Geohydrological Assessment and Borehole Siting at Eendekuil, West Coast, Western Cape

REPORT:
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GROUNDWATER AND EARTH SCIENCES
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EXECUTIVE SUMMARY

GEOSS South Arica (Pty) Ltd was appointed by Western Cape Local Government to complete a geohydrological assessment and borehole siting at Eendekuil, West Coast, Western Cape. The aim of this study is to locate optimal targets for drilling of boreholes for groundwater abstraction on municipality-owned property. From discussion with the Berg River Municipality personnel, it was determined that a back-up supply in the region of 2.5 to 3 L/s is needed to supplement water supply in the future.

The study included an initial remote geological and topographical investigation of the area and lineament mapping; this preceded the site visit. The site visit included a hydrocensus and evaluation of the site geology and geophysics. The area is generally flat, and low-lying - situated in a basin surrounded by the mountains of the Winterhoek Mountain Catchment Area on the right and the Pikenberg Mountains on the left. The area around the town is extensively characterised by the phyllitic shale, schist and greywacke of the Porterville Formation (MaS). This formation steeply dips at an average of 70° west, with no deformation features mapped. The regional aquifer directly underlying the Eendekuil town fractured aquifer with a potential yield range (0.1 to 0.5 L/s), while the area where the current supply borehole and spring is located, (also classified as a fractured aquifer) has a higher potential yield range (0.5 to 2 L/s). A fractured or secondary aquifer describes an aquifer in which groundwater flows through fractures or fault structures. The groundwater quality for the site is classified as "poor" with an associated electrical conductivity (EC) of 300 – 1 000 mS/m.

No borehole targets have been delineated in this study, due to the high error percentage seen in the processed resistivity data. The geology beneath the study sites was no favourable, i.e., electrode contact with the subsurface was difficult due to the excess of dry clay. The high error percentages seen make it difficult to delineate targets with confidence within the fractured aquifer. Additionally, the electromagnetic survey (EM 1) shows a potentially favourable site, however it is beyond the boundary extend of the water treatment works property that the municipality own. There is no hydrogeological basis that would allow for the potential point to be extrapolated to the property.

Further, given that most of the sites are cemetery properties, extreme care needs to be taken in order to drill in these properties and ensure no contamination in the form of seepage occurs, i.e., deep solid steel casings. Coupled to this, the public perception associated with a water supply borehole located in a cemetery can be challenging. Lastly, the water requirement is in the region of 2.5 L/s to 3 L/s, which, taking into account the hydrocensus, is unlikely to be achieved sustainably at the sites investigated.

However, two areas of interest have been delineated for drilling of water supply boreholes. These areas are based on the 1: 250 000 geological map series (3218, Clanwilliam) and information obtained from the current town supply borehole (HBH11). Two inferred faults (within the Porterville Formation) cross cut the approximate municipal servitude location. The servitude is registered to the municipality for the purpose of the water supply pipeline running from the slopes of the Piketberg Mountain, to the water treatment works just outside town. The dimensions of the servitude are not currently known, however, should they extend to wider than the pipeline, the servitude land at these areas of interest should be considered for drilling of water supply boreholes.

TABLE OF CONTENTS

LIST OF FIGURES AND MAPS

LIST OF TABLES

ABBREVIATIONS

CGS	Council for Geoscience
DD	decimal degrees
DWAF	Department of Water Affairs and Forestry
EC	electrical conductivity
ID	Identity
ID	Inside diameter
L/s	litres per second
m	metres
mm	millimetre
mS/m	milliSiemens per metre
uPVC	Unplasticised polyvinyl chloride
SANS	South African National Standard
WGS84	Since the 1st January 1999, the official co-ordinate system for South Africa is based on the World Geodetic System 1984 ellipsoid, commonly known as WGS84.

GLOSSARY OF TERMS

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

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

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Cover photo:

Photo of Syscal Pro system on the ground during the Resistivity survey outside the northern cemetery site.

Review:

Charl Muller and Julian Conrad (19 March 2021).

1. INTRODUCTION

GEOSS South Arica (Pty) Ltd was appointed by Western Cape Local Government to complete a geohydrological assessment and borehole siting at Eendekuil, West Coast, Western Cape (**Figure** 1). The aim of this study is to locate optimal targets for drilling of boreholes for groundwater abstraction on municipality-owned property. From discussions with Berg River Municipality personal, it was determined that a back-up supply in the region of 2.5 to 3 L/s is needed to supplement future water demand for Eendekuil.

The study included an initial remote geological and topographical investigation of the area and lineament mapping; this preceded the site visit. The site visit included a hydrocensus and evaluation of the site geology and geophysics. The geophysical survey was carried out using the resistivity and electromagnetic methods to identify geological structures favourable for groundwater development.

Three municipal properties were investigated, namely: the southern cemetery, water treatment works property as well as the northern cemetery. The southern cemetery is full and no new burials can take place here, with space being limited. The northern cemetery (new), is being filled up from the southern end of the property with only the northern section to possibly drill in.

2. SITE GEOLOGY AND GEOHYDROLOGY

2.1 Geology

The Council for Geoscience (CGS) has mapped the area at 1: 250 000 scale (Clanwilliam). The geological setting is shown in **Figure 2** and the main geology of the area is listed in **Table 1**. Information indicated in bold font is directly linked to the geology of the town and infrastructure areas.

Table 1: Geological formations within the study area

Code	Formation	Group	Description
⋀⋀	Quaternary to Tertiary Deposits		Alluvium
Q1	Springfontein Formation	Quaternary	Sandy Soil
△ △ △ △	Quaternary to Tertiary Deposits		Scree gradin into piedmont gravel
QRf			Ferricrete
C1Q2	Nardouw Subgroup	Table Mountain Group (TMG)	Light grey, well-bedded, quarzitic /feldspathic sandstone
C1S2G	Cederberg Formation		Dark-grey, thinly laminated to massive shale, siltstone, lenticular sandstone
C1Q1	Peninsula Formation		Quartzitic sandstone with minor shale and conglomerate lenses
C1S1	Graafwater Formation		Reddish brown shale, sandy shale and siltstone
C1Q1R	Piekenierskloof Formation		Quartzitic sandstone and conglomerate

Kl	Klipheuwel Formation	Klipheuwel Group	Brightly coloured shale, sandstone, greywacke and conglomerate
dol	Malmesbury Group		Dolerite dyke
MGs			Greenstone
MaQg	**Piketberg Formation**	**Malmesbury Group**	**Feldspathic grit, greywacke, quartz schist, conglomerate and limestone beds with thin lenses of phyllite**
MaS	**Porterville Formation**		**Phyllitic shale, schist and greywacke, with scattered thin grit lenses**
MaC	-		Dark grey limestone bed located within MaS
MaQw2	Moorreesburg Formation		Greywacke, phyllite and quartz schist with thin lenses of limestone and grit
MaQ	Klipplaat Formation		Quartz schist, phyllite and chert
MaQw1	Berg River Formation		Fine-grained greywacke and schist with thin limestone lenses

The area is generally flat, and low-lying - situated in a basin surrounded by the mountains of the Winterhoek Mountain Catchment Area on the right and the Piketberg Mountains on the left. The area around the town is extensively characterised by the phyllitic shale, schist and greywacke of the Porterville Formation (MaS). This formation steeply dips at 65 - 70° west, with no deformation features mapped. Piketberg Formation (feldspathic grit, greywacke, quartz schist, conglomerate) lies between the Porterville Formation and younger formations of the Table Mountain Group (TMG) forming the Piketberg mountain on the left. TMG formations are largely characterise by quartzitic sandstone and minor shale in this setting.

Fractured and weathered zones in the bedrock are optimal for groundwater development, with sufficient recharge. **Figure 3** graphically shows the geological setting of the study area in a southwest-northeast orientation.

