

Extension of the Kwazulu-Natal Groundwater Monitoring Network

Hydrogeological Report

Report Prepared for

Maragela Consulting Engineers (Pty) Ltd



Report Number 488058/2



Report Prepared by

The logo for srk consulting, featuring a stylized orange 's' symbol followed by the text 'srk consulting' in a grey, sans-serif font.

June 2016

Extension of the KwaZulu-Natal Groundwater Monitoring Network

Hydrogeological Report

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June 2016

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Executive Summary

Maragela Consulting Engineers (MCE) on behalf of the Department of Water and Sanitation (DWS) appointed SRK Consulting (Pty) Ltd (SRK) to conduct geohydrological work as part of the extension of the groundwater monitoring network within the Zululand District Municipality (Ulundi) and the uMzinyathi District Municipality (Nquthu), in KwaZulu-Natal. The new monitoring sites will assist the DWS to formulate strategies around groundwater availability (in storage) and quality, disaster management (drought) and planning of new groundwater supply projects in KwaZulu-Natal, based on temporal groundwater level and chemistry data.

Both sites were visited prior to the commencement of the planned field work. This site visits were used to meet with the relevant land owners and obtain the necessary permissions and servitude agreements to be instated to locate a borehole on these properties. At Site A (Ulundi) - KZN15-0675 a single magnetic traverse of 500 m in length, orientated roughly northeast to southwest was undertaken. At Site B (Nquthu) - KZN15-0676, the magnetic traverse conducted was 700 m in length and roughly orientated southeast to northwest. The magnetic survey was conducted in an attempt to identify the regional scale geological anomalies represented on the geological map.

- During drilling, no water strikes were encountered at Site A (Ulundi) - KZN 15-0675. A single water strike was intercepted at Site B (Nquthu) - KZN15-0676 at a depth of 32 m bgl with a final airlift yield of 0.3 L/s.
- At Site A (Ulundi) - KZN15-00675 a constant discharge test was undertaken for 250 minutes where the discharge was at 0.15 L/s with water level recovery monitoring thereafter occurring. The average transmissivity was estimated in the order of 0.3 m²/day from the testing data.
- At Site B (Nquthu)- KZN15-0676, a constant discharge test was undertaken for 24 hours where the discharge was at 0.2 L/s. Based on interpretation of the data using the FC Method, the recommended abstraction rate for the borehole is 0.03 L/s over an 8 hour pumping period. The average transmissivity is estimated to be in the order of 0.2 m²/day.
- The parameters tested on the sample from Site A (Ulundi) - KZN15-0675 conforms to the SANS 241:2015 requirements for drinking water, with the exception of E. Coli, nitrate, standard plate count, total coliforms, and the combined ratio of nitrate and nitrite. The presence of E Coli in the water sample could have been introduced into the borehole during the drilling process from the shallow zones.
- The analyses of the water sample retrieved from the borehole at Site B (Nquthu)- KZN15-0676 shows that the water shows elevated concentrations of Iron, Lead, Standard Plate Count, Total Coliforms and Turbidity when compared against SANS 241:2015 Drinking Water Standards and is therefore not suitable for human consumption. The elevated lead levels are not common with the geology in this area. Also, the borehole is positioned in an area where it is not likely to be impacted by any industrial activities that could have attributed to the lead in the sample. The results have been queried at the laboratory and SRK awaits their response. SRK also recommends that the groundwater be re-sampled.

Based on the above, the following is recommended:

- Water level monitoring devices (also called "divers") should be installed in the boreholes to record temporal groundwater level trends.
- The nearest rainfall gauging station (located within the catchment containing the monitoring borehole) should be identified to assist with understanding water level fluctuations in response to

rainfall patterns. Should a gauging station not be located in close proximity, then a station should be installed close to the borehole.

- Regular water quality monitoring of the borehole be undertaken to monitor parameters identified for SANS 241 (Abbrev.). It is further recommended that resampling of both these boreholes be undertaken.
- Should the boreholes be considered for drinking water supply, the treatment options as provided in the report options can be considered to deem the water suitable for human consumption:
-

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Disclaimer

The opinions expressed in this Report are provided in response to a specific request from Maragela Consulting Engineers (Pty) Ltd (MCE) to do so. Opinions presented in this report apply to the site conditions and features as they existed at the time of SRK's investigations, and those reasonably foreseeable. These opinions do not necessarily apply to conditions and features that may arise after the date of this Report, about which SRK had no prior knowledge nor had the opportunity to evaluate.

Glossary

Abstraction: The removal of water from a groundwater resource e.g. the pumping of groundwater from an aquifer.

Aquifer: An aquifer is defined as a saturated permeable geological formation or group of formations that is permeable enough to yield economic quantities of water.

Aquifer Testing: Aquifer testing involves the withdrawal of measured quantities of water from or the addition of water to, a borehole(s); and the measurement of resulting changes in head in the aquifer both during and after the period of abstraction or addition.

Available Drawdown: Is the difference between the static water level or piezometric surface and the main water strike (in fractured aquifers) or the pump depth (in porous aquifers) in a borehole.

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)].

Contamination: The introduction of any substance into groundwater systems by the action of man which may become harmful to both humans and the environment.

Electrical Conductivity (EC): Electrical conductivity is a measure of how well a material accommodates the transport of electric charge. The more salts dissolved in the water, the higher the EC value. It is used to estimate the amount of total dissolved salts, or the total amount of dissolved ions in the water.

Fault: A zone of displacement in rock formations resulting from forces of tension or compression in the earth's crust.

Fracture: Any break in a rock including cracks, joints and faults.

Fractured Aquifer: An aquifer that owes its water-bearing properties to fracturing.

Groundwater: Water found in the subsurface in the saturated zone below the water table

Hydraulic Head: Hydraulic head is the height above a datum plane such as sea level of the column of water that can be supported by the hydraulic pressure at a given point in a groundwater system.

Intergranular Aquifer: A term used in the South African map series referring to aquifers in which groundwater flows in openings and void space between grains or weathered rock.

Oil shale: Also known as kerogen shale, is an organic-rich fine-grained sedimentary rock containing kerogen (a solid mixture of organic chemical compounds) from which liquid hydrocarbons called shale oil (not to be confused with tight oil—crude oil occurring naturally in shales) can be produced.

Resource: A resource is a substance or item available for use. A natural resource is a resource that man can use, but cannot manufacture or create.

Static Water Level: The groundwater level in a borehole not influenced by abstraction or artificial recharge.

Sustainable Yield: Is defined as the maximum rate of withdrawal that can be sustained by an aquifer without causing an unacceptable decline in the hydraulic head or deterioration in water quality in the aquifer.

Transmissivity (T): The rate at which water is transmitted through a unit width of an aquifer under a unit hydraulic gradient. It is expressed as the product of the average hydraulic conductivity and thickness of the saturated portion of an aquifer.

Yield: The quantity of water removed from a water resource e.g. yield of a borehole.

1 Introduction and Scope of Report

Maragela Consulting Engineers (MCE) on behalf of the Department of Water and Sanitation (DWS) appointed SRK Consulting (Pty) Ltd (SRK) to site and drill monitoring boreholes as part of the extension of the groundwater monitoring network within the Zululand District Municipality (Ulundi) and the uMzinyathi District Municipality (Nquthu), in KwaZulu-Natal.

The new monitoring sites will assist the DWS to formulate strategies around groundwater availability (in storage) and quality, disaster management (drought) and planning of new groundwater supply projects in KwaZulu-Natal, based on temporal groundwater level and chemistry data.

2 Project Background and Brief

According to the Department of Water and Sanitation (DWS), groundwater management is often focused on the long-term sustainability of the resource in terms of quantity and quality. The objectives of the National Water Act (Act 36 of 1998) includes for the monitoring, gathering of information on water resources on a National scale and the management of the resource, which in part is the role of the DWS. Currently, many rural communities are wholly reliant on groundwater as their sole source of domestic water supply. Therefore the need to manage the groundwater resource through a carefully designed and managed monitoring borehole protocol is critical.

In an attempt to achieve its mandate within Southern Africa, South Africa and the province of KwaZulu-Natal in particular, it needs to establish Regional and National groundwater information systems and groundwater networks, aquifer characterisation, exchange information between countries, capacity building and institutional framework and development of minimum common standards for groundwater development and management.

With this in mind, it is vital that a groundwater monitoring network is extended to ensure adequate allocation of groundwater resources. DWS therefore recommended that level one monitoring boreholes were to be drilled in different geological areas of non-impacted (human activities), natural conditions. The area chosen for these boreholes were to be accessible, safe, not highly populated and have minimum irrigation. Level two boreholes will be on a local scale where the focus will be on the monitoring of key groundwater parameters and the interpretation of this data, aimed at ensuring a sustainable resource to be used for domestic purposes and limited use in local industries and agriculture (DWS, 2015).

