	6 – 14	Large	High	High	High	8	8
ESN BH 18	None	-	5 – 6	-	Medium	Medium	Medium	Medium	3 / 4	3 / 4
ESN BH 19	None	-	-	-	Medium	Medium	Medium	Medium	3 / 4	3 / 4
ESN BH 20	None	-	-	-	Medium	Medium	Medium	Medium	3 / 4	3 / 4
ESN BH 21	None	9-11	9 - 13	9 – 11 12.5 – 21	Large	High	High	High	7	7

6.3. LAND USE RESTRICTIONS

Table 2 below shows the general requirements for the development of D1, D2, D3 and D4 dolomite area designation. For a detailed view of the precautionary measures required for the D2, D3 and D4 dolomite area designation, please view the extracts from SANS 1936-3. As these are very comprehensive and detailed, it will suffice to say that these foundation design and water precautionary related measures cover the proposed new development type, as well as their future upgrading and maintenance.

Table 2: Shows a general overview of the requirements for D2, D3 and D4 dolomite land.

Dolomite area designation	Description
D1	No precautionary measures are required.
D2	General precautionary measures, in accordance with the requirements of SANS 936-3, that are intended to prevent the concentrated ingress of water into the ground, are required.
D3	Precautionary measures in addition to those pertaining to the prevention of concentrated ingress of water into the round, in accordance with the relevant requirements of SANS 1936-3 are required.
D4	The precautionary measures required in terms of SANS 1936-3 are unlikely to result in a tolerable hazard. Site-specific precautionary measures are required.

6.4. PRECAUTIONARY MEASURES FOR ESKOM ESSELEN SUBSTATION

The development on the site needs to adhere to several precautionary measures as stipulated in SANS 1936-3:2012 and these include:

- No ponding of surface water should be able to occur adjacent to foundations both during and after construction

- Storm water should be effectively captured and led well away from all structures.

- All wet services should be flexible in design and should specifically be designed to accommodate movement where entering or leaving structures.

- All foundations should be inspected by a competent person to ensure that the desired founding medium has been attained and that recommendations made in this report have been adhered to.

- Brick force should be incorporated in all layers of the plinth wall for load bearing brickwork and in every fourth layer. At least three layers of brick force should be placed above all openings such as doors.

- All building on site shall be constructed in accordance with relevant codes of practice.

- Sinkhole manifestation is expected to be in the form of medium to large sinkholes. The notional sinkhole diameter at the site is thus deduced to be equals to or greater than 5 m in diameter.

- Development on D3 + FPI sites should be constructed in such a manner that a sinkhole or subsidence that has a likelihood of occurring and that has the notional diameter of surface manifestation indicated in the geotechnical report within or adjacent to the footprint of such building, shall not result in the toppling or sliding failure of the building or a portion thereof into such a sinkhole or subsidence (SANS 1936-3:2012).

- Thus all new structures developed should be designed to span at least 5 - 15 m loss of support

- An engineered soil raft / raft should be used in areas of shallow dolomite bedrock. This mattress has the dual purpose of improving founding conditions. The construction of such a mattress involves the removal and replacement of unsuitable soil beneath and for 3 m beyond the periphery of buildings. The precise design of the mattress will be dependent on bedrock depth and the nature of the local soil materials.

- Storm water upstream of building and structures shall be diverted away from the building or structure in such a manner that concentration of storm water is minimized or led to a storm water drainage system.

- According to SANS 1936, in addition to the above mentioned precautionary measures, sites which fall under D4 dolomite land need to adhere to site-specific precautionary measures.

- According to the guidelines for consultants for development of infrastructure on dolomite (Department of Public Works, 2004). High risk areas should adhere to precautionary measures as shown below:

- Use only HDPE piping for water (Class PN 12, 5 and higher), sewer (Class PN 10 minimum) and storm water (8 kN/m^2 ring stiffness) in 21 high-risk areas or where services traverse high-risk areas. All material for HDPE pipes, structures and fittings must be in accordance with SABS ISO 4427/SANS 4427 for type PE 100 and all welding and manufacturing to be in accordance with SABS 0268/SANS 10268, SABS 0269/SANS 10269, SABS 0270/SANS 10270, SABS 1655/SANS 1655 and SABS 1671/SANS 1671 codes.

- In extremely problematic areas water reticulation may be placed above ground or all services may be placed in ducts or sleeves where within fifteen metres of a building. Sleeves to be provided with inspection chambers at both ends and must comply with the requirements of a sewer system for high risk areas. All sleeve systems must be constructed to designed slopes that permit drainage to predetermined inspection manholes.

- Ablution facilities should not be included in the principal buildings or infrastructure. These facilities should be isolated in such a manner as to avoid damage to other parts of the development in the event of service failure and sinkhole/doline formation.

- Use aprons of large (5.0 m width) impervious paved areas around structures to enhance drainage. If rapid drainage (slopes 1:15 and steeper) away from structures is possible apron slabs may be reduced to 3.0 m width.

- Blanketing of geotechnical problematic areas with impervious material (clayey soil and/or HDPE sheeting), concrete or paving bricks need to be introduced if such areas could influence the structural integrity of buildings.

- Contouring of site to achieve a fall of least 1:40 in general and to 1:15 away from structures within a distance of 8 m of a structure is required.

6.5. DOLOMITE RISK MANAGEMENT PLAN & RECOMMENDATIONS

A crucial requirement of development on dolomitic lands, as stipulated in SANS 1936-1, is the establishment and implementation of a dolomite risk management strategy (DRMS) by the developer, which must tie in with that in place and controlled by the relevant local authority which in this regard the relevant authority would be the Ekurhuleni Municipality. SANS 1936-4 describes this in detail.

It is therefore highly recommended that Thoka Geosciences be appointed to develop a dolomite risk management strategy so as to minimize further development of sinkholes within the station. The dolomite risk management strategy will entail amongst others, monitoring regional groundwater, monitoring local groundwater fluctuations, monitoring of surface flow on site and emergency preparedness plan in cases where sinkholes develop.

The risk management strategy will be tied with local municipalities risk management strategy in place also providing reporting strategies of sinkhole and subsidence events. The training of local personnel occupying the Esselen Substation will be part and parcel of the risk management strategy. Training will include amongst other aspects, training of personnel on identification of sinkholes, subsidence, tension cracks leading to sinkholes, and management of surface water ponding and reporting strategies.

Urgency to rehabilitate existing sinkholes must be placed and further assessment of the dolomite stability beyond the outer parameter fence onto the boundary of Eskom Esselen Substation servitude needs to be prioritised as a matter of urgency.

Areas deduced to be IHC 8 from this investigation are recommended for proactive rehabilitation in the form of overburden strip, expose cavity throat and rehabilitation to prevent highly likely sinkhole occurrences.

7. CONCLUSIONS

Due to the variable depth to dolomite bedrock, the site is inferred to be more prone to develop medium to large sinkholes respective to the borehole results. Medium sinkholes are sinkholes expected to have a nominal diameter of 2 – 5 m and large sinkhole expected to have 5 – 15 m diameter. Based on the assessment of the geophysics, gravity low zones have deeper bedrock and more prone to develop large sinkholes and gravity high zones are more prone to develop medium to large sinkholes.

The blanketing material at the site may be summed up as ferrugenised SILTY SAND, SILT and SOFT CLAY with fragments of highly weathered CHERT. The geological profiles of the blanketing material at the site although sometimes as thick as 8 m from surface is easily permeable due to the nature and characteristics of the material. Drilling penetration rates recorded to be less 1 minute per meter drilled over the blanketing material suggest easily permeable material susceptible to collapse/movements. **Thus instability triggered by water ingress from the surface is highly likely in situations whereby surface water is not drained at sufficient rate.**

The occurrence of highly weathered chert/dolomite horizons and cavity at shallow and deeper depths as per gravity high and gravity low zones throughout the site suggests typical high inherent hazard for karst formation as voids and cavities form part of receptacles for material of the overlaying strata. Recorded historic sinkhole and subsidence on the western flank of the site further imply high risk zones and caution. The vast area on the western flank of the Eskom Esselen Substation has been zoned of as a high risk area as a whole due to evident sinkhole formation within that area. The triggering mechanism for sinkhole formation is by assessment due to sudden loss of support accelerated by surface water ingress.

Considering all the discussed attributes of mobilization /blanketing material agency, cavities, sinkhole size and nature of blanketing material, dolomite bedrock topography and geohydrology, the site is regarded to have variable hazard classes. Boreholes representing high inherent hazard (IHC 6 – 8) dominate by about 70 % of the drilled borehole classifying either as IHC 6/7/8. Most of the high inherent hazard areas are characterised by either gravity low zones/deep bedrock or contact zones between gravity high and gravity low zones e.g. ESN BH 13. This assessment suggests platforms of shallow dolomite adjacent to troughs of weathered zones covered by soil sediment deposits (FERRUGENISED CLAYEY SILT). The

platforms of shallow dolomite in most instances represent intermediate inherent hazard classified as IHC 2/3/4.

The Dolomite Land Classification for the site will be pre-determined by the type of development to be pursued at the site. SANS 1936-1, Table 2 shows the permissible land usage per inherent hazard class for dolomite land. Any proposed development will thus be guided by the permissible land usage guidelines. **The site falls under C3 type development, thus developable with footprint requirements up until IHC 6.** Therefore any future development at the site should be prioritised on the gravity high zones of the site **but with care to avoid the contact zones of gravity high platforms and gravity low troughs. No future development at the site should be conducted or permitted without a detailed footprint investigation.**

Portions of the site are thus regarded to be conditionally developable under D3 + Footprint Investigation conditions as a C3 Development Type. Should any future footprint investigations proof worse conditions, the respective area must be regarded as a D4 area with high inherent hazard.

A crucial requirement of development on dolomitic lands, as stipulated in SANS 1936-1, is the establishment and implementation of a dolomite risk management strategy (DRMS) by the developer, which must tie in with that in place and controlled by the relevant local authority which in this regard the relevant authority would be the Ekurhuleni Municipality. SANS 1936-4 describes this in detail.

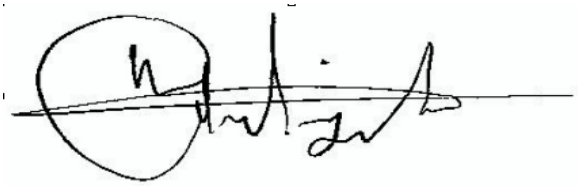
It is therefore highly recommended that Thoka Geosciences be appointed to develop a dolomite risk management strategy so as to minimize further development of sinkholes within the station. The dolomite risk management strategy will entail amongst others, monitoring regional groundwater, monitoring local groundwater fluctuations, monitoring of surface flow on site and emergency preparedness plan in cases where sinkholes develop.

The risk management strategy will be tied with local municipalities risk management strategy in place also providing reporting strategies of sinkhole and subsidence events. The training of local personnel occupying the Esselen Substation will be part and parcel of the risk management strategy. Training will include amongst other aspects, training of personnel on identification of sinkholes, subsidence, tension cracks leading to sinkholes, and management of surface water ponding and reporting strategies.

Urgency to rehabilitate existing sinkholes must be placed and further assessment of the dolomite stability beyond the outer parameter fence onto the boundary of Eskom Esselen Substation servitude needs to be prioritised as a matter of urgency.

Areas deduced to be IHC 8 from this investigation are recommended for proactive rehabilitation in the form of overburden strip, expose cavity throat and rehabilitation to prevent highly likely sinkhole occurrences.

REPORT SIGN OFF



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Tshwaro ME Mogadime Pr.Sci.Nat.
Managing Director

PROJECT TEAM

Mr Melusi Mashego BSc Hons Geology Candi.Sci.Nat.
Tseliso Lebasa BSc Env & Engineering Geology

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9. APPENDICES

Appendix I

FIGURES

Chart 1: Locality and Layout Map

Chart 2: Geological Map 2628 East Rand

Chart 3: Inherent Hazard Class Zonation

Appendix II

Borehole Summary Table

Appendix III

Percussion Borehole Profile Log Sheets

Appendix IV

Drillers Logs

Appendix V

Gravity Survey Results

Appendix VI

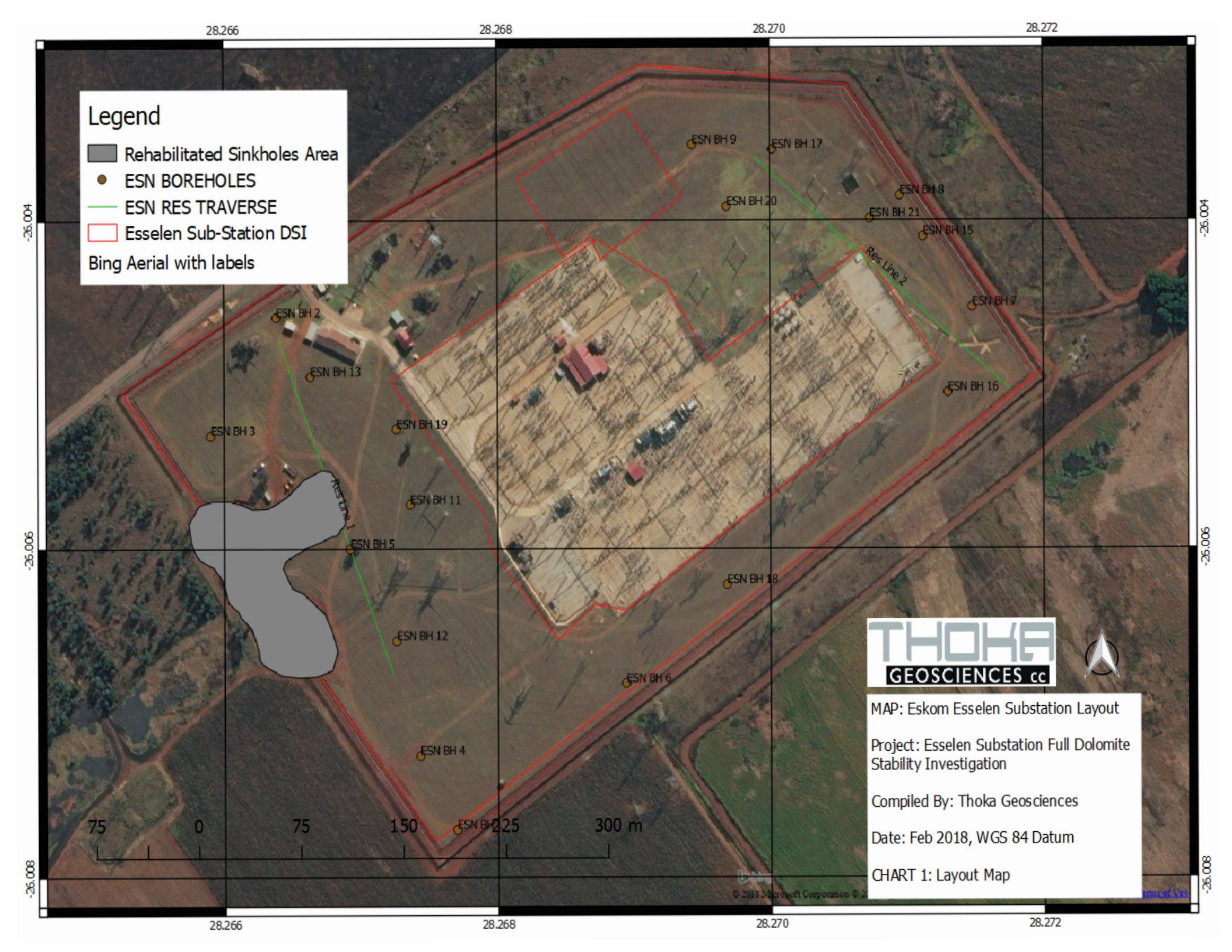
Council for Geosciences Review

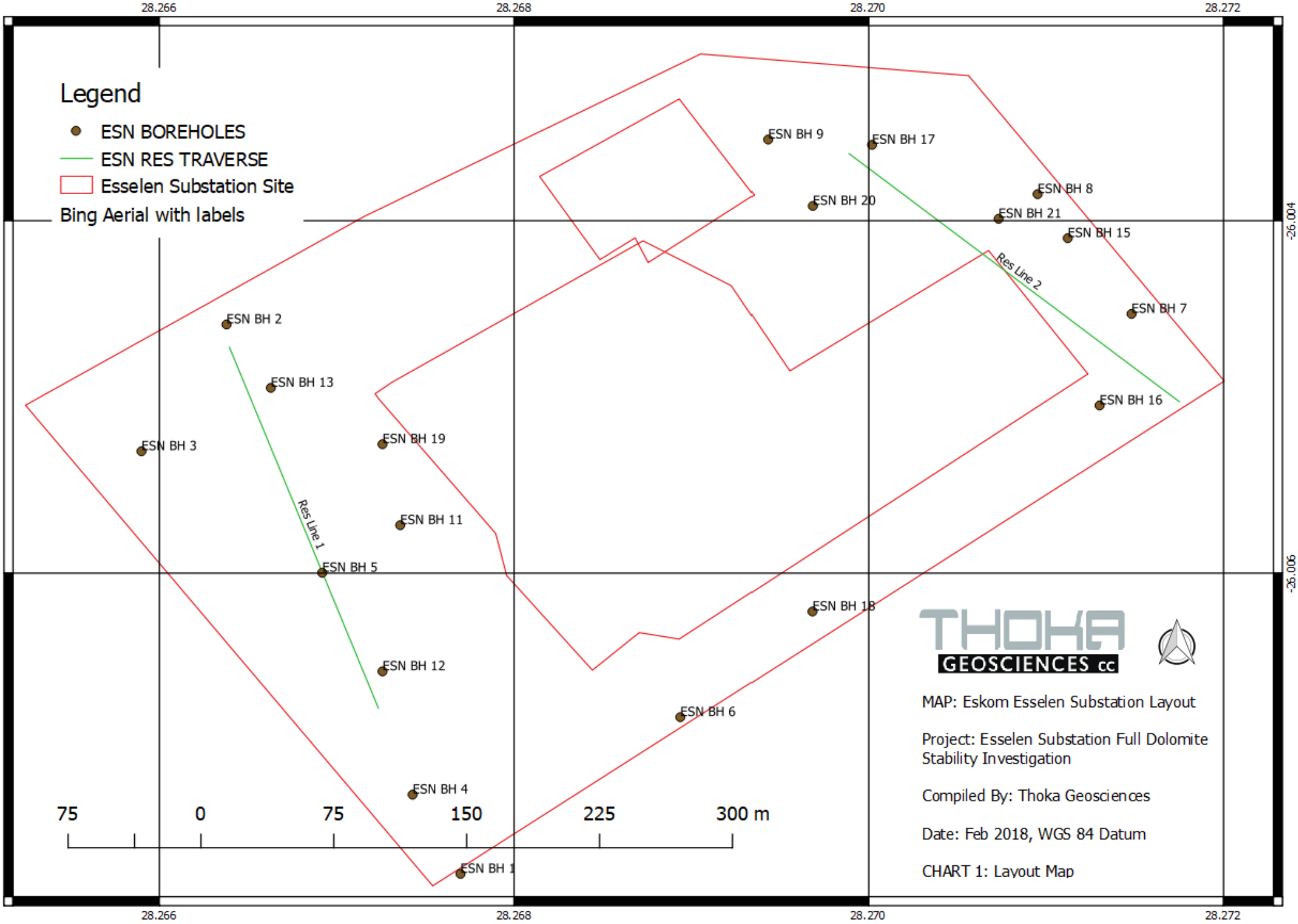
Appendix I

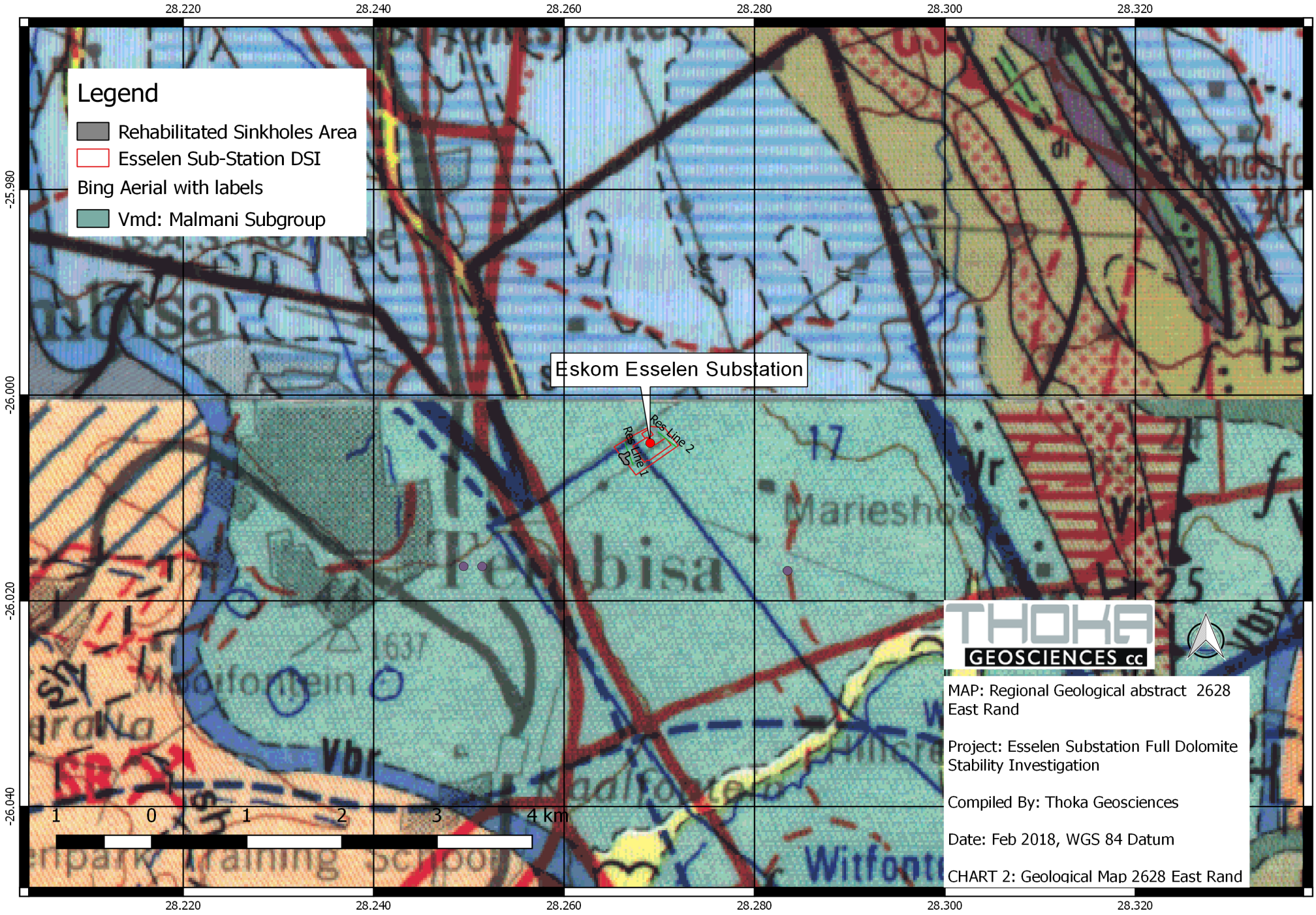
Chart 1: Locality and Layout Map

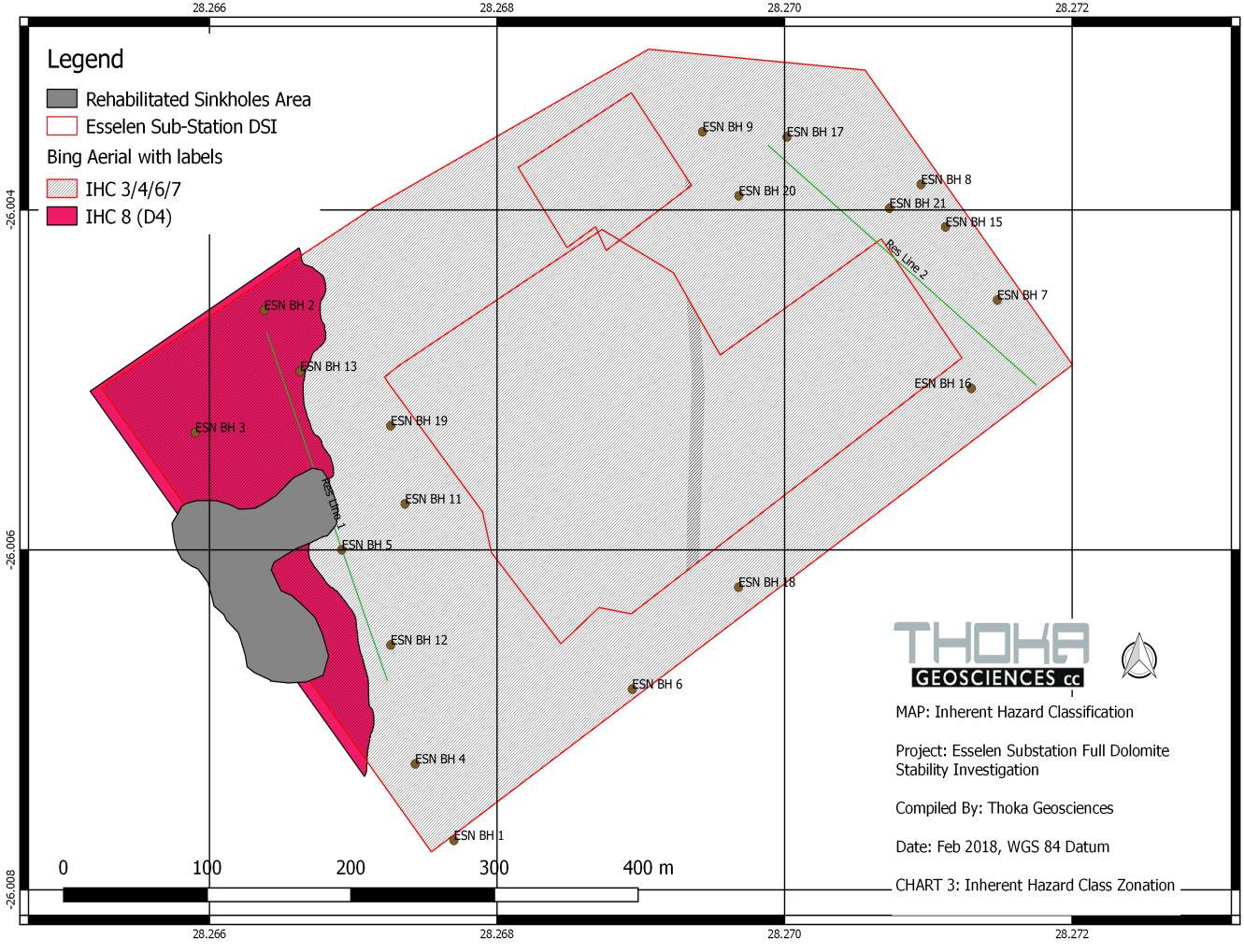
Chart 2: Geological Map 2628 East Rand

Chart 3: Inherent Hazard Class Zonation


Legend
Rehabilitated Sinkholes Area
ESN BOREHOLES
ESN RES TRAVERSE
Esselen Sub-Station DSI
Bing Aerial with labels
28.266
28.268
28.270
28.272
-26.004
-26.006
-26.008
ESN BH 9
ESN BH 17
ESN BH 20
ESN BH 8
ESN BH 21
ESN BH 15
Res Line 2
ESN BH 7
ESN BH 2
ESN BH 13
ESN BH 16
ESN BH 3
ESN BH 19
ESN BH 11
Res Line 1
ESN BH 5
ESN BH 18
ESN BH 12
ESN BH 6
ESN BH 4
ESN BH 1
75
0
75
150
225
300 m
THOKA
GEOSCIENCES cc
MAP: Eskom Esselen Substation Layout
Project: Esselen Substation Full Dolomite Stability Investigation
Compiled By: Thoka Geosciences
Date: Feb 2018, WGS 84 Datum
CHART 1: Layout Map


28.266
28.268
28.270
28.272
-26.004
-26.006
Legend
ESN BOREHOLES
ESN RES TRAVERSE
Esselen Substation Site
Bing Aerial with labels
ESN BH 9
ESN BH 17
ESN BH 8
ESN BH 20
ESN BH 21
ESN BH 15
Res Line 2
ESN BH 7
ESN BH 2
ESN BH 13
ESN BH 16
ESN BH 3
ESN BH 19
Res Line 1
ESN BH 11
ESN BH 5
ESN BH 18
ESN BH 12
ESN BH 6
ESN BH 4
75
0
75
150
225
300 m
ESN BH 1
THOKA
GEOSCIENCES cc
MAP: Eskom Esselen Substation Layout
Project: Esselen Substation Full Dolomite Stability Investigation
Compiled By: Thoka Geosciences
Date: Feb 2018, WGS 84 Datum
CHART 1: Layout Map