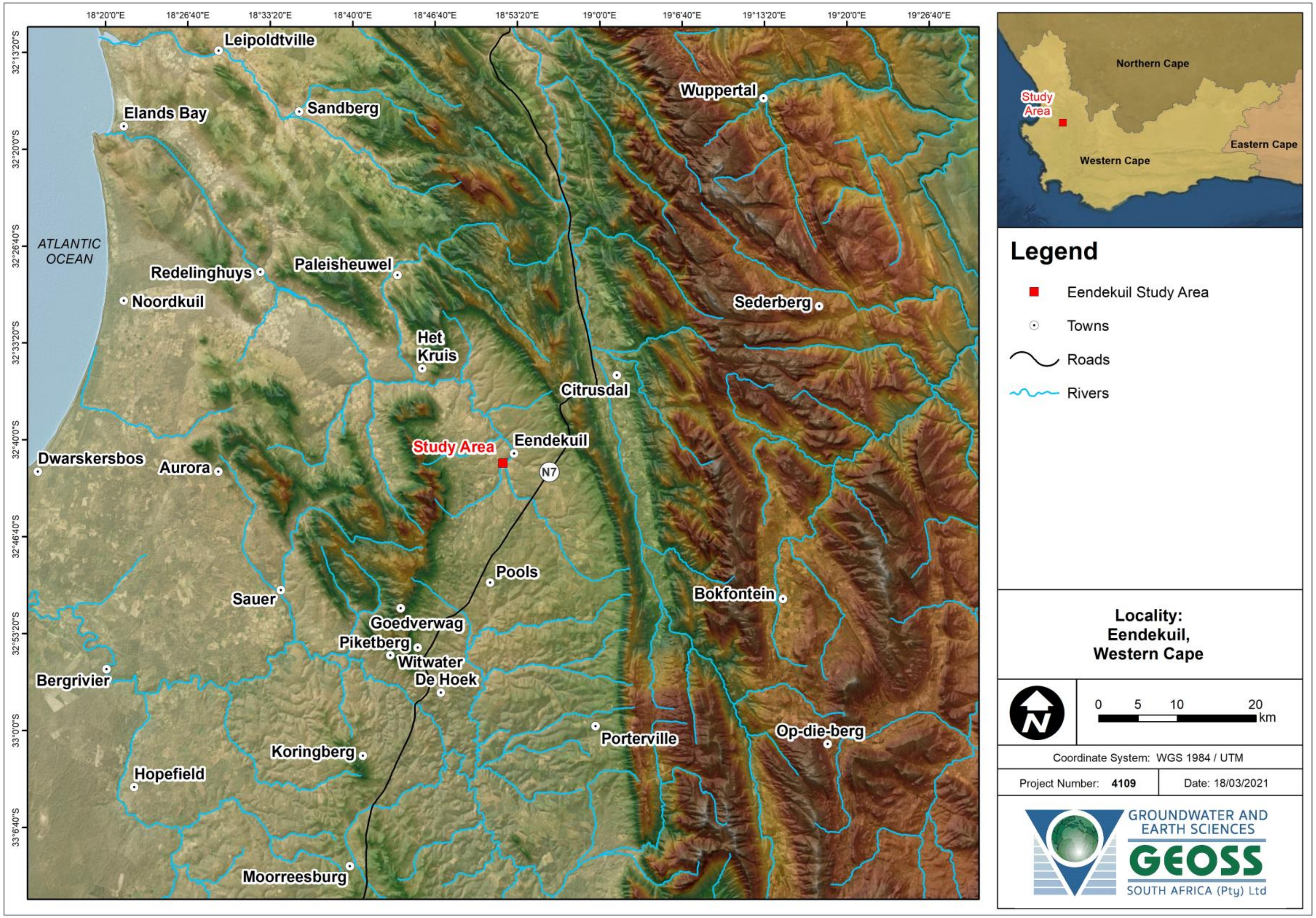


Figure 1: Locality of Eendekuil, West Coast, Western Cape.

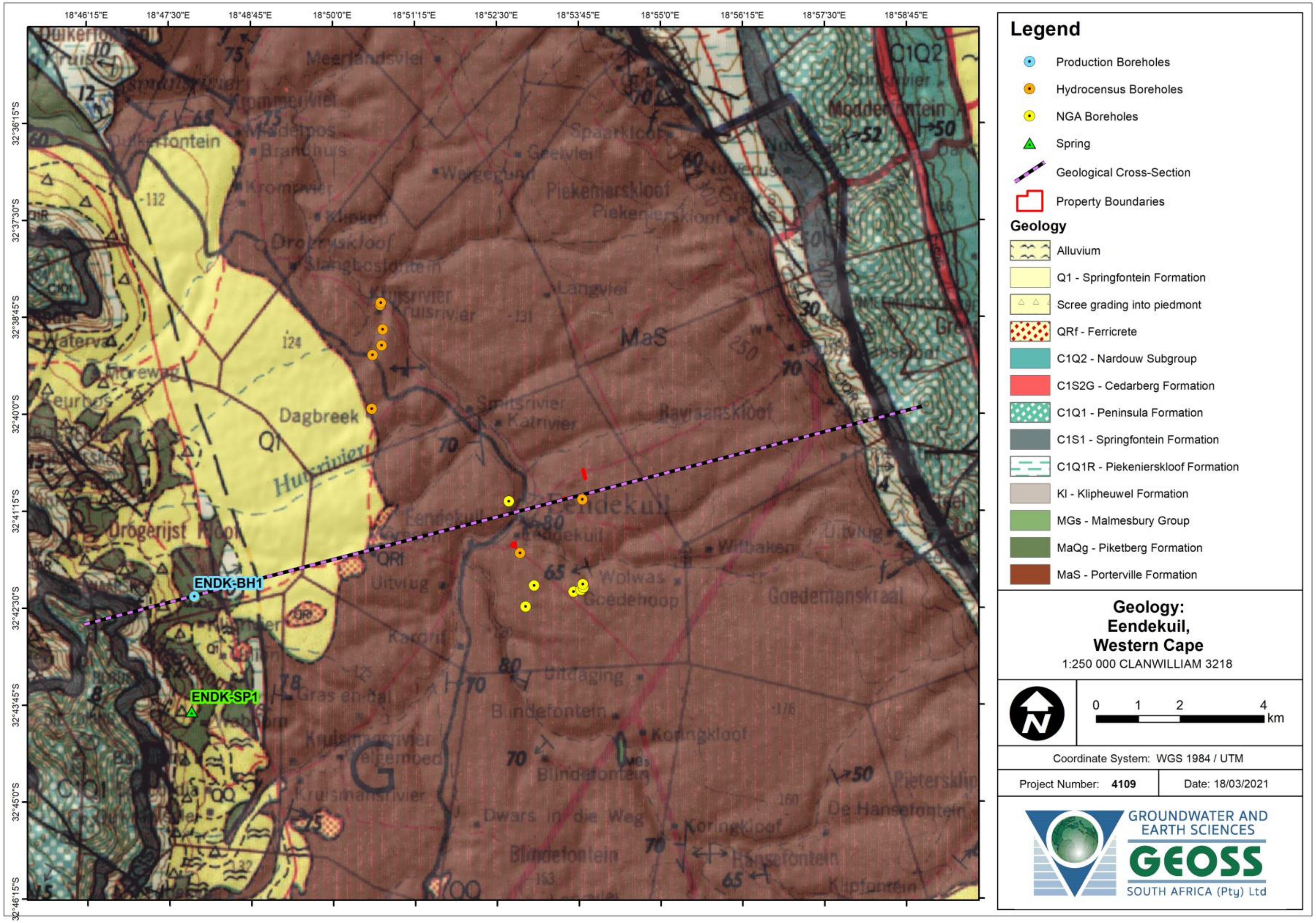


Figure 2: 1: 250 000 geological map series (3218 Clanwillian) (CGS)