3 Scope of Work

The proposed Scope of Work (SoW) for the hydrogeological assessment to address the Terms of Reference (ToR) supplied by the DWS and comprised the following:

- A desktop study which include a literature review of all available maps, reports and data for the area.
- A limited geophysical survey using the magnetic and resistivity techniques to scientifically site suitable drilling positions within the Ulundi and Nquthu areas.
- Drilling of one monitoring borehole in each area via the rotary air percussion technique to a depth ranging from 50 m to 100 m below ground level (m bgl) in an attempt to intercept water bearing geological structures.
- Drilling supervision and geological logging of the monitoring boreholes.
- Aquifer testing of the monitoring boreholes for the determination of aquifer hydraulic parameters, Transmissivity (T) and abstraction rate (Q). The testing comprised:
 - A step test comprising four, one hour duration discharge events followed by a four hour recovery monitoring test.

- A 24 hour constant rate discharge and recovery monitoring test.
- Analysis of the water sample to establish a baseline. The chemistry was also compared to the SANS 241 (Abbreviated) Drinking Water Standards in order to assess suitability for human consumption.
- Equipping of these boreholes with a lockable DWS designed borehole cap to prevent tampering or vandalism of the borehole.
- Based on the analyses of the borehole testing data and water quality analysis, to provide geohydrological recommendations and suitable conclusions regarding the boreholes drilled.
- Compilation of a technical Hydrogeological Assessment Report.

Geosite numbers were obtained for both boreholes from DWS. These are KZN15-0675 for the borehole drilled in Ulundi and KZN15-0676 for the borehole drilled in Nquthu.

For ease of reference and the purpose of this report, the monitoring borehole drilled in Ulundi (Zululand District Municipality)- KZN15-0675 will be referred to as Site whilst the monitoring borehole drilled in Nquthu (uMzinyathi District Municipality) - KZN15-0676 will be referred to as Site B.

4 Site Description

4.1 Site description and land-use

Site A is located in Tholwane Village at the coordinates of 28.3124°S, 31.3807°E c. 3.5 km west of the town of Ulundi in northern KwaZulu-Natal. The site occurs at an elevation of 629 m above mean sea level (m amsl). The surrounding land use comprises scattered rural dwellings with large areas of vacant land between the dwellings. Small scale subsistence farming is evident as is the presence of livestock rearing for domestic purposes.

Site B is situated 7.5 km north west of the town of Nquthu in the village of Mkonjane at coordinates of 28.18506°S, 30.60956°E. The site occurs at an elevation of 1368 m amsl. . The immediate vicinity of the borehole is surrounded by vacant land.

4.2 Topography and drainage

Site A is located adjacent to a gravel surfaced road on a ridge with gently undulating hills. Numerous non-perennial tributaries of the Ndlovana River flank the site to the south east and north west. The site is surrounded by rural dwellings. The site is easily accessible using the gravel surfaced road network within Tholwane Village. These features are shown in Figure 4-1.

Site B is located on the side of a ridge with gentle topography. A bird foots delta of the Batshe River is present to the immediate north east of the site. The land-use of the area is that of cultivated lands. Well maintained informal gravel roads are used to access the site. These features are shown in Figure 4-2.

4.3 Geology

According to the 1:250 000 geological map 2830, Dundee, the geology at Site A indicates that the site is underlain by sedimentary rock units of the Dwyka Group, Karoo Supergroup. This formation comprises tillite, minor shale, varved shale and sandstone which is depicted in Figure 4-3. No significant fault zones are present in the immediate vicinity of the site.

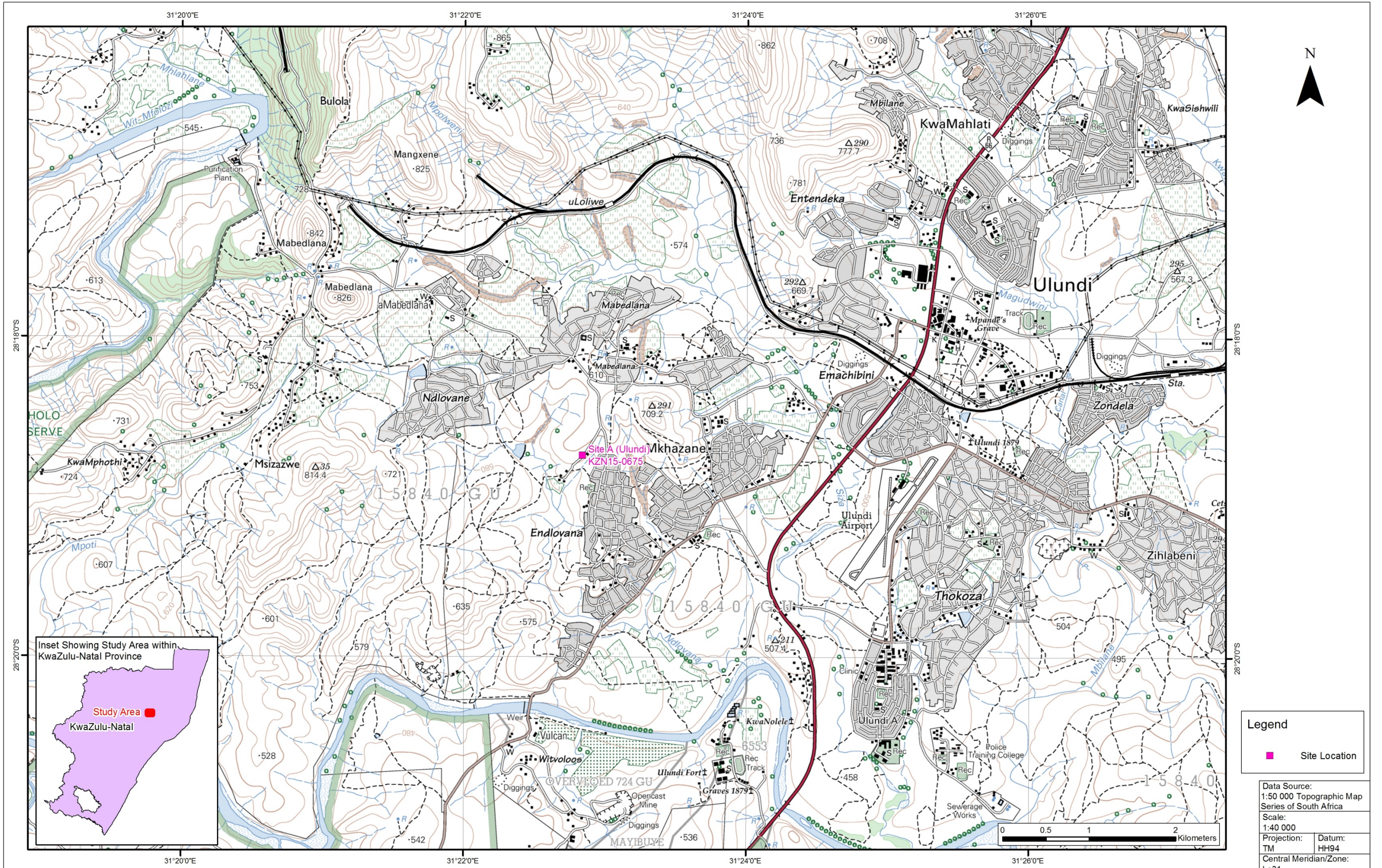
Based on the aforementioned geological map, the geology at Site B indicates that the site is underlain by sedimentary rock units of the Vryheid Formation, Karoo Supergroup. This formation comprises sandstone, shale and grit with coal and oil-shale beds which is depicted in Figure 4-4. Localised post Karoo Dolerite was also noted in the area. Quaternary aged clay, gravel beds,