28.220
28.240
28.260
28.280
28.300
28.320
-25.980
-26.000
-26.020
-26.040
Legend
Rehabilitated Sinkholes Area
Esselen Sub-Station DSI
Bing Aerial with labels
Vmd: Malmani Subgroup
Eskom Esselen Substation
Res Line 2
Res Line 1
Vbr
1637
1 0 1 2 3 4 km
THOKA
GEOSCIENCES cc
MAP: Regional Geological abstract 2628 East Rand
Project: Esselen Substation Full Dolomite Stability Investigation
Compiled By: Thoka Geosciences
Date: Feb 2018, WGS 84 Datum
CHART 2: Geological Map 2628 East Rand


Legend
Rehabilitated Sinkholes Area
Esselen Sub-Station DSI
Bing Aerial with labels
IHC 3/4/6/7
IHC 8 (D4)
28.266
28.268
28.270
28.272
-26.004
-26.006
-26.008
ESN BH 9
ESN BH 17
ESN BH 8
ESN BH 20
ESN BH 21
ESN BH 15
Res Line 2
ESN BH 7
ESN BH 2
ESN BH 13
ESN BH 16
ESN BH 3
ESN BH 19
Res Line 1
ESN BH 11
ESN BH 5
ESN BH 18
ESN BH 12
ESN BH 6
ESN BH 4
ESN BH 1
0
100
200
300
400 m
THOKA
GEOSCIENCES cc
MAP: Inherent Hazard Classification
Project: Esselen Substation Full Dolomite Stability Investigation
Compiled By: Thoka Geosciences
Date: Feb 2018, WGS 84 Datum
CHART 3: Inherent Hazard Class Zonation

Appendix II

Borehole Summary Table

Borehole Number	Borehole Coordinates	Ferricrete Soil with Highly Weathered Chert Fragments / Transported Soils	Highly to Moderately Weathered Chert and Dolomite	Moderately - Slightly Weathered Chert & Dolomite	Cavity / Voids	Solid Unweathered Dolomite Rock/Bedrock	Depth to Water Table Levels after 24 Hours	Inherent Hazard Class - Water Ingress Scenario	Inherent Hazard Class - Dewatering Scenario
ESN BH 1	28.26770 26.00771	0 – 7 m: Ferricrete Soil with Fragments of Highly Weathered CHERT		8 – 12 m: Moderately Weathered CHERT		12 – 18 m: Solid Unweathered Dolomite	Dry	6	6
ESN BH 2	28.26638 26.00459	0 – 4 m: Ferruginous SILTY SAND	4 – 8 m: Moderately weathered CHERT		8 – 19 m: Cavity		Dry	8	8
ESN BH 3	28.26590 26.00531	0 – 3 m: Highly Weathered Chert & Ferricrete soils	3 – 7 m: Highly weathered Chert 10 – 13 m: Highly weathered CHERT	16 – 18 m: Highly to Slightly weathered Dolomite	7 – 10 m: Rapid Penetration Rate (Cavities) 13 – 16 m: Rapid Penetration Rate (Cavities)	18 – 24 m: Solid Dolomite	Dry	8	8
ESN BH 4	28.26743 26.00726	0 – 1 m: Ferricrete soil with fragments of Highly weathered CHERT	1 – 6 m: Highly weathered CHERT		6 – 13 m: Rapid Penetration Rate (Cavities)		Dry	8	8
ESN BH 5	28.26692 26.00600	0 – 2 m: Ferricrete soil with fragments of Highly weathered CHERT		2 – 4 m: Slightly weathered Dolomite		4 – 10 m: Solid Dolomite	Dry	2	2
ESN BH 6	28.26894 26.00682	0 – 3 m: Ferricrete soil		3 – 4 m: Moderately weathered Dolomite		4 – 10 m: Solid Dolomite	Dry	3	3
ESN BH 7	28.27148 26.00453	0 – 7 m: Clayey SILT		10 – 13 m: Moderately weathered DOLOMITE and CHERT	7 – 10 Rapid Penetration Rate (Cavities)	13 – 19 m: Solid DOLOMITE	Dry	6	6
ESN BH 8	28.27095 26.00385	0 – 8 m: Soft CLAY			8 – 14 m: Rapid Penetration Rate (Cavities)	14 – 20 m: Solid DOLOMITE	Dry	6	6
ESN BH 9	28.26943 26.00354	0.- 1 m: Colluvium Material	1 – 6 m: Moderately weathered CHERT		6 – 8 m: Cavities	8 – 14 m: Solid Dolomite	Dry	6	6
ESN BH 11	28.26736 26.00573	0 – 2 m: Ferruginsed soil with Highly weathered CHERT fragments	2 – 3 m: Highly weathered CHERT 5 – 8 m: Highly to moderately weathered CHERT and DOLOMITE		3 – 5 m: Rapid Penetration Rate (Cavities)	8 – 14 m: Solid Dolomite	Dry	6	6

Borehole Number	Borehole Coordinates	Ferricrete Soil with Highly Weathered Chert Fragments / Transported Soils	Highly to Moderately Weathered Chert and Dolomite	Moderately - Slightly Weathered Chert & Dolomite	Cavity / Voids	Solid Unweathered Dolomite Rock/Bedrock	Depth to Water Table Levels after 24 Hours	Inherent Hazard Class - Water Ingress Scenario	Inherent Hazard Class - Dewatering Scenario
ESN BH 12	28.26726 26.00656	0 – 3 m: Ferruginsed soil with Highly weathered CHERT fragments		3 – 6 m: Moderately weathered DOLOMITE		6 – 12 m: Solid DOLOMITE	Dry	3	3
ESN BH 13	28.26663 26.00495	0 – 3 m: Highly Weathered CHERT with Ferricrete nodules	3 – 9 m: Highly Weathered CHERT			9 – 15 m: Solid DOLOMITE	Dry	6	6
ESN BH 15	28.27112 26.00410	0 – 8 m: Silty Clay			8 – 18 m: Cavities with hanging boulders at 9 – 15 m	18 – 24 m: Solid Dolomite	Dry	7	7
ESN BH 16	28.27130 26.00505	0 – 3 m: Highly weathered CHERT in ferruginised SAND matrix	3 – 9 m: Highly weathered CHERT and DOLOMITE		9 – 19 m: Cavities		Dry	8	8
ESN BH 17	28.270016 26.00357	0 – 6 m: CHERT in a SILTY CLAY matrix			6 – 14 m: Cavities		Dry	8	8
ESN BH 18	28.26968 26.00622	0 – 7 m: Highly weathered CHERT		7 – 11 m: Slightly weathered CHERT and DOLOMITE		11 – 17 m: Solid DOLOMITE	Dry	3/4	3/4
ESN BH 19	28.26726 26.00527	0 – 2 m: HILLWASH	2 – 7 m: Moderately weathered CHERT	7 – 11 m: Moderately weathered DOLOMITE		11 – 17 m: Solid DOLOMITE	Dry	3/4	3/4
ESN BH 20	28.269682 -26.003917	0 – 2 m: Highly weathered CHERT	2 – 3 m: Highly weathered CHERT and DOLOMITE			3 – 9 m: Solid DOLOMITE	Dry	2/3	2/3
ESN BH 21	28.27073 26.00399	0 – 5 m: Clayey Ferruginous clayey SILT and ferruginous Gravel	5 - 9 m: Moderately weathered CHERT and DOLOMITE	11 – 12.5 m: Moderately weathered to slightly weathered DOLOMITE	9 – 11 m: Cavity 12.5 – 15 m: Cavity	15 – 21 m: NO SAMPLE return but drilling indicates solid bedrock conditions	Dry	7	7

Appendix III

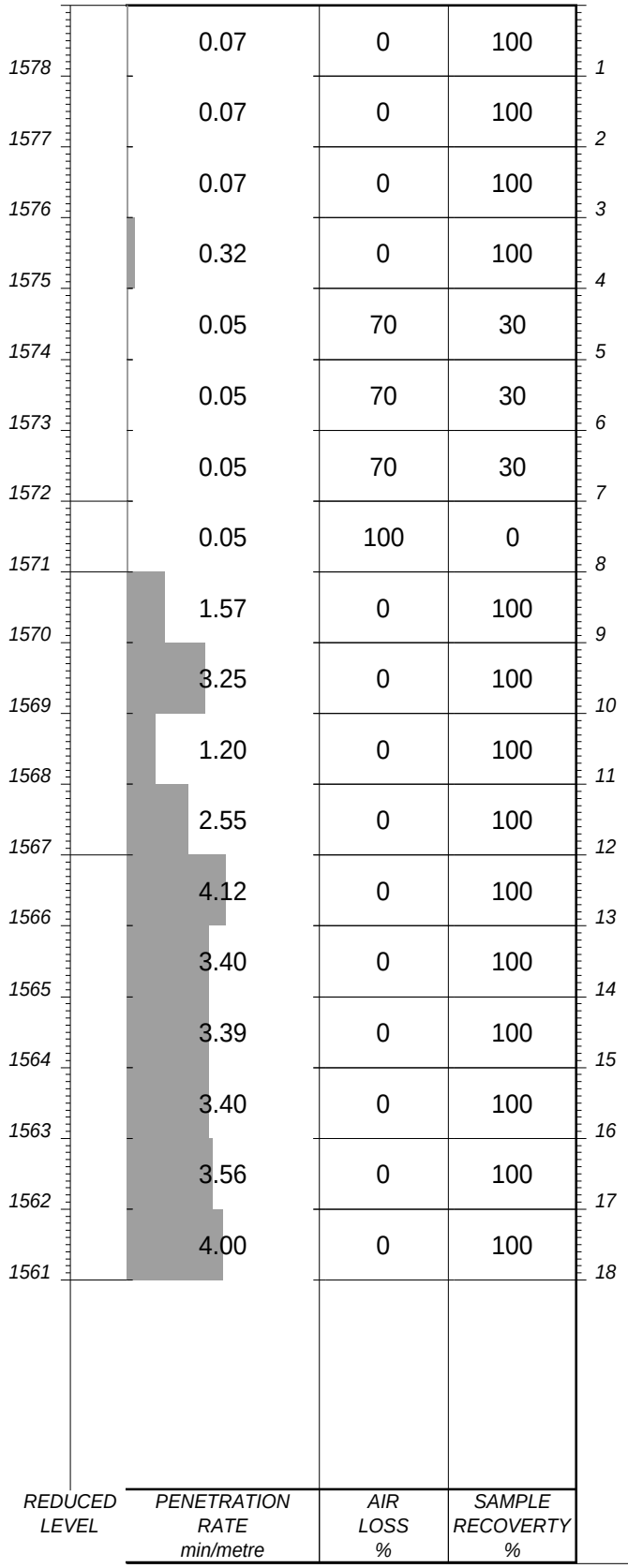
Percussion Borehole Profile Log Sheets

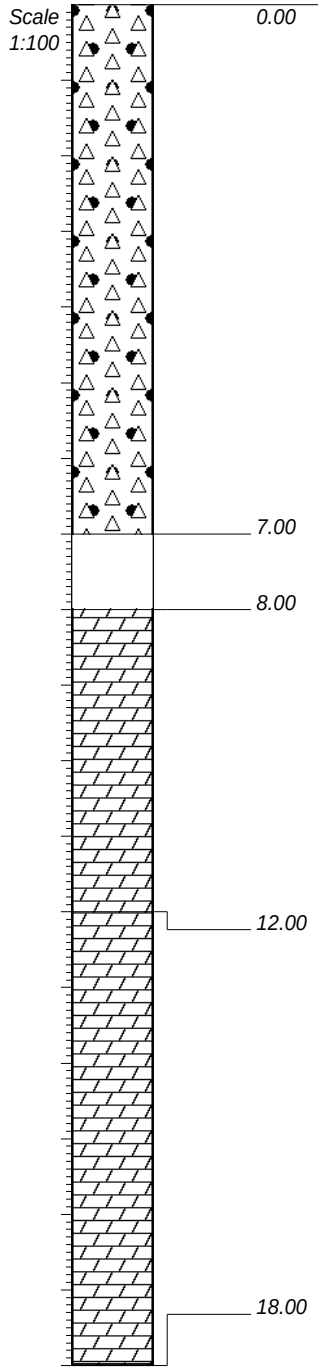
THOKA GEOSCIENCES cc

ESKOM
ESSELEN SUBSTATION FULL DSI

HOLE No: 1
Sheet 1 of 1

JOB NUMBER: ESN BH 1





Bulk sample: Moist, brown to maroon brown, clayey silt at 1m and sandy gravel in a slightly clayey matrix. **Sieve washed:** 60% loss. Wet, fine to medium gravel chips of rounded sub-rounded highly weathered CHERT and rounded ferricrete nodules. **Interpretation:** Ferrugenised soil and highly weathered CHERT.

NO SAMPLE RETURN

Bulk sample: Dry, greyish brown, sandy gravel. **Sieve washed:** 45-50% loss. Wet, fine gravel chips of brown stained sub-anglular moderately weathered DOLOMITE chips **Interpretation:** Moderately weathered DOLOMITE

Bulk sample: Dry, grey, sandy gravel. **Sieve washed:** <10% loss. Wet, fine to medium gravel chips of sub-angular bluish grey unweathered DOLOMITE **Interpretation:** Solid unweathered DOLOMITE

NOTES

1) 1)

2) 2)

3) 3.

REDUCED LEVEL	PENETRATION RATE min/metre	AIR LOSS %	SAMPLE RECOVERTY %

CONTRACTOR : Thoka Geosciences
MACHINE : THOR 5000
DRILLED BY :
PROFILED BY : Melusi Mashego
TYPE SET BY :
SETUP FILE : STANDARD.SET

INCLINATION : VERTICAL
DIAM :
DATE :
DATE : 15 JANUARY 2018
DATE : 05/02/2018 15:23
TEXT : ..I\ProfileLogs\ESNBH1.TXT

ELEVATION : 1579m
X-COORD : 28.26770
Y-COORD : 26.00771

HOLE No: 1
Esselen Substation, Tembisa

ESKOM
ESSELEN SUBSTATION FULL DSI

LEGEND
Sheet 1 of 1

JOB NUMBER: ESN BH 1

	DOLOMITE	{SA13}
	CHERT	{SA21}
	FERRICRETE NODULES	{SA24}

CONTRACTOR :
MACHINE :
DRILLED BY :
PROFILED BY :
TYPE SET BY :
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE :
DATE :
DATE : 05/02/2018 15:23
TEXT : ..I\ProfileLogs\ESNBH1.TXT

ELEVATION :
X-COORD :
Y-COORD :

LEGEND
SUMMARY OF SYMBOLS

THOKA GEOSCIENCES cc

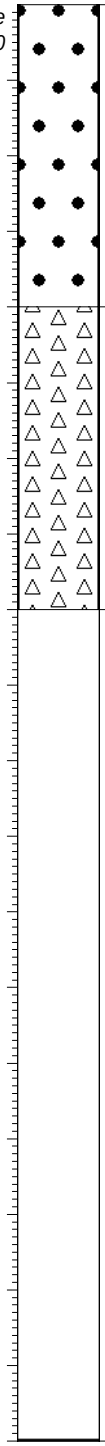
ESKOM
ESSELEN SUBSTATION FULL DSI

HOLE No: 02
Sheet 1 of 1

JOB NUMBER: ESN BH 2

REDUCED LEVEL	PENETRATION RATE min/metre	AIR LOSS %	SAMPLE RECOVERTY %
1580	0.1	0	100
1579	0.11	0	100
1578	0.12	0	100
1577	0.17	0	100
1576	0.49	0	100
1575	0.58	0	100
1574	0.36	60	40
1573	0.06	100	0
1572	0.06	100	0
1571	0.06	100	0
1570	0.06	100	0
1569	0.06	100	0
1568	0.06	100	0
1567	0.06	100	0
1566	0.06	100	0
1565	0.06	100	0
1564	0.06	100	0
1563	0.06	100	0
1562	0.06	100	0

Scale 1:100



Bulk sample: Moist, reddish brown, silty sand with gravel. **Sieve washed:** 65-70% loss. Wet, fine gravel chips of rounded black and dark red ferricrete nodules **Interpretation:** Ferruginous soil

Bulk sample: Moist, brown, sandy gravel. **Sieve washed:** 20% loss. Wet, fine and medium gravel chips of angular dark grey CHERT **Interpretation:** Moderately weathered CHERT

Interpretation: TOTAL SAMPLE LOSS. Rapid penetration rates indicate cavities.

NOTES

1) 2)

2) 3.

CONTRACTOR : Thoka Geosciences
MACHINE : THOR 5000
DRILLED BY :
PROFILED BY : Melusi Mashego
TYPE SET BY :
SETUP FILE : STANDARD.SET

INCLINATION : VERTICAL
DIAM :
DATE :
DATE : 10 JANUARY 2018
DATE : 05/02/2018 15:26
TEXT : ..I\ProfileLogs\ESNBH2.TXT

ELEVATION : 1581 m
X-COORD : 28.26638
Y-COORD : 26.00459

HOLE No: 02
Esselen Substation, Tembisa

ESKOM
ESSELEN SUBSTATION FULL DSI

LEGEND
Sheet 1 of 1

JOB NUMBER: ESN BH 2

	CHERT	{SA21}
	FERRICRETE NODULES	{SA24}

CONTRACTOR :
MACHINE :
DRILLED BY :
PROFILED BY :
TYPE SET BY :
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE :
DATE :
DATE : 05/02/2018 15:26
TEXT : ..I\ProfileLogs\ESNBH2.TXT

ELEVATION :
X-COORD :
Y-COORD :

LEGEND
SUMMARY OF SYMBOLS

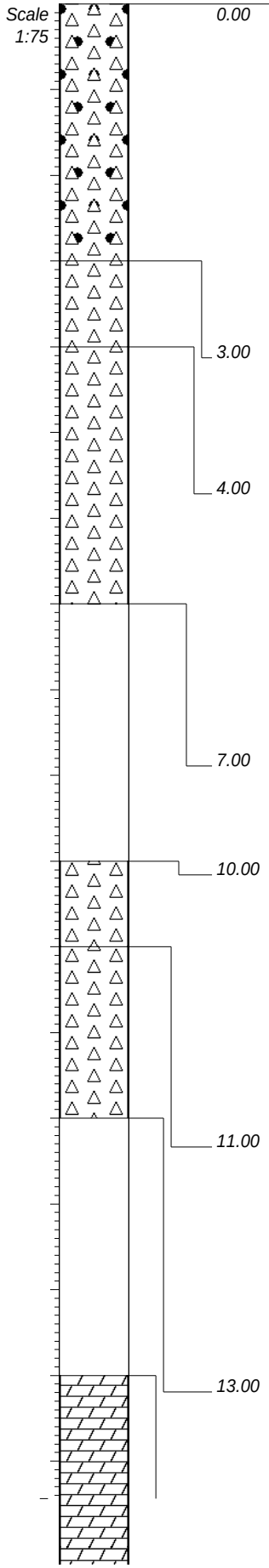
THOKA GEOSCIENCES cc

ESKOM
ESSELEN SUBSTATION FULL DSI

HOLE No: 03
Sheet 1 of 2

JOB NUMBER: ESN BH 3

REDUCED LEVEL	PENETRATION RATE min/metre	AIR LOSS %	SAMPLE RECOVERTY %	
1573	0.18	0	100	1
1572	0.20	0	100	2
1571	0.16	0	100	3
1570	0.33	0	100	4
1569	0.33	0	100	5
1568	0.40	0	100	6
1567	0.47	60	40	7
1566	0.08	100	0	8
1565	0.31	100	0	9
1564	0.08	100	0	10
1563	0.08	70	40	11
1562	0.38	70	30	12
1561	0.14	70	30	13
1560	0.08	100	0	14
1559	0.08	100	0	15
1558	0.08	100	0	16
1557	0.29	60	40	17



Bulk sample: Moist, reddish brown, sandy gravel. **Sieve washed:** 20% loss. Wet, fine to coarse gravel chips of sub-rounded and rounded brown to reddish brown stained highly weathered CHERT with rounded fine gravel chips of ferricrete nodules. **Interpretation:** Highly weathered CHERT and FERRICRETE nodules

Bulk sample: Dry, translucent angular gravel chips of CHERT **Interpretation:** Moderately weathered CHERT

Bulk sample: Moist,reddish brown, medium to coarse gravel in a sandy matrix. **Sieve washed:** 70-75% loss. Wet, fine to medium gravel chips of angular dark grey CHERT. **Interpretation:** Moderately to Highly weathered CHERT

TOTAL SAMPLE LOSS. Rapid penetration rates indicate cavities.

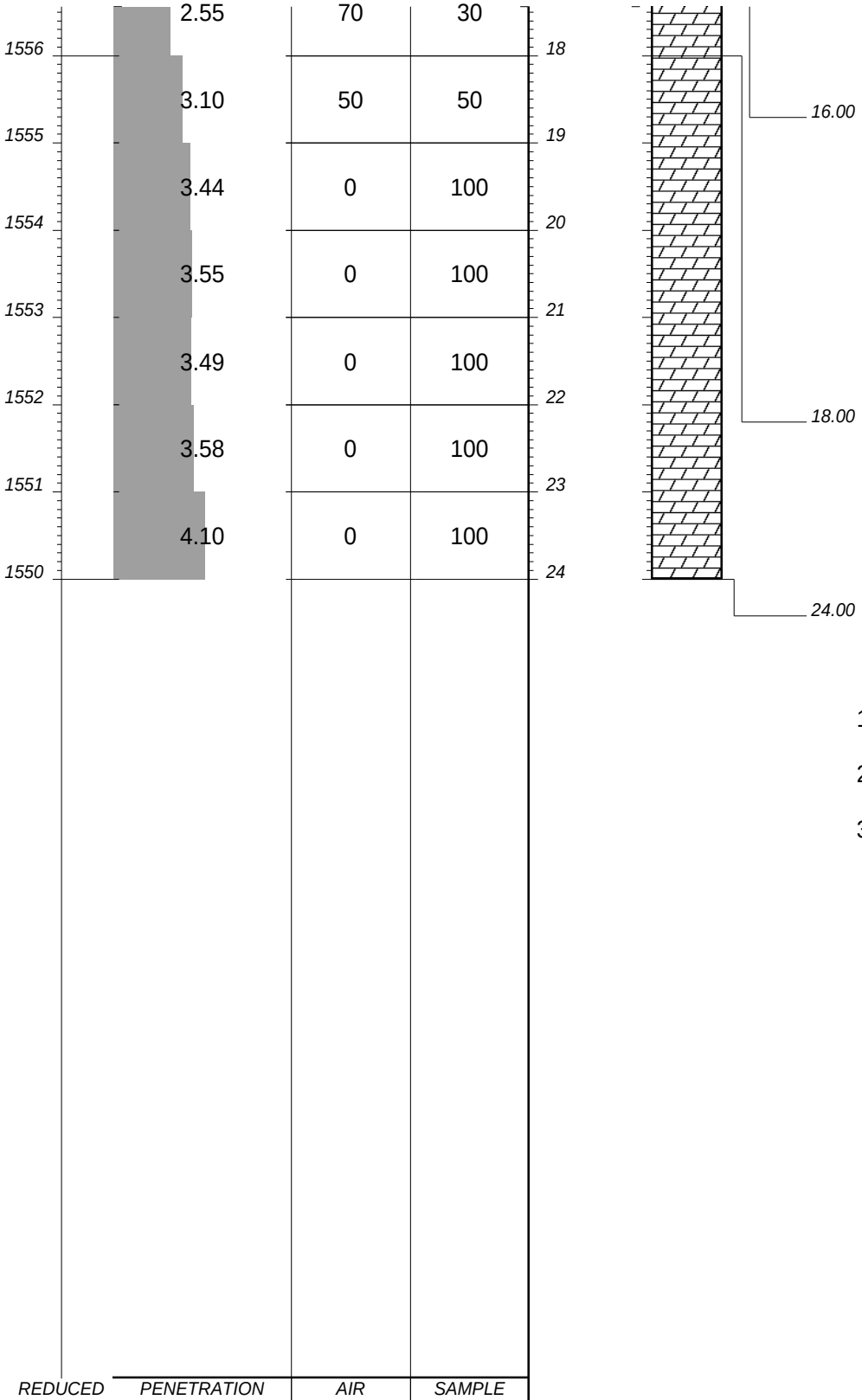
Bulk sample: Moist,reddish brown, medium to coarse gravel in a sandy matrix. **Sieve washed:** 70-75% loss. Wet, fine to medium gravel chips of angular dark grey CHERT. **Interpretation:** Moderately to Highly weathered CHERT

Bulk sample: Slightly moist, greyish brown, sandy gravel. **Sieve washed:** 65-70% loss. Wet, fine to medium gravel chips of sub-rounded and angular highy weathered CHERT **Interpretation:** Highly weathered CHERT

ESKOM
ESSELEN SUBSTATION FULL DSI

HOLE No: 03
Sheet 2 of 2

JOB NUMBER: ESN BH 3



TOTAL SAMPLE LOSS, rapid penetration rate indicate cavities

Bulk sample: Slightly moist, brown to dark grey sandy gravel. **Sieve washed:** 60% loss. Wet, fine to medium gravel chips of sub angular bluish grey with minor brown stains slightly weathered DOLOMITE **Interpretation:** Highly to Slightly weathered DOLOMITE

Bulk sample: Dry, grey, gravel. **Sieve washed:** <15% loss. Wet, fine to medium gravel chips of angular grey DOLOMITE **Interpretation:** Unweathered DOLOMITE

NOTES

1) 1)

2) 2)

3) 3.