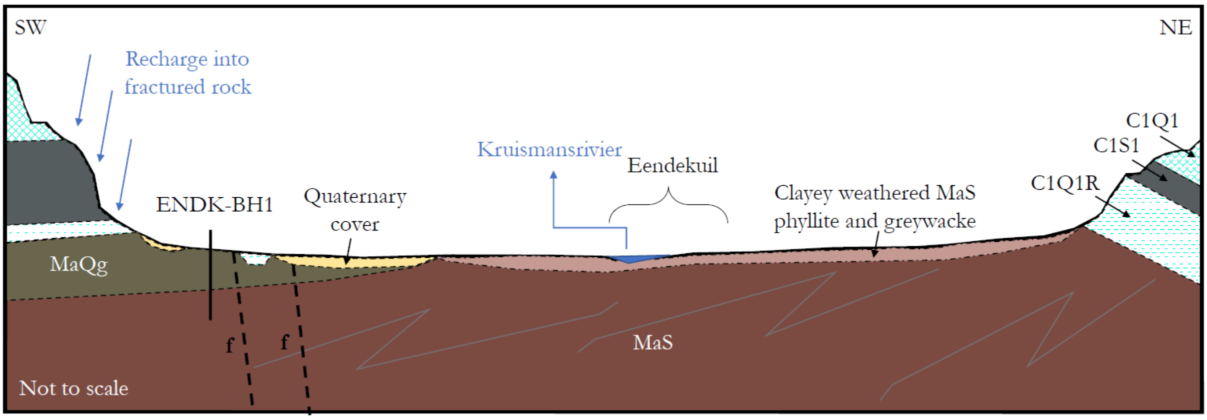


Figure 3: Schematic geological southeast-northwest cross section for the study area

2.1 Geohydrology

The regional aquifer directly underlying the Eendekuil town is classified by the Department of Water Affairs and Forestry (DWAF, 2002) as a fractured aquifer with a potential yield range (0.1 to 0.5 L/s) (**Figure 4**). The area where the current supply borehole and spring is located, is also classified as a fractured aquifer but with a higher potential yield range (0.5 to 2 L/s). A fractured or secondary aquifer describes an aquifer in which groundwater flows through fractures or fault structures.

The groundwater quality for the town and surrounds is classified as "poor" with an associated electrical conductivity (EC) of 300 – 1 000 mS/m (**Figure 5**) (DWAF, 2002). These classifications are based on regional datasets, and therefore only provide an indication of conditions to be expected.

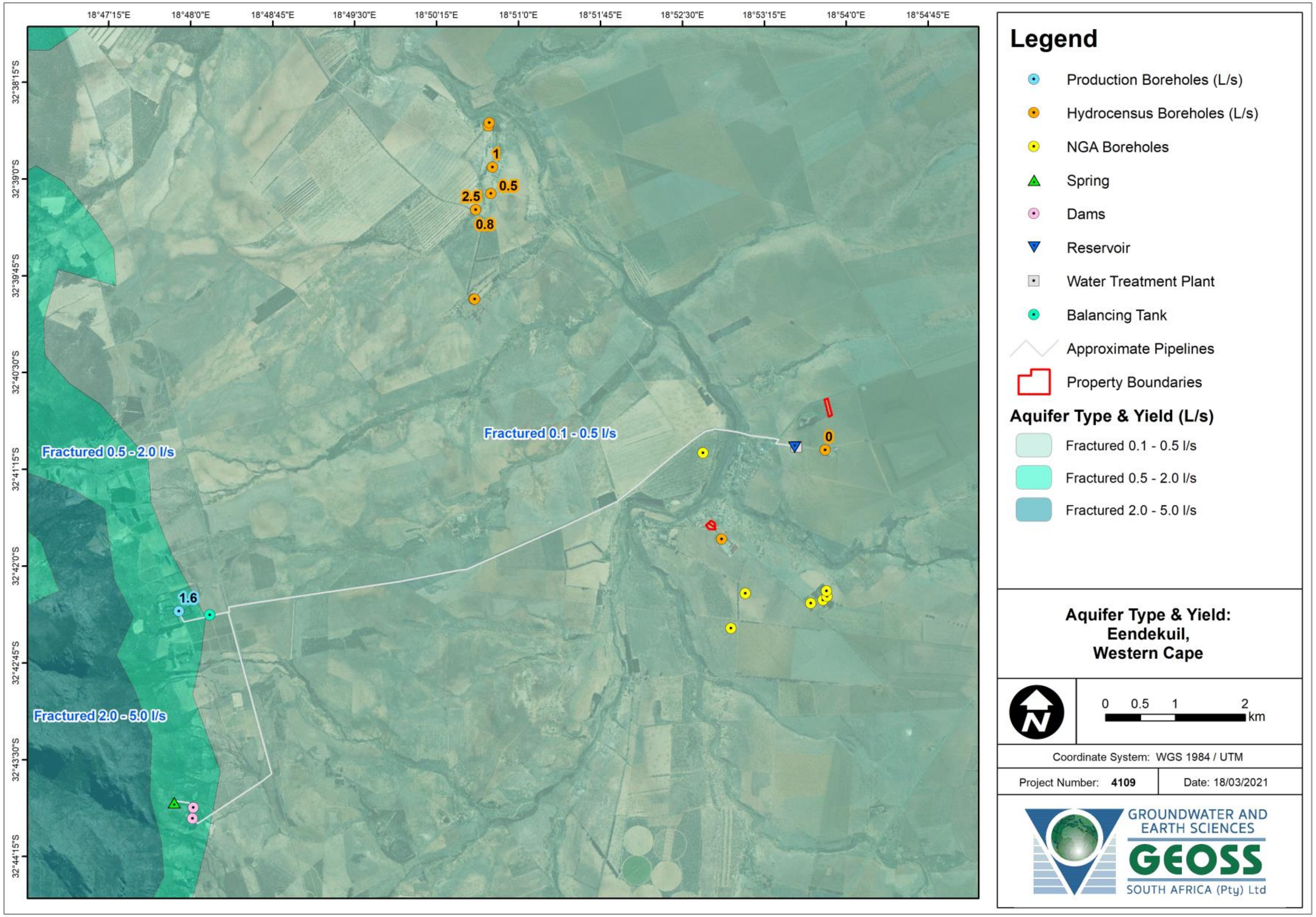


Figure 4: Regional aquifer type and yield map (L/s) showing hydrocensus boreholes, NGA boreholes, Production boreholes and associated water infrastructure (DWAF, 2002)