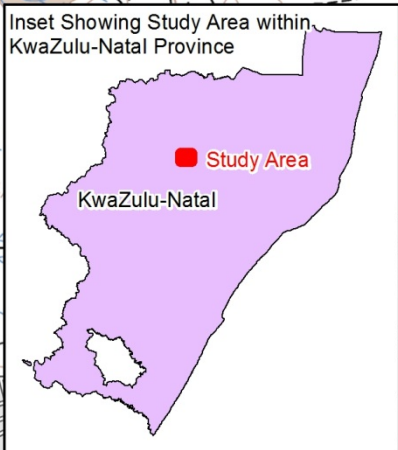
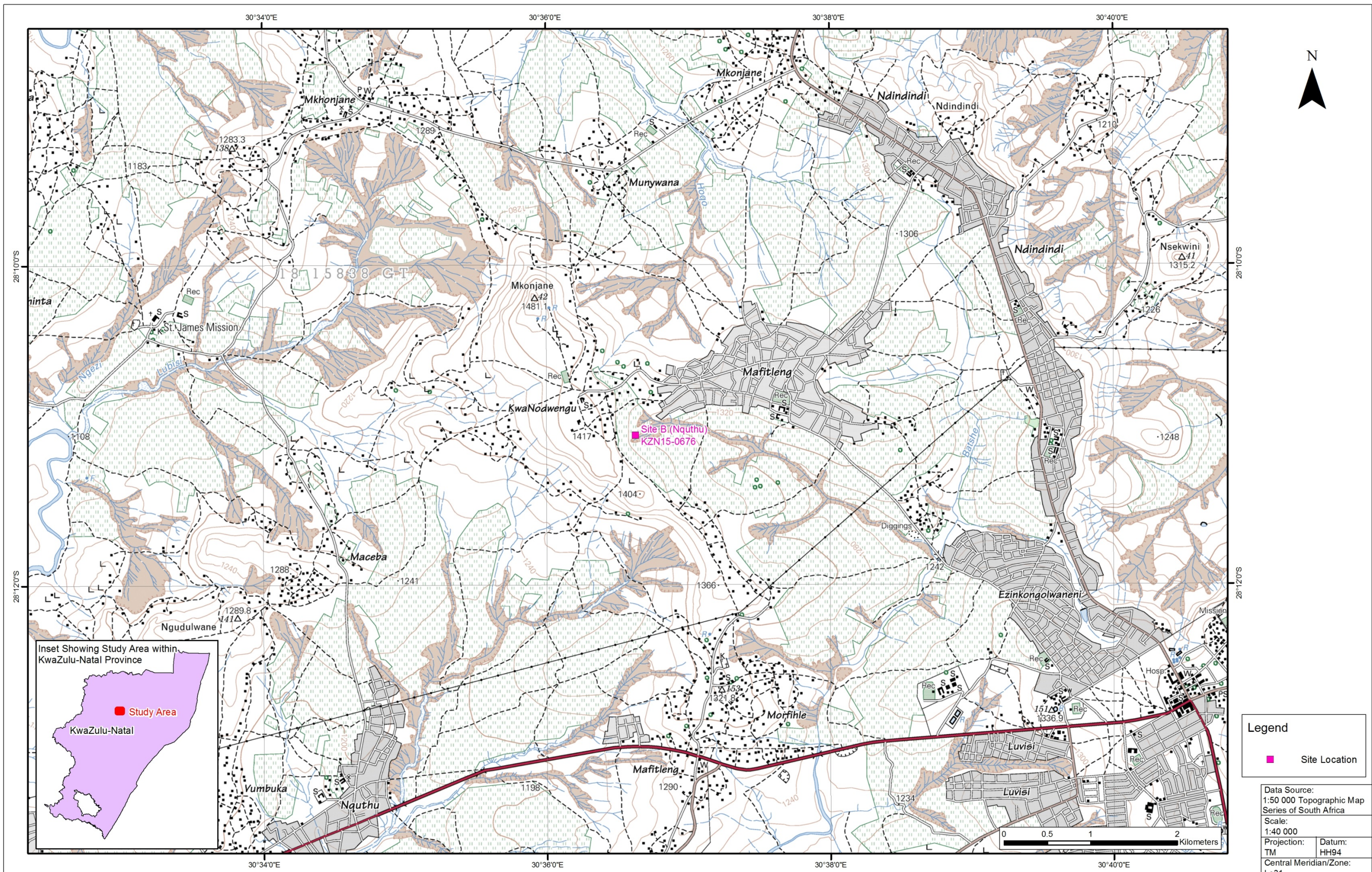
laterite, silcrete and soil is presence along the drainage features in the vicinity of the site. No significant fault zones were noted in the immediate vicinity of the site.

4.4 Hydrogeology

Site A is underlain by a fractured (*b3*) aquifer which is typically associated with borehole yields (median) ranging between 0.5 – 2.0 L/s (Figure 4-5). The Groundwater Resources Map for South Africa (1995) indicates that regional groundwater levels are expected at 15 m bgl. Electrical conductivity, which is a broad indicator of groundwater quality, is indicated to be 70-300 mS/m in the study area. A search of the National Groundwater Archive (NGA) showed three registered boreholes (2831AD00007, 2831AD00100 and 2831AD00122) within a 1 km radius of the site. None of these boreholes were identified during the hydrocensus of the surrounding area. A broken windmill was identified approximately 500 m south west off the site.

For Site B the regional hydrogeology indicates that the site is underlain by an intergranular and fractured (*d3*) aquifer which is typically associated with borehole yields (median) ranging between 0.5 – 2.0 L/s (Figure 4-6). The Groundwater Resources Map for South Africa (1995) indicates that regional groundwater levels are expected at 15 m bgl. Electrical Conductivity, is indicated to be 0-70 mS/m in the study area. A search of the National Groundwater Archive (NGA) showed no registered boreholes within the vicinity of the site.

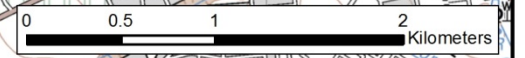


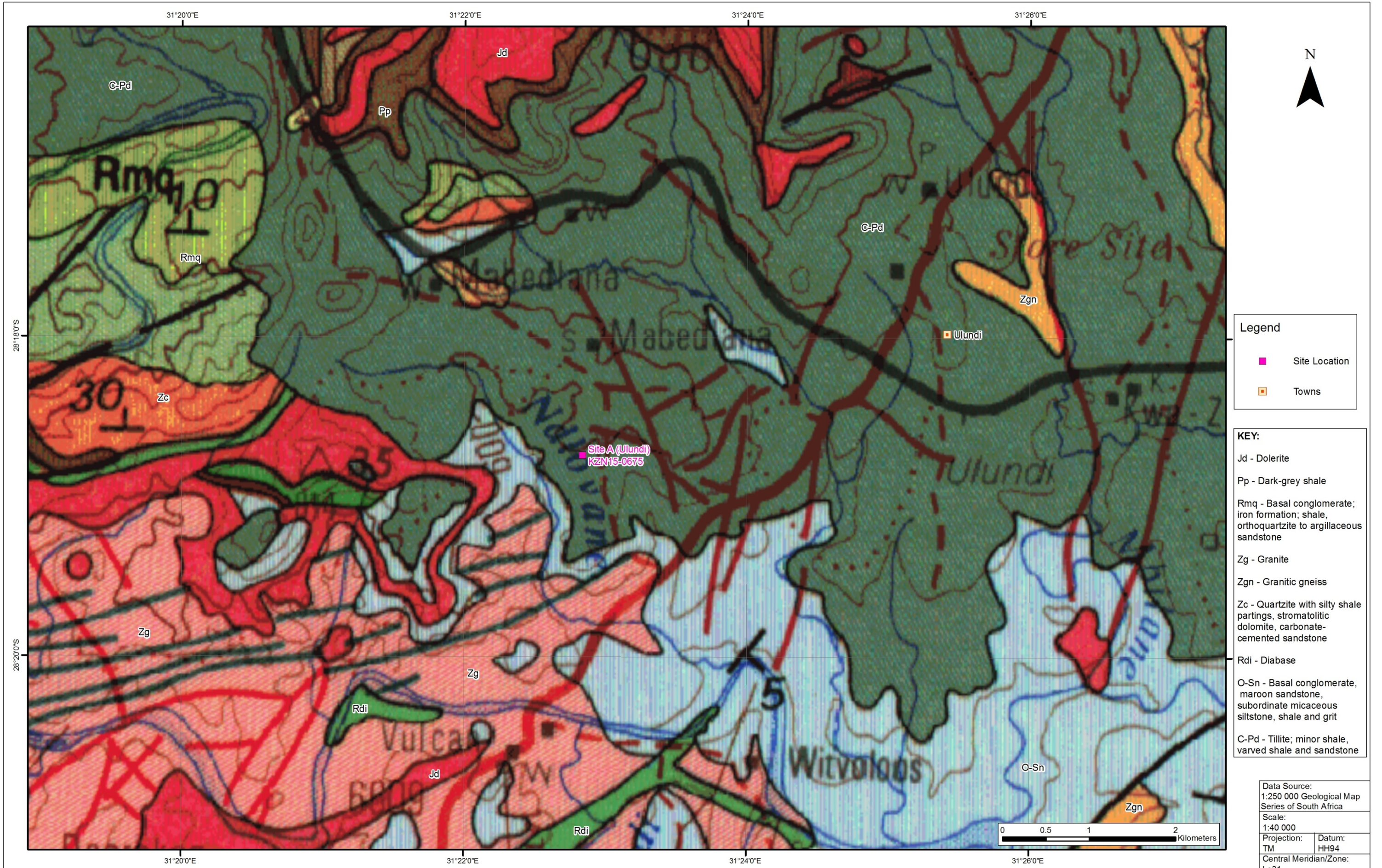


Legend

- Site Location

Data Source:
1:50 000 Topographic Map
Series of South Africa
Scale:
1:40 000
Projection: TM Datum: HH94
Central Meridian/Zone:
Lo31





Legend

- Site Location
- Towns

KEY:

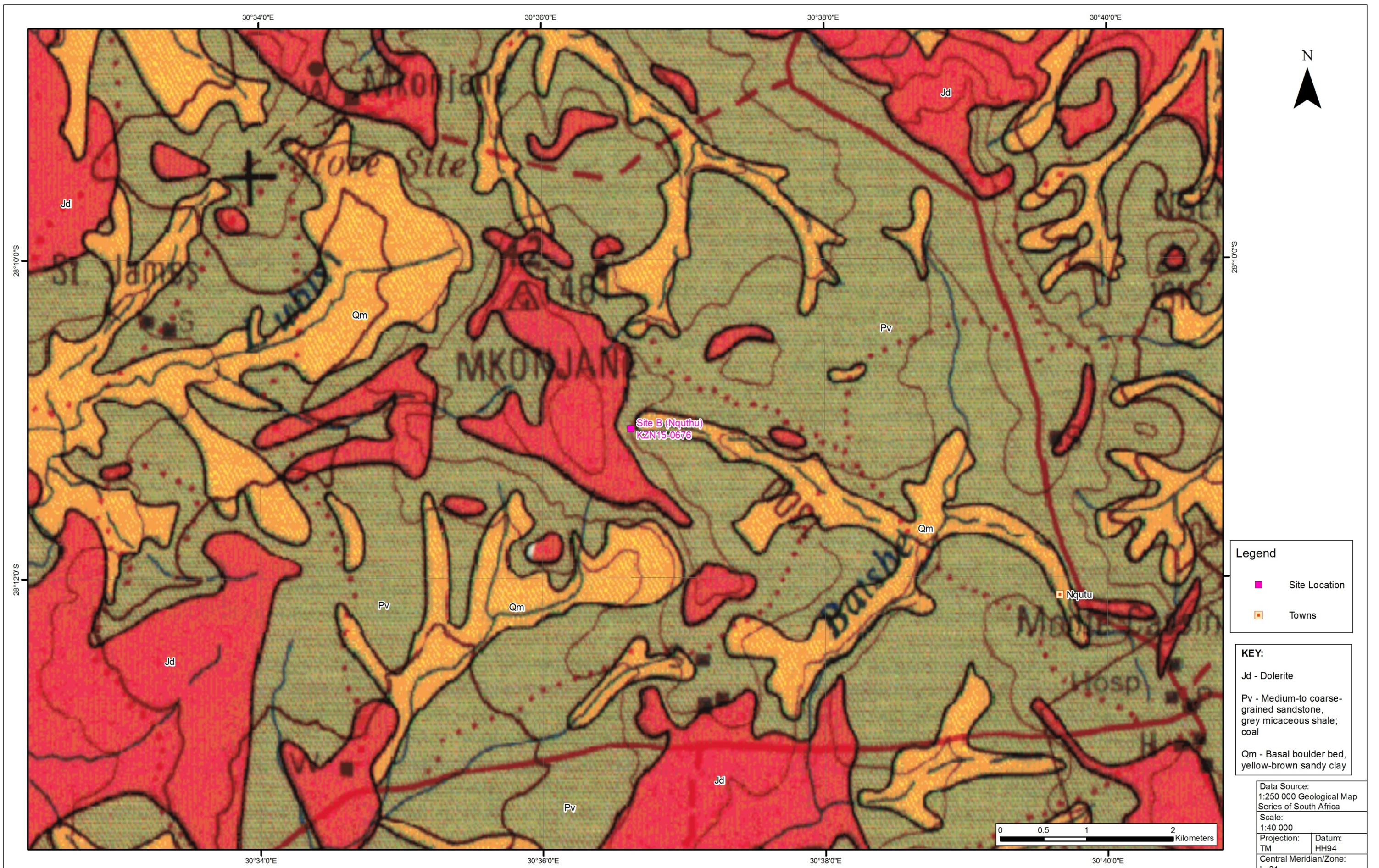
- Jd - Dolerite
- Pp - Dark-grey shale
- Rmq - Basal conglomerate; iron formation; shale, orthoquartzite to argillaceous sandstone
- Zg - Granite
- Zgn - Granitic gneiss
- Zc - Quartzite with silty shale partings, stromatolitic dolomite, carbonate-cemented sandstone
- Rdi - Diabase
- O-Sn - Basal conglomerate, maroon sandstone, subordinate micaceous siltstone, shale and grit
- C-Pd - Tillite; minor shale, varved shale and sandstone

Data Source:
1:250 000 Geological Map Series of South Africa
Scale:
1:40 000
Projection: TM Datum: HH94
Central Meridian/Zone: Lo31



**EXTENSION TO THE KWAZULU-NATAL GROUNDWATER MONITORING NETWORK
GEOLOGICAL PLAN- SITE A- ULUNDI**

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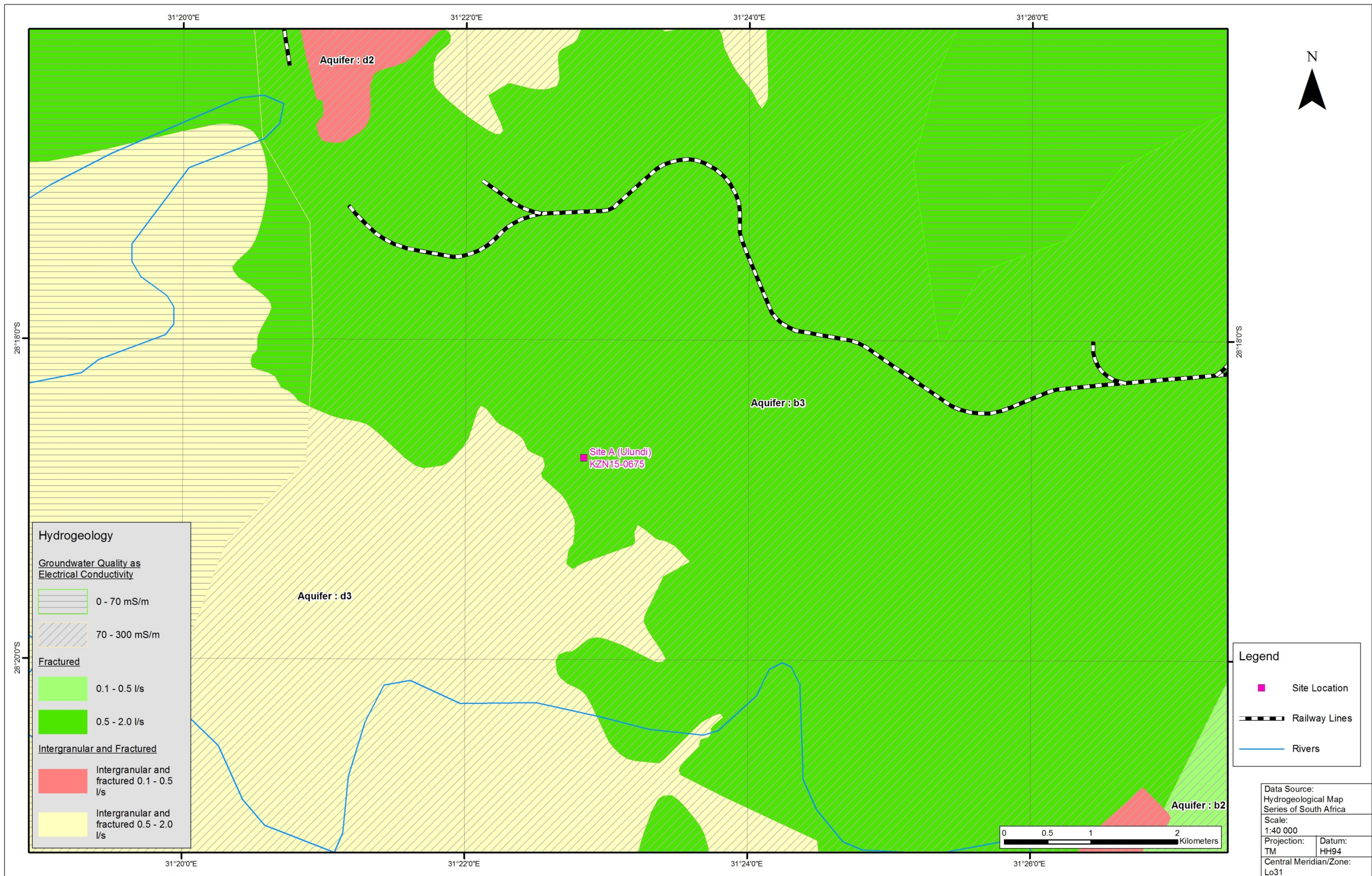
- Site Location
- Towns

KEY:

- Jd - Dolerite
- Pv - Medium-to coarse-grained sandstone, grey micaceous shale; coal
- Qm - Basal boulder bed, yellow-brown sandy clay

Data Source: 1:250 000 Geological Map Series of South Africa	
Scale: 1:40 000	
Projection: TM	Datum: HH94
Central Meridian/Zone: Lo31	
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01/06/2016	GOVD
Project No: 488058	Fig No: 4-4
Revision: A Date: 01 06 2016	