REDUCED LEVEL	*PENETRATION RATE min/metre*	*AIR LOSS %*	*SAMPLE RECOVERTY %*

CONTRACTOR : Thoka Geosciences
MACHINE : THOR 5000
DRILLED BY :
PROFILED BY : Melusi Mashego

INCLINATION : VERTICAL
DIAM :
DATE :
DATE : 10 JANUARY 2018

ELEVATION : 1574m
X-COORD : 28.26590
Y-COORD : 26.00531

TYPE SET BY :
SETUP FILE : STANDARD.SET

DATE : 05/02/2018 15:26
TEXT : ..I\ProfileLogs\ESNBH3.TXT

HOLE No: 03
Esselen Substation, Tembisa

ESKOM
ESSELEN SUBSTATION FULL DSI

LEGEND
Sheet 1 of 1

JOB NUMBER: ESN BH 3

	DOLOMITE	{SA13}
	CHERT	{SA21}
	FERRICRETE NODULES	{SA24}

CONTRACTOR :
MACHINE :
DRILLED BY :
PROFILED BY :
TYPE SET BY :
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE :
DATE :
DATE : 05/02/2018 15:26
TEXT : ..I\ProfileLogs\ESNBH3.TXT

ELEVATION :
X-COORD :
Y-COORD :

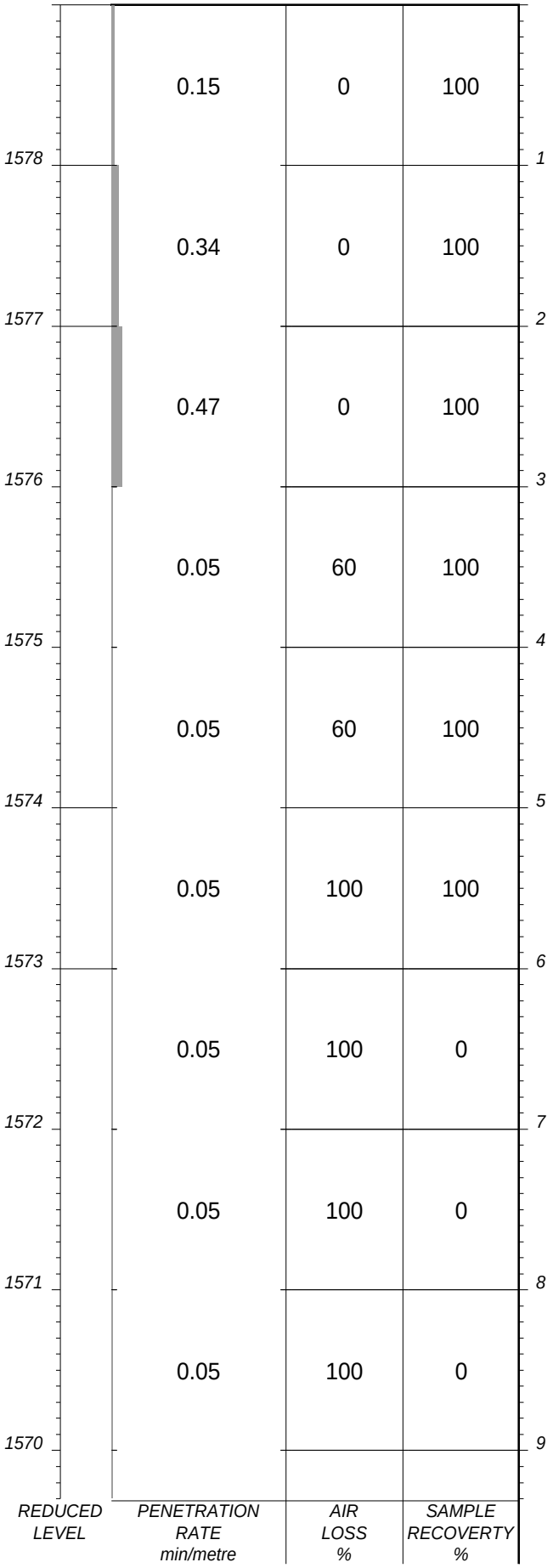
LEGEND
SUMMARY OF SYMBOLS

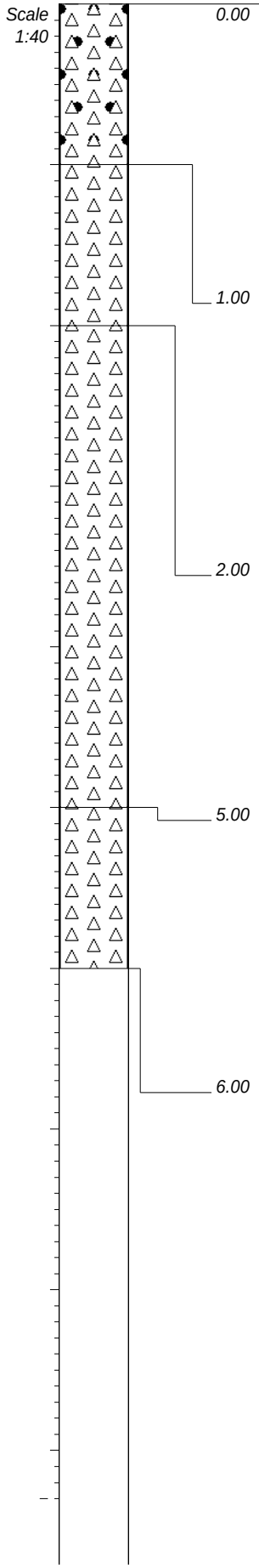
THOKA GEOSCIENCES cc

ESKOM
ESSELEN SUBSTATION FULL DSI

HOLE No: **4**
Sheet 1 of 2

JOB NUMBER: ESN BH 4





Bulk sample: Moist, brown, gravel in a silty clay matrix. **Sieve washed:** 30% loss. Wet, fine to medium gravel chips of sub-angular highly weathered CHERT and fine gravel of rounded ferricrete **Interpretation:** Highly weathered CHERT in a ferruginous soil matrix

Bulk sample: Dry, brown, sandy gravel. **Sieve washed:** 20% loss. Wet, fine to medium gravel chips of angular tranlucent and brown moderately to highly weathered CHERT. **Interpretation:** Highly weathered CHERT

Bulk sample: Moits, brown, sandy gravel. **Sieve washed:** 10% loss. Wet, coarse and minor fine to medium gravel chips of highly weathered sub-angular CHERT. **Interpretation:** Highly weathered CHERT.

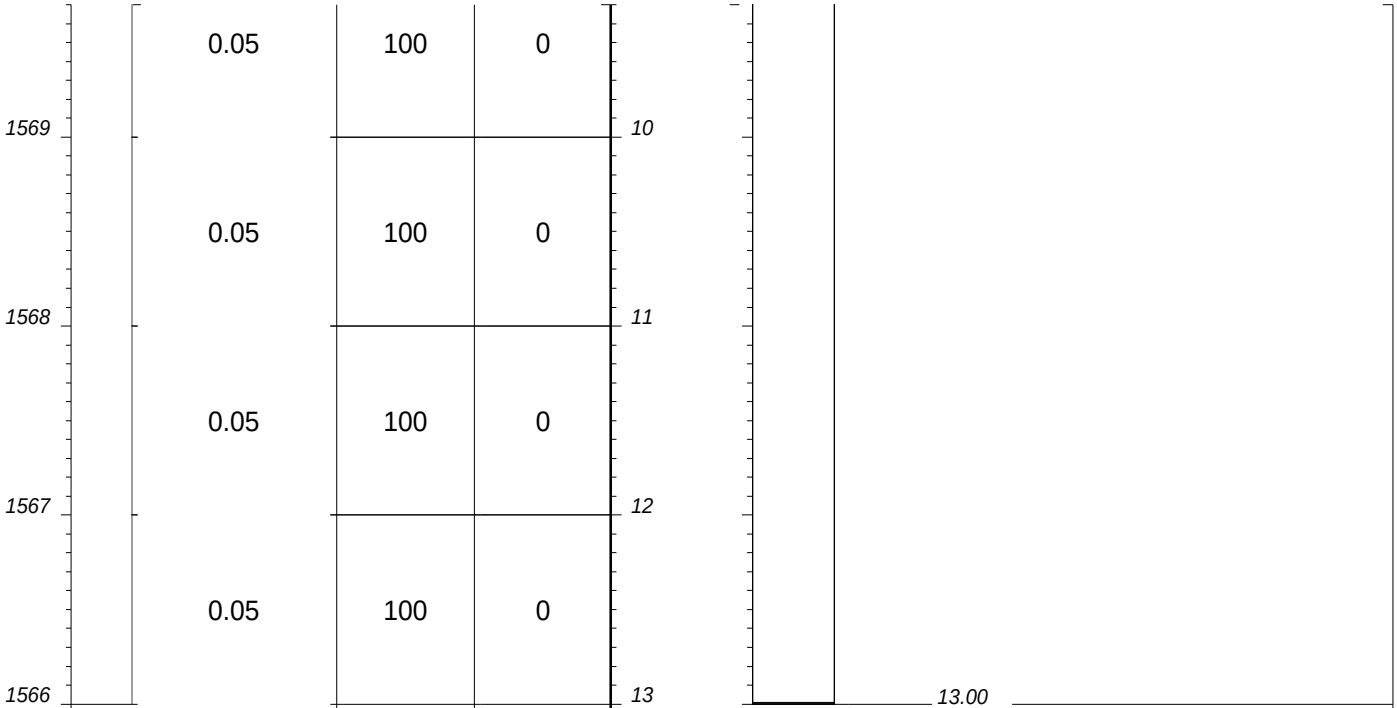
Bulk sample: Moist, dark brown, sandy gravel in a slightly clayey matrix. **Sieve washed:** 40% loss. Wet, fine to medium gravel chips of sub-angular black highly weathered CHERT. **Interpretation:** Highly weathered CHERT.

NO SAMPLE RETURN, rapid penetration rates indicate cavities. Drilling terminated due to deep cavity.

ESKOM
ESSELEN SUBSTATION FULL DSI

HOLE No: 4
Sheet 2 of 2

JOB NUMBER: ESN BH 4



NOTES

1) 1)

2) 2)

3) 3.

REDUCED LEVEL	PENETRATION RATE min/metre	AIR LOSS %	SAMPLE RECOVERTY %

CONTRACTOR : Thoka Geosciences
MACHINE : THOR 5000
DRILLED BY :
PROFILED BY : Melusi Mashego
TYPE SET BY :
SETUP FILE : STANDARD.SET

INCLINATION : VERTICAL
DIAM :
DATE :
DATE : 15 JANUARY 2018
DATE : 05/02/2018 15:28
TEXT : ..I\ProfileLogs\ESNBH4.TXT

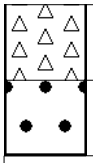
ELEVATION : 1579m
X-COORD : 28.26743
Y-COORD : 26.00726

HOLE No: 4
Esselen Substation, Tembisa

ESKOM
ESSELEN SUBSTATION FULL DSI

LEGEND
Sheet 1 of 1

JOB NUMBER: ESN BH 4

	CHERT	{SA21}
	FERRICRETE	{SA24}

CONTRACTOR :
MACHINE :
DRILLED BY :
PROFILED BY :
TYPE SET BY :
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE :
DATE :
DATE : 05/02/2018 15:28
TEXT : ..I\ProfileLogs\ESNBH4.TXT

ELEVATION :
X-COORD :
Y-COORD :

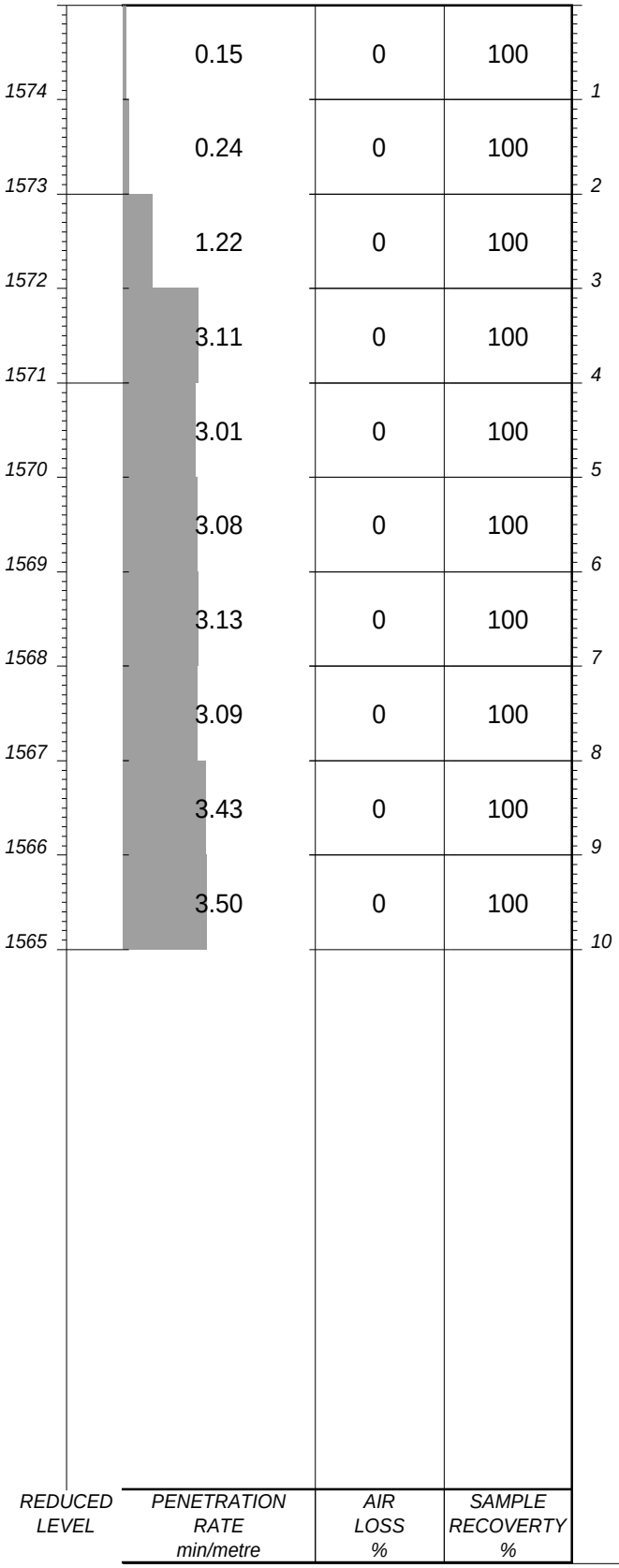
LEGEND
SUMMARY OF SYMBOLS

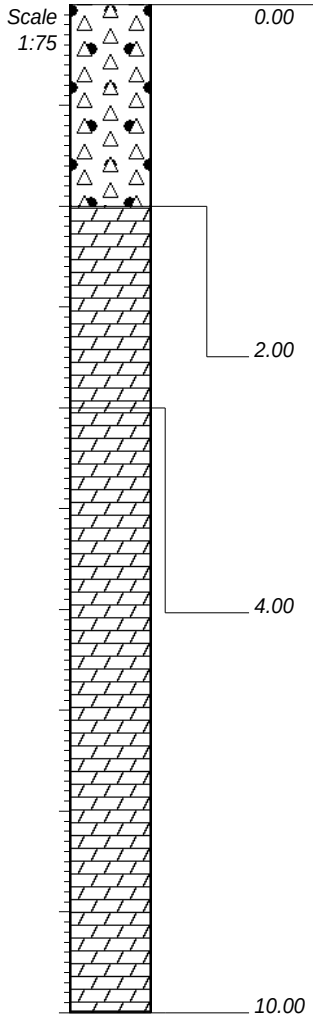
THOKA GEOSCIENCES cc

ESKOM
ESSELEN SUBSTATION FULL DSI

HOLE No: 5
Sheet 1 of 1

JOB NUMBER: ESN BH 5





Bulk sample: Slightly moist, brown, sandy gravel. **Sieve washed:** 30% loss. Wet, fine to medium gravel chips of highly weathered sub-angular CHERT and rounded ferricrete material **Interpretation:** Highly weathered CHERT in ferruginous soil

Bulk sample: Dry, brownish grey to grey, sandy gravel with silt **Sieve washed:** 35% loss.Wet, fine gravel chips of bluish grey slightly weathered DOLOMITE **Interpretation:** Slightly weathered DOLOMITE

Bulk sample: Dry, grey, sandy gravel. **Sieve washed:** 10% loss. Wet, fine to medium gravel chips of sub-angular bluish grey unweathered DOLOMITE **Interpretation:** Solid unweathered DOLOMITE

NOTES

1) 1)

2) 2)

3) 3.

REDUCED LEVEL	*PENETRATION RATE min/metre*	*AIR LOSS %*	*SAMPLE RECOVERTY %*

CONTRACTOR : Thoka Geosciences
MACHINE : THOR 5000
DRILLED BY :
PROFILED BY : Melusi Mashego
TYPE SET BY :
SETUP FILE : STANDARD.SET

INCLINATION : VERTICAL
DIAM :
DATE :
DATE : 12 JANUARY 2018
DATE : 05/02/2018 15:29
TEXT : ..I\ProfileLogs\ESNBH5.TXT

ELEVATION : 1575m
X-COORD : 28.26692
Y-COORD : 26.00600

HOLE No: 5
Esselen Substation, Tembisa

ESKOM
ESSELEN SUBSTATION FULL DSI

LEGEND
Sheet 1 of 1

JOB NUMBER: ESN BH 5

	DOLOMITE	{SA13}
	CHERT	{SA21}
	FERRICRETE	{SA24}

CONTRACTOR :
MACHINE :
DRILLED BY :
PROFILED BY :
TYPE SET BY :
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE :
DATE :
DATE : 05/02/2018 15:29
TEXT : ..I\ProfileLogs\ESNBH5.TXT

ELEVATION :
X-COORD :
Y-COORD :

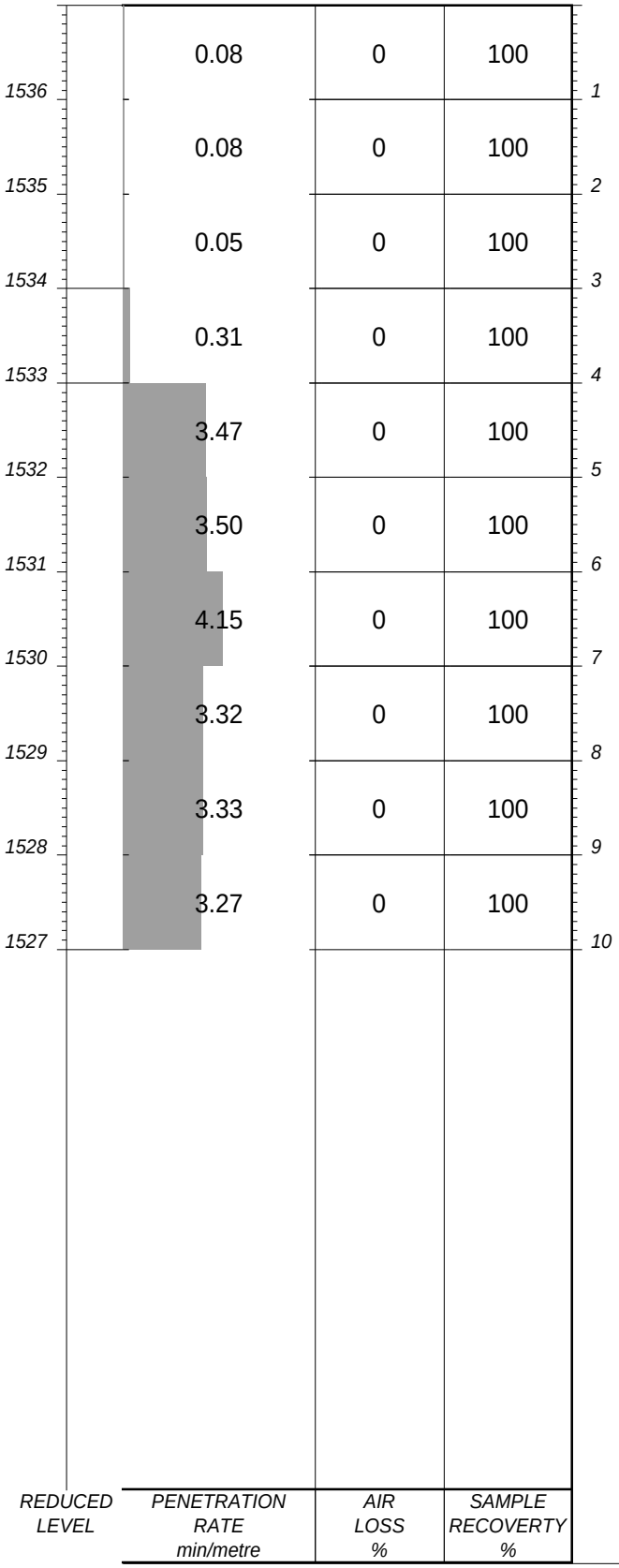
LEGEND
SUMMARY OF SYMBOLS

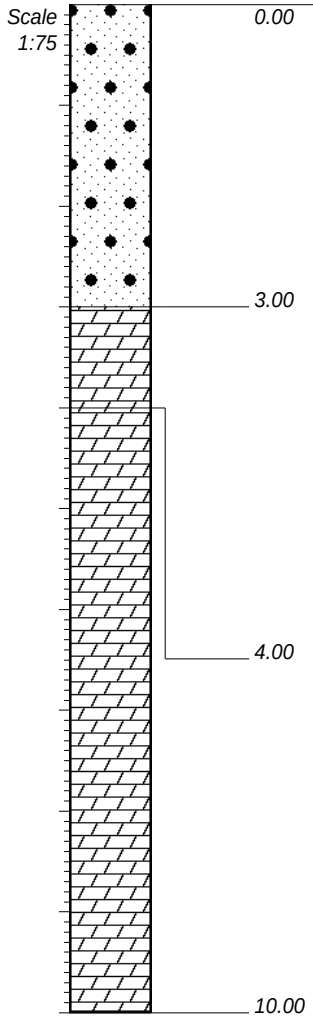
THOKA GEOSCIENCES cc

ESKOM
ESSELEN SUBSTATION FULL DSI

HOLE No: 6
Sheet 1 of 1

JOB NUMBER: ESN BH 6





Bulk sample: Very moist, reddish brown to maroon clayey sand. **Sieve washed:** 85% loss. Wet, fine gravel chips of ferricrete gravel. **Interpretation:** Minor ferricrete nodules in clayey sand

Bulk sample: Moist, brown, sandy gravel with minor clay. **Sieve washed:** 65% loss. Wet, fine to medium gravel with minor coarse gravel chips of sub-angular moderately weathered DOLOMITE **Interpretation:** Moderately weathered DOLOMITE

Bulk sample: Slightly moist, grey, sandy gravel. **Sieve washed:** 10-15% loss. Wet, fine to medium gravel chips of sub-angular bluish grey DOLOMITE **Interpretation:** Solid unweathered DOLOMITE

NOTES

1) Drilling Terminated due to deep cavity

2) 2)

3) 3.

REDUCED LEVEL	*PENETRATION RATE min/metre*	*AIR LOSS %*	*SAMPLE RECOVERTY %*
1536	0.08	0	100
1535	0.08	0	100
1534	0.05	0	100
1533	0.31	0	100
1532	3.47	0	100
1531	3.50	0	100
1530	4.15	0	100
1529	3.32	0	100
1528	3.33	0	100
1527	3.27	0	100

CONTRACTOR : Thoka Geosciences
MACHINE : THOR 5000
DRILLED BY :
PROFILED BY : Melusi Mashego
TYPE SET BY :
SETUP FILE : STANDARD.SET

INCLINATION : VERTICAL
DIAM :
DATE :
DATE : 15 JANUARY 2018
DATE : 05/02/2018 15:31
TEXT : ..I\ProfileLogs\ESNBH6.TXT

ELEVATION : 1537 m
X-COORD : 28.26894
Y-COORD : 26.00682

HOLE No: 6
Esselen Substation, Tembisa

ESKOM
ESSELEN SUBSTATION FULL DSI

LEGEND
Sheet 1 of 1

JOB NUMBER: ESN BH 6

	SAND	{SA04}
	DOLOMITE	{SA13}
	FERRICRETE	{SA24}

CONTRACTOR :
MACHINE :
DRILLED BY :
PROFILED BY :
TYPE SET BY :
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE :
DATE :
DATE : 05/02/2018 15:31
TEXT : ..I\ProfileLogs\ESNBH6.TXT

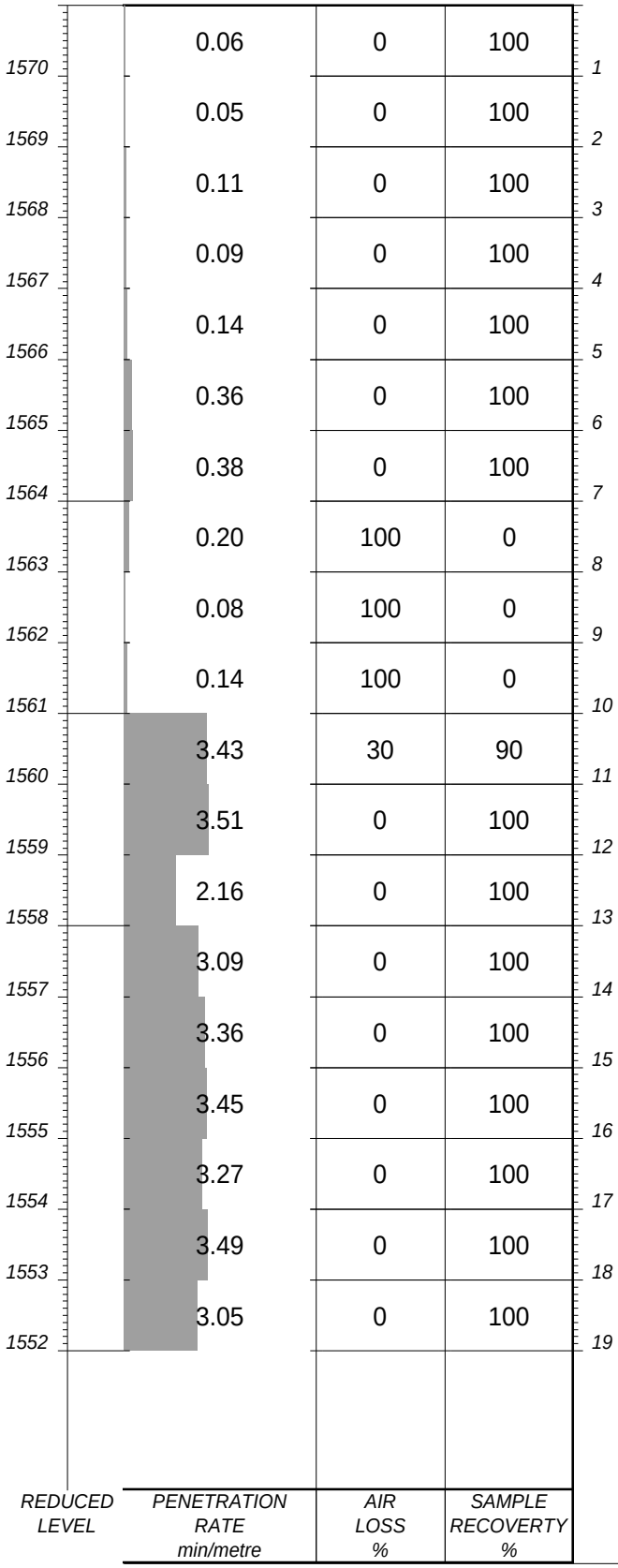
ELEVATION :
X-COORD :
Y-COORD :

LEGEND
SUMMARY OF SYMBOLS

ESKOM
ESSELEN SUBSTATION FULL DSI

HOLE No: 7
Sheet 1 of 1

JOB NUMBER: ESN BH 7



REDUCED LEVEL	PENETRATION RATE min/metre	AIR LOSS %	SAMPLE RECOVERTY %
1570	0.06	0	100
1569	0.05	0	100
1568	0.11	0	100
1567	0.09	0	100
1566	0.14	0	100
1565	0.36	0	100
1564	0.38	0	100
1563	0.20	100	0
1562	0.08	100	0
1561	0.14	100	0
1560	3.43	30	90
1559	3.51	0	100
1558	2.16	0	100
1557	3.09	0	100
1556	3.36	0	100
1555	3.45	0	100
1554	3.27	0	100
1553	3.49	0	100
1552	3.05	0	100

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Bulk sample: Moist, maroon clayey silt. **Sieve washed:** 95% loss. Wet, silt with traces of highly weathered rounded ferruginised material. **Interpretation:** HILLWASH

NO SAMPLE, rapid penetration rates are characteristic of cavities

Bulk sample: Dry, greyish brown, sandy gravel. **Sieve washed:** 70% loss. Wet, fine gravel chips of sub-rounded bluish grey motttled white DOLOMITE and traces of translucent CHERT **Interpretation:** Moderately weathered DOLOMITE with traces of CHERT

Bulk sample: Dry, light grey, sandy gravel. **Sieve washed:** <10% loss. Wet, fine to medium gravel chips of sub-angular light bluish grey DOLOMITE **Interpretation:** Slightly to unweathered solid DOLOMITE

NOTES

1) 1)

2) 2)

3) 3.

CONTRACTOR : Thoka Geosciences
MACHINE : THOR 5000
DRILLED BY :
PROFILED BY : Melusi Mashego
TYPE SET BY :
SETUP FILE : STANDARD.SET

INCLINATION : VERTICAL
DIAM :
DATE :
DATE : 16 JANUARY 2018
DATE : 05/02/2018 15:36
TEXT : ..I\ProfileLogs\ESNBH7.TXT

ELEVATION : 1571m
X-COORD : 28.27148
Y-COORD : 26.00453

HOLE No: 7
Esselen Substation, Tembisa

ESKOM
ESSELEN SUBSTATION FULL DSI

LEGEND
Sheet 1 of 1

JOB NUMBER: ESN BH 7

	SILT	{SA06}
	CLAYEY	{SA09}
	DOLOMITE	{SA13}
	CHERT	{SA21}
	FERRICRETE	{SA24}

CONTRACTOR :
MACHINE :
DRILLED BY :
PROFILED BY :
TYPE SET BY :
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE :
DATE :
DATE : 05/02/2018 15:36
TEXT : ..I\ProfileLogs\ESNBH7.TXT

ELEVATION :
X-COORD :
Y-COORD :

LEGEND
SUMMARY OF SYMBOLS

ESKOM
ESSELEN SUBSTATION FULL DSI

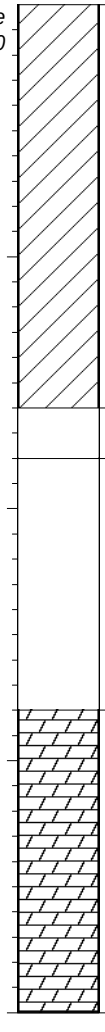
HOLE No: 08
Sheet 1 of 1

JOB NUMBER: ESN BH 8

REDUCED LEVEL	PENETRATION RATE min/metre	AIR LOSS %	SAMPLE RECOVERTY %
	0.06	0	100
	0.06	0	100
	0.07	0	100
1570	0.12	0	100
	0.11	0	100
	0.16	0	100
	0.24	0	100
	1.20	0	100
	0.07	100	0
1565	0.58	50	0
	0.14	100	0
	0.03	100	0
	1.37	100	00
	0.11	100	0
1560	6.50	90	50
	3.33	50	50
	3.19	40	60
	3.54	20	80
	3.29	10	90
1555	3.40	0	100

5
10
15
20

Scale 1:150



0.00

Bulk sample: Moist, maroon to dark reddish brown, silty clay **Interpretation:** Reddish brown SOFT CLAY

8.00

TOTAL SAMPLE LOSS, rapid penetration rate indicates cavities

9.00

TOTAL SAMPLE LOSS

14.00

Bulk sample: Dry, brown with grey tint, sandy gravel. **Sieve washed:** Wet, fine and medium gravel chips of bluish grey, mottled white sub-angular DOLOMITE **Interpretation:** Moderately to slightly weathered DOLOMITE

20.00

NOTES

1) 1)

2) 2)

3) 3.