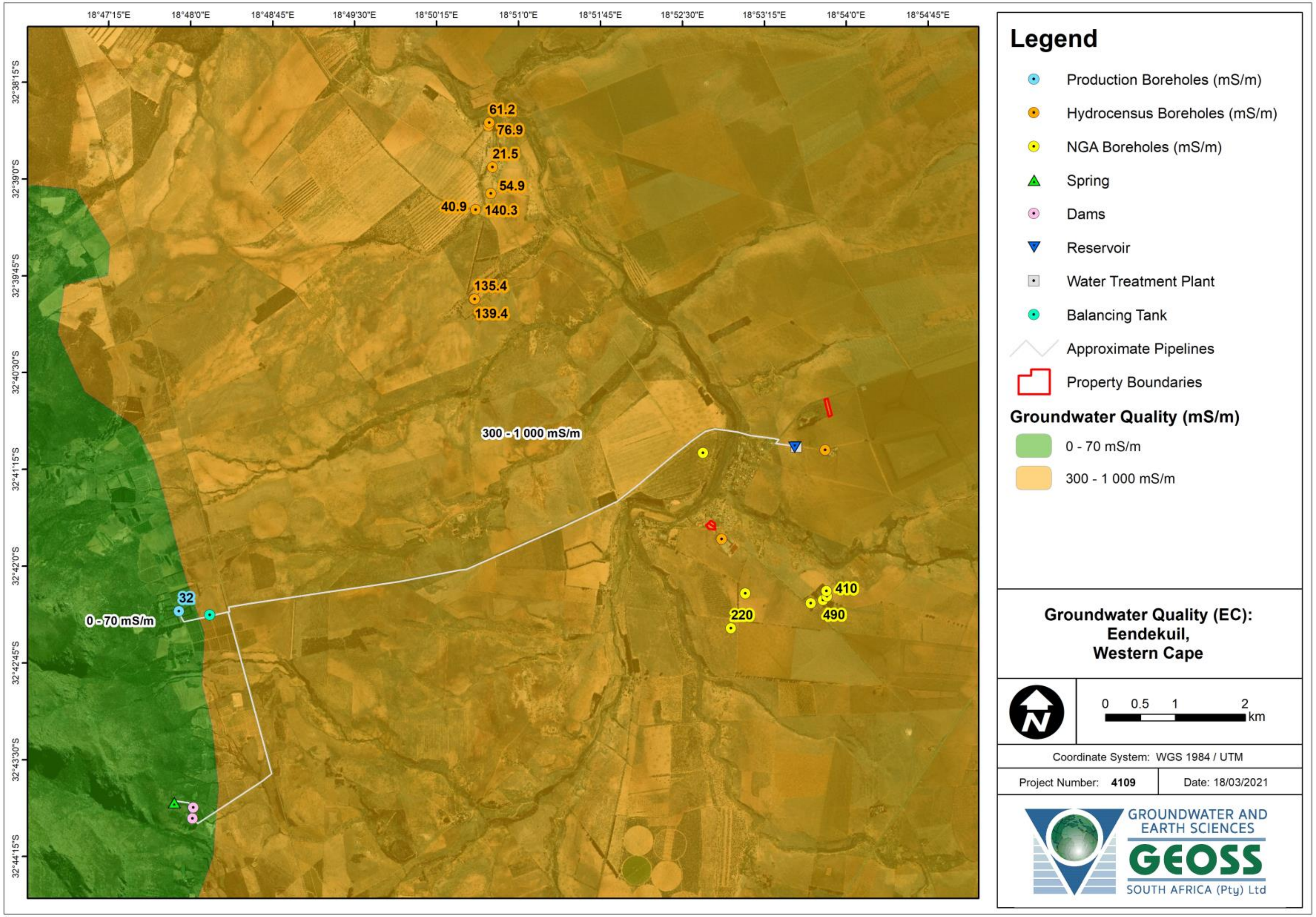


Figure 5: Regional groundwater quality EC (mS/m) map showing hydrocensus boreholes, NGA boreholes, current production borehole and associated water infrastructure DWAF (2002).

3. DESKTOP STUDY AND HYDROCENSUS

3.1 Desktop Study

A desktop study was initially carried out around the property to determine if there were any groundwater users in the area. The National Groundwater Archive (NGA) database which provides data on borehole positions, groundwater chemistry and yield, indicated that there are seven boreholes within the search radius of 2.5 km from the centre of town. Details pertaining to these sites are summarised in **Table 2** and shown spatially in **Figure 6**.

Limited data was available for the boreholes identified in the NGA database search. Two boreholes south of town were drilled shallow (up to 50 m), intercepting saline water where electrical conductivity (EC) was measured 410 and 490 mS/m in 1999. Water strike and yield information is lacking and therefore there is insufficient information on the fractured aquifer which is likely being taped into. Water level at a site west of the Kruismans river was measured at 6.4 mbgl in 1988, while southeast of the town 2 boreholes water levels were measured closer to 19 mbgl. The data is outdated as groundwater conditions are likely to have changed since then, especially in relation to water levels. In some cases, the co-ordinates of the boreholes are plotted over each other, and accuracy of location is not confirmed.

In addition, several registered Water Authorisation and Registration Management System (WARMS) sites were found. The sites are all plotted on the same location and it is not possible to decipher them spatially. The site is plotted in Figure 7, where the water is likely used for small scale domestic use and agricultural irrigation.

Table 2: Summary of NGA sites

ID	Latitude (DD, WGS84)	Longitude (DD, WGS84)	Depth (m)	Casing depth (m)	Date measured	EC (mS/m)	Water level (mbgl)	Lithology
3218DB00215	-32.70817	18.88233	-	-	1990/01/07	220	-	-
3218DB00211	-32.70497	18.89453	-	-	-	-	-	-
3218DB00209	-32.70457	18.89643	50	3	1999/01/06	490	18.9	-
3218DB00208	-32.70407	18.89703	50	4	1999/01/06	410	19.3	-
3218DB00212	-32.70367	18.88453	-	-	-	-	-	-
3218DB00210	-32.70337	18.89693	-	-	-	-	-	-
3218DB00018	-32.68554	18.87812	91.4	-	1988/05/11	-	6.4	Alternating shale and sandstone, with quartz veining present at 78 m

3.2 Hydrocensus

A site visit was conducted on 8 March 2021 to assess the groundwater use on the property, the current municipal water supply and infrastructure as well as identify any structures favourable in terms of groundwater.

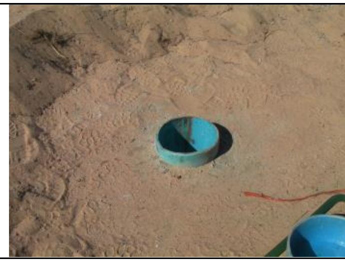
No existing boreholes were identified on the municipal properties. However, through conversation with nearby landowners, mention was made of boreholes drilled in the area. Most of the sites identified in the hydrocensus was identified in GEOSS (2015) as part of groundwater exploration project for a private client (**Table 3**). The area is not known for good groundwater quality and high yield potential, resulting in limited successful boreholes for the area.

Boreholes drilled into the fractured aquifer show low salinity (EC < 70 mS/m), whereas those drilled into the unconsolidated (primary) aquifer have higher EC values. Due to the deeper, fresher water most boreholes were drilled in excess of 100 m. Fracture depths cannot be verified as water strikes are unknown and yields vary but do not exceed 2 L/s. A dry borehole at a depth of 180 m was also noted (HBH8). Based on the hydrocensus data, the Porterville Formation although hosting good quality water, appears to be low yielding – in line with the yield potential range indicated in **Section 2.1**.

All sites identified are summarised and referenced in **Table 3** and superimposed on aerial photographs, in **Figure 6**.

Table 3: Summary of boreholes identified during the hydrocensus

ID	Latitude (DD, WGS84)	Longitude (DD, WGS84)	Depth (m)	Yield (L/s)	Water level (mbgl)	EC (mS/m)	TDS (mg/L)	pH	Date	Notes	Photograph
HBH1	-32.652	18.84579	130	0.45	70	54.9	462	6.89	2014/12/02	Water used for home/drinking. Sample collected. Farm Kruisrivier	
HBH2	-32.64859	18.84605	100	1	-	21.53	182.3	6.86	2014/12/02	Borehole deeper than 100m. Used for irrigation. Pumped 24/7 during summer. Sample collected. Farm Kruisrivier	
HBH3	-32.64328	18.84542	-	-	-	76.9	640	6.65	2014/12/02	Used for house/drinking water and irrigation of lemon trees and garden	
HBH4	-32.64284	18.84556	-	-	-	61.2	505	6.62	2014/12/02	Water pumped into dam, used for irrigation, livestock. In summer when river flow is lower, borehole water level drops	

HBH5	-32.66562	18.84314	-	-	-	135.4	1114	6.27	2014/12/02	Borehole used for houses/drinking, garden irrigation and for cattle	
HBH6	-32.66563	18.84328	-	-	-	139.4	1117	6.01	2014/12/02	Borehole used for houses/drinking, garden irrigation and for cattle	
HBH7	-32.696666	18.88094	-	-	-	-	-	-	2021/03/08	Access restricted, however, yield is reportedly low	
HBH8	-32.685179	18.896761	180	0	-	-	-	-	2021/03/08	Dry. Information from farm owner.	No access to borehole
HBH9	-32.65408	18.84347	25	2.5	3.6	140.3	989	6.32	2014/12/02	Abstracting from alluvial aquifer. Elevated Na, Cl and N. PVC casing installed.	