Hydrogeology

Groundwater Quality as Electrical Conductivity

- 0 - 70 mS/m
- 70 - 300 mS/m

Fractured

- 0.1 - 0.5 l/s
- 0.5 - 2.0 l/s

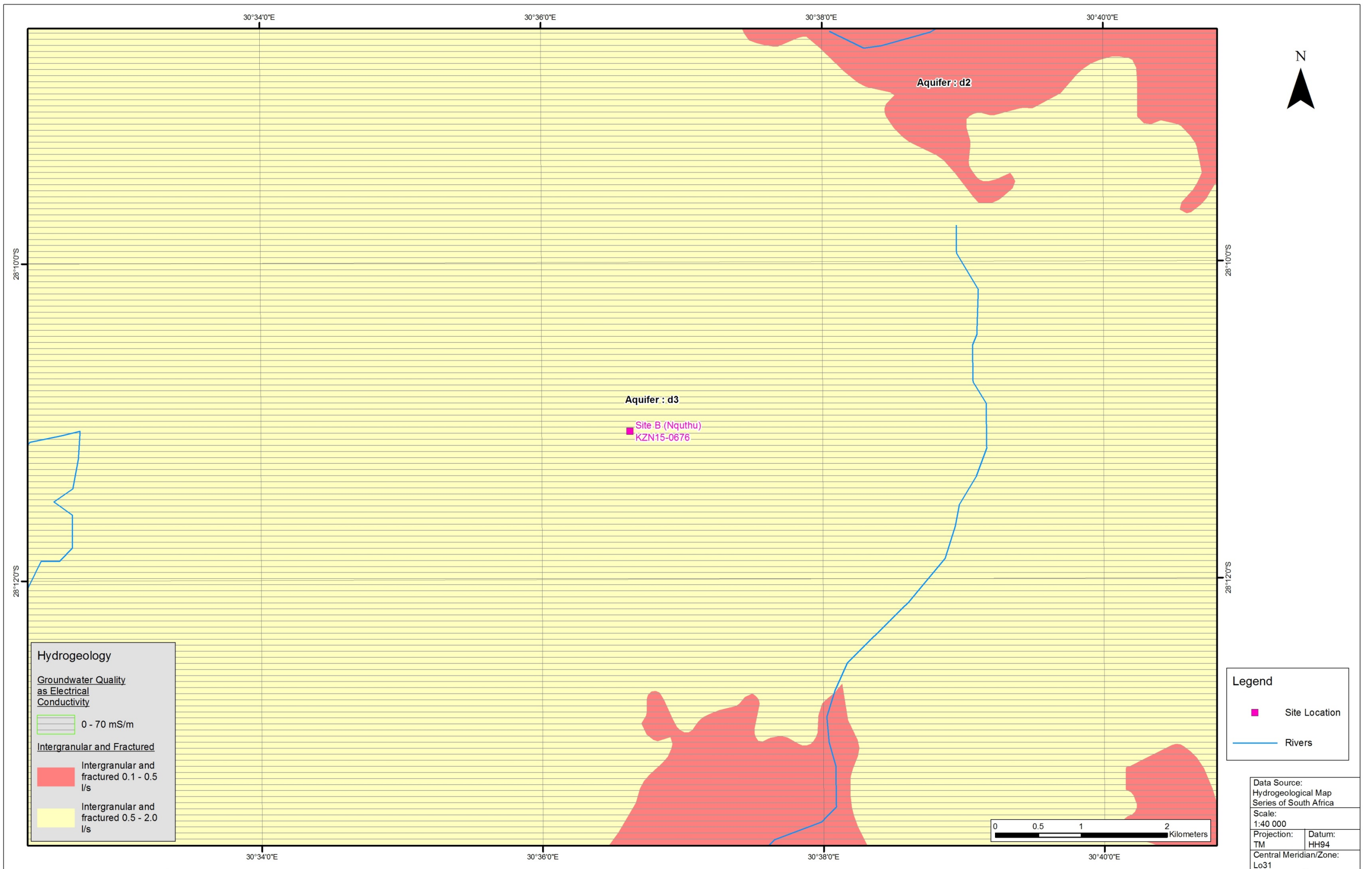
Intergranular and Fractured

- Intergranular and fractured 0.1 - 0.5 l/s
- Intergranular and fractured 0.5 - 2.0 l/s

Legend

- Site Location
- Railway Lines
- Rivers

Data Source: Hydrogeological Map Series of South Africa	
Scale: 1:40 000	
Projection: TM	Datum: HH94
Central Meridian/Zone: Lo31	
Date: 01/06/2016	Compiled by: GOVD
Project No: 488058	Fig No: 4-5
Revision: A Date: 01 06 2016	



Hydrogeology

Groundwater Quality as Electrical Conductivity

0 - 70 mS/m

Intergranular and Fractured

Intergranular and fractured 0.1 - 0.5 l/s

Intergranular and fractured 0.5 - 2.0 l/s

Legend

■ Site Location

— Rivers

Data Source: Hydrogeological Map Series of South Africa	
Scale: 1:40 000	
Projection: TM	Datum: HH94
Central Meridian/Zone: Lo31	
Date: 01/06/2016	Compiled by: GOVD
Project No: 488058	Fig No: 4-6
Revision: A Date: 01 06 2016	



**EXTENSION TO THE KWAZULU-NATAL GROUNDWATER MONITORING NETWORK
HYDROGEOLOGICAL PLAN- SITE B- NQUTHU**

5 Field work

Both sites were visited prior to the commencement of the planned field work. The site visits were used to meet with the relevant land owners and obtain the necessary permissions and servitude agreements to be instated to locate a borehole on these properties.

Site A is located on land owned by the Ingonyama Trust. In order to gain permission to drill at this site, SRK were advised to meet with the Local Traditional Council of the area. A site meeting was undertaken at Site A on 25 November 2015 with the Mbathata Traditional Council whereby the intended works to be undertaken was explained to the Traditional Council. A formal Tenure Application Form was completed and signed by the Traditional Council Chairman, members and secretary and DWS officials.

Site B is situated on municipally owned land. A meeting was held at the Municipal Offices in Nquthu on 24 November 2015. Written permission to proceed with the proposed scope of work, in the form of acceptance of a request by the DWS for the placing and monitoring of the borehole was obtained from the Mayor of Nquthu, Mrs. Emily Molefe.

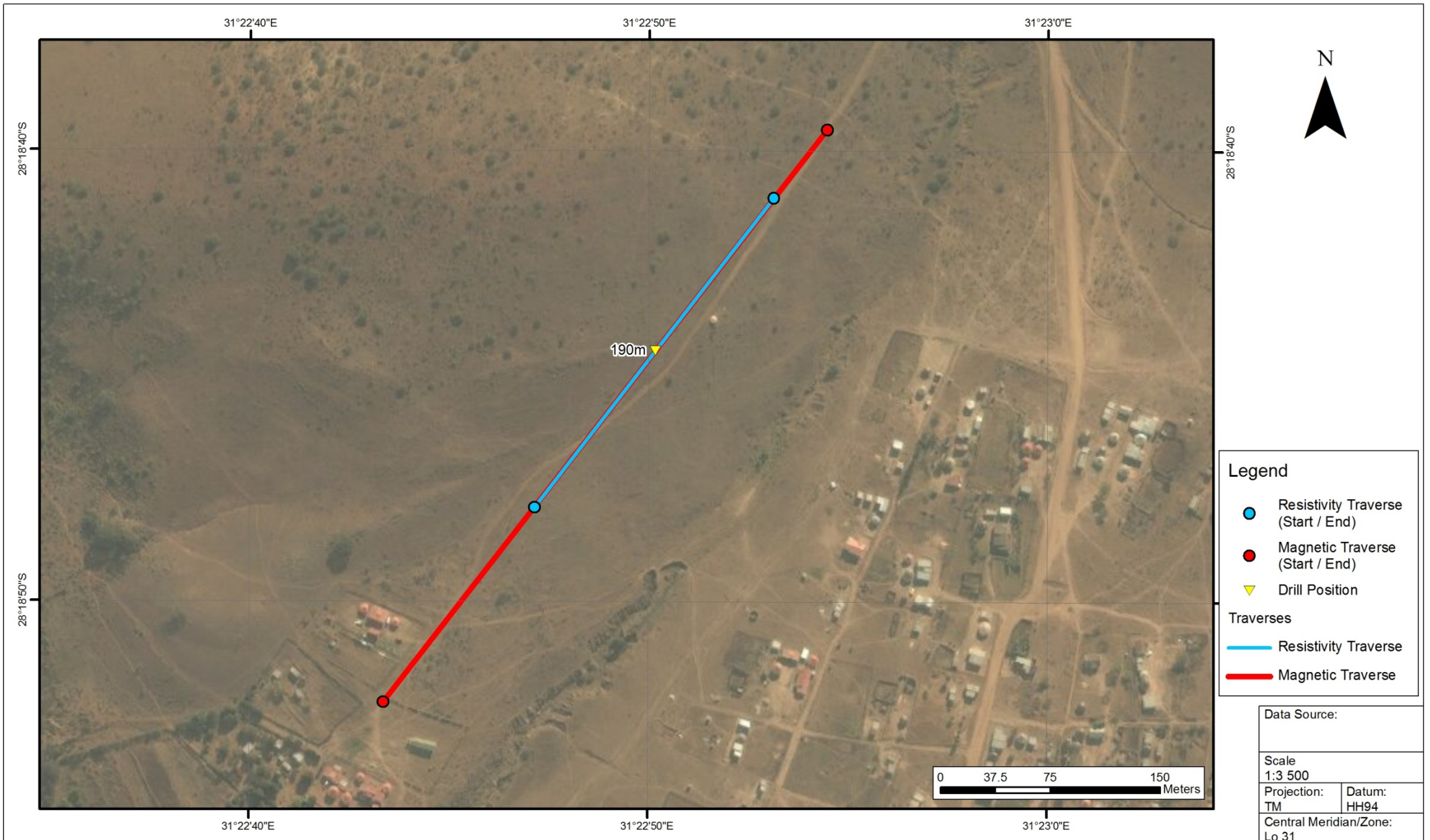
5.1 Geophysical investigation

The geophysical survey made use of magnetic and resistivity methods to site the boreholes. A magnetic survey was undertaken using the Proton G4 Magnetometer which was used as a coarse screening tool for geological anomalies i.e. faults, dykes and sills.