CONTRACTOR : Thoka Geosciences
MACHINE : THOR 5000
DRILLED BY :
PROFILED BY : Melusi Mashego

INCLINATION : VERTICAL
DIAM :
DATE :
DATE : 17 JANUARY 2018

ELEVATION : 1574m
X-COORD : 28.27095
Y-COORD : 26.00385

TYPE SET BY :
SETUP FILE : STANDARD.SET

DATE : 05/02/2018 15:38
TEXT : ..I\ProfileLogs\ESNBH8.TXT

HOLE No: 08
Esselen Substation, Tembisa

ESKOM
ESSELEN SUBSTATION FULL DSI

LEGEND
Sheet 1 of 1

JOB NUMBER: ESN BH 8

	CLAY	{SA08}
	DOLOMITE	{SA13}

CONTRACTOR :
MACHINE :
DRILLED BY :
PROFILED BY :
TYPE SET BY :
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE :
DATE :
DATE : 05/02/2018 15:38
TEXT : ..I\ProfileLogs\ESNBH8.TXT

ELEVATION :
X-COORD :
Y-COORD :

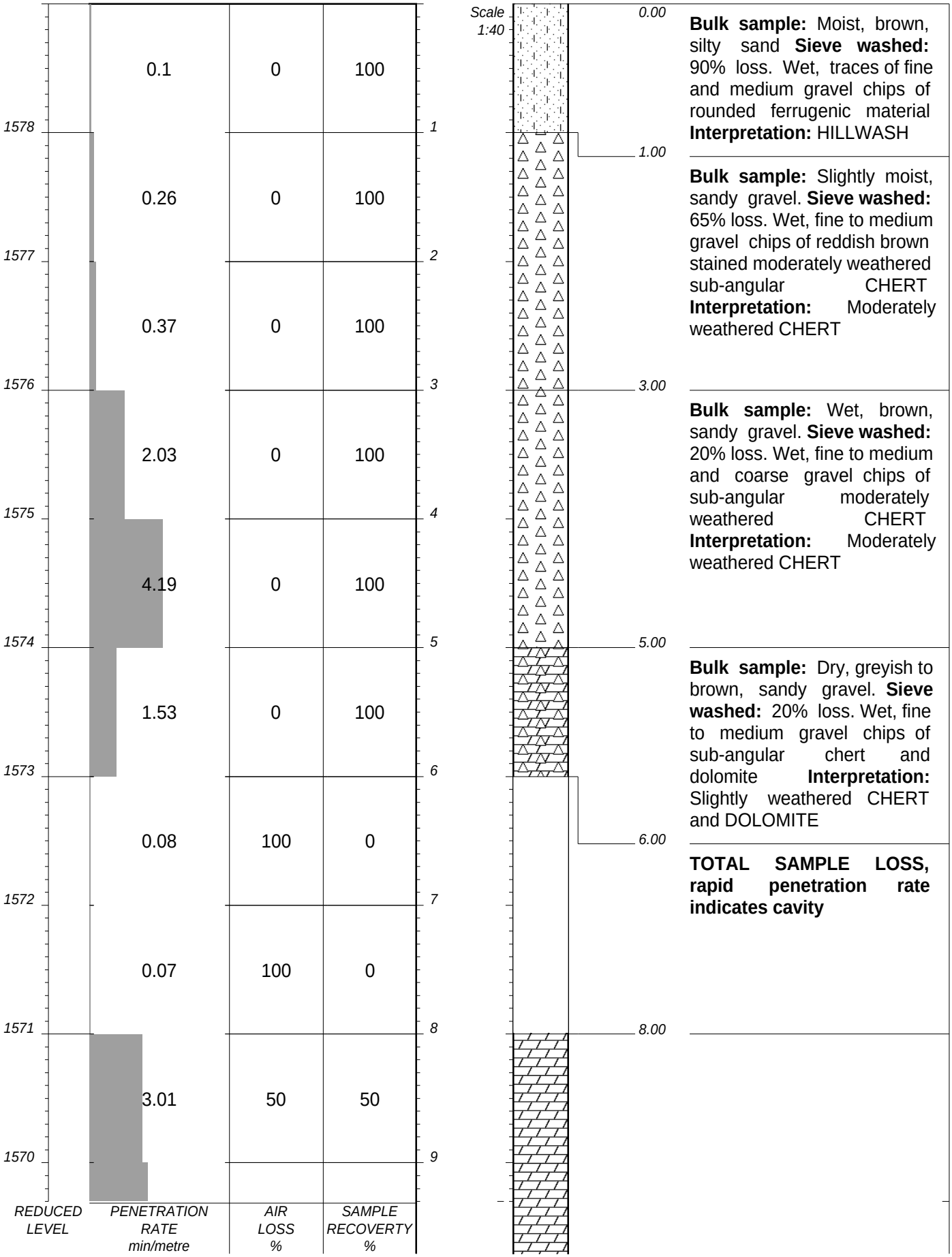
LEGEND
SUMMARY OF SYMBOLS

THOKA GEOSCIENCES cc

ESKOM
ESSELEN SUBSTATION FULL DSI

HOLE No: 9
Sheet 1 of 2

JOB NUMBER: ESN BH 9



Bulk sample: Moist, brown, silty sand **Sieve washed:** 90% loss. Wet, traces of fine and medium gravel chips of rounded ferrugenic material **Interpretation:** HILLWASH

Bulk sample: Slightly moist, sandy gravel. **Sieve washed:** 65% loss. Wet, fine to medium gravel chips of reddish brown stained moderately weathered sub-angular CHERT **Interpretation:** Moderately weathered CHERT

Bulk sample: Wet, brown, sandy gravel. **Sieve washed:** 20% loss. Wet, fine to medium and coarse gravel chips of sub-angular moderately weathered CHERT **Interpretation:** Moderately weathered CHERT

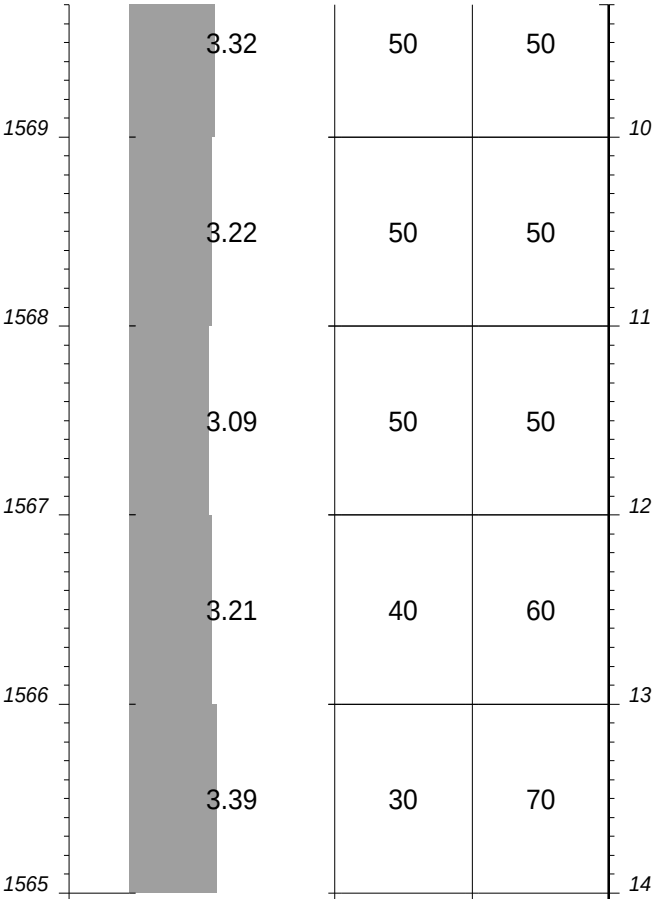
Bulk sample: Dry, greyish to brown, sandy gravel. **Sieve washed:** 20% loss. Wet, fine to medium gravel chips of sub-angular chert and dolomite **Interpretation:** Slightly weathered CHERT and DOLOMITE

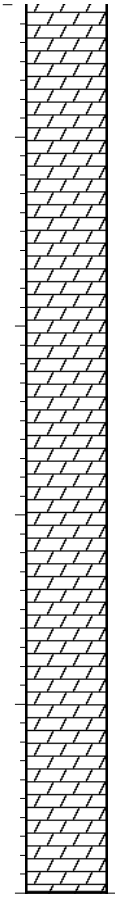
TOTAL SAMPLE LOSS, rapid penetration rate indicates cavity

ESKOM
ESSELEN SUBSTATION FULL DSI

HOLE No: 9
Sheet 2 of 2

JOB NUMBER: ESN BH 9





Bulk sample: Dry, greyish to brown, sandy gravel. **Sieve washed:** <10% loss. Wet, fine bluish grey gravel chips of sub-angular dolomite with minor brown stains **Interpretation:** Solid DOLOMITE

NOTES

1) 1)

2) 2)

3) 3.

REDUCED LEVEL	*PENETRATION RATE min/metre*	*AIR LOSS %*	*SAMPLE RECOVERTY %*

CONTRACTOR : Thoka Geosciences
MACHINE : THOR 5000
DRILLED BY :
PROFILED BY : Melusi Mashego
TYPE SET BY :
SETUP FILE : STANDARD.SET

INCLINATION : VERTICAL
DIAM :
DATE :
DATE : 17 JANUARY 2018
DATE : 05/02/2018 15:40
TEXT : ..I\ProfileLogs\ESNBH9.TXT

ELEVATION : 1579m
X-COORD : 28.26943
Y-COORD : 26.00354

HOLE No: 9
Esselen Substation, Tembisa

ESKOM
ESSELEN SUBSTATION FULL DSI

LEGEND
Sheet 1 of 1

JOB NUMBER: ESN BH 9

	SAND	{SA04}
	SILTY	{SA07}
	DOLOMITE	{SA13}
	CHERT	{SA21}

CONTRACTOR :
MACHINE :
DRILLED BY :
PROFILED BY :
TYPE SET BY :
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE :
DATE :
DATE : 05/02/2018 15:40
TEXT : ..I\ProfileLogs\ESNBH9.TXT

ELEVATION :
X-COORD :
Y-COORD :

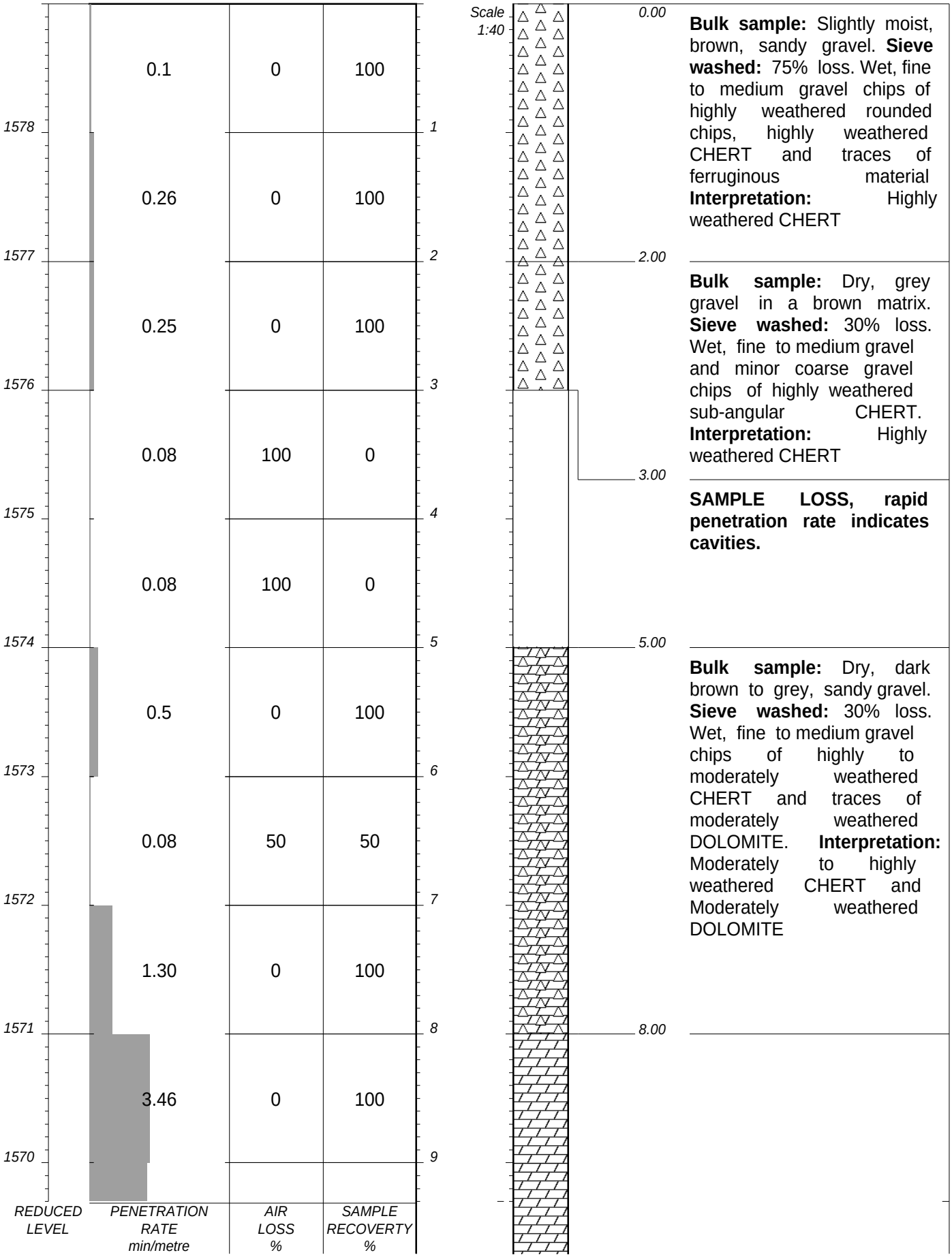
LEGEND
SUMMARY OF SYMBOLS

THOKA GEOSCIENCES cc

ESKOM
ESSELEN SUBSTATION FULL DSI

HOLE No: **11**
Sheet 1 of 2

JOB NUMBER: ESN BH 11



Bulk sample: Slightly moist, brown, sandy gravel. **Sieve washed:** 75% loss. Wet, fine to medium gravel chips of highly weathered rounded chips, highly weathered CHERT and traces of ferruginous material **Interpretation:** Highly weathered CHERT

Bulk sample: Dry, grey gravel in a brown matrix. **Sieve washed:** 30% loss. Wet, fine to medium gravel and minor coarse gravel chips of highly weathered sub-angular CHERT. **Interpretation:** Highly weathered CHERT

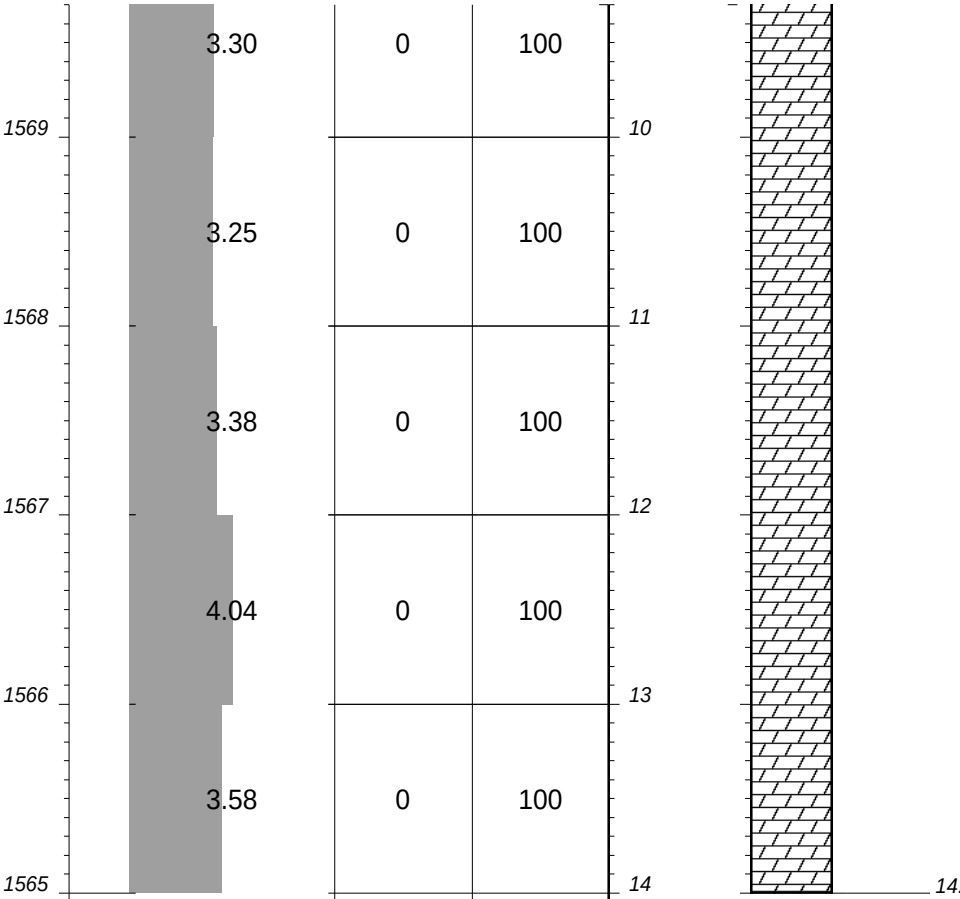
SAMPLE LOSS, rapid penetration rate indicates cavities.

Bulk sample: Dry, dark brown to grey, sandy gravel. **Sieve washed:** 30% loss. Wet, fine to medium gravel chips of highly to moderately weathered CHERT and traces of moderately weathered DOLOMITE. **Interpretation:** Moderately to highly weathered CHERT and Moderately weathered DOLOMITE

ESKOM
ESSELEN SUBSTATION FULL DSI

HOLE No: 11
Sheet 2 of 2

JOB NUMBER: ESN BH 11



Bulk sample: Dry, light grey, sandy gravel. **Sieve washed:** <10% loss. Wet, fine to medium gravel chips of grey sub-angular unweathered DOLOMITE **Interpretation:** Solid unweathered DOLOMITE

NOTES

1) 1)

2) 2)

3) 3.

REDUCED LEVEL	*PENETRATION RATE min/metre*	*AIR LOSS %*	*SAMPLE RECOVERTY %*

CONTRACTOR : Thoka Geosciences
MACHINE : THOR 5000
DRILLED BY :
PROFILED BY : Melusi Mashego
TYPE SET BY :
SETUP FILE : STANDARD.SET

INCLINATION : VERTICAL
DIAM :
DATE :
DATE : 12 JANUARY 2018
DATE : 05/02/2018 15:42
TEXT : ..\ProfileLogs\ESNBH11.TXT

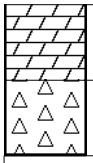
ELEVATION : 1579m
X-COORD : 28.26736
Y-COORD : 26.00573

HOLE No: 11
Esselen Substation, Tembisa

ESKOM
ESSELEN SUBSTATION FULL DSI

LEGEND
Sheet 1 of 1

JOB NUMBER: ESN BH 11



DOLOMITE	{SA13}
CHERT	{SA21}

CONTRACTOR :
MACHINE :
DRILLED BY :
PROFILED BY :
TYPE SET BY :
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE :
DATE :
DATE : 05/02/2018 15:42
TEXT : ..\ProfileLogs\ESNBH11.TXT

ELEVATION :
X-COORD :
Y-COORD :

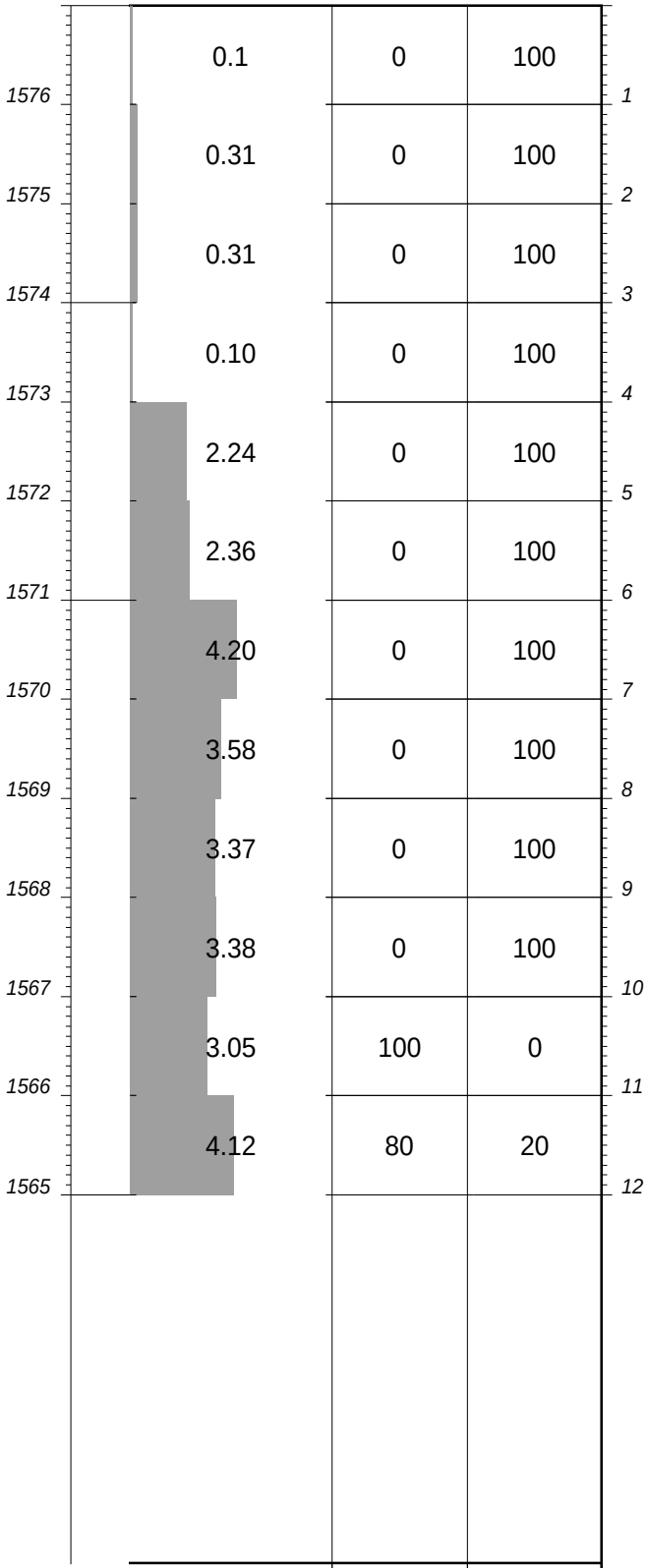
LEGEND
SUMMARY OF SYMBOLS

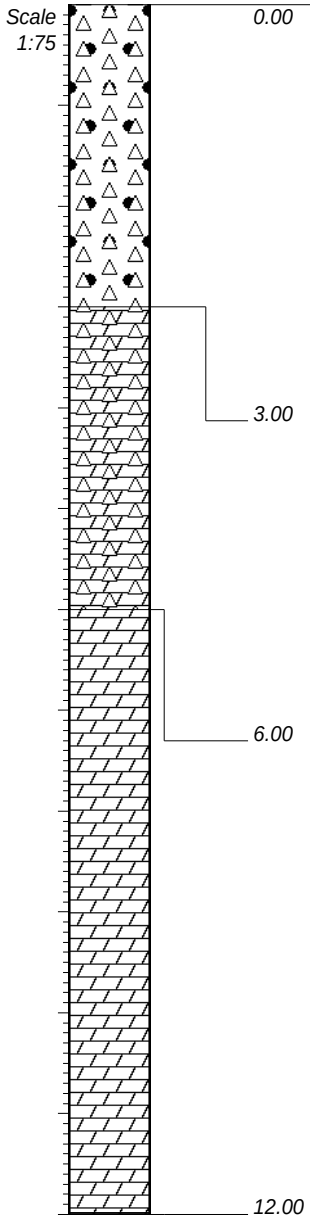
THOKA GEOSCIENCES cc

ESKOM
ESSELEN SUBSTATION FULL DSI

HOLE No: 12
Sheet 1 of 1

JOB NUMBER: ESN BH 12





Bulk sample: Moist, reddish brown, sandy gravel with coarse gravel **Sieve washed:** 40% loss. Wet, fine to medium and coarse gravel chips of reddish brown coated highly weathered CHERT and ferruginous material. **Interpretation:** Highly weathered CHERT in a matrix of ferrugenised sandy gravel.

Bulk sample: Dry, grey, sandy gravel. **Sieve washed:** 10% loss. Wet, fine to medium gravel chips of bluish grey slightly brown stained DOLOMITE and traces of CHERT. **Interpretation:** Moderately weathered DOLOMITE

Bulk sample: Dry, grey, sandy gravel. **Sieve washed:** 10% loss. Wet, fine to medium gravel chips of bluish grey sub-angular DOLOMITE. **Interpretation:** Solid unweathered DOLOMITE

NOTES

1) 1)

2) 2)

3) 3.

REDUCED LEVEL	*PENETRATION RATE min/metre*	*AIR LOSS %*	*SAMPLE RECOVERTY %*

CONTRACTOR : Thoka Geosciences
MACHINE : THOR 5000
DRILLED BY :
PROFILED BY : Melusi Mashego
TYPE SET BY :
SETUP FILE : STANDARD.SET

INCLINATION : VERTICAL
DIAM :
DATE :
DATE : 12 JANUARY 2018
DATE : 05/02/2018 15:46
TEXT : ..\ProfileLogs\ESNBH12.TXT

ELEVATION : 1577 m
X-COORD : 28.26726
Y-COORD : 26.00656

HOLE No: 12
Esselen Substation, Tembisa

ESKOM
ESSELEN SUBSTATION FULL DSI

LEGEND
Sheet 1 of 1

JOB NUMBER: ESN BH 12

	DOLOMITE	{SA13}
	CHERT	{SA21}
	FERRICRETE	{SA24}

CONTRACTOR :
MACHINE :
DRILLED BY :
PROFILED BY :
TYPE SET BY :
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE :
DATE :
DATE : 05/02/2018 15:46
TEXT : ..\ProfileLogs\ESNBH12.TXT

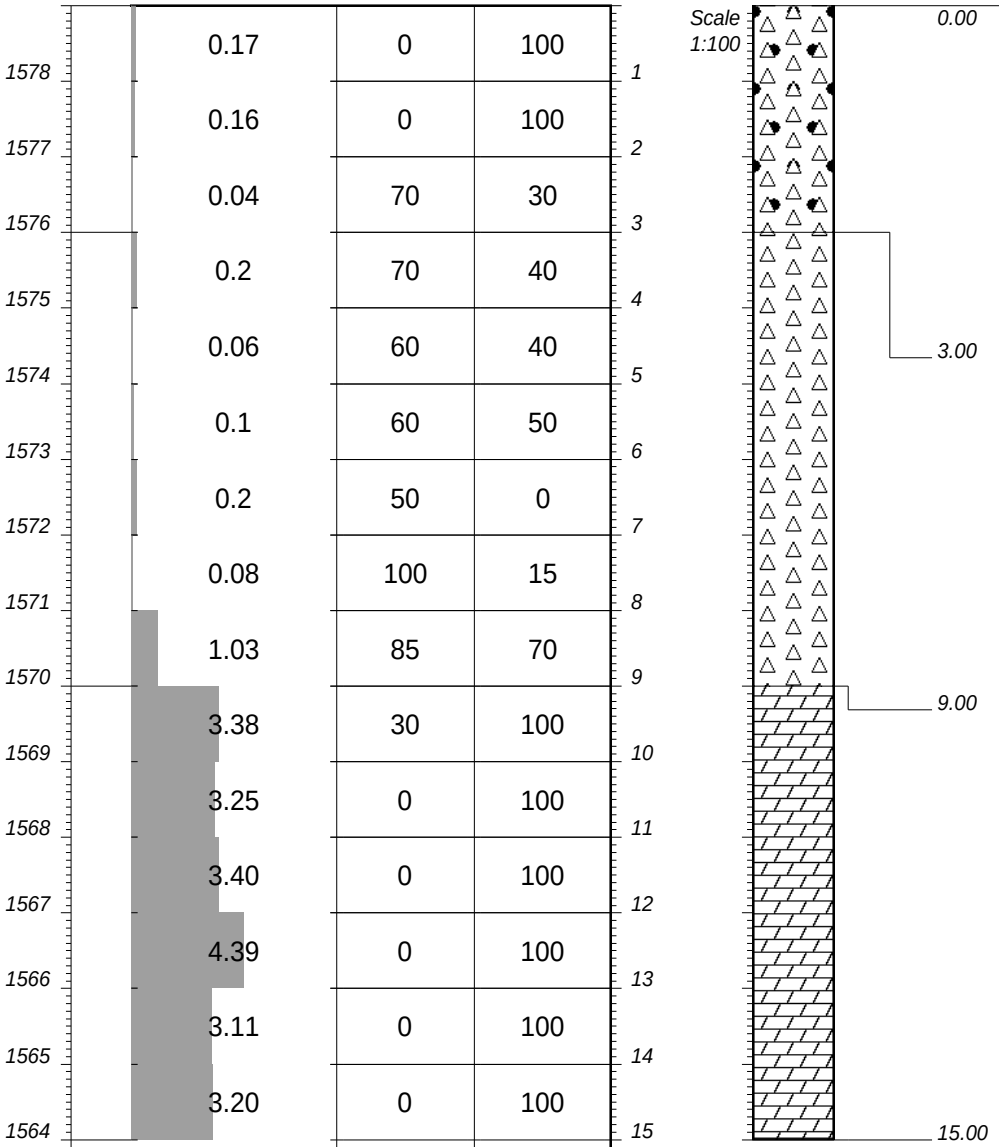
ELEVATION :
X-COORD :
Y-COORD :

LEGEND
SUMMARY OF SYMBOLS

ESKOM
ESSELEN SUBSTATION FULL DSI

HOLE No: 13
Sheet 1 of 1

JOB NUMBER: ESN BH 13



REDUCED LEVEL	PENETRATION RATE min/metre	AIR LOSS %	SAMPLE RECOVERTY %
1578	0.17	0	100
1577	0.16	0	100
1576	0.04	70	30
1575	0.2	70	40
1574	0.06	60	40
1573	0.1	60	50
1572	0.2	50	0
1571	0.08	100	15
1570	1.03	85	70
1569	3.38	30	100
1568	3.25	0	100
1567	3.40	0	100
1566	4.39	0	100
1565	3.11	0	100
1564	3.20	0	100

Bulk sample: Slightly moist, cream white angular gravel in a brown sand matrix. **Sieve washed:** 25% loss. Wet, fine to medium gravel chips of angular highly weathered CHERT and rounded ferricrete nodules **Interpretation:** Highly weathered CHERT

Bulk sample: Slightly moist, dark reddish brown, sandy gravel matrix with traces of coarse gravel. **Sieve washed:** 50 - 70% loss. Wet, fine to medium gravel chips of angular grey to black highly weathered CHERT. **Interpretation:** Highly weathered CHERT

Bulk sample: Dry, bluish grey, gravel. **Sieve washed:** 15 - 20% loss. Wet, fine to medium gravel chips of angular bluish grey DOLOMITE **Interpretation:** Solid unweathered DOLOMITE

NOTES

1) 2)

2) 3.