HBH10	-32.65409	18.84348	164	0.83	4.3	40.9	275	7.7	2014/12/02	Pump rate is for 12 hours. 100 m of steel casing	
HBH11	-32.706039	18.798177	146	1.5	-	32	150	6.4	2021/03/08	Supply borehole owned by farmer. Yield tested.	

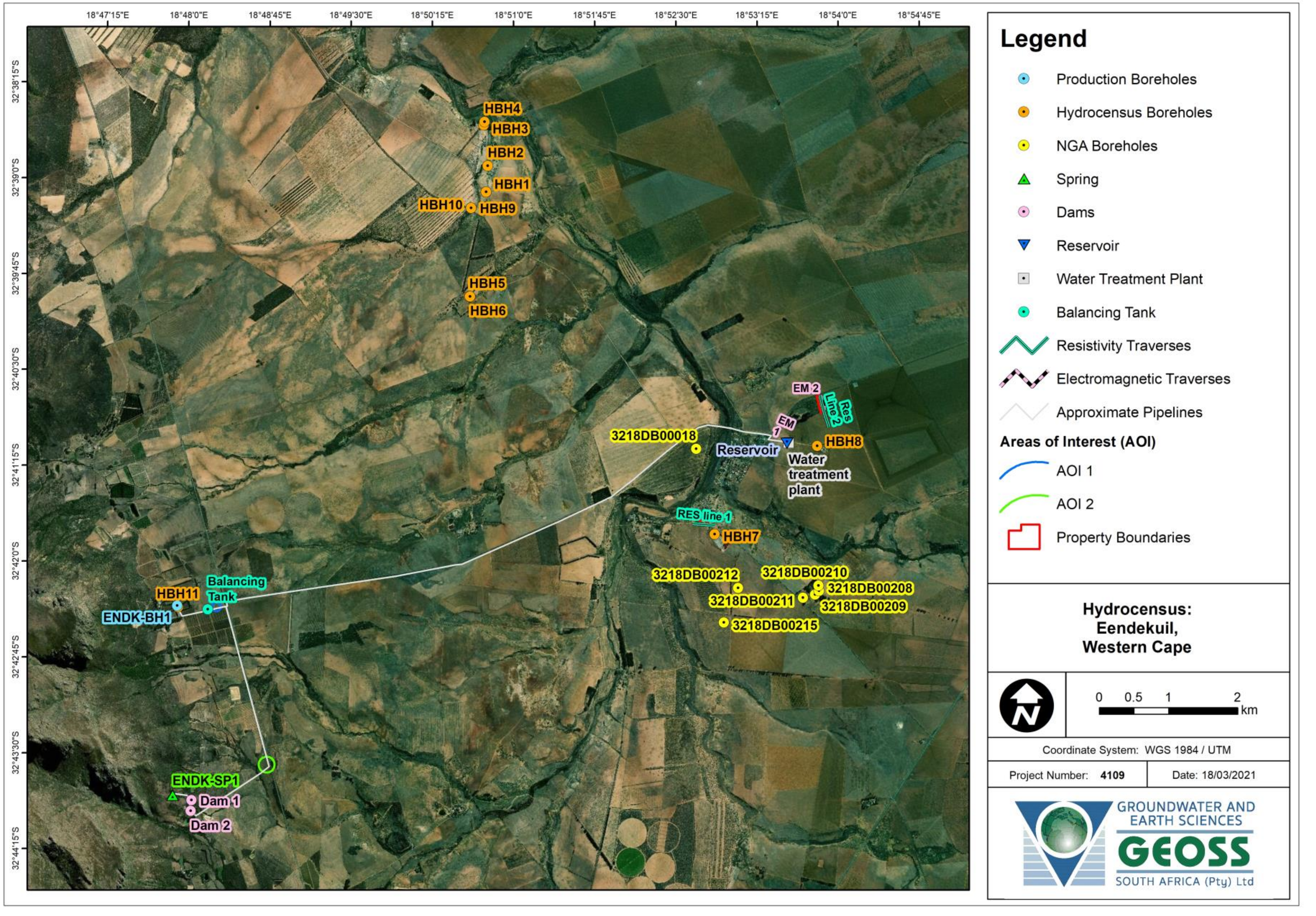


Figure 6: Boreholes identified during the hydrocensus as well as current water supply infrastructure superimposed on an aerial photograph.

3.3 Geophysics

The geophysical survey was conducted using the electrical resistivity tomography method and electromagnetic methods. Data was acquired along two resistivity traverses and two electromagnetic profiles. The electromagnetic method and electrical resistivity methods are used in conjunction based on the principle that conductivity is inversely proportional to resistivity. The areas investigated during the geophysical survey are shown in **Figure 6** along with areas of interest.

3.3.1 Electromagnetic method

The electromagnetic surveys were carried out using a CMD-DUO electromagnetic conductivity meter which measures the ground conductivity of the subsurface. It is a rapid data acquisition instrument that can be successfully applied to groundwater exploration. The CMD-DUO induces a changing electromagnetic (EM) field with a known frequency into the subsurface using a sender coil. This changing EM field induces current flow in conductive subsurface areas (for example fractured sandstone saturated with groundwater), which is measured by the receiver coil. This is then automatically converted to ground conductivity. In general, the ground conductivity measured has a direct correlation with formation porosity and groundwater salinity; i.e. if porosity of the formation or groundwater salinity increases, this will be reflected as a higher ground conductivity measurement (Telford *et al*, 1990). The 40 m coil separation with horizontal and vertical coil set-up was used for the survey. In general, this will result in depths of investigation of 30 m for the vertical (VC) coil set-up and 60 m for the horizontal (HC) coil set-up and. This set-up was used to define areas of increased saturation in the fractured aquifer. Note that the second survey was carried out along a property purposed as a cemetery and therefore the primary aquifer cannot be targeted for groundwater supply.

3.3.1.1 EM Line 1

The data for EM Line 1 was acquired from the west to the east along the resistivity traverse completed along the southern boundary of the water treatment works property (**Figure 7**). In general, the background conductivity for both the HC and VC coil set-up measures around 25 – 35 mS/m throughout the profile. Station 11 shows the EC of the VC and HC set ups almost matching each other, indicative of some degree of connectivity between 30 m to 60 m depth. However, station 11 lies just beyond the boundaries of the water treatment site and therefore cannot be targeted.

3.3.1.2 EM Line 2

The data for EM Line 2 was acquired from south to north (adjacent to the northern cemetery property) (**Figure 8**). In general, the data shows EC fluctuating for most of the profile for VC set up between 70 and 140 mS/m. The HC set-up on the other hand, fluctuates between 10 and 30 mS/m for most of the profile with a subtle decrease towards the north op the profile. No clear anomalies are visible in the data obtained from this profile outside the northern cemetery site.