At Site A, a single magnetic traverse of 500 m in length, orientated roughly northeast to southwest was undertaken. Whilst at Site B, the magnetic traverse conducted was 700 m in length and roughly orientated southeast to northwest. The magnetic survey was conducted in an attempt to identify the regional scale geological anomalies represented on the geological map (See Figure 5-1 and Figure 5-2).

In order to determine the conductive nature of the identified geological anomalies at the site, resistivity profiling was undertaken within the faulted zone identified with the magnetic survey.

Based on an interpretation of the geophysical data, two potential drilling targets were identified for Site A and one target was identified for Site B. For Site A, the primary and secondary drilling targets were at 190 m (-28.31242 and 31.3807) and 240 m (-28.31272 and 31.38033), respectively. The single drilling target for Site B was at 330 m (-28.18506 and 30.60956). The location of the geophysical traverses is shown on Figure 5-1 and Figure 5-2, for Site A and Site B and the graphs for the geophysical data are shown in Figure 5-3 and Figure 5-4, respectively. The actual geophysical data are included in Appendix A.

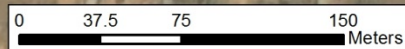


Legend

- Resistivity Traverse (Start / End)
- Magnetic Traverse (Start / End)
- ▼ Drill Position

Traverses

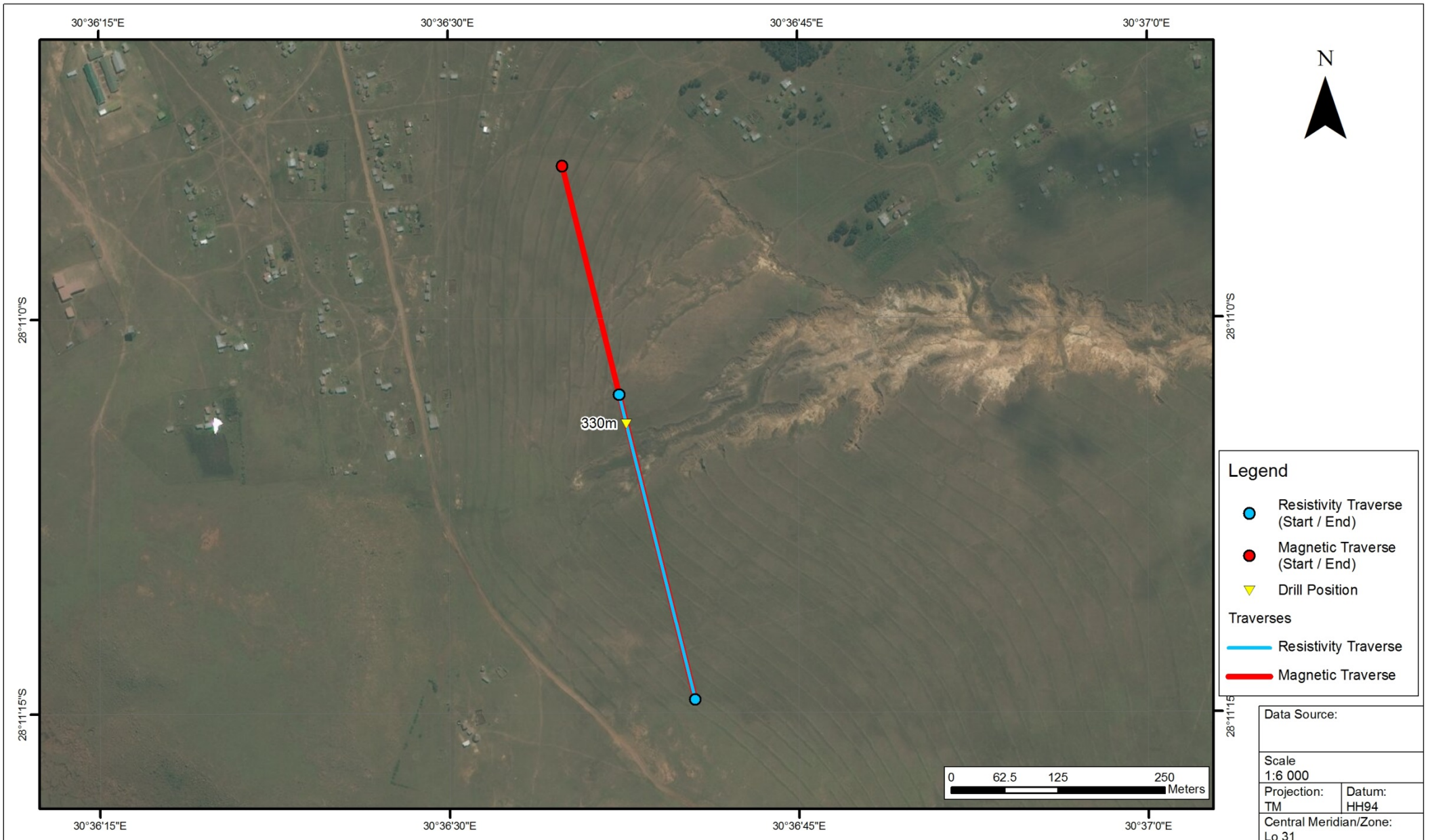
- Resistivity Traverse
- Magnetic Traverse



Data Source:	
Scale 1:3 500	
Projection: TM	Datum: HH94
Central Meridian/Zone: Lo 31	
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Project No. 488058	Fig No. 5-1



EXTENSION TO THE KWAZULU-NATAL GROUNDWATER MONITORING NETWORK
AERIAL PHOTOGRAPH SHOWING THE GEOPHYSICAL TRAVERSES - SITE A- ULUNDI



Legend

- Resistivity Traverse (Start / End)
- Magnetic Traverse (Start / End)
- ▼ Drill Position