CONTRACTOR : Thoka Geosciences
MACHINE : THOR 5000
DRILLED BY :
PROFILED BY : Melusi Mashego
TYPE SET BY :
SETUP FILE : STANDARD.SET

INCLINATION : VERTICAL
DIAM :
DATE :
DATE : 10 JANUARY 2018
DATE : 20/03/2018 14:57
TEXT : ..\ProfileLogs\ESNBH13.TXT

ELEVATION : 1579 m
X-COORD : 28.26663
Y-COORD : 26.00495

HOLE No: 13
Esselen Substation, Tembisa

ESKOM
ESSELEN SUBSTATION FULL DSI

LEGEND
Sheet 1 of 1

JOB NUMBER: ESN BH 13

	DOLOMITE	{SA13}
	CHERT	{SA21}
	FERRICRETE NODULES	{SA24}

CONTRACTOR :
MACHINE :
DRILLED BY :
PROFILED BY :
TYPE SET BY :
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE :
DATE :
DATE : 20/03/2018 14:57
TEXT : ..\ProfileLogs\ESNBH13.TXT

ELEVATION :
X-COORD :
Y-COORD :

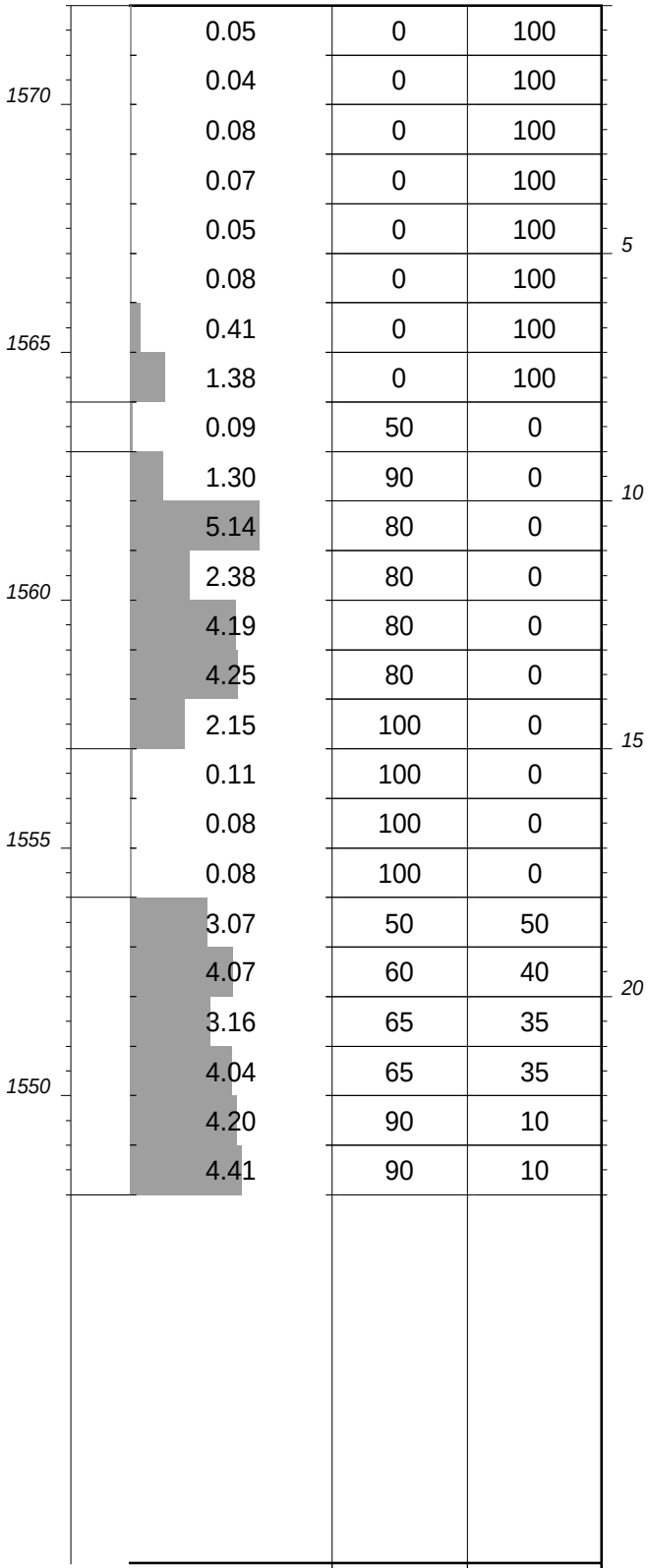
LEGEND
SUMMARY OF SYMBOLS

THOKA GEOSCIENCES cc

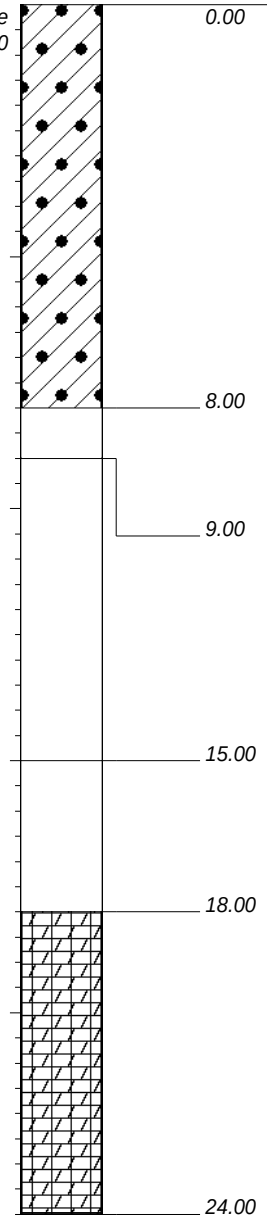
ESKOM
ESSELEN SUBSTATION FULL DSI

HOLE No: 15
Sheet 1 of 1

JOB NUMBER: ESN BH 15



REDUCED LEVEL	PENETRATION RATE min/metre	AIR LOSS %	SAMPLE RECOVERTY %
	0.05	0	100
	0.04	0	100
	0.08	0	100
	0.07	0	100
	0.05	0	100
	0.08	0	100
	0.41	0	100
	1.38	0	100
	0.09	50	0
	1.30	90	0
	5.14	80	0
	2.38	80	0
	4.19	80	0
	4.25	80	0
	2.15	100	0
	0.11	100	0
	0.08	100	0
	0.08	100	0
	3.07	50	50
	4.07	60	40
	3.16	65	35
	4.04	65	35
	4.20	90	10
	4.41	90	10



Bulk sample: Moist, dark maroon to reddish brown silty clay **Interpretation:** Soft Clay with minor rounded ferricrete material

TOTAL SAMPLE LOSS, rapid penetration rate indicates cavity

Drilling indicates solid rock conditions but no sample return

SAMPLE LOSS, rapid penetration rates indicate cavities

Bulk sample: Dry, ligt grey, SILT **Interpretation** Solid rock pulverised to silt during drilling process. Solid DOLOMITE (Dissolves in weak acid)

NOTES

1) 1)

2) 2)

3) 3.

CONTRACTOR : Thoka Geosciences
MACHINE : THOR 5000
DRILLED BY :
PROFILED BY : Melusi Mashego
TYPE SET BY :
SETUP FILE : STANDARD.SET

INCLINATION : VERTICAL
DIAM :
DATE :
DATE : 17 JANUARY 2018
DATE : 30/01/2018 07:55
TEXT : ..\ProfileLogs\ESNBH15.TXT

ELEVATION : 1572m
X-COORD : 28.27112
Y-COORD : 26.00410

HOLE No: 15
Esselen Substation, Tembisa

ESKOM
ESSELEN SUBSTATION FULL DSI

LEGEND
Sheet 1 of 1

JOB NUMBER: ESN BH 15

	SILT	{SA06}
	CLAY	{SA08}
	DOLOMITE	{SA13}
	FERRICRETE	{SA24}

CONTRACTOR : *INCLINATION :* *ELEVATION :*
MACHINE : *DIAM :* *X-COORD :*
DRILLED BY : *DATE :* *Y-COORD :*
PROFILED BY : *DATE :*

LEGEND
SUMMARY OF SYMBOLS

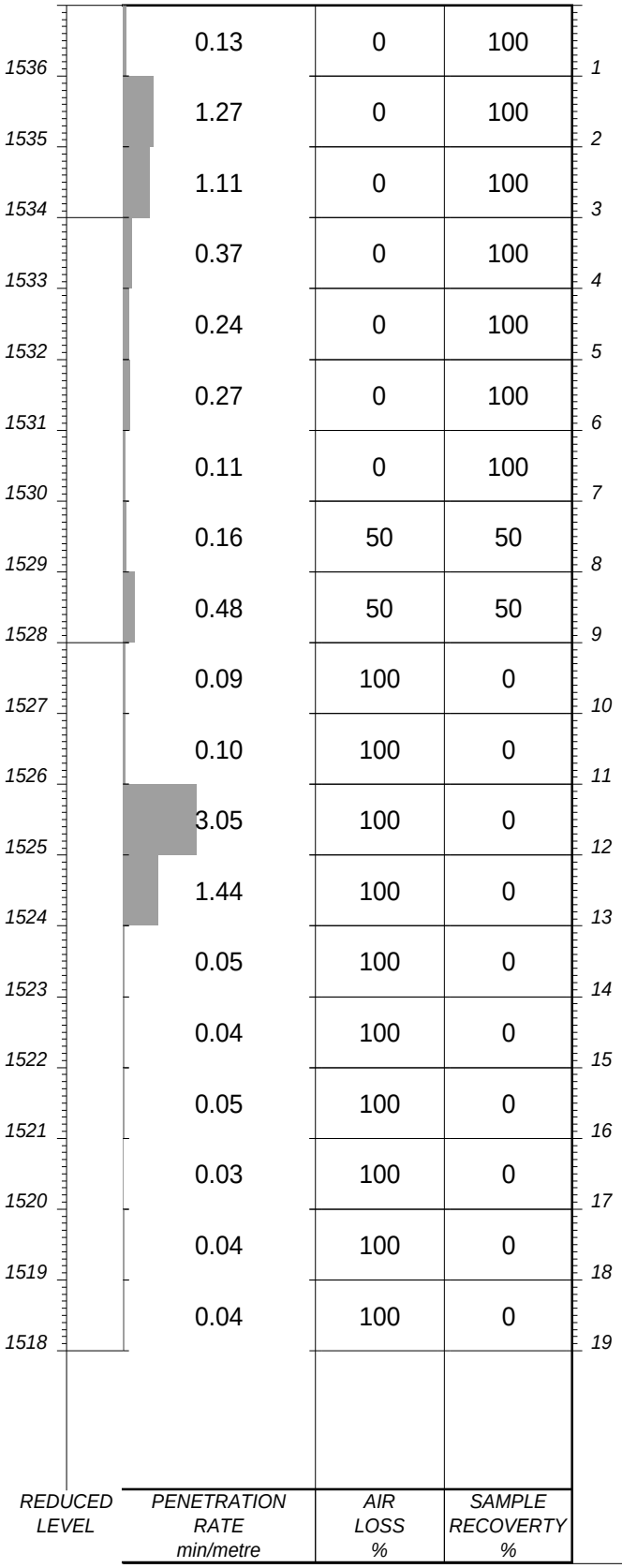
TYPE SET BY : *DATE : 30/01/2018 07:55*
SETUP FILE : STANDARD.SET *TEXT : ..\ProfileLogs\ESNBH15.TXT*

THOKA GEOSCIENCES cc

ESKOM
ESSELEN SUBSTATION FULL DSI

HOLE No: 16
Sheet 1 of 1

JOB NUMBER: ESN BH 16



REDUCED LEVEL	PENETRATION RATE min/metre	AIR LOSS %	SAMPLE RECOVERTY %
1536	0.13	0	100
1535	1.27	0	100
1534	1.11	0	100
1533	0.37	0	100
1532	0.24	0	100
1531	0.27	0	100
1530	0.11	0	100
1529	0.16	50	50
1528	0.48	50	50
1527	0.09	100	0
1526	0.10	100	0
1525	3.05	100	0
1524	1.44	100	0
1523	0.05	100	0
1522	0.04	100	0
1521	0.05	100	1
1520	0.03	100	0
1519	0.04	100	0
1518	0.04	100	0

Bulk sample: Slightly moist, reddish brown, sandy gravel. **Sieve washed:** 75% loss. Wet, fine to medium gravel chips of rounded ferricrete nodules with highly weathered sub-angular CHERT. **Interpretation:** Ferricrete and highly weathered CHERT

Bulk sample: Moist, dark maroon brown, sandy gravel. **Sieve washed:** 70% loss. Wet, fine to medium gravel chips of highly weathered CHERT and traces of highly weathered DOLOMITE **Interpretation:** Highly weathered CHERT and DOLOMITE

NO SAMPLE RETURN, rapid penetration rates suggest cavities

NOTES

1) Drilling Terminated due to deep cavity

2) 2)

3) 3.

CONTRACTOR : Thoka Geosciences
MACHINE : THOR 5000
DRILLED BY :
PROFILED BY : Melusi Mashego
TYPE SET BY :
SETUP FILE : STANDARD.SET

INCLINATION : VERTICAL
DIAM :
DATE :
DATE : 16 JANUARY 2018
DATE : 01/02/2018 11:04
TEXT : ..\ProfileLogs\ESNBH16.TXT

ELEVATION : 1537 m
X-COORD : 28.27130
Y-COORD : 26.00505

HOLE No: 16
Esselen Substation, Tembisa

ESKOM
ESSELEN SUBSTATION FULL DSI

LEGEND
Sheet 1 of 1

JOB NUMBER: ESN BH 16

	DOLOMITE	{SA13}
	CHERT	{SA21}
	FERRICRETE NODULES	{SA24}

CONTRACTOR :
MACHINE :
DRILLED BY :
PROFILED BY :
TYPE SET BY :
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE :
DATE :
DATE : 01/02/2018 11:04
TEXT : ..\ProfileLogs\ESNBH16.TXT

ELEVATION :
X-COORD :
Y-COORD :

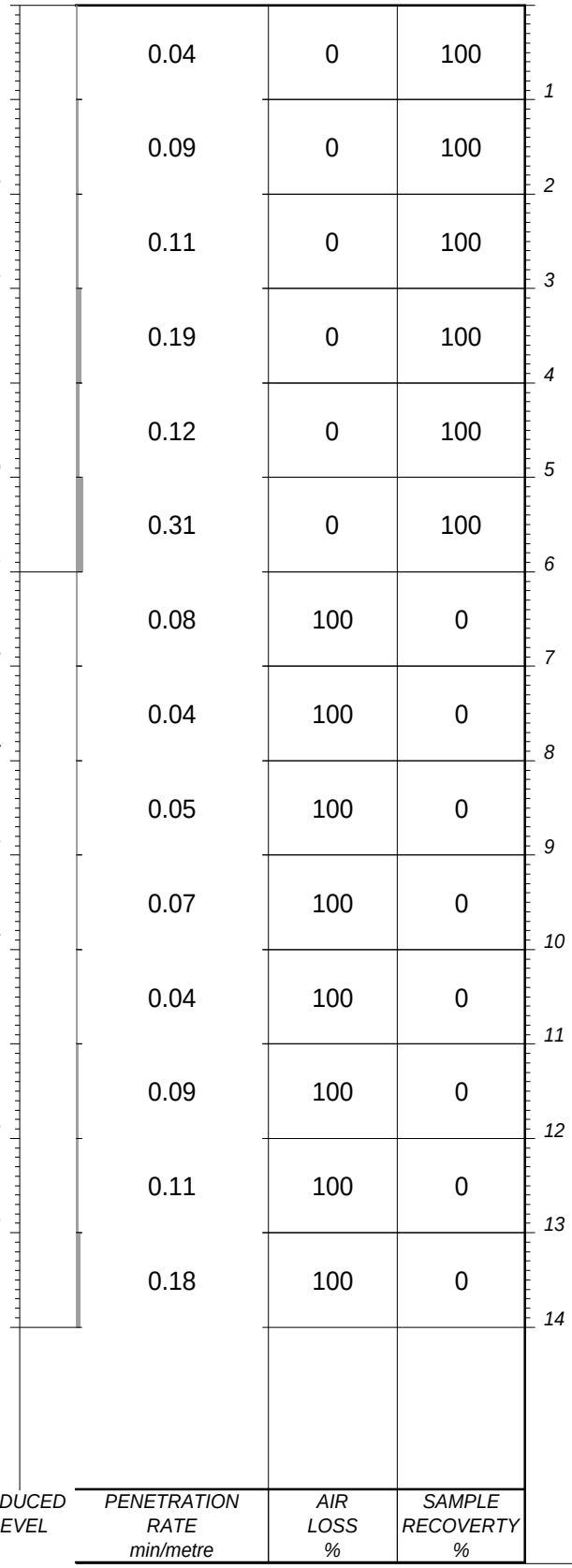
LEGEND
SUMMARY OF SYMBOLS

THOKA GEOSCIENCES cc

ESKOM
ESSELEN SUBSTATION FULL DSI

HOLE No: 17
Sheet 1 of 1

JOB NUMBER: ESN BH 17



REDUCED LEVEL	PENETRATION RATE min/metre	AIR LOSS %	SAMPLE RECOVERTY %
1574	0.04	0	100
1573	0.09	0	100
1572	0.11	0	100
1571	0.19	0	100
1570	0.12	0	100
1569	0.31	0	100
1568	0.08	100	0
1567	0.04	100	0
1566	0.05	100	0
1565	0.07	100	0
1564	0.04	100	0
1563	0.09	100	0
1562	0.11	100	0
1561	0.18	100	0
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			

Bulk sample: Moist, reddish brown-maroon, silty clay with medium gravel and coarse gravel. **Sieve washed:** Coarse gravel chips of highly weathered CHERT and fine gravel chips of sub-angular orangish brown stained moderately weathered CHERT in a silty clay matrix **Interpretation:** Moderately and highly weathered CHERT in a SILTY CLAY matrix

TOTAL SAMPLE LOSS, rapid penetration rate indicates cavities. Borehole terminated due to deep cavity

NOTES

1) 1)

2) 2)

3) 3.

CONTRACTOR : Thoka Geosciences
MACHINE : THOR 5000
DRILLED BY :
PROFILED BY : Melusi Mashego
TYPE SET BY :
SETUP FILE : STANDARD.SET

INCLINATION : VERTICAL
DIAM :
DATE :
DATE : 17 JANUARY 2018
DATE : 26/01/2018 13:41
TEXT : ..\ProfileLogs\ESNBH17.TXT

ELEVATION : 1575m
X-COORD : 28.270016
Y-COORD : 26.00357

HOLE No: 17
Esselen Substation, Tembisa

ESKOM
ESSELEN SUBSTATION FULL DSI

LEGEND
Sheet 1 of 1

JOB NUMBER: ESN BH 17

	SILTY	{SA07}
	CLAY	{SA08}
	CHERT	{SA21}

CONTRACTOR :
MACHINE :
DRILLED BY :
PROFILED BY :
TYPE SET BY :
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE :
DATE :
DATE : 26/01/2018 13:41
TEXT : ..\ProfileLogs\ESNBH17.TXT

ELEVATION :
X-COORD :
Y-COORD :

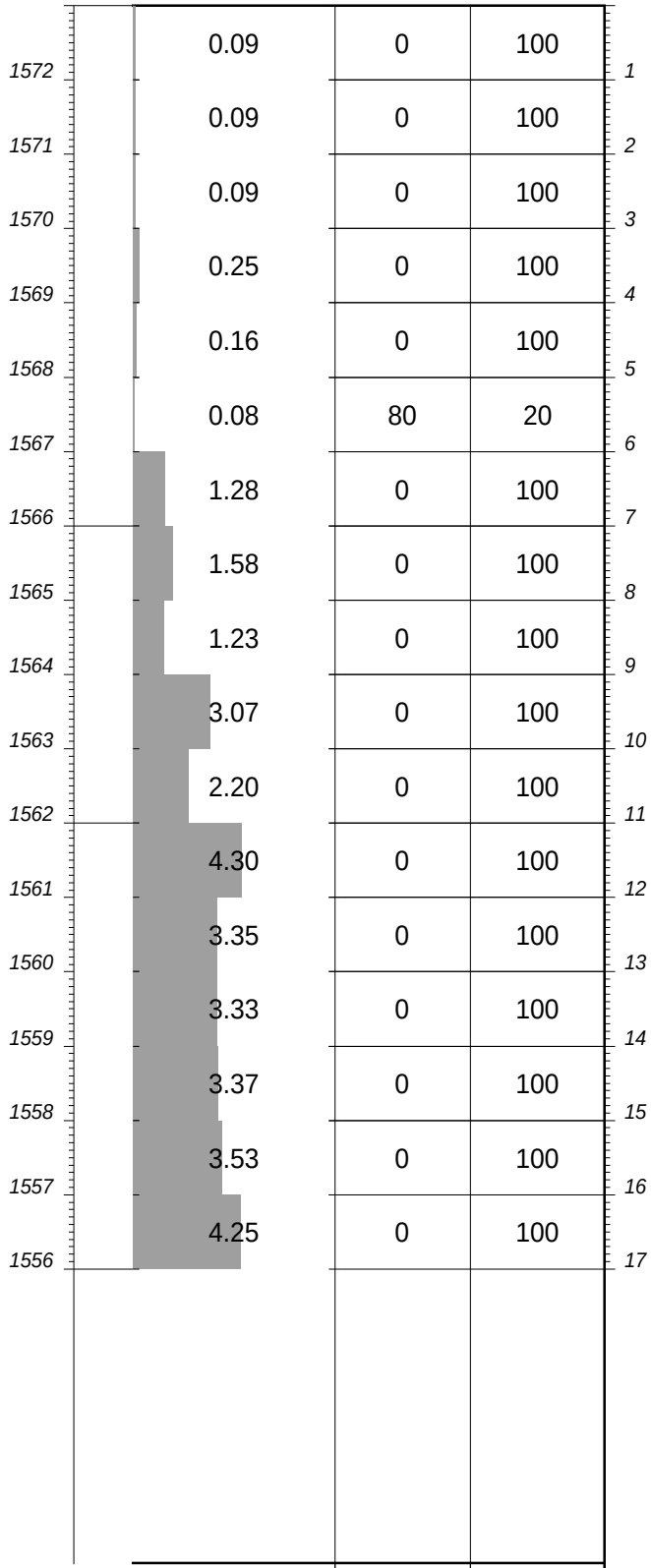
LEGEND
SUMMARY OF SYMBOLS

THOKA GEOSCIENCES cc

ESKOM
ESSELEN SUBSTATION FULL DSI

HOLE No: 18
Sheet 1 of 1

JOB NUMBER: ESN BH 18



REDUCED LEVEL	PENETRATION RATE min/metre	AIR LOSS %	SAMPLE RECOVERTY %
1572	0.09	0	100
1571	0.09	0	100
1570	0.09	0	100
1569	0.25	0	100
1568	0.16	0	100
1567	0.08	80	20
1566	1.28	0	100
1565	1.58	0	100
1564	1.23	0	100
1563	3.07	0	100
1562	2.20	0	100
1561	4.30	0	100
1560	3.35	0	100
1559	3.33	0	100
1558	3.37	0	100
1557	3.53	0	100
1556	4.25	0	100

Bulk sample: Moist, dark brown to reddish maroon brown, sandy gravel with minor coarse gravel in a sandy clay matrix. **Sieve washed:** 25% loss.Wet, fine to medium gravel with minor coarse gravel chips of rounded ferricrete material and sub-angular highly weathered CHERT **Interpretation:** Highly weathered CHERT

Bulk sample: Dry, grey, sandy gravel. **Sieve washed:** 30% loss. Wet, fine to medium angular CHERT and dark grey DOLOMITE. **Interpretation:** Slightly weathered CHERT and DOLOMITE

Bulk sample: Dry, grey, sandy gravel. **Sieve washed:** <10% loss. Wet, fine to medium gravel chips of sub-angular bluish grey DOLOMITE. **Interpretation:** Solid unweathered DOLOMITE

NOTES

1) 1)

2) 2)

3) 3.