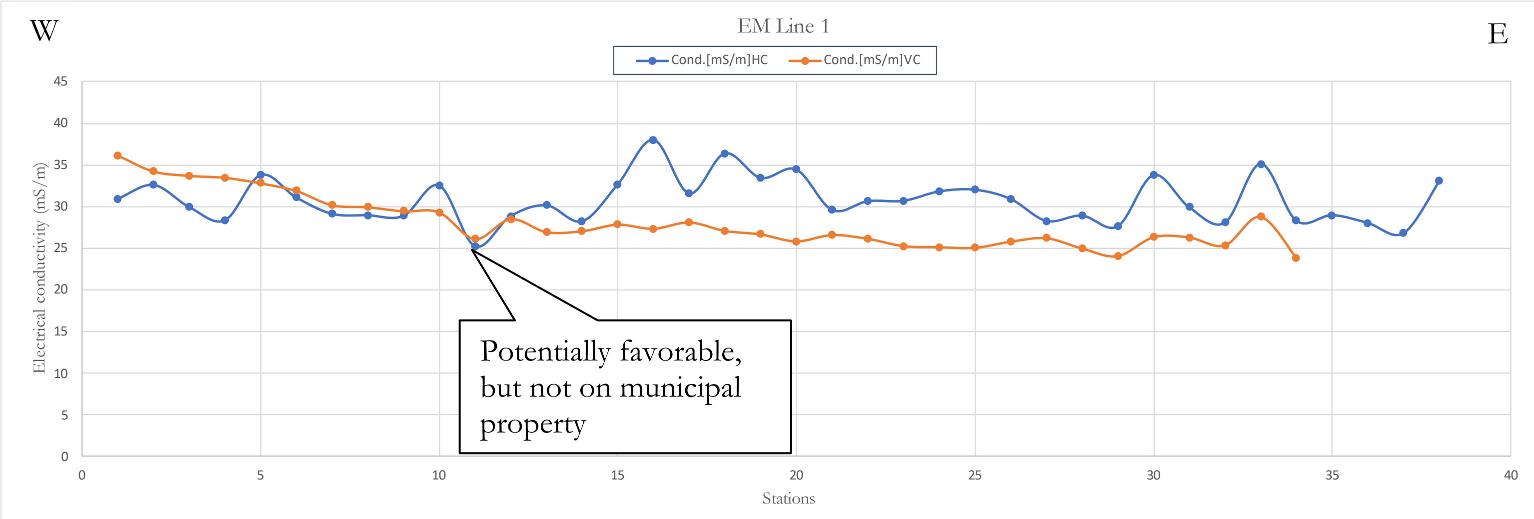


Figure 7: EM line 1 data, for survey completed adjacent to the water treatment works

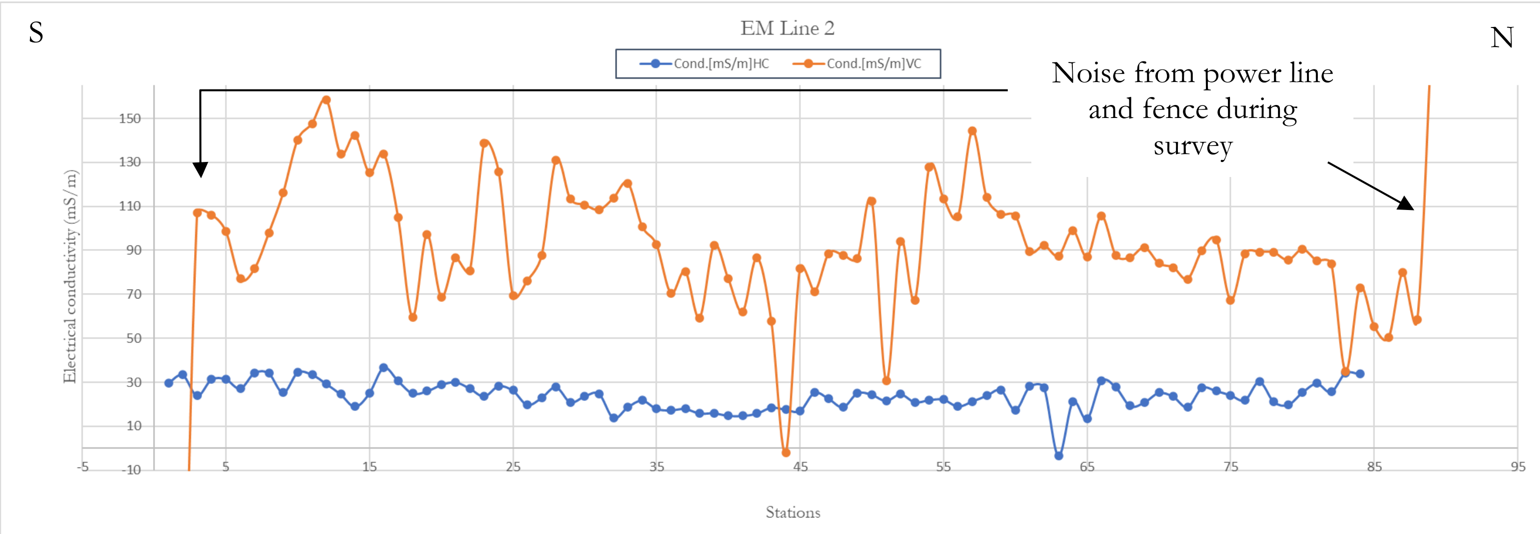


Figure 8: EM line 2 data, for survey completed adjected to the new cemetery north of town (northern cemetery)

3.3.2 Resistivity Tomography Method

Resistivity is a non-invasive geophysical tool that can provide cost-effective solutions to geological questions. The bulk resistivity of different geological units varies mostly because of changes in water saturation or porosity and/or salinity of the pore fluid (Telford et al, 1990). The Syscal Pro system is a completely automated resistivity tomography data acquisition system. The resistivity tomography method provides a pseudo-section of change in electrical properties in the subsurface along a specified profile line. Six multi-core cables with 8 electrode take-outs every 10 m were used. These cables were laid out on the ground end to end in a straight line (where possible). An electrode (metal stake) is inserted into the ground next to every electrode take-out on the cable, using a hammer. The electrode take-out is then connected to the electrode with a short cable jumper. The multi-core cables are connected to the Syscal Pro unit that controls the measurement sequence and takes the apparent resistivity measurements. The data were collected using a standard protocol with the Wenner array. All data were acquired for n = 1 to 8 and 10, 12, 14 and 16 where "n" is the electrode separation multiplication factor.

The apparent resistivity data acquired in the field were inverted using the RES2DINV software (Loke and Barker, 1996) to provide a true-depth resistivity section. The only pre-processing done was to erase obvious erratic data points (minimal). The resulting true resistivity pseudo-section is used for the interpretation.

3.3.2.1 Res Line 1: Along initial cemetery boundary

The resistivity traverse was completed from west to east along the southern boundary of the southern cemetery property owned by the municipality and the data is shown in **Figure 9**. The traverse (four cables in length), was completed to delineate fracturing within the Porterville Formation that may be associated with a possible fault affecting the Kruismansrivier to the west. The subsurface can be divided into several homogenous zones with similar physical characteristics. The resistivity values are interpreted as follows:

- Dark blue to light blue contours (9.31 – 66.4 ohm.m) values is likely indicative of clay rich unconsolidated material.
- Light green to dark green (66.4 – 474 ohm.m) values is likely indicative of clayey material grading into weathered bedrock. At depths > 20 meters this is likely indicative of moderately weathered bedrock and potential fracturing.
- Yellow to orange contours (474 – 3 381 ohm.m) values is likely indicative of moderately weathered to competent bedrock with possible fracturing.
- Red to purple contours (3 381 – 9 031 ohm.m) is likely indicative of hard fresh competent bedrock with little to no weathering.

The data for Res line 1 shows a general zone of high resistivity in the west, grading to low in the east. Higher resistivity in the west is likely associated with hard, competent phyllitic shale, which is anticipated to have weathered into unconsolidated clay material in the east and which grades into weathered bedrock with depth (**Figure 9**). Due to the abundance of clay, especially dry clays, contact between electrodes and the ground during the survey was difficult which resulted in a high error percentage (i.e., 52.2 %). Therefore, the data obtained cannot be relied upon to delineate drill targets.