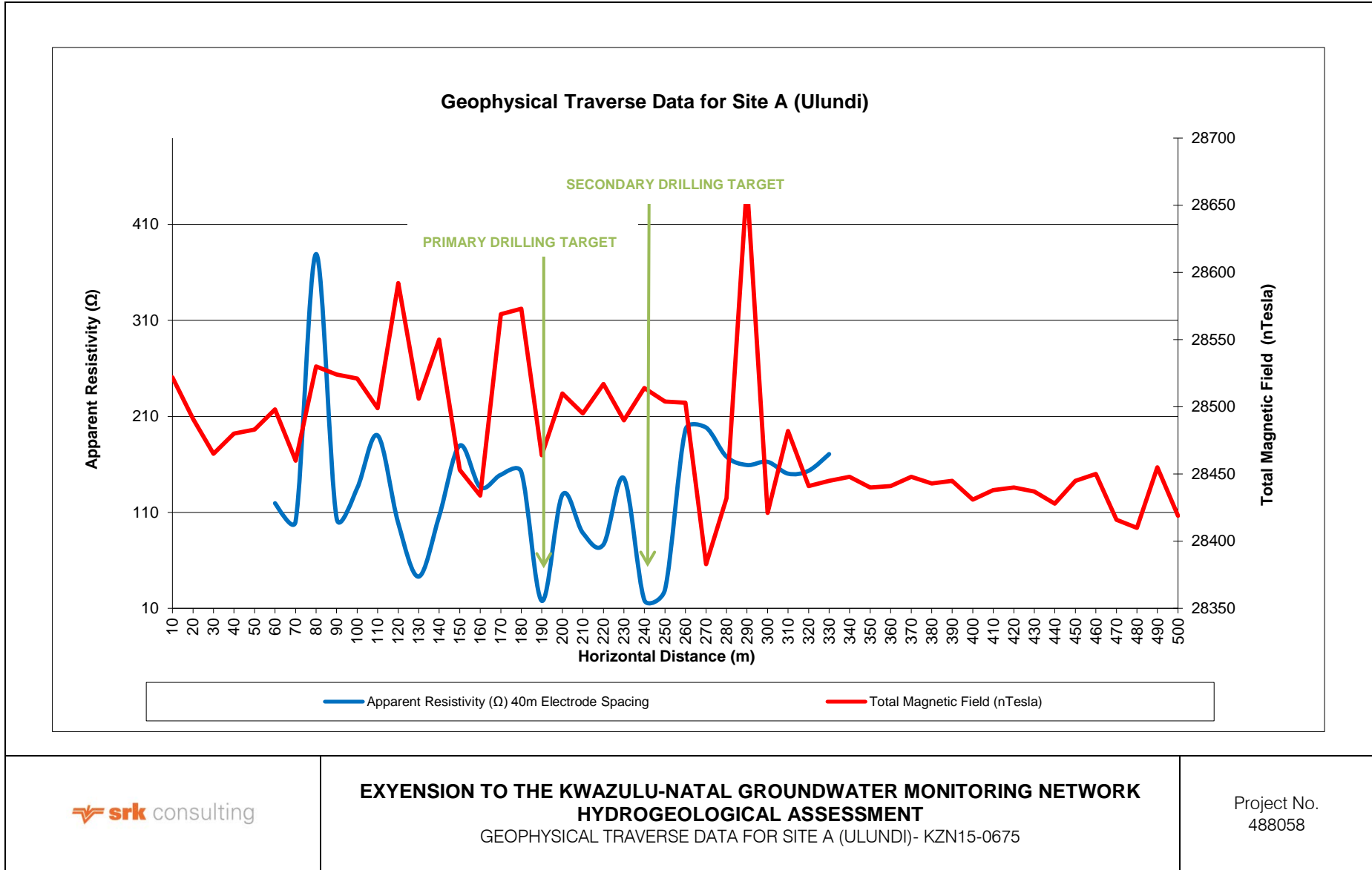
Traverses

- Resistivity Traverse
- Magnetic Traverse

Data Source:	
Scale 1:6 000	
Projection: TM	Datum: HH94
Central Meridian/Zone: Lo 31	
Date: 06/06/2016	Compiled by: GOVD
Project No. 488058	Fig No. 5-2



EXTENSION TO THE KWAZULU-NATAL GROUNDWATER MONITORING NETWORK
AERIAL PHOTOGRAPH SHOWING THE GEOPHYSICAL TRAVERSES - SITE B- NQUTHU



**EXENSION TO THE KWAZULU-NATAL GROUNDWATER MONITORING NETWORK
HYDROGEOLOGICAL ASSESSMENT
GEOPHYSICAL TRAVERSE DATA FOR SITE A (ULUNDI)- KZN15-0675**

Project No.
488058

Figure 5-3: Graph for the Magnetic and Resistivity Data- Site A- Ulundi KZN15-0675

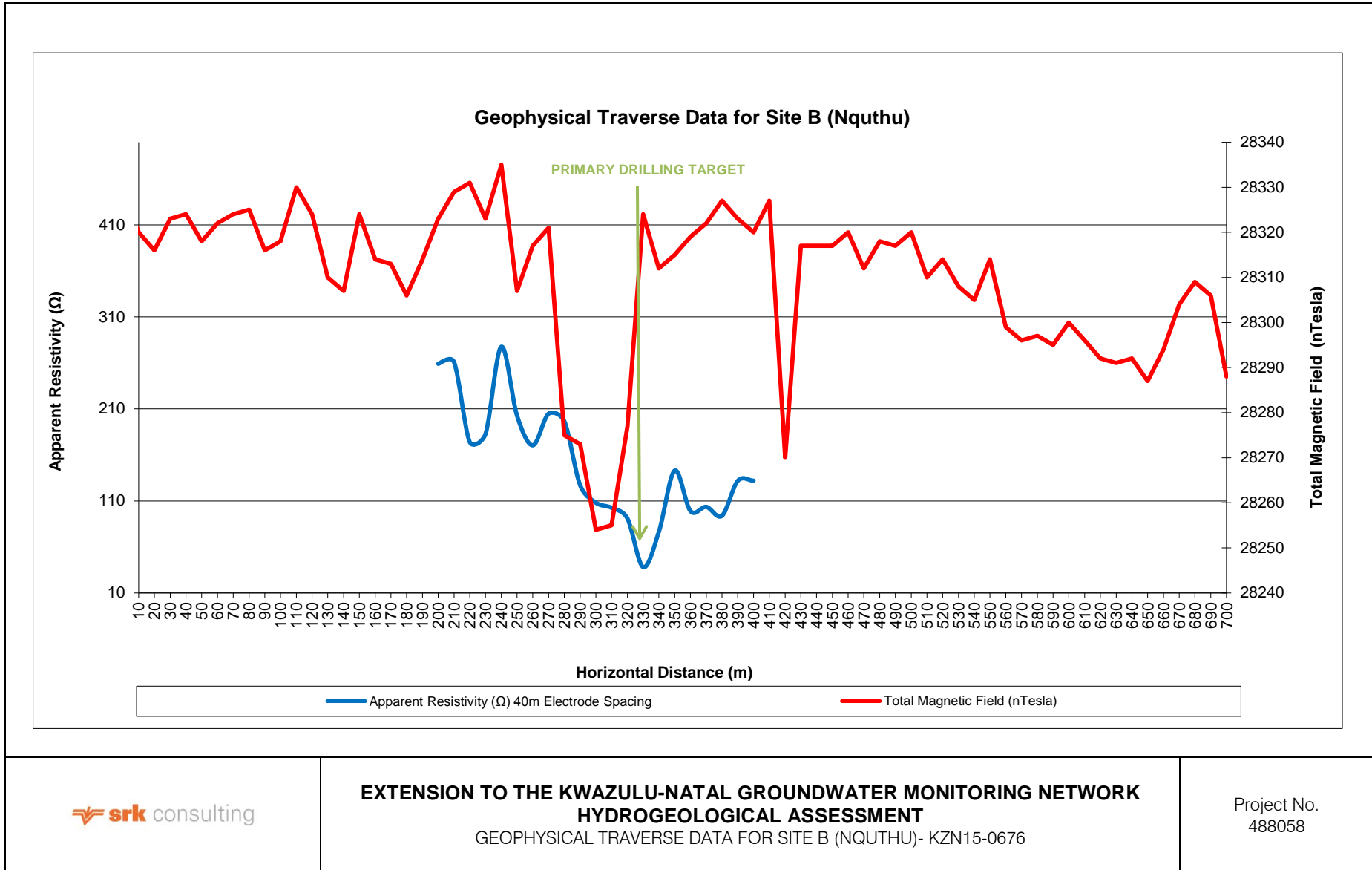


Figure 5-4: Graph for the Magnetic and Resistivity Data- Site B- Nquthu- KZN15-0676

5.2 Borehole drilling

The drilling commenced on 29 February 2016 at Site A and on 2 March 2016 at Site B . The rotary air percussion drilling technique was used. The drilling was undertaken by National Drilling.

At Site A, the borehole was drilled to a final depth of 100 m bgl. The geology intercepted comprised unconsolidated sands and silts to approximately 8.0 m. Tillite bedrock with an increasing competency and ranging from highly to slightly weathered with depth was present to a depth of 100 m. The weathered profile (silty sand and sandy silt) was cased-off with 12 m of steel casing (177 mm outer diameter and 169 mm inner diameter). No water was intercepted in this borehole during the drilling however, a water table did establish over time to a depth of approximately 33 m bgl. A sanitary seal and concrete collar was installed in the borehole to protect the water resource from potential surface contamination sources.

Site B was drilled to a depth of 50 m bgl, and intercepted grey brown sandstone of the Vryheid Formation. The highly weathered sandstone material was cased-off with 6 m of steel casing (177 mm outer diameter and 169 mm inner diameter). A single water strike, with an approximate final air lift yield of 0.33 L/s, was intercepted at 32 m bgl. The groundwater intercepted was clear during flushing and no odour was recorded. A sanitary seal and concrete collar was installed in the borehole.

The borehole logs for Site A and Site B are presented in Appendix B with photographs of the drilling activities presented in Figure 5-5 below.

	
<p>a) Drilling at Site A</p>	<p>b) Drilling at Site B</p>
	
<p>c) Completed borehole with sanitary seal and concrete collar at Site A</p>	<p>d) Water strike intercepted at Site B</p>
	
<p>e) Installation of DWS manhole cover at Site A</p>	<p>f) Completed borehole at Site B</p>

Figure 5-5: Photographs of the drilling activities at Site A (Ulundi) and Site B (Nquthu)

5.3 Aquifer Testing

Aquifer testing commenced on 5 April 2016 at the Site A borehole and on 6 May 2016 at the Site B borehole to assess the hydraulic properties of the aquifers. The aquifer field testing data were analysed by using the Flow Characteristic (FC) Method (a software program developed by IGS, Free State University) mainly for estimation of sustainable yields in fractured rock aquifers.

Due to the fact that the Site A borehole was drilled dry, the testing at this borehole comprised removing the seepage water from the borehole and then monitoring the recovery. The rest water level (RWL) in the borehole established at 33.18 m bgl and the available drawdown was 56.82 m. A constant discharge test was undertaken for 250 minutes where the discharge was at 0.15 L/s with subsequent water level recovery monitoring. The average transmissivity was estimated at 0.3 m²/day from the testing data.