CONTRACTOR : Thoka Geosciences
MACHINE : THOR 5000
DRILLED BY :
PROFILED BY : Melusi Mashego

INCLINATION : VERTICAL
DIAM :
DATE :
DATE : 15 JANUARY 2018

ELEVATION : 1573m
X-COORD : 28.26968
Y-COORD : 26.00622

TYPE SET BY :
SETUP FILE : STANDARD.SET

DATE : 01/02/2018 15:07
TEXT : ..\ProfileLogs\ESNBH18.TXT

HOLE No: 18
Esselen Substation, Tembisa

ESKOM
ESSELEN SUBSTATION FULL DSI

LEGEND
Sheet 1 of 1

JOB NUMBER: ESN BH 18

	GRAVEL	{SA02}
	SANDY	{SA05}
	CLAY	{SA08}
	DOLOMITE	{SA13}
	CHERT	{SA21}
	FERRICRETE	{SA24}

CONTRACTOR :
MACHINE :
DRILLED BY :
PROFILED BY :
TYPE SET BY :
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE :
DATE :
DATE : 01/02/2018 15:07
TEXT : ..\ProfileLogs\ESNBH18.TXT

ELEVATION :
X-COORD :
Y-COORD :

LEGEND
SUMMARY OF SYMBOLS

ESKOM
ESSELEN SUBSTATION FULL DSI

HOLE No: 19
Sheet 1 of 1

JOB NUMBER: ESN BH 19

REDUCED LEVEL	PENETRATION RATE min/metre	AIR LOSS %	SAMPLE RECOVERTY %
1571	0.06	0	100
1570	0.06	0	100
1569	0.06	0	100
1568	0.18	0	100
1567	0.22	0	100
1566	0.14	0	100
1565	0.18	0	100
1564	1.42	0	100
1563	2.24	0	100
1562	3.35	0	100
1561	1.37	40	60
1560	3.46	0	100
1559	3.32	0	100
1558	3.35	0	100
1557	3.10	0	100
1556	3.05	0	100
1555	3.10	0	100
1			
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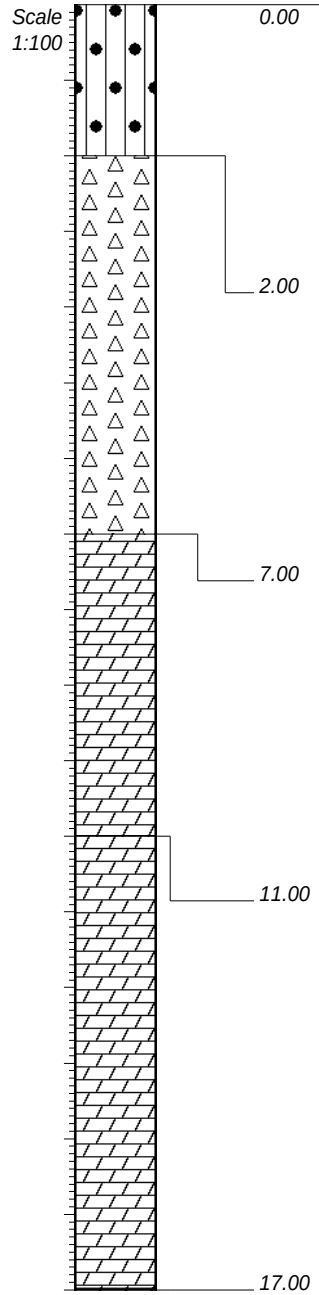
17			



Bulk sample: Moist, dark brown, silty sand with gravel. **Sieve washed:** 90% loss. Wet, SILT with traces of rounded ferricrete nodules **Interpretation:** SILT with traces of ferricrete (HILLWASH)

Bulk sample: Slightly moist, dark brown, sandy gravel. **Sieve washed:** 65% loss. Wet, fine to medium sub-angular translucent brown stained CHERT **Interpretation:** Moderately weathered CHERT

Bulk sample: Dry, brownish grey to grey sandy gravel. **Sieve washed:** 35% loss. Wet, fine to medium gravel with traces of coarse gravel chips of bluish grey and brown stained DOLOMITE **Interpretation:** Moderately weathered DOLOMITE

Bulk sample: Dry, grey, sandy gravel. **Sieve washed:** <10% loss. Wet, fine and medium gravel chips of unweathered DOLOMITE **Interpretation:** Solid unweathered DOLOMITE

NOTES

1) 1)

2) 2)

3) 3.

CONTRACTOR : Thoka Geosciences
MACHINE : THOR 5000
DRILLED BY :
PROFILED BY : Melusi Mashego
TYPE SET BY :
SETUP FILE : STANDARD.SET

INCLINATION : VERTICAL
DIAM :
DATE :
DATE : 12 JANUARY 2018
DATE : 31/01/2018 11:35
TEXT : ..\ProfileLogs\ESNBH19.TXT

ELEVATION : 1572m
X-COORD : 28.26726
Y-COORD : 26.00527

HOLE No: 19
Esselen Substation, Tembisa

ESKOM
ESSELEN SUBSTATION FULL DSI

LEGEND
Sheet 1 of 1

JOB NUMBER: ESN BH 19

	SILT	{SA06}
	DOLOMITE	{SA13}
	CHERT	{SA21}
	FERRICRETE NODULES	{SA24}

CONTRACTOR :
MACHINE :
DRILLED BY :
PROFILED BY :
TYPE SET BY :
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE :
DATE :
DATE : 31/01/2018 11:35
TEXT : ..\ProfileLogs\ESNBH19.TXT

ELEVATION :
X-COORD :
Y-COORD :

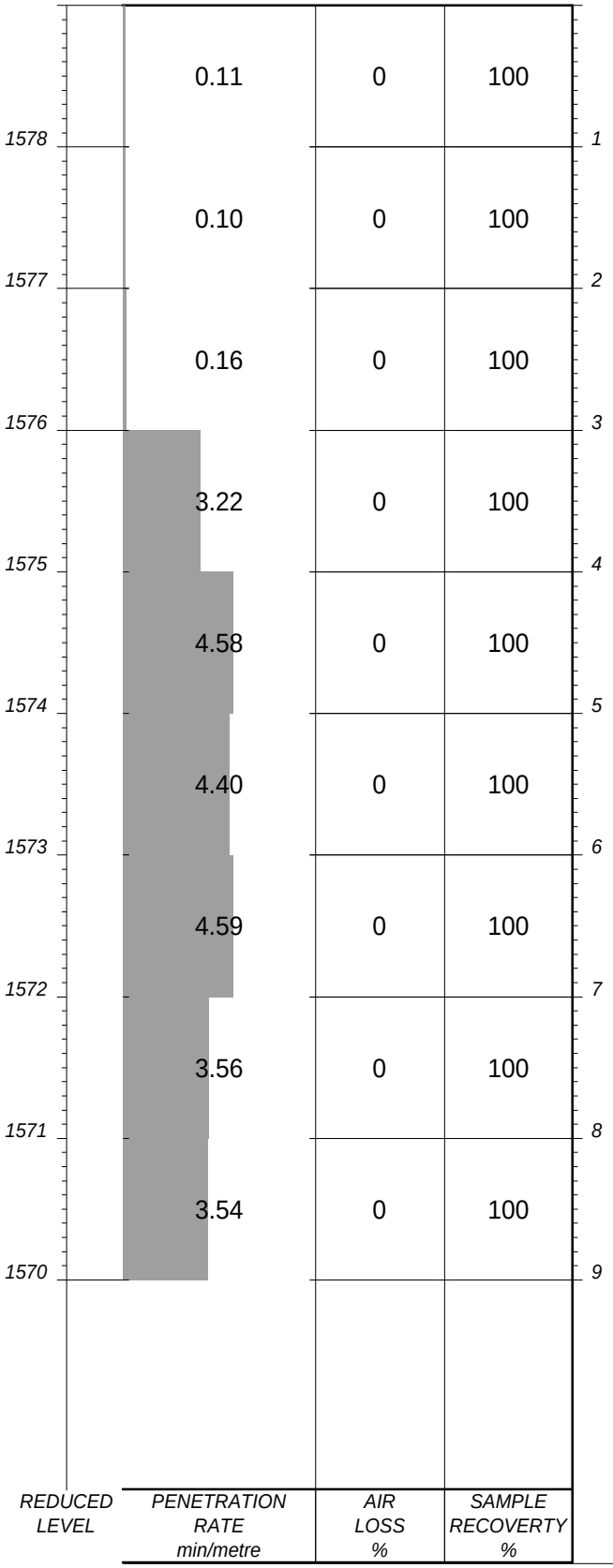
LEGEND
SUMMARY OF SYMBOLS

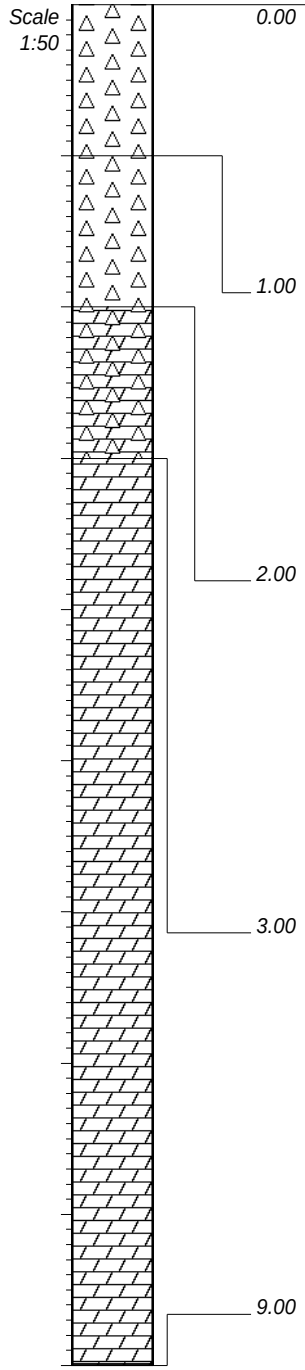
THOKA GEOSCIENCES cc

ESKOM
ESSELEN SUBSTATION FULL DSI

HOLE No: 20
Sheet 1 of 1

JOB NUMBER: ESN BH 20





Bulk sample: Moist, brown, sandy gravel. **Sieve washed:** 30% loss. Wet, fine to medium gravel with coarse gravel chips of sub angular highly weathered white CHERT **Interpretation:** Highly weathered CHERT

Bulk sample: Moist, brown, sandy gravel with distinct coarse gravel chips. **Sieve washed:** 10% loss. Wet, coarse gravel chips of highly weathered CHERT. **Interpretation:** Highly weathered CHERT

Bulk sample: Moist, brown, sandy gravel. **Sieve washed:** 30% loss. Wet, fine to medium gravel chips of DOLOMITE with traces of coarse gravel chips of sub-angular CHERT. **Interpretation:** Highly weathered CHERT and Moderately weathered DOLOMITE

Bulk sample: Moist, to dry, brownish grey, sandy gravel. **Sieve washed:** 40% loss. Wet, fine to medium gravel chips of angular bluish grey sometimes mottled white DOLOMITE. **Interpretation:** Solid unweathered DOLOMITE

NOTES

1) 1)

2) 2)

3) 3.

REDUCED LEVEL	*PENETRATION RATE min/metre*	*AIR LOSS %*	*SAMPLE RECOVERTY %*

CONTRACTOR : Thoka Geosciences
MACHINE : THOR 5000
DRILLED BY :
PROFILED BY : Melusi Mashego
TYPE SET BY :
SETUP FILE : STANDARD.SET

INCLINATION : VERTICAL
DIAM :
DATE :
DATE : 15 JANUARY 2018
DATE : 01/02/2018 15:28
TEXT : ..\ProfileLogs\ESNBH20.TXT

ELEVATION : 1579m
X-COORD : 28.269682
Y-COORD : -26.003917

HOLE No: 20
Esselen Substation, Tembisa

ESKOM
ESSELEN SUBSTATION FULL DSI

LEGEND
Sheet 1 of 1

JOB NUMBER: ESN BH 20

	DOLOMITE	{SA13}
	CHERT	{SA21}

CONTRACTOR :
MACHINE :
DRILLED BY :
PROFILED BY :
TYPE SET BY :
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE :
DATE :
DATE : 01/02/2018 15:28
TEXT : ..\ProfileLogs\ESNBH20.TXT

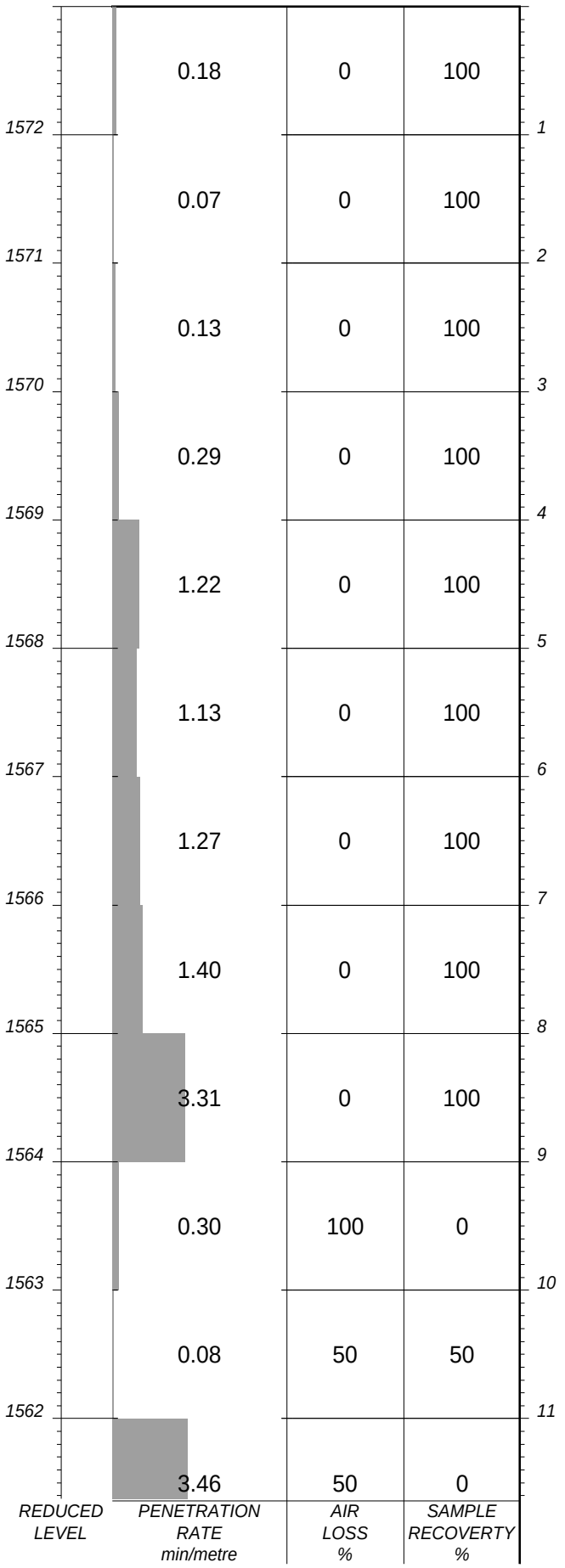
ELEVATION :
X-COORD :
Y-COORD :

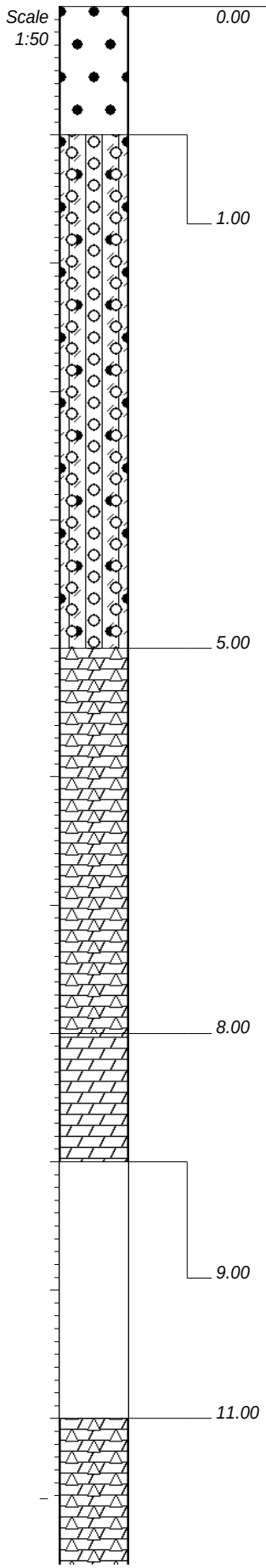
LEGEND
SUMMARY OF SYMBOLS

ESKOM
ESSELEN SUBSTATION FULL DSI

HOLE No: 21
Sheet 1 of 2

JOB NUMBER: ESN BH 21





Bulk sample: Moist, brown, sandy gravel with silt. **Sieve washed:** 65% loss. Wet, fine to medium gravel chips of maroon rounded ferricrete nodules **Interpretation:** Ferricrete

Bulk sample: Moist reddish brown to maroon clayey silt with gravel. **Sieve washed:** 70% loss. Wet, fine and medium rounded dark reddish brown ferricrete soil **Interpretation:** Ferricrete soil

Bulk sample: Dry, brown, light brown to grey sandy gravel. **Sieve washed:** 70% loss. Wet, fine to medium brown coated sub-rounded CHERT and traces of bluish mottled white sub-angular DOLOMITE **Interpretation:** Moderately weathered CHERT and solid DOLOMITE

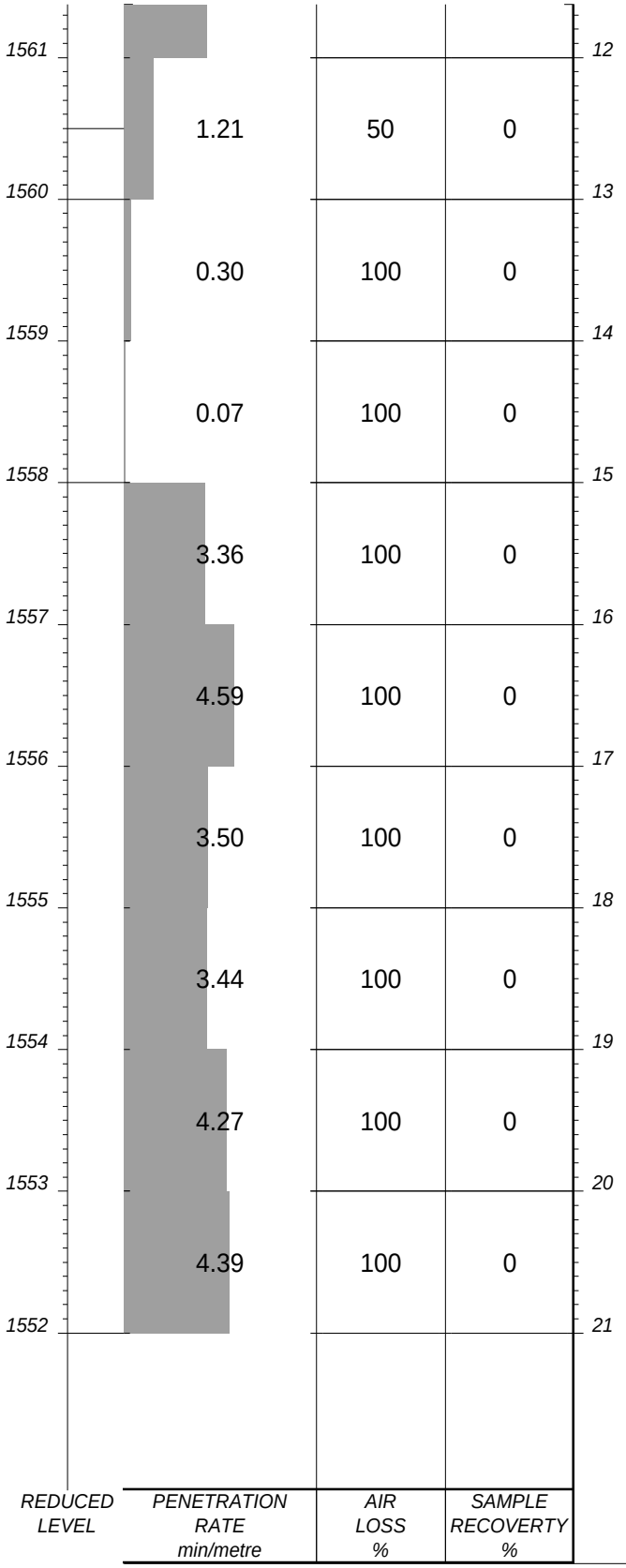
Bulk sample: Dry, light grey, sandy gravel with silt. **Sieve washed:** 25% loss. Wet, fine to medium gravel chips of sub-angular bluish mottled white DOLOMITE **Interpretation:** Dolomite pinacle/boulder at 8 - 9 m

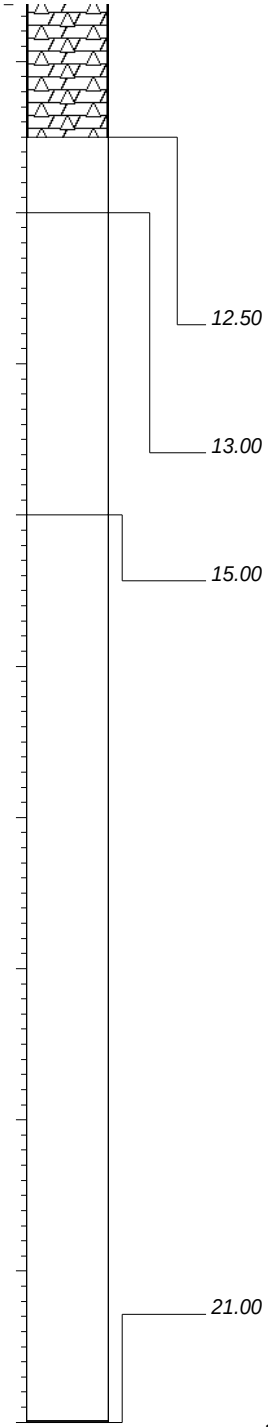
NO SAMPLE, rapid penetration rates indicate cavities.

ESKOM
ESSELEN SUBSTATION FULL DSI

HOLE No: 21
Sheet 2 of 2

JOB NUMBER: ESN BH 21





Bulk sample: Dry, brown, sandy gravel with silt. **Sieve washed:** 30% loss. Wet, fine to medium gravel chips of brown stained DOLOMITE and traces of sub-angular CHERT. **Interpretation:** Moderately weathered DOLOMITE

NO SAMPLE RETUR,rapid penetration noted during drilling

NO SAMPLE, rapid penetration indicates cavities

TOTAL SAMPLE LOSS, drilling indicates competent rock conditions

NOTES

1) 1)

2) 2)

3) 3.

REDUCED LEVEL	*PENETRATION RATE min/metre*	*AIR LOSS %*	*SAMPLE RECOVERTY %*

CONTRACTOR : Thoka Geosciences
MACHINE : THOR 5000
DRILLED BY :
PROFILED BY : Melusi Mashego
TYPE SET BY :
SETUP FILE : STANDARD.SET

INCLINATION : VERTICAL
DIAM :
DATE :
DATE : 17 JANUARY 2018
DATE : 20/03/2018 14:21
TEXT : ..\ProfileLogs\ESNBH21.TXT

ELEVATION : 1573m
X-COORD : 28.27073
Y-COORD : 26.00399

HOLE No: 21
Esselen Substation, Tembisa

ESKOM
ESSELEN SUBSTATION FULL DSI

LEGEND
Sheet 1 of 1

JOB NUMBER: ESN BH 21

	GRAVEL	{SA02}
	SILT	{SA06}
	CLAYEY	{SA09}
	DOLOMITE	{SA13}
	CHERT	{SA21}
	FERRICRETE NODULES	{SA24}

CONTRACTOR :
MACHINE :
DRILLED BY :
PROFILED BY :
TYPE SET BY :
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE :
DATE :
DATE : 20/03/2018 14:21
TEXT : ..\ProfileLogs\ESNBH21.TXT

ELEVATION :
X-COORD :
Y-COORD :

LEGEND
SUMMARY OF SYMBOLS

Appendix IV

Drillers Logs

Percussion Borehole Drilling Records

THOKA GEOSCIENCES cc

Head Office: 35 Woltemade Street, Culemborg Park, Randfontein, 1759, Postal Address: P O Box 1910, Silverton, 0127 Tel/Cell: +27 82 932 8465
Fax: +27 86 516 8363 Email: thokageo@gmail.com

PROJECT INFORMATION	BOREHOLE INFORMATION	HYDROLOGY INFORMATION	
Client: ESKOM	BH Name: ESN BH 02	Date: 15/01/2018	Air Capacity (m3/m):
Project: DOLOMITE STUDY	Total Depth (m):	Air Pressure (kPa):	Casing In & Out (m):
Location: ESSELEN	Casing Installed (m):	Blow Yield (L/s):	Casing Permanently Damaged (m):
X Coord: 26,10071	Elevation (m):	Water Rest Level (m) (After 24 Hrs):	
Y Coord: 28,26710	Bit Diameter (mm):	Water Strike (m):	

General Remarks:

Depth	Penetration Rate (min/m)	Formation Hardness	Hammer Rate	Air Loss	Sample Recovery	Moisture Condition	Hole Collapse	Water Strike	Water Foam Applied	Comments
0-1	0.07	Soft	Regular	0%	100%	Smooth				
1-2	0.07	"	"	"	"	"				
2-3	0.07	"	"	"	"	"				
3-4	0.32	"	"	"	"	"				Chert
4-5	0.05		Irregular	~~70%~~	30%	"				
5-6	0.05	Cavity	"	"	"	"				&
6-7	0.05		"	"	"	"				Clay
7-8	0.05			100%	0%					with
8-9	1.57		Regular	0%	100%	Smooth				~~[illegible]~~
9-10	3.25		"	"	"	"				
10-11	1.20		"	"	"	"				
11-12	2.58		"	"	"	"				Dolomite
12-13	4.12		"	"	"	"				
13-14	3.40		"	"	"	Dry				
14-15	3.39		"	"	"	"				
15-16	3.40		"	"	"	"				
16-17	3.86		"	"	"	"				
17-18	4.00		"	"	"	"				
18-19										
19-20										
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58-59										
59-60										

Rig Operator: PRINCE MONGWE
Data Descriptions by: TSELISO GERAJA

FIELD ASSISTANTS
BONGANI SABEBE
SELLO MGWENYE
LUFEFE MPARUMPARU
HLULANI MAHLOBO

Doc Engine **Start:** **Finish:**
Compressor **Start:** **Finish:**

Percussion Borehole Drilling Records

Version Date: May 2015

Head Office: 35 Woltemade Street, Culemborg Park, Randfontein, 1759, Postal Address: P O Box 1910, Silverton, 0127 Tel/Cell: +27 82 932 8465
Fax: +27 86 516 8363 Email: thokageo@gmail.com

PROJECT INFORMATION		BOREHOLE INFORMATION		HYDROLOGY INFORMATION		
Client:	ESKom	BH Name:	ESN BH 06	Date:	09/01/2018	Air Capacity (m3/m):
Project:	DOLOMITE STUDY	Total Depth (m):		Air Pressure (kPa):		Casing In & Out (m):
Location:	ESSELEN	Casing Installed (m):		Blow Yield (L/s):		Casing Permanently Damaged (m):
X Coord:	26.00459°	Elevation (m):	1581 m	Water Rest Level (m) (After 24 Hrs):		
Y Coord:	29.26638°	Bit Diameter (mm):		Water Strike (m):		

General Remarks:

Depth	Penetration Rate (min/m)	Formation Hardness	Hammer Rate	Air Loss	Sample Recovery	Moisture Condition	Hole Collapse	Water Strike	Water Foam Applied	Comments
0-1	0:10		Regular	0%	100%	S.MOIST				Colluvium.
1-2	0:11		"	"	"	"				
2-3	0:12		"	"	"	"				=
3-4	0:17		"	"	"	"				
4-5	0:49		"	"	"	"				CHERT
5-6	0:58		"	"	"	"				
6-7	0:36		"	60%	40%	"				
7-8	0:06			0%	100%		X			
8-9	0:06			"	"		X			
9-10	0:06			"	"		X			
10-11	0:06	CAUTY		"	"		X			
11-12	0:06			"	"					
12-13	0:06	"		"	"					
13-14	0:06			"	"					
14-15	0:06			"	"					
15-16	0:06	"		"	"					
16-17	0:06			"	"					ABANDONED THE HOLE DUE TO DEEP CAUTY. (12m)
17-18	0:06	"		"	"					
18-19	0:06									
19-20										
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59-60										

Rig Operator: PRINCE MONGWE
Data Descriptions by: TSELISO LEBASA

FIELD ASSISTANTS:
SELLO MGWENYE
BONGANI SADEBE
LUFEFO MPAKUMPAKY
HLULANI MALULEKE

Doc Engine Start: Finish:
Compressor Start: Finish:

The borehole has collapse to 500mm

Percussion Borehole Drilling Records

Version Date: May 2015

THOKA GEOSCIENCES cc

Head Office: 35 Woltemade Street, Culemborg Park, Randfontein, 1759. Postal Address: P O Box 1910, Silverton, 0127 Tel/Cell: +27 82 932 8465
Fax: +27 86 516 8363 Email: thokageo@gmail.com

PROJECT INFORMATION	BOREHOLE INFORMATION	HYDROLOGY INFORMATION	
Client: ESKOM	BH Name: ESN-BH 03	Date: 09/01/2018	Air Capacity (m3/m):
Project: DOLOMITE STUDY	Total Depth (m):	Air Pressure (kPa):	Casing In & Out (m):
Location: ESSELEN	Casing Installed (m):	Blow Yield (L/s):	Casing Permanently Damaged (m):
X Coord: 26.00531	Elevation (m): 1574 m	Water Rest Level (m) (After 24 Hrs):	
Y Coord: 28.26590	Bit Diameter (mm):	Water Strike (m):	

General Remarks:

Depth	Penetration Rate (min/m)	Formation Hardness	Hammer Rate	Air Loss	Sample Recovery	Moisture Condition	Hole Collapse	Water Strike	Water Foam Applied	Comments
0-1	0.18					S/M	—			
1-2	0.20					"	—			Colluvium
2-3	0.16					"	—			
3-4	0.33					"	—			
4-5	0.33			0%	100%	"	—			
5-6	0.40			"	"	"	—			CHERT & Clay
6-7	0.47			60%	40%	"	—			
7-8	0.68	CAVITY		60%	40%	"	—			
8-9	0.31			60%	40%	"	—			
9-10	0.08			60%	40%	"	—			
10-11	0.04	CAVITY		60%	40%	"	—			
11-12	0.38		Regular	70%	30%	"	—			Clay
12-13	0.14		"	70%	30%	S/M	—			
13-14	0.08	CAVITY	"	100%	0%	"	—			
14-15	0.08		"	"	"	"	—			
15-16	0.08			"	"	"	—			
16-17	0.29		Regular	60%	40%	"	—			
17-18	2.55	Hard	"	70%	30%	"	—			
18-19	3.10	"	"	50%	50%	"				
19-20	3.44	"	"	0%	100%	DRY				
20-21	3.55	"	"	"	"	"				
21-22	3.49	"	"	"	"	"				
22-23	3.38	"	"	"	"	"				
23-24	4.10	"	"	"	"	"				Dolomite
24-25										
25-26										
26-27										
27-28										
28-29										
29-30										
30-31										
31-32										
32-33										
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59-60										

Rig Operator: PRINCE MONGWE
Data Descriptions by: TSEKISO LEBAKA

S 26.00531
E 28.26590

Doc Engine Start: Finish:
Compressor Start: Finish:

FIELD ASSISTANTS: SELLO MGWENYE
BONGANI SABERE
LEFOFO MPATELI MAKA
HLULANI MALULEKE

THOKA GEOSCIENCES CC

Percussion Borehole Drilling Records

Version Date: May 2015

Head Office: 35 Woltemade Street, Culemborg Park, Randfontein, 1759, Postal Address: P O Box 1910, Silverton, 0127 Tel/Cell: +27 82 932 8465
Fax: +27 86 516 8363 Email: thokageo@gmail.com

PROJECT INFORMATION		BOREHOLE INFORMATION		HYDROLOGY INFORMATION		
Client:	ESKOM	BH Name:	ESN BH 03	Date:	09/01/2018	Air Capacity (m3/m):
Project:	DOLOMITE STUDY	Total Depth (m):		Air Pressure (kPa):		Casing In & Out (m):
Location:	ESICLEN	Casing Installed (m):		Blow Yield (L/s):		Casing Permanently Damaged (m):
X Coord:	26.00 631°	Elevation (m):	1574m	Water Rest Level (m) (After 24 Hrs):		
Y Coord:	25.265900	Bit Diameter (mm):		Water Strike (m):		

General Remarks:

Depth	Penetration Rate (min/m)	Formation Hardness	Hammer Rate	Air Loss	Sample Recovery	Moisture Condition	Hole Collapse	Water Strike	Water Foam Applied	Comments
0-1	0.18					S.moist				Colluvium
1-2	0.20					"				
2-3	0.16					"				
3-4	0.33					"				
4-5	0.33			0%	100%	"				CHERT & Clay
5-6	0.40			"	"	"				
6-7	0.47			"	"	"				
7-8	0.08	CAVITY		60%	40%	"				
8-9	0.31			"	"	"				
9-10	0.08			"	"	"				Clay
10-11	0.03	CAVITY		"	"	"				
11-12	0.38		Regular	"	"	"				
13-14	0.08			60%	40%	"				
14-15	0.08	CAVITY		"	"	"				
15-16	0.08			60%	40%	"				
16-17	0.29		Regular	70%	30%	"				
17-18	2.55	Hard	"	70%	30%	"				
18-19	3.10	"	"	50%	50%	"				
19-20	3.44	"	"	0%	100%	DRY				Dolomite
20-21	3.55	"	"	"	"	"				
21-22	3.49	"	"	"	"	"				
22-23	3.58	"	"	"	"	"				
23-24	4.10	"	"	"	"	"				
24-25										
25-26										
26-27										
27-28										
28-29										
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59-60										

Rig Operator: PRINCE MOYSWE
Data Descriptions by: TSOLISO LEBASA

THOKA ASSISTANTS:
SELLO NGWENYE
LUFOFE MAKUMBANE
BONGANI BABOE
HLULANI MABUDE

Doc Engine Start: Finish:
Compressor Start: Finish:

24m no collapse
borehole dry

THOKA GEOSCIENCES cc

Percussion Borehole Drilling Records

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Fax: +27 86 516 8363 Email: thokageo@gmail.com

PROJECT INFORMATION	BOREHOLE INFORMATION	HYDROLOGY INFORMATION	
Client: ESKOM	BH Name: BSN BH 4	Date: 15/01/2018	Air Capacity (m3/m):
Project: Dolomite Study	Total Depth (m):	Air Pressure (kPa):	Casing In & Out (m):
Location: [illegible]	Casing Installed (m):	Blow Yield (L/s):	Casing Permanently Damaged (m):
X Coord: 26,00726	Elevation (m):	Water Rest Level (m) (After 24 Hrs):	
Y Coord: 28,26143	Bit Diameter (mm):	Water Strike (m):	

General Remarks:

Depth	Penetration Rate (min/m)	Formation Hardness	Hammer Rate	Air Loss	Sample Recovery	Moisture Condition	Hole Collapse	Water Strike	Water Foam Applied	Comments
0-1	0.15		Rapidly	0%	100%	S.moist				Collected
1-2	0.34		"	"	"	"				
2-3	0.49		"	"	"	"				
3-4	0.05		Irregular	60%	40%	"				Collect @
4-5	0.05		"	"	"	"				
5-6	0.05	Cavity	"	100%	100%	"				WASS
6-7	0.05		"	"	"	"				"
7-8	0.05		"	"	"					"
8-9	0.05		"	"	"					
9-10	0.05		"	"	"	Cavity & No Sample				
10-11	0.05		"	"	"					
11-12	0.05		"	"	"					
12-13	0.05		"	"	"					
13-14										
14-15										
15-16										Hole abandoned
16-17										
17-18										due to deep
18-19										
19-20										
20-21										Cavity (10m)
21-22										
22-23										
23-24										
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28-29										
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Rig Operator: PRINCE MONGWE
Data Descriptions by: TSELISO LEBASA

Field Assistants:
Bongani Gadebe
Selo Mgwenya
Lufefo Mpambampamba
Hlulani Maluleke

Doc Engine Start: Finish:
Compressor Start: Finish:

S 26.00600°
E28.26692°
EG = 1575 m.

Version Date: May 2015

Percussion Borehole Drilling Records

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PROJECT INFORMATION	BOREHOLE INFORMATION	HYDROLOGY INFORMATION		
Client: ESKOM	BH Name: ESN BH 5	Date: 12/01/2018	Air Capacity (m3/m):	
Project: DOLOMITE ITHAA	Total Depth (m):	Air Pressure (kPa):	Casing In & Out (m):	
Location: EVELEN	Casing Installed (m):	Blow Yield (L/s):	Casing Permanently Damaged (m):	
X Coord: 26.00600°	Elevation (m): 1575 m	Water Rest Level (m) (After 24 Hrs):		
Y Coord: 28.26692°	Bit Diameter (mm):	Water Strike (m):		

General Remarks:

Depth	Penetration Rate (min/m)	Formation Hardness	Hammer Rate	Air Loss	Sample Recovery	Moisture Condition	Hole Collapse	Water Strike	Water Foam Applied	Comments
0-1	0 : 15	SOFT	Regular	02	100%	Smash	—	—	—	
1-2	0 : 24	"	"	0	100	"	—	—	—	
2-3	1 : 22	"	"	0	100	DRY	—	—	—	Dolomite
3-4	3 : 11	HARD	"	0	100	"	—	—	—	
4-5	3.01	"	"	"	"	"				
5-6	3.08	"	"	"	"	"				
6-7	3.13	"	"	"	"	"			X	
7-8	3.09	"	"	"	"	"				
8-9	3.43	"	"	"	"	"				
9-10	3.50	"	"	"	"	"				
10-11										
11-12										
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Rig Operator: PRINCE MOYANE
Data Descriptions by: TSELISO LEBABA

Doc Engine **Start:** **Finish:**
Compressor **Start:** **Finish:**

FIELD ASSISTANTS:
SELLO MGWENYE
LUFEFE MPAKUMPAKA
BONGANI GABEBE
HLULANI MAHLOKE

Percussion Borehole Drilling Records

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PROJECT INFORMATION		BOREHOLE INFORMATION		HYDROLOGY INFORMATION		
Client:	ESKOM	BH Name:	ESN BH 06	Date:	15/01/2018	Air Capacity (m3/m):
Project:	DOLOMITE STUDY	Total Depth (m):		Air Pressure (kPa):		Casing In & Out (m):
Location:	ESSELEN	Casing Installed (m):		Blow Yield (L/s):		Casing Permanently Damaged (m):
X Coord:	26, 00682	Elevation (m):		Water Rest Level (m) (After 24 Hrs):		
Y Coord:	28, 26894	Bit Diameter (mm):		Water Strike (m):		

General Remarks:

Depth	Penetration Rate (min/m)	Formation Hardness	Hammer Rate	Air Loss	Sample Recovery	Moisture Condition	Hole Collapse	Water Strike	Water Foam Applied	Comments
0-1	0.08	Soft	Regular	0%	100%	MOIST				
1-2	0.08	"	"	"	"	"				
2-3	0.08	"	"	"	"	"				CHERT & Clay
3-4	3.31	"	"	"	"	SMOOTH				
4-5	3.47	Hard	"	"	"	DRY				
5-6	3.50	"	"	"	"	S. MOIST			X	
6-7	4.15	"	"	"	"	"			X	
7-8	3.32	"	"	"	"	"			X	
8-9	3.33	"	"	"	"	"			X	Dolomite
9-10	3.27					DRY				
10-11										
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Rig Operator: PRINCE MONYEWE
Data Descriptions by: TSELISO LEMATA

FIELD ASSISTANTS:
BONGANI SABELO
SELLO MGWENYE
LUFEFO MBAU MPAKO
HLULANI MALULEKE

Doc Engine Start: Finish:
Compressor Start: Finish:

Percussion Borehole Drilling Records

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PROJECT INFORMATION	BOREHOLE INFORMATION	HYDROLOGY INFORMATION		
Client:	BH Name: ESN BH07	Date: 16/01/2018	Air Capacity (m3/m):	
Project:	Total Depth (m):	Air Pressure (kPa):	Casing In & Out (m):	
Location:	Casing Installed (m):	Blow Yield (L/s):	Casing Permanently Damaged (m):	
X Coord: 26,00 45.5°	Elevation (m): 1571m	Water Rest Level (m) (After 24 Hrs):		
Y Coord: 28,27 45°	Bit Diameter (mm):	Water Strike (m):		

General Remarks:

Depth	Penetration Rate (min/m)	Formation Hardness	Hammer Rate	Air Loss	Sample Recovery	Moisture Condition	Hole Collapse	Water Strike	Water Foam Applied	Comments
0-1	0:06	SOFT	Regulas	0	100	MOIST				Red Top Soil
1-2	0:05	〃	〃	0	100	〃				
2-3	0:11	〃	〃	0	100	〃				
3-4	0:09	〃	〃	0	100	〃				
4-5	0:14	〃	〃	0	100	〃				
5-6	0:36	〃	〃	0	100	〃				Red Clay Soil
6-7	0:38	〃	〃	0	100	〃				
7-8	0:20	〃	〃	No SAMPLE						
8-9	0:08	〃	〃	No SAMPLE						Small Cavity
9-10	0:14	〃	〃	No SAMPLE						
10-11	3:43	HARD	〃	30%	70%	〃				
11-12	3:51	HARD	〃	0	100	〃			✓	DRILLING HARD Rock
12-13	2:16	Medium	〃	0	100	〃				
13-14	3:09	HARD	〃	0	100	〃			✓	
14-15	3:36	HARD	〃	0	100	〃			✓	
15-16	3:45	HARD	〃	0	100	〃				
16-17	3:27	HARD	〃	0	100	〃			✓	
17-18	3:49	HARD	〃	0	100	〃			✓	
18-19	3:05	HARD	〃	0	100	〃			✓	
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Rig Operator:
Data Descriptions by:

Doc Engine **Start:** **Finish:**
Compressor **Start:** **Finish:**

Percussion Borehole Drilling Records

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PROJECT INFORMATION	BOREHOLE INFORMATION	HYDROLOGY INFORMATION		
Client:	BH Name: DSN BH08	Date: 17/01/2018	Air Capacity (m3/m):	
Project:	Total Depth (m):	Air Pressure (kPa):	Casing In & Out (m):	
Location:	Casing Installed (m):	Blow Yield (L/s):	Casing Permanently Damaged (m):	
X Coord: 26,00385°	Elevation (m): 1574 m	Water Rest Level (m) (After 24 Hrs):		
Y Coord: 28,27096°	Bit Diameter (mm):	Water Strike (m):		

General Remarks:

Depth	Penetration Rate (min/m)	Formation Hardness	Hammer Rate	Air Loss	Sample Recovery	Moisture Condition	Hole Collapse	Water Strike	Water Foam Applied	Comments
0-1	0:06	SOFT	Regulas	0%	100%	Moist				Red Top Soil
1-2	0:06	"	"	0	100	"				
2-3	0:07	"	"	0	100	"				
3-4	0:12	"	"	0	100	"				
4-5	0:11	"	"	0	100	"				
5-6	0:16	"	"	0	100	"				
6-7	0:24	"	"	0	100	"				
7-8	1:20	"	Regulas	0	100	"				CAVITY
8-9	0:07	"	"	NO SAMPLE		—				
9-10	0:58	"	"	50%	50%	Moist				
10-11	0:14	"	"	NO SAMPLE		—				
11-12	0:03	"	"	"	"	—	CAVITY			
12-13	1:37	"	Regulas	"	"	—				
13-14	0:11	"	"	"	"	—				
14-15	3:50	HARD	"	90%	"	—				
15-16	3:33	HARD	"	50	50	Moist			✓	
16-17	3:19	HARD	"	40	60	"			✓	
17-18	3:54	HARD	"	20	80	"			✓	
18-19	3:29	HARD	"	10	90	"			✓	
19-20	3:40	HARD	"	0%	100	"			✓	
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Rig Operator:
Data Descriptions by:

Doc Engine **Start:** **Finish:**
Compressor **Start:** **Finish:**

Percussion Borehole Drilling Records

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PROJECT INFORMATION		BOREHOLE INFORMATION		HYDROLOGY INFORMATION		
Client:		BH Name:	ESN BH09	Date:	17/11/2018	Air Capacity (m3/m):
Project:		Total Depth (m):		Air Pressure (kPa):		Casing In & Out (m):
Location:		Casing Installed (m):		Blow Yield (L/s):		Casing Permanently Damaged (m):
X Coord:	26,00354°	Elevation (m):	1579m	Water Rest Level (m) (After 24 Hrs):		
Y Coord:	28;26943°	Bit Diameter (mm):		Water Strike (m):		

General Remarks:

Depth	Penetration Rate (min/m)	Formation Hardness	Hammer Rate	Air Loss	Sample Recovery	Moisture Condition	Hole Collapse	Water Strike	Water Foam Applied	Comments
0-1	0:10	SOFT	Regular	0	100	MOIST				
1-2	0:26	SOFT	"	0	100	"				
2-3	0:37	SOFT	"	0	100	"				
3-4	2:03	Medium	"	0	100	DRY			✓	
4-5	4:19	HARD	"	0	100	"			✓	
5-6	1:55	SOFT	"	0	100	MOIST				HALF METER CAVITY
6-7	0:08	SOFT	NO HAMMER		0%					CAVING
7-8	0:07	"	" "		0%					
8-9	3:01	HARD	Regular	50%	50%	MOIST				
9-10	3:32	"	"	50	50	"				
10-11	5:22	"	"	50	50	"				
11-12	3:09	"	"	50	50	"				
12-13	3:21	"	"	40%	60%	"				
13-14	3:39	"	"	30%	7%					
14-15										
15-16										
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Rig Operator:
Data Descriptions by:

Doc Engine **Start:** **Finish:**
Compressor **Start:** **Finish:**

Percussion Borehole Drilling Records

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PROJECT INFORMATION	BOREHOLE INFORMATION	HYDROLOGY INFORMATION		
Client: ESKOM	BH Name: ESN BH 11	Date: 12/01/2018	Air Capacity (m3/m):	
Project: DOLOMITE STUDY	Total Depth (m):	Air Pressure (kPa):	Casing In & Out (m):	
Location: ESSELEN	Casing Installed (m):	Blow Yield (L/s):	Casing Permanently Damaged (m):	
X Coord: 26.005730°	Elevation (m): 1579m	Water Rest Level (m) (After 24 Hrs):		
Y Coord: 28.26736°	Bit Diameter (mm):	Water Strike (m):		

General Remarks:

Depth	Penetration Rate (min/m)	Formation Hardness	Hammer Rate	Air Loss	Sample Recovery	Moisture Condition	Hole Collapse	Water Strike	Water Foam Applied	Comments
0-1	0.10		Regular			S.moist				
1-2	0.26		"			"				
2-3	0.25 0.08		"			"				
3-4	0.08	CAVITY		100%	0%	"				CHERT
4-5	0.08			100%	0%	"				
5-6	0.10		Irregular	0%	100%	"	X			
6-7	0.08	CAVITY	"	50%	50%	"	X			WAD
7-8	1.30		Regular	0%	100%	DRY				
8-9	3.46		"	"	"	M				DOLOMITE
9-10	3.30		"	"	"	"				
10-11	3.25		"	"	"	"				
11-12	3.33		"	"	"	"				"
12-13	4.04		"	"	"	"				"
13-14	3.58		"	"	"	"				"
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15-16										
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Rig Operator: PRINCE MONSWE
Data Descriptions by: TSELISO GOBASA

FIELD ASSISTANTS:
SELLO MGWENYE
LUFUFO MBAKUMBAKU
BONGANI GADEBE
HLULANI MALULEKE

Doc Engine Start: Finish:
Compressor Start: Finish:

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PROJECT INFORMATION		BOREHOLE INFORMATION		HYDROLOGY INFORMATION		
Client:	ESKOM	BH Name:	GN BH 12	Date:	12/01/2018	Air Capacity (m3/m):
Project:	DOLOMITE STUDY	Total Depth (m):		Air Pressure (kPa):		Casing In & Out (m):
Location:	ESSELEN	Casing Installed (m):		Blow Yield (L/s):		Casing Permanently Damaged (m):
X Coord:	26.00656°	Elevation (m):	1577m	Water Rest Level (m) (After 24 Hrs):		
Y Coord:	28.26726°	Bit Diameter (mm):		Water Strike (m):		

General Remarks:

Depth	Penetration Rate (min/m)	Formation Hardness	Hammer Rate	Air Loss	Sample Recovery	Moisture Condition	Hole Collapse	Water Strike	Water Foam Applied	Comments
0-1	0.10	Soft	Regular	0%	100%	S.moist				Colluvium
1-2	0.31	"	"	"	"	"				Clayey Sand
2-3	0.31	"	"	"	"	"				
3-4	0.10	"	"	"	"	"				
4-5	2.24	Hard	"	"	"	Dry				
5-6	2.36	"	"	"	"	"				
6-7	4.20	"	"	"	"	"				
7-8	3.58	"	"	"	"	"				
8-9	3.37	"	"	"	"	"				
9-10	3.38	"	"	"	"	"				
10-11	3.05	CAVITY	Irregular	100%	0%	"				
11-12	4.12	Hard rock	Regular	80%	20%	"				
12-13										
13-14										
14-15										
15-16										
16-17										
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Rig Operator: PRINCE MONSWE
Data Descriptions by: TSELISO CEBASH

FIELD ASSISTANTS:
ZELLO MSWENYE
BONGANI GADEBE
LUFEFE MPAKANYAKA
HLULANI MAHLEKE

Doc Engine Start: Finish:
Compressor Start: Finish:

Percussion Borehole Drilling Records

Head Office: 35 Woltemade Street, Culemborg Park, Randfontein, 1759. Postal Address: P O Box 1910, Silverton, 0127 Tel/Cell: +27 82 932 8465
Fax: +27 86 516 8363 Email: thokageo@gmail.com

PROJECT INFORMATION		BOREHOLE INFORMATION		HYDROLOGY INFORMATION		
Client:	ESKOM	BH Name:	ESN BH 13	Date:	09/09/2013	Air Capacity (m3/m):
Project:	DOLOMITE STUDY	Total Depth (m):		Air Pressure (kPa):		Casing In & Out (m):
Location:	ESELEN	Casing Installed (m):		Blow Yield (L/s):		Casing Permanently Damaged (m):
X Coord:	26.00495°	Elevation (m):	1579	Water Rest Level (m) (After 24 Hrs):		
Y Coord:	28.26663°	Bit Diameter (mm):		Water Strike (m):		

General Remarks:

Depth	Penetration Rate (min/m)	Formation Hardness	Hammer Rate	Air Loss	Sample Recovery	Moisture Condition	Hole Collapse	Water Strike	Water Foam Applied	Comments
0-1	0.17		Regular	0%		Some				CHERT
1-2	0.16		"	"		"				"
2-3	0.04	CAVITY	CAVITY	70%	30%	Cr				
3-4	0.20		IRRegular	"	"	"				SOIL
4-5	0.06	CAVITY	"	60%	40	"	X			
5-6	0.10		CAVITY	"	"	"	X			CLAY
6-7	0.20		IRRegular	50%	50%	"				
7-8	0.08	CAVITY				"				
8-9	1.03			85%	15%	"				
9-10	3.38		Regular	30%	~~70%~~	DRY				
10-11	3.25		"	0%	100%	"				DOLOMITE
11-12	3.40		"	"	"	"				"
12-13	4.39		"	"	"	"				
13-14	3.11		"	"	"	"				
14-15	3.20		"	"	"	"				
15-16										
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Rig Operator: PRINCE MONSWE
Data Descriptions by: TSELISO LEBASA

FIELD ASSISTANTS:
LUFEFE MAKUNGA
BONGANI GADEBE
BELLO MGWENYA
HLULANI MALULEKE

Doc Engine Start: Finish:
Compressor Start: Finish:

Dry hole
No collapse

Percussion Borehole Drilling Records

ESN BH15

Head Office: 35 Woltemade Street, Culemborg Park, Randfontein, 1759. Postal Address: P O Box 1910, Silverton, 0127 Tel/Cell: +27 82 932 8465
Fax: +27 86 516 8363 Email: thokageo@gmail.com

PROJECT INFORMATION	BOREHOLE INFORMATION	HYDROLOGY INFORMATION		
Client:	BH Name: ESN BH15	Date: 17/01/2018	Air Capacity (m3/m):	
Project:	Total Depth (m):	Air Pressure (kPa):	Casing In & Out (m):	
Location:	Casing Installed (m):	Blow Yield (L/s):	Casing Permanently Damaged (m):	
X Coord: 26.004100°	Elevation (m): 1572 m	Water Rest Level (m) (After 24 Hrs):		
Y Coord: 28.271120°	Bit Diameter (mm):	Water Strike (m):		

General Remarks:

Depth	Penetration Rate (min/m)	Formation Hardness	Hammer Rate	Air Loss	Sample Recovery	Moisture Condition	Hole Collapse	Water Strike	Water Foam Applied	Comments
0-1	0:05	Soft	Regular	0%	100%	Moist				Red Top Soil
1-2	0:04	"	"	0	100	"				
2-3	0:08	"	"	0	100	"				
3-4	0:07	"	"	0	100	"				
4-5	0:05	"	"	0	100	"				
5-6	0:08	"	"	0	100	"	✓			Clay Soil
6-7	0:41	"	"	0	100	"				
7-8	1:38	"	"	0	100	"				
8-9	0:09	"	No hammer	50%	50%	"				Cavity
9-10	1:30	"	Regular	90	—	—				
10-11	5:14	HARD	"	80	—	—				Drilling HARD Rock
11-12	2:38	Medium	"	80	—	—				but no
12-13	4:19	HARD	"	80	—	—				SAMPLE
13-14	4:25	HARD	"	80	—	—				
14-15	2:15	Medium	"							
15-16	0:11	Soft	"	Cavity						
16-17	0:08	"	"							
17-18	0:08	"	"							
18-19	3:07	HARD	Regular	50%	50%	DRY				
19-20	4:25	HARD	"	60	40	"				
20-21	5:16	HARD	"	65	35	"				
21-22	4:04	HARD	"	65	35	"				
22-23	4:20	HARD	"	90	10	"				
23-24	4:41	HARD	"	90	10	"				
24-25										
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Rig Operator:
Data Descriptions by:

Doc Engine **Start:** **Finish:**
Compressor **Start:** **Finish:**

Percussion Borehole Drilling Records

Head Office: 35 Woltemade Street, Culemborg Park, Randfontein, 1759. Postal Address: P O Box 1910, Silverton, 0127 Tel/Cell: +27 82 932 8465
Fax: +27 86 516 8363 Email: thokageo@gmail.com

PROJECT INFORMATION	BOREHOLE INFORMATION	HYDROLOGY INFORMATION		
Client:	BH Name: ESN BH16	Date: 16/01/2018	Air Capacity (m3/m):	
Project:	Total Depth (m):	Air Pressure (kPa):	Casing In & Out (m):	
Location:	Casing Installed (m):	Blow Yield (L/s):	Casing Permanently Damaged (m):	
X Coord: 26.005053°	Elevation (m): 1537 m	Water Rest Level (m) (After 24 Hrs):		
Y Coord: 28.217130°	Bit Diameter (mm):	Water Strike (m):		

General Remarks:

Depth	Penetration Rate (min/m)	Formation Hardness	Hammer Rate	Air Loss	Sample Recovery	Moisture Condition	Hole Collapse	Water Strike	Water Foam Applied	Comments
0-1	0:13	Soft	Regular	0%	100%	moist				TOP SOIL
1-2	1:27	"	"	0	100	"				
2-3	1:11	"	"	0	100	"				
3-4	0:37	"	Irregular	0	100	"				Small cavity
4-5	0:24	"	"	0	100	"				Small cavity
5-6	0:27	"	"	0	100	"				Small cavity
6-7	0:11	"	"	0	100	"				cavity
7-8	0:16	"	"	50%	50	"				
8-9	0:48	"	"	50%	50	"				
9-10	0:09	"	"	100	0	"	✓			cavity
10-11	0:10	"	"	100	0	"	✓			"
11-12	3:05	HARD	Regular	100	0	"				"
12-13	1:44	Soft	Irregular	100	0	"				"
13-14	0:05	"	"	100	0	"				"
14-15	0:04	"	"	100	0	"				"
15-16	0:05	"	"	100	0	"				"
16-17	0:03	"	"	100	0	"				"
17-18	0:04	"	"	100	0	"				"
18-19	0:04	"	"	100	no sample					"
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Rig Operator:
Data Descriptions by:

Doc Engine **Start:** **Finish:**
Compressor **Start:** **Finish:**

Percussion Borehole Drilling Records

Head Office: 35 Woltemade Street, Culemborg Park, Randfontein, 1759. Postal Address: P O Box 1910, Silverton, 0127 Tel/Cell: +27 82 932 8465
Fax: +27 86 516 8363 Email: thokageo@gmail.com

PROJECT INFORMATION	BOREHOLE INFORMATION	HYDROLOGY INFORMATION		
Client:	BH Name: OSN BH17	Date: 17/01/2018	Air Capacity (m3/m):	
Project:	Total Depth (m):	Air Pressure (kPa):	Casing In & Out (m):	
Location:	Casing Installed (m):	Blow Yield (L/s):	Casing Permanently Damaged (m):	
X Coord: 26, 00 35 7°	Elevation (m): 1575	Water Rest Level (m) (After 24 Hrs):		
Y Coord: 28, 2700 16°	Bit Diameter (mm):	Water Strike (m):		

General Remarks:

Depth	Penetration Rate (min/m)	Formation Hardness	Hammer Rate	Air Loss	Sample Recovery	Moisture Condition	Hole Collapse	Water Strike	Water Foam Applied	Comments
0-1	0 : 04	Soft	Regular	0%	100	MOIST				
1-2	0 : 09	〃	〃	0	100	〃				
2-3	0 : 11	〃	〃	0	100	〃				
3-4	0 : 19	〃	〃	0	100	〃				
4-5	0 : 12	〃	〃	0	100	〃	V			
5-6	0 : 31	〃	〃	0	100	〃	V			
6-7	0 : 08	〃	No hammer	no sample						
7-8	0 : 04	〃	Regular	100	0	—				Cavity
8-9	0 : 05	〃	〃	100	0	—				
9-10	0 : 07	〃	〃	100	0	—				
10-11	0 : 04	〃	〃	100	0	—				
11-12	0 : 09	〃	〃	100	0	—				
12-13	0 : 11	〃	〃	100	0	—				
13-14	0 : 18	〃	〃	100	0	—				
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Rig Operator:
Data Descriptions by:

Doc Engine **Start:** **Finish:**
Compressor **Start:** **Finish:**

STOP because of big cavity: High Risk of Rods

Percussion Borehole Drilling Records

Head Office: 35 Woltemade Street, Culemborg Park, Randfontein, 1759, Postal Address: P O Box 1910, Silverton, 0127 Tel/Cell: +27 82 932 8465
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PROJECT INFORMATION		BOREHOLE INFORMATION		HYDROLOGY INFORMATION		
Client:	ESKOM	BH Name:	ESK BH 18	Date:	15/01/2018	Air Capacity (m3/m):
Project:	Alumina Study	Total Depth (m):		Air Pressure (kPa):		Casing In & Out (m):
Location:	ESSELEN	Casing Installed (m):		Blow Yield (L/s):		Casing Permanently Damaged (m):
X Coord:	26:06622	Elevation (m):		Water Rest Level (m) (After 24 Hrs):		
Y Coord:	28:26963	Bit Diameter (mm):		Water Strike (m):		

General Remarks:

Depth	Penetration Rate (min/m)	Formation Hardness	Hammer Rate	Air Loss	Sample Recovery	Moisture Condition	Hole Collapse	Water Strike	Water Foam Applied	Comments
0-1	0.09	Soft	Regular	0%	100%	S.moist				
1-2	0.09	"	"	"	"	"				
2-3	0.09	"	"	"	"	"				Chert &
3-4	0.25	"	"	"	"	"				Clay
4-5	0.16	"	"	"	"	"				
5-6	0.08	cavity		80%	20%	"				
6-7	1.28	Hard	Regular	0%	100%	"				
7-8	1.58	"	"	"	"	"				
8-9	1.23	"	"	"	"	"				CHERT &
9-10	2.07	"	"	"	"	DRY				
10-11	2.20	"	"	"	"	"				BOTH
11-12	4.30	"	"	"	"	Smoist			A	
12-13	3.38	"	"	"	"	DRY				
13-14	3.33	"	"	"	"	"				
14-15	3.37	"	"	"	"	"				
15-16	3.53	"	"	"	"	"				
16-17	4.25									
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Rig Operator: PRINCE MONGWE
Data Descriptions by: TSELISO COBASA

Doc Engine **Start:** **Finish:**
Compressor **Start:** **Finish:**

FIELD ASSISTANTS:
BONGANI SADEBE
SELLO MGWENYA
LUFOFO MPAKUMPAKY
HLANGANANI MAHLOKO

S 26.00527°
E 28.26726°
ELV 1572m.