3.3.2.2 Res Line 2: Along second cemetery

The resistivity traverse was completed from north to south along the eastern boundary of the northern cemetery property and the data is shown in **Figure 10**. The traverse was completed to delineate fracture zones associated within the Porterville Formation. The measured resistivity values, the subsurface can be divided into several homogenous zones with similar physical characteristics. The resistivity values are interpreted as follows:

- Dark blue to light blue contours (10 – 73.7 ohm.m) values is likely indicative of clay rich unconsolidated material.
- Light green to dark green (73.7 – 200 ohm.m) values is likely indicative of clayey material grading into weathered bedrock. At depths > 20 meters this is likely indicative of moderately weathered bedrock with signs of fracturing.
- Yellow to orange contours (200 – 1 472 ohm.m) values is likely indicative of moderately weathered to more competent bedrock with possible fracturing.
- Red to purple contours (1 472 – 10 837 ohm.m) is likely indicative of hard fresh competent bedrock with little to no weathering.

The data for Res line 2 shows a general zone of low resistivity at station 160 and higher resistivity on either side. The shallow high resistivity indicated in red in the north is likely associated with dry clay which weathered from phyllitic shale bedrock. The transition of high to low resistivity from the southern end of the pseudo section toward station 160 is indicative hard bedrock weathering into clay (**Figure 10**). Although the transition zone would normally be targeted for siting a water supply borehole, a high error percentage was obtained in the data. Further, extreme interference was encountered where data from cable 5 onward could not be used. Thus, no target has been defined based on this.

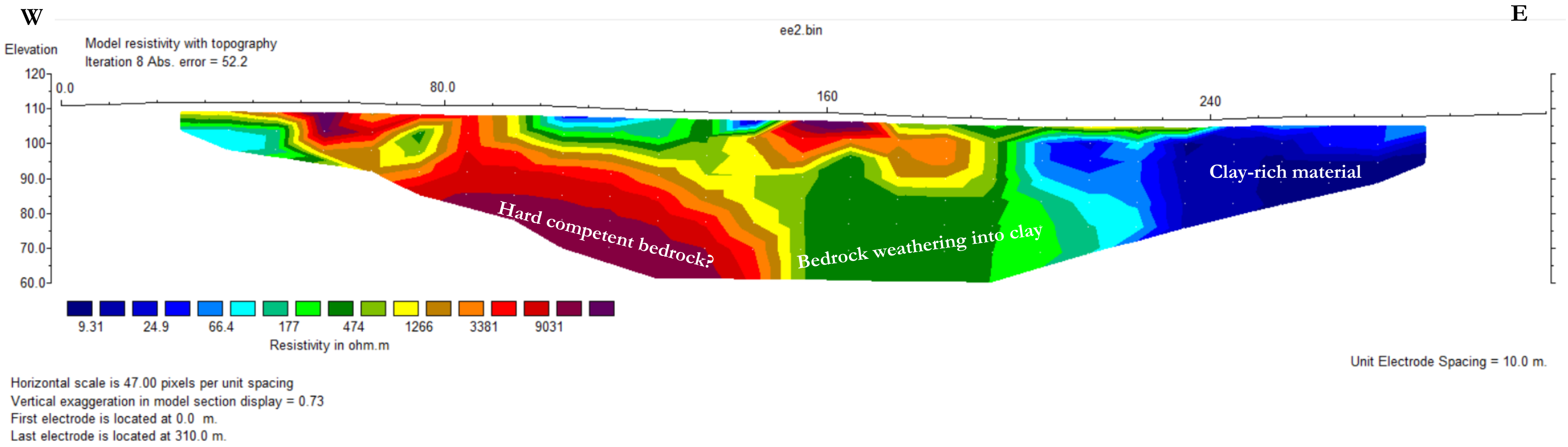


Figure 9: Pseudo section shown for Res Line 1, data acquired adjacent to the initial cemetery property

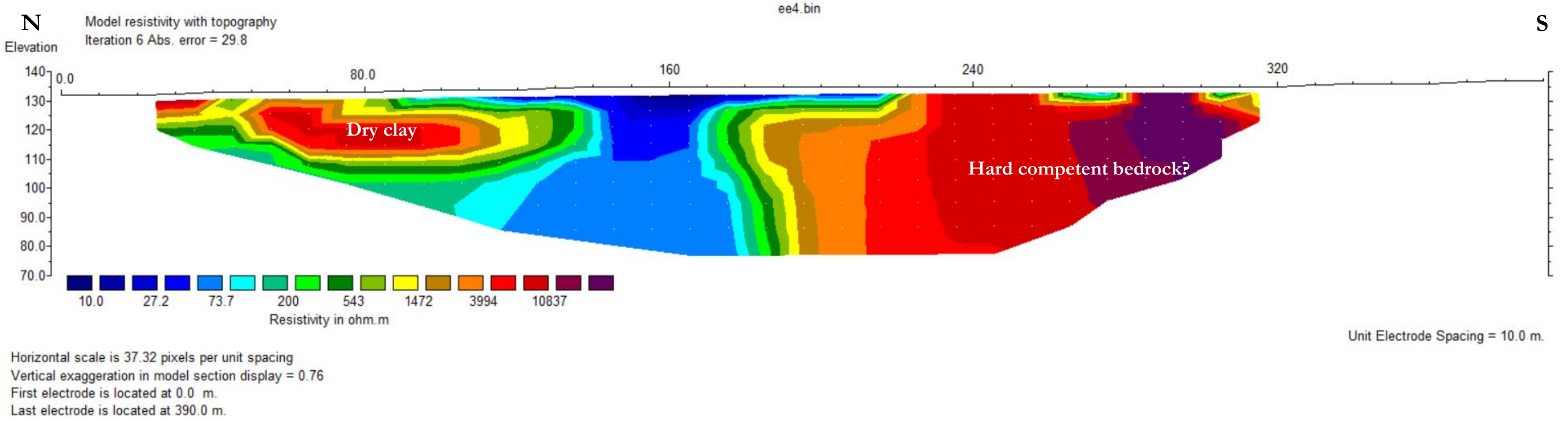


Figure 10: Pseudo section of Res Line 2, data acquired adjacent to the cemetery property

4. GROUNDWATER DEVELOPMENT

No borehole targets have been delineated form the geophysics due to the high error percentage seen in the processed resistivity data. The geology beneath the study sites was not favourable, i.e., electrode contact with the subsurface was poor and unreliable most likely due to excess of dry clays. The high error percentages seen make it difficult to delineate targets with confidence within the fractured aquifer. Additionally, the electromagnetic survey (EM 1) shows a potentially favourable site, however it is beyond the boundary extend of the water treatment works property that the municipality own. There is no hydrogeological basis that would allow for the potential point to be extrapolated to the municipal property.

Further, given that most of the sites are cemetery properties, extreme care needs to be taken in order to drill in these properties and ensure no contamination in the form of seepage occurs, i.e., deep solid steel casings. Coupled to this, the public perception associated with a water supply borehole located in a cemetery can be challenging. Lastly, the water requirement is in the region of 2.5 L/s to 3 L/s, which, taking into account the hydrocensus, is unlikely to be achieved sustainably at the sites investigated.

However, two areas of interest (AOIs) have been delineated for drilling of water supply boreholes – the areas have been superimposed on aerial photographs shown in **Figure 11**. These areas are based on the 1: 250 000 geological map series (3218, Clanwilliam) as well as information obtained from the current town supply borehole (HBH11). Two inferred faults cross cut the approximate municipal servitude location. The servitude is registered to the Berg River Municipality for the purpose of the water supply pipeline running from the slopes of the Piketberg Mountain, eastward to the water treatment works just outside town. The dimensions of the servitude are not currently known, however, should they extend to wider than the pipeline, the servitude land at these areas of interest should be considered for drilling of water supply boreholes. HBH11 has been yield tested and shows that 1.5 L/s for 24 hours of pumping is sustainable (this has also been verified through flow meter readings over the last 7 years by the municipality).

4.1 Groundwater development discussion

From a groundwater potential perspective, groundwater development on the Berg River municipal properties investigated in this report is not <u>feasible</u>. However, the municipal servitude areas east of the Piketberg mountain shows potential and can be investigated further.

Both areas of interest have potential; however, it should be duly noted that groundwater occurs in narrow fractures within the bedrock and if recharge is not sufficient or no fractures are intersected during drilling the borehole may be low yielding or dry.

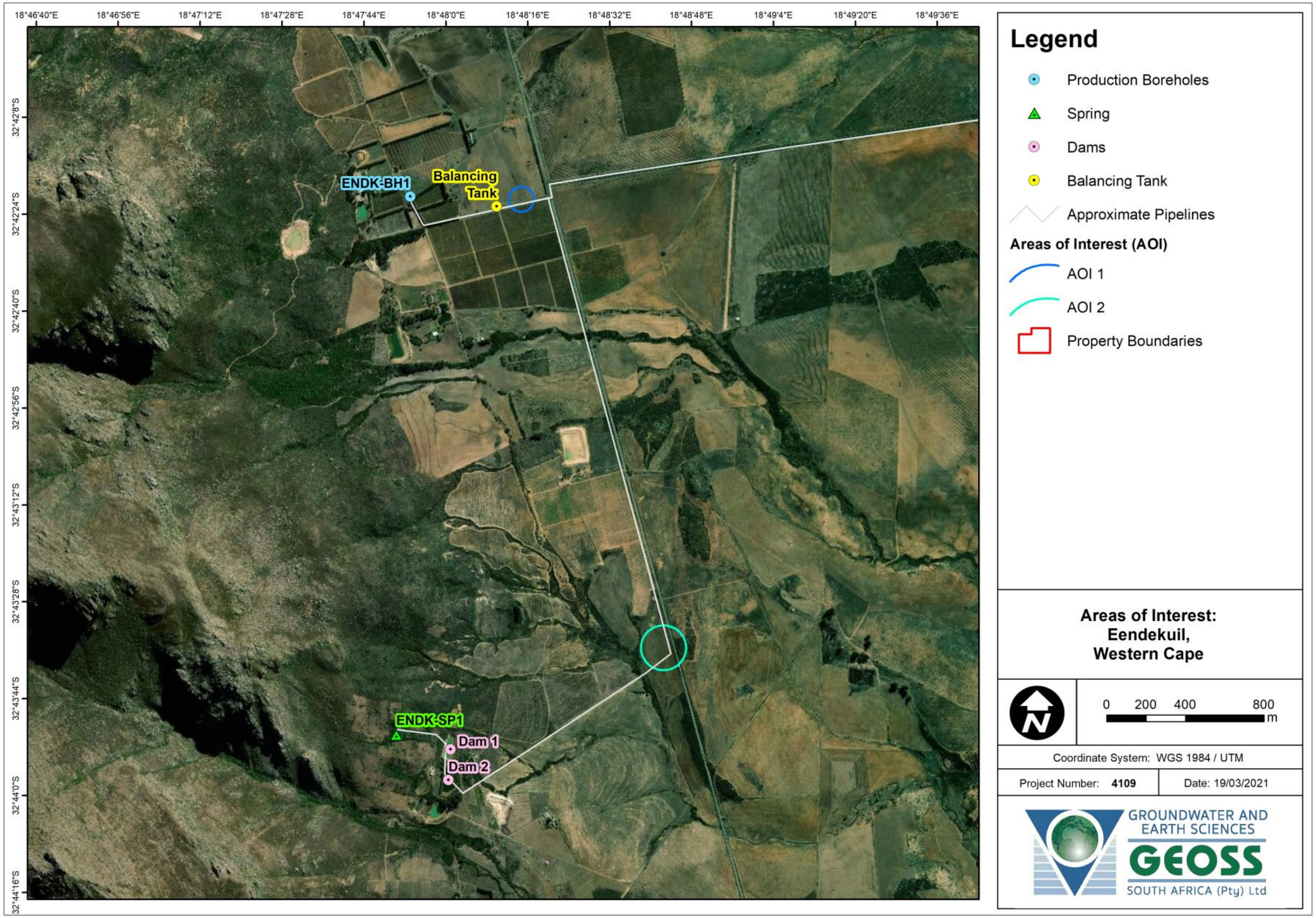


Figure 11: Areas of interest (AOI) for further groundwater development shown on an aerial photograph

5. RECOMMENDATIONS

Should further groundwater development be necessary, additional boreholes should be drilled in the areas of interest shown in **Figure 11**. The exact drill sites should be determined by a hydrogeologist in the field.

The expected drilling conditions per hole should be assessed and discussed in consultation with the driller before drilling starts. Abstraction from boreholes with high yields can be limited by the diameter drilled. It is recommended that a hydrogeologist be on site to help define the depth and design of the borehole. Should the drilling be successful, the borehole should be properly developed with compressed air upon completion. If successful, abstraction from the borehole will also need to be carefully managed to ensure sustainable use.

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

- Drill depths and borehole construction should be advised by a hydrogeologist.
- During the borehole drilling, geological samples must be collected for every 1 m drilled and the depth of fractures and associated yields noted. **A hydrogeologist should be on site to help with borehole construction and design and log the borehole details**. When drilling a borehole the main issue is "when is the borehole deep enough" and this issue is best addressed by a hydrogeologist.
- The borehole should be developed with compressed air for at least two hours upon completion of the borehole (if successful).
- The borehole, once drilled, should be tested to determine the groundwater yield available. This is to be done according to scientifically acceptable standards (as outlined by the SABS) and will form part of the groundwater use license application process. **Please note that non-SABS yield tests (Farmer method or constant-head) are not accepted by Department of Water and Sanitation (DWS) during a license application.**
- Samples of the groundwater should be submitted to an accredited laboratory for analysis to determine if the quality is suitable for its intended use.
- Licensing of the water use should be addressed upon successful completion of the borehole drilling and testing.
- A registered Environmental Assessment Practitioner (EAP) may need to be consulted, with respect to potential groundwater development triggers in terms of the National Environmental Management Act (No. 107 of 1998). Relevant aspects, include (but are not limited to): development of infrastructure in a watercourse or within 32 m from a watercourse, removal of more than 10 m^3 of earth material from a watercourse and clearance of 300 m^2 or more of indigenous vegetation within a critical biodiversity area (CBA).

The boreholes if successful should be equipped with monitoring infrastructure. Borehole monitoring can be done automatically using a water level logger or done manually. The monitoring should be done at least on a monthly basis. A rest water level can be manually taken using a dip meter, along with a flow meter measurement. This monitoring infrastructure includes:

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

The importance of monitoring a production borehole cannot be overstated. It is critical for sustainable management of groundwater and promoting longevity of boreholes. Collapse of fractures due to over abstraction is permanent.

6. REFERENCES

Council for Geoscience, (1984). Geological series 1: 250 000 scale (3218, Clanwilliam)

DWAF (2001). The hydrogeological map series of the republic of South Africa. Clanwilliam, 3218. Scale: 1:500 000.

GEOSS (2015). Water Use Licence Application - Geohydrological Assessment: Farm Kruisrivier, Eendekuil. GEOSS Report Number: 2015/01-04. GEOSS - Geohydrological& Spatial Solutions International (Pty) Ltd. Stellenbosch, South Africa.

Loke, M.H., 2004. Tutorial: Rapid 2D Resistivity & IP Inversion, Geotomo software, Malaysia.

National Water Act (1998). The National Water Act, No 36. Department of Water Affair and Forestry. Pretoria.

Telford W.M., Geldart L.P. and Sheriff R.E., (1990). Applied Geophysics: Second Edition. Cambridge University Press.

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