Percussion Borehole Drilling Records

Version Date: May 2015

Head Office: 35 Woltemade Street, Culemborg Park, Randfontein, 1759, Postal Address: P O Box 1910, Silverton, 0127 Tel/Cell: +27 82 932 8465
Fax: +27 86 516 8363 Email: thokageo@gmail.com

PROJECT INFORMATION		BOREHOLE INFORMATION		HYDROLOGY INFORMATION		
Client:	ESKOM	BH Name:	ESN BH 19	Date:	12/01/2018	Air Capacity (m3/m):
Project:	DOLOMITE STUDY	Total Depth (m):		Air Pressure (kPa):		Casing In & Out (m):
Location:	ESSELEN	Casing Installed (m):		Blow Yield (L/s):		Casing Permanently Damaged (m):
X Coord:	26.00 S 27°	Elevation (m):	1572 m	Water Rest Level (m) (After 24 Hrs):		
Y Coord:	28.26726°	Bit Diameter (mm):		Water Strike (m):		

General Remarks:

Depth	Penetration Rate (min/m)	Formation Hardness	Hammer Rate	Air Loss	Sample Recovery	Moisture Condition	Hole Collapse	Water Strike	Water Foam Applied	Comments
0-1	0.06	Soft	Regular	0%	100%	Smooth				Colluvium
1-2	0.06	"	"	"	"	"				
2-3	0.06	"	"	"	"	"				
3-4	0.18	"	"	"	"	"				
4-5	0.22	"	"	"	"	"				Clay
5-6	0.14	"	"	"	"	"				- wet
6-7	0.18	"	"	"	"	"				
7-8	1.42	S.Hard	"	"	"	Dry				
8-9	2.24	Hard	"	"	"	"				
9-10	3.55	"	"	"	"	"				
10-11	1.37	"	"	40%	60%	"				Dolomite
11-12	3.46	"	"	0%	100%	"				
12-13	3.32	"	"	"	"	"				
13-14	3.35	"	"	"	"	"				
14-15	3.10	"	"	"	"	"				
15-16	3.05	"	"	"	"	"				
16-17	3.10									
17-18										
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Rig Operator: PRINCE MONOWE
Data Descriptions by: TSELISO GEBASA

FIELD ASSISTANTS:
SELLO MGWENYE
BONGANI SHOEBE
LUYEFO MPAKAMPAKA
HLUCANI MALULEKE

Doc Engine **Start:** **Finish:**
Compressor **Start:** **Finish:**

THOKA GEOSCIENCES cc

Percussion Borehole Drilling Records

Head Office: 35 Woltemade Street, Culemborg Park, Randfontein, 1759, Postal Address: P O Box 1910, Silverton, 0127 Tel/Cell: +27 82 932 8465
Fax: +27 86 516 8363 Email: thokageo@gmail.com

PROJECT INFORMATION	BOREHOLE INFORMATION	HYDROLOGY INFORMATION	
Client: ESKOM	BH Name: ESN BH 20	Date: 15/01/2018	Air Capacity (m3/m):
Project: Dolomite Study	Total Depth (m):	Air Pressure (kPa):	Casing In & Out (m):
Location: ESSELEN	Casing Installed (m):	Blow Yield (L/s):	Casing Permanently Damaged (m):
X Coord: 26,00558	Elevation (m):	Water Rest Level (m) (After 24 Hrs):	
Y Coord: 27,27080	Bit Diameter (mm):	Water Strike (m):	

***General Remarks*:**

Depth	Penetration Rate (min/m)	Formation Hardness	Hammer Rate	Air Loss	Sample Recovery	Moisture Condition	Hole Collapse	Water Strike	Water Foam Applied	Comments
0-1	0.11	Soft	Regular	0%	100%	S.moist				
1-2	0.10	"	"	"	"	"				CHERT
2-3	0.16	"	"	"	"	"				
3-4	3.22	Hard	"	"	"	"				
4-5	4.58	"	"	"	"	Wet				
5-6	4.40	"	"	"	"	"				
6-7	4.59	"	"	"	"	"				Dolomite
7-8	3.56	"	"	"	"	DRY				
8-9	3.54	"	"	"	"	"				
9-10										
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Rig Operator: BELLO MGWENYE
Data Descriptions by: TSELISO LEBASA

FIELD ASSISTANTS
BONGANI SADEBE
PRINCE MONGWE
LEFOFE MPAKUMPAKU
HLULANI MAHLEKE

Doc Engine **Start:** **Finish:**
Compressor **Start:** **Finish:**

Percussion Borehole Drilling Records

Head Office: 35 Woltemade Street, Culemborg Park, Randfontein, 1759. Postal Address: P O Box 1910, Silverton, 0127 Tel/Cell: +27 82 932 8465
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PROJECT INFORMATION	BOREHOLE INFORMATION	HYDROLOGY INFORMATION		
Client:	BH Name: BSN BH21	Date: 17/01/2018	Air Capacity (m3/m):	
Project:	Total Depth (m):	Air Pressure (kPa):	Casing In & Out (m):	
Location:	Casing Installed (m):	Blow Yield (L/s):	Casing Permanently Damaged (m):	
X Coord: 26 00 399.0	Elevation (m): 1573m	Water Rest Level (m) (After 24 Hrs):		
Y Coord: 28 27 07.3	Bit Diameter (mm):	Water Strike (m):		

General Remarks:

Depth	Penetration Rate (min/m)	Formation Hardness	Hammer Rate	Air Loss	Sample Recovery	Moisture Condition	Hole Collapse	Water Strike	Water Foam Applied	Comments
0-1	0:18	SOFT	Regular	0%	100%	Moist				
1-2	0:07	"	"	0	100	"				
2-3	0:13	"	"	0	100	"				
3-4	0:29	"	"	0	100	"				
4-5	1:22	"	"	0	100	"				
5-6	1:13	"	"	0	100	"				
6-7	1:27	"	"	0	100	"				
7-8	1:40	"	"	0	100	"				
8-9	3:31	HARD	"	0	100	"				
9-10	0:30	SOFT	"							cavity
10-11	0:08	"	"	no SAMPLE						cavity
11-12	3:46	HARD	"	50%	50%					Rock
12-13	1:21	SOFT	"	50	50					small cavity
13-14	0:30	"								" "
14-15	0:07	"	no hammer							
15-16	3:36	HARD	Regular							
16-17	4:59	"	"							
17-18	3:50	"	"							
18-19	3:44	"	"							
19-20	4:27	"	"							
20-21	4:39	"	"							
21-22										
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Sample but drilling HARD Rock

Rig Operator:
Data Descriptions by:

Doc Engine **Start:** **Finish:**
Compressor **Start:** **Finish:**

Appendix V

Gravity Survey Results

GeoFocus
Geophysical Services
Reg: 2016 / 324488 / 07

106 Clearwaters Cove
Haenertsburg 0730
Limpopo
RSA

gavin@geofocus.co.za (083 478 4345)
bjorn@geofocus.co.za (072 086 9829)

05 February 2018

Thoka Geosciences CC
35 Woltemade Str
Culemborg Park
Randfontein, 1759
Gauteng
RSA

Attention: Melusi Mashego

Tel: 011 412 1449
Cell: 079 327 5439
E-mail: melusim@thokageo.co.za

Esellen Substation – Gravity Survey

1. General

A gravity survey, in support of a dolomite-stability study, was conducted over roughly 12.5 ha surrounding Escom's Esselen Sub-Station, across the R21 from Tembisa, on 10 October 2017. The area was covered with a 15m grid comprising 622 stations.

2. Methodology

Gravity was observed with a Scintrex CG5 gravimeter whilst a Javad DGPS recorded station locations. Gravity data processing procedures commonly used for dolomite studies were applied, firstly reducing the data to relative Bouguer values by applying elevation, terrain and Bouguer corrections. Secondly, an estimation of the regional gravity field (slope), calculated either through linear regression or a grid trend, is removed from the relative Bouguer gravity to produce an uncorrected or provisional residual gravity map emphasizing local changes.

The final residual gravity map is produced by correcting for bedrock head intersections acquired during outcrop mapping, pitting and/or drilling. This usually entails a base shift (adjustment by a constant) so that the residual gravity values agree on average with bedrock depths. This is done by shifting the residual Bouguer highs to represent outcrop, where present, as zero (0) mGal. Otherwise drill locations where bedrock was intersected are adjusted so that the corresponding residual Bouguer value approximates the ratio of -1mGal = 48m. In some cases, notably small surveys, bedrock head intersections can provide the necessary spatial correlation needed to recalculate the regional gravity field in order to achieve a better fit.

3. Results

The median elevation of the survey area is approximately 1,599 masl (relative) sloping southwest to northeast by roughly 7 m (Figure 1). A 1st-order approximation of the regional gravity field was removed from the Bouguer anomaly data (Figure 2) resulting in a residual gravity dataset with peak-to-peak distribution of approximately 0.4 mGal (Figure 3).

4. Residual Gravity

Corrections were applied to the residual gravity data based on a set of nineteen (19) boreholes drilled across the site (Figure 3). It is understood that rehabilitated sinkholes exist within the surveyed area which are likely underlain by concrete and other foreign rock material. The broad gravity high which spans most of the surveyed area, and surrounds the existing substation, is shown to consist of shallow (3m to 4m) dolomite bedrock head as intersected by boreholes BH20 and BH6. Subtle changes in the residual

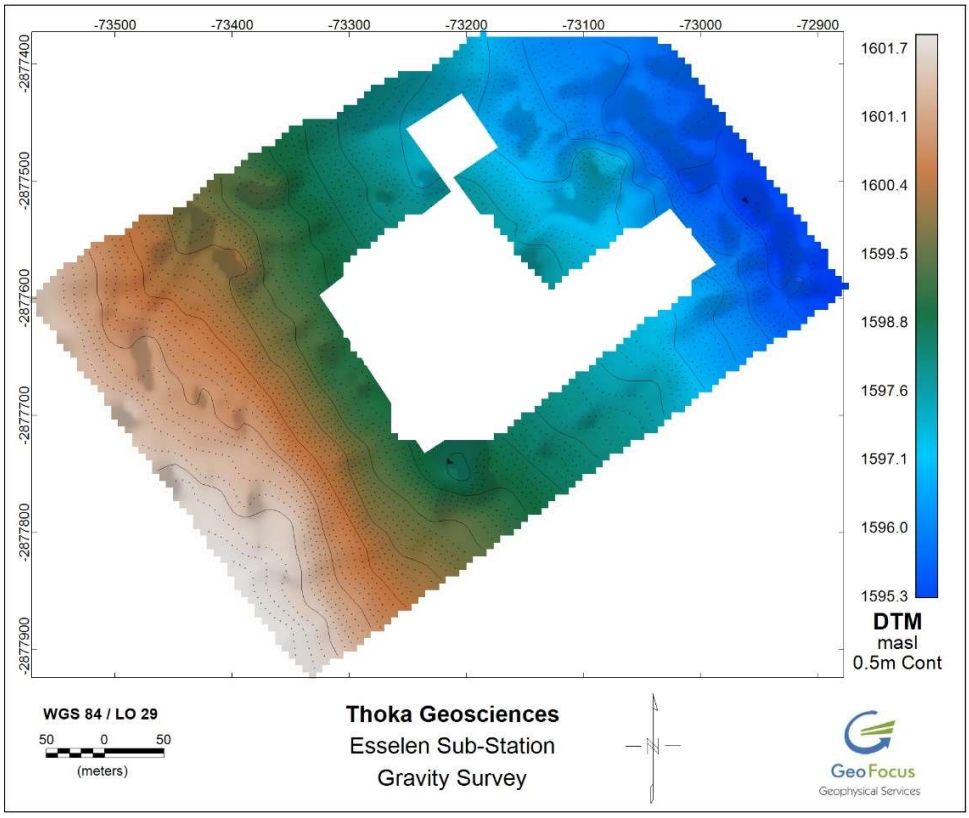

***Figure 1**: Elevation Map*

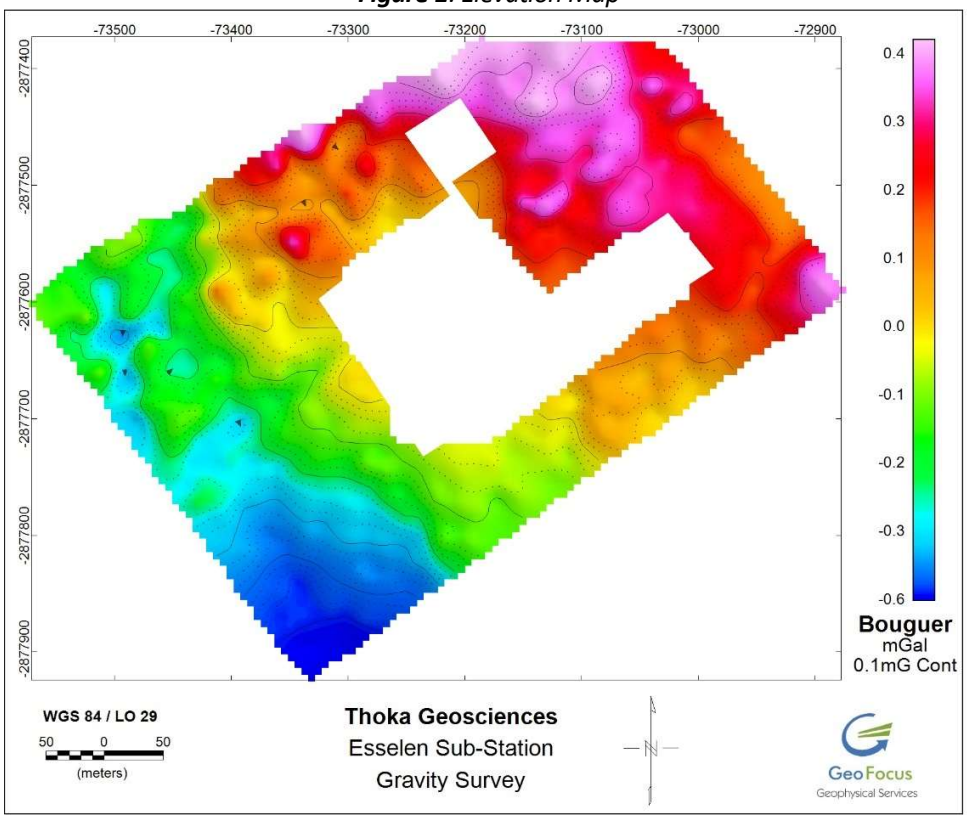

***Figure 2**: Relative Bouguer Map*

gravity, within the broader high, correspond with variations in weathering as noted by boreholes BH9, 11, 13 & 18 - 19 which intersected competent bedrock formation at between 8m and 11m deep. Bedrock deepens toward the northeast, coincident with a broader gravity low, where boreholes BH7 - 8, 15 & 21 intersected bedrock head between 13m and 18m deep. In most cases small cavities were intersected which caused sample loss. Boreholes 16 & 17, drilled on the gravity gradient, intersected fairly large cavities and were terminated at 19m and 14m respectively; both of these locations fall on subtle and small lows originating from the larger gravity low. The gravity low toward the southwest is more irregular and appears to be comprised of two lows, located in the northwest and southwest, connected by narrow, rectilinear lows. This is supported by boreholes BH1 & 3 which intersected bedrock at 12m and 18m respectively while boreholes BH2 & 4 were terminated after intersecting fairly large voids. Although boreholes BH5 & 12 showed bedrock to be around 5m depth, the gravity suggests they may have been drilled on the edge of a slot. Overall the drilling results show the gravity to be a fair reflection of bedrock topography.

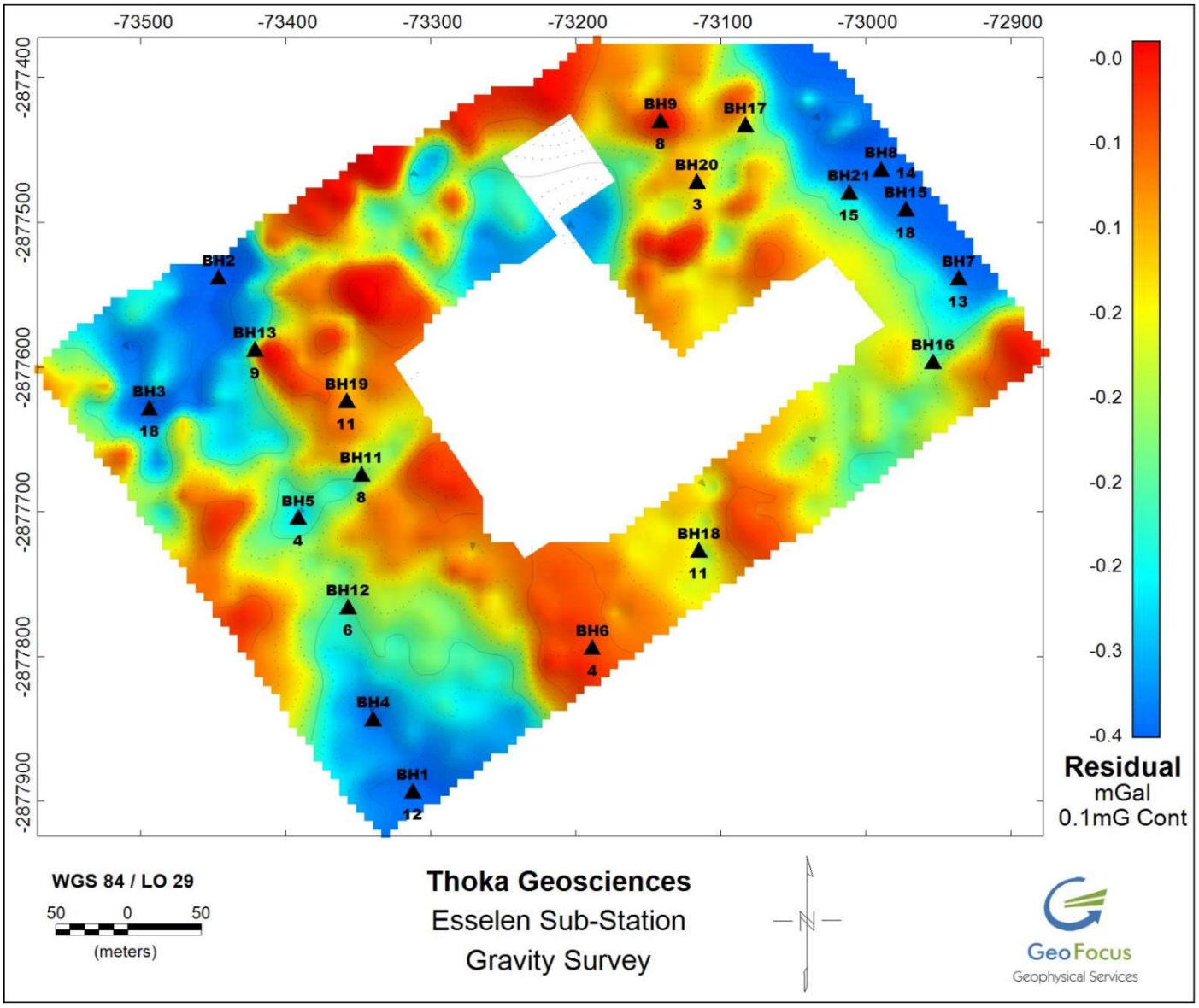

***Figure 3**: Residual gravity (0.1mGal contours) & drilling results*

Appendix VI

Council for Geosciences Review

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Council for Geoscience

Our Reference: F5281.1
Eskom Esselen Substation, Esselen Park, Thembisa
Your Reference: 380-02-2018
Enquiries: S Ngubelanga
Tel: 012 841 1140/
033 345 6265/6
Email: sngubelanga@geoscience.org.za
No. of Pages: 4

14 March 2018

Ekurhuleni Metropolitan Municipality
P O Box 13
Kempton Park
1620

ATTENTION: Mr. Pilusa Mashamaite

By Email: *Pilusa.Mashamaite@ekurhuleni.gov.za*

Dear Sir,

ESKOM ESSELEN SUBSTATION IN ESSELEN PARK, THEMBISA

The firm, Thoka Geosciences CC (TG) submitted their report: "Dolomite Stability Investigation Report: Eskom Esselen Substation, Esselen, Thembisa, Gauteng, South Africa", dated February 2018 to this office for comment on behalf of their client, Eskom SOC Ltd, on 13 February 2018. This office acts as an agent to state authorities in reviewing dolomite stability investigations on their behalf.

The purpose of the current investigation was to assess the exposure and vulnerability of the site to dolomite geo-hazards which have historically manifest into sinkholes and surface subsidence. Esselen Substation covers a surface area of about **19 hectares** measuring from the outer perimeter fence. This investigation is solely for the area bound by the outer parameter fence and the HV Plant, which covers about **12.5 hectares of the total 19 hectares** that makes up Eskom Esselen Substation. The site is located in Esselen Park, Tembisa bounded by the R21 Highway on the west and the R25 on the south.

The proposed land use is a substation, **C3** type development in terms of the SANS 1936:2012.

The following is noted from TG's report:

1) The regional geology of the area is underlain by the Malmani Subgroup dolomitic rocks of the Chuniespoort Group (1: 250 000 Geological Series, 2628 East Rand). The assessment of the geology within the site boundaries indicated outcropping dolomite at isolated parts of the site interpreted to be panicles of dolomite.

2) In Section 3.1 of the report, TG indicates that none of the drilled borehole at site encountered groundwater. The deepest borehole drilled at site reached depth of 24 m from the surface. This infers a deeper groundwater table at the site and that sinkhole or subsidence associated with groundwater drawdown is unlikely but rather ingress from ponding / percolating surface water is the main trigger for sinkhole formation at the site.

   TG further states that the assessment of regional groundwater indicates groundwater levels to be at maximum depth of about 30 m from the surface for monitoring station A2N0627. The site is located within the Sterkfontein Dolomite Compartment in the A21A Groundwater Management Unit in the Crocodile West and Marico Water Management Area. The hydrogeological properties of the compartment are characterized by the karst nature of dolomite aquifers.

3) A gravity survey was conducted on a 15 m grid spacing by GeoFocus Geophysical Services in October 2017.

4) A total of twenty one (21) percussion boreholes were drilled during the current study. These boreholes varied in depth between 9 m and 24 m below surface and they generally intersected:
   - Transported soils (colluvium) between surface and 8 m depths,
   - Highly weathered chert and dolomite between 1 m and 5 m depths,
   - Cavities between 3 m and 9 m depths,
   - Weathered to solid rock (chert & dolomite) between 2 m and 19 m depths,

5) Based on the available information, TG has classified the site as having the following Inherent Hazard Class (IHC) zones
   - **IHC 3/4/6/7** with a **D3** dolomite area designation.
   - **IHC 8** with a **D4** dolomite area designation.

6) TG has made recommendations in section 6 and conclusions in section 7 of the report and the following is noted:
   - All new structures developed should be designed to span at least 5 - 15 m loss of support. An engineered soil raft / raft should be used in areas of shallow dolomite bedrock. This mattress has the dual purpose of improving founding conditions.
   - According to SANS 1936, in addition to the above mentioned precautionary measures, sites which fall under D4 dolomite land need to adhere to site-specific precautionary measures.
   - A groundwater monitoring station at the site is recommended as part of a risk management facility.

- The site falls under C3 type development, thus portions of the site are regarded to be conditionally developable with footprint requirements up until IHC 6.
- A crucial requirement of development on dolomitic lands is the establishments and implementation of a dolomite risk management strategy (DRMS) by the developer in terms of SANS 1936:2012.

This office would like to comment as follows:

a) This office is broadly in agreement with the hazard assessment and zonation of the site. TG has classified the site as follows:
   - **IHC 3/4/6/7** with a **D3** dolomite area designation and this is supported.
   - **IHC 8** with a **D4** dolomite area designation and this is supported.

b) TG has indicated that the proposed land use is considered to be a electrical substation, **(C3)** type development. According to Table 2 of SANS 1936-1:2012, **C3** type developments are permissible up to **IHC 6** land, subject to **D3** precautionary measures and footprint investigations:
   - This office confirms that the drilling of twenty one (21) boreholes is considered adequate and meets the minimum drilling requirements as stipulated in SANS 1936:2012.
   - This office confirms that the geological conditions as revealed by drilling results are considered to be highly variable and generally high hazard in water ingress scenario.
   - Dolomite instability events (sinkholes) have occurred in the vicinity of the substation.

c) Given that the site has revealed patches of IHC 7/8 conditions within generally good conditions (3-6), any new development may only be considered provided that additional infill investigations (footprint) and stringent precautionary measures are adhered to, with appropriate foundation designs or a "D4-Route" development process would have to be followed, including a review of all information by the Level 4 Geo-professional as per SANS 1936:2012.

d) The conclusions in recommendations in section 6 and conclusions in section 7 of the report are generally supported

Therefore this office confirms the provisional support of the proposed Eskom Eselen substation, **(C3)** type development on Essellen Park in Thembisa, subject to the points above and the following:

e) Additional investigations FPI), must be conducted and the results thereof, submitted to this office for further comments, prior to any construction on this site.

f) A certified site development plan should be submitted to this office for co-signing.

g) TG or the professional team involved are to certify that additional investigations, the development proposal and precautionary measures are in accordance with SANS 1936:2012 requirements.

h) A site specific Dolomite Risk Management Plan in accordance with SANS 1936-4:2012 must be compiled and implemented for the site. The owners/responsible persons must be made aware of the risks involved in building on dolomite, and be informed about how to be vigilant and act pro-actively by applying sound water management principles.

i) The Local Authority must implement a risk management system. Commenting on the suitability of sites within its jurisdiction is based on the premise that this system will be implemented.

This letter reflects the Council for Geoscience's view and approach to development on dolomite at this time, as reflected by the above date. These comments may not be viewed as open-ended. If a property changes ownership or land-use changes are made, the comment may in part or wholly no longer apply. This Office should be informed of such changes and the Competent Person responsible for the dolomite stability investigation should be given the opportunity to indicate the influence such changes could have on the overall stability.

If you have any further queries, please do not hesitate to contact this office.

Yours faithfully,

S NGUBELANGA
Engineering Geologist

Eskom Esselen Substation, Esselen Park, Thembisa (F5281.1)

CC: **Thoka Geosciences CC**

ATTENTION: **Mr. Tshwaro Mogadime,**

By email: *thokageo@gmail.com*