At Site B, the RWL in the borehole established at 10.55 m bgl and the available drawdown was 36.45 m. It was initially proposed that a 240 minute step test (4 steps of 60 min each) was to be undertaken with the initial discharge set at 0.1 L/s and the fourth step at 0.4 L/s however it was only possible to undertake a 3 step test (of 60 min each) for 180 minutes due to the diminished available drawdown. Recovery monitoring was undertaken for 300 minutes. Thereafter, a constant discharge test was undertaken for 24 hours at a discharge of 0.2 L/s. Subsequent water level monitoring was undertaken. Based on interpretation of the data using the FC Method, the recommended abstraction rate for the borehole is 0.03 L/s over an 8 hour pumping period. The average transmissivity was estimated in the order of 0.2 m²/day

The field aquifer testing data as well as the analyses of the aquifer testing data for both the sites are included in Appendix C.

5.4 Water Quality

Following the aquifer testing at both boreholes, representative water samples comprising 1 x 2 L and 1 x 500 mL were collected from the boreholes and submitted to Talbot and Talbot Laboratories for SANS241 (Abbrev.) analyses to assess the drinking water quality of the groundwater sample.

The water sample retrieved from the Site A borehole conform to the SANS 241:2015 requirement for drinking water, with the exception of E. Coli, nitrate, standard plate count, total coliforms, and the combined ratio of nitrate and nitrite. The presence of E Coli in the water sample could have been introduced into the borehole during the drilling process from the shallow zones. As the borehole was drilled to establish baseline conditions, in terms of water quality, and not intended for water supply purposes, the borehole was not disinfected.

The analyses of the water sample retrieved from the borehole at Site B shows that the water shows elevated concentrations of Iron, Lead, Standard Plate Count, Total Coliforms and Turbidity when compared against SANS 241:2015 Drinking Water Standards and is therefore not suitable for human consumption. The elevated lead levels are not common with the geology in this area. Also, the borehole is positioned in an area where it is not likely to be impacted by any industrial activities that could have attributed to the lead in the sample.

The findings of the analyses are tabulated in Table 5-1 below.

Table 5-1: Groundwater Quality Results

Determinand	Units	SANS 241-1:2015 Standard Limits Required	Site A (Ulundi)-KZN15-0675	Site B (Nquthu)-KZN15-0676
Chloride	mg Cl/l	< 300	177	19
Colour*	mg Pt-Co/l	< 15	<1	<1
Copper	µg Cu/l	< 2000	5.60	6.96
Dissolved calcium	mg Ca/l	Not specified	62	22
Dissolved magnesium	mg Mg/l	Not specified	55	19
<i>E. coli</i>	colonies per 100ml	0	8	0
Electrical conductivity at 25°C	mS/m	< 170	138	37
Fluoride	µg F/l	< 1500	740	410
Iron	µg Fe/l	Chronic ≤2000 Aesthetic ≤300	1 457	2 193
Lead	µg Pb/l	< 10	1.94	14.6
Manganese	µg Mn/l	Chronic ≤400 Aesthetic ≤100	66	77
Nitrate*	mg N/l	< 11	15.2	0.27
Nitrite*	mg N/l	< 0.9	<0.1	<0.1
Combined Nitrate + Nitrite (sum of Ratios)*	-	<1	1.40	< 0.1
pH at 25°C	pH units	5.0 - 9.7	7.7	7.6
Sodium	mg Na/l	< 200	107	19
Standard plate count	colonies per ml	<1000	>10 000	>10 000
Sulphate	mg SO ₄ /l	Acute Health ≤500 Aesthetic ≤250	16.1	5
Total alkalinity	mg CaCO ₃ /l	Not specified	290	133
Total coliforms	colonies per 100ml	<10	260	236
Total hardness*	mg CaCO ₃ /l	Not specified	383	132
Turbidity	NTU	Operational ≤1 Aesthetic ≤5	1 060	92.6
		Aesthetic ≤5		

Cognisance of the following should be given regarding the water quality from the boreholes drilled:

At Site A

- The presence of E Coli shows faecal contamination and renders this water unsuitable for human consumption unless properly disinfected. As the borehole was drilled to establish baseline conditions, in terms of water quality, and not intended for water supply purposes, the borehole was not disinfected.
- The nitrate result on this sample is higher than the SANS specification of 11mg N/L but lower than 20 mg/l where a chronic risk to some babies would be seen. High nitrate causes methaemoglobanaemia, which reduces the oxygen carrying capacity of the blood. This especially affects young children and the aged.
- Nitrate stimulates algal growth, and thus may indirectly lead to secondary treatment problems.
- The turbidity of the water exceeds the SANS limit of <5 NTU and is one of the indirect indicators of microbiological water quality and of inefficient water treatment. The presence of turbidity in

water results in a cloudy or muddy appearance, and may also affect the taste and the colour of the water.

- The total hardness indicates that this water is very hard where one would experience severe impairment of lathering of soap and severe scaling of appliances. Health and aesthetic effects include possible chronic effects in sensitive groups and an effect on the taste of the water.

At Site B

- The iron content of the water exceeds the limit of 2 000 µg/l Fe/L recommended by the SANS 241 specifications for drinking water.
- The concentration of iron in the water has increasing effects in sensitive groups and can cause objectionable taste and appearance. The lead content of the water does not impose any adverse health effects except for a slight risk of behavioural changes and the possibility of neurological impairment, if the exposure to lead from other sources, such as food is not minimised.
- The presence of coliforms shows contamination from soil or vegetation which may become more serious after rain. The water is of doubtful quality and cannot be recommended for drinking unless properly disinfected.
- The turbidity of the water exceeds the SANS limit of <5 NTU and is one of the indirect indicators of microbiological water quality and of inefficient water treatment. The presence of turbidity in water results in a cloudy muddy appearance, and may also affect the taste and colour of the water.
- The total hardness indicates that this water is slightly hard where lathering of soap would become slightly impaired. Further to this, slight scaling of kettles will also occur at these levels.

The laboratory certificates of analyses are provided in Appendix D.

6 Equipping of boreholes

Both boreholes were equipped based on following recommendations stipulated by the DWS:

- The top of the casing was raised by at least 30- 50 cm above the general ground surface to ensure that the surface run-off does not flow into the borehole during flood conditions.
- A concrete block was installed around the top of the casing, to protect the casing and borehole, as well as to prevent surface pollution from flowing down the side of the casing with a minimum dimension of 750 mm x 750 mm x 300 mm.
- A lockable cap obtained from the DWS to prevent tampering or vandalism was installed at each of the boreholes.

Photographs of the installed borehole caps at each of the sites are provided in Figure 6-1 below.

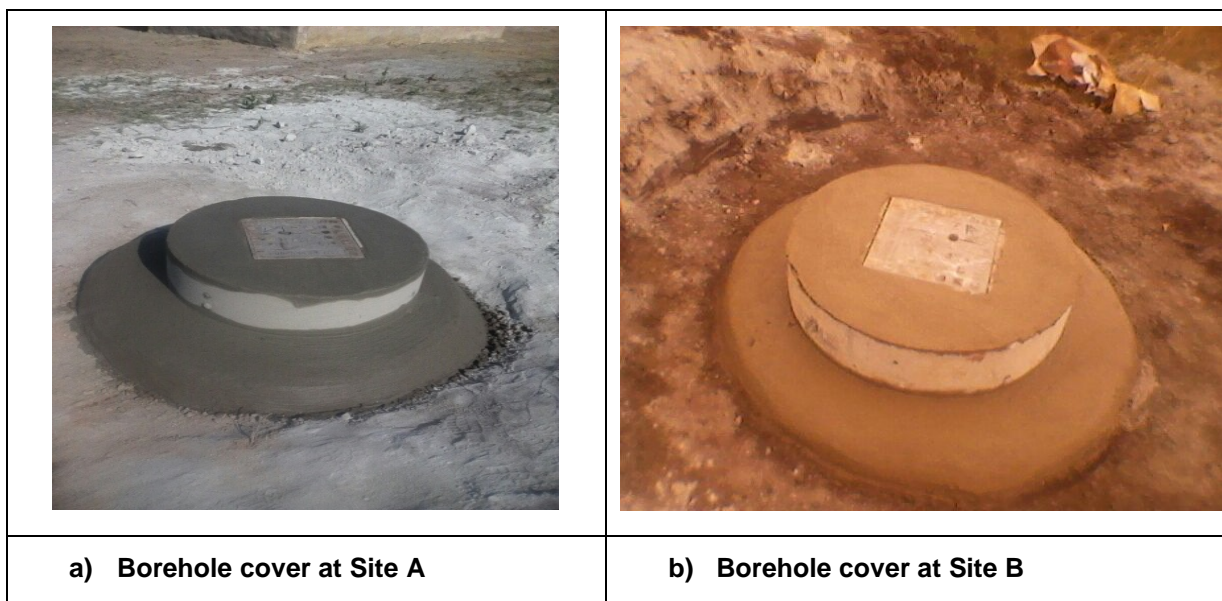


Figure 6-1: Installed borehole covers

7 Conclusions and recommendations

The findings of the hydrogeological assessment are summarised below:

- Based on the results of the geophysical surveys conducted for both the sites, fractured and weathered geological formations were identified, which were pegged for drilling.
- No water strikes were encountered at Site A. A single water strike was intercepted at Site B at a depth of 32 m bgl with a final airlift yield of 0.3 L/s.
- At Site A, a constant discharge test was undertaken for 250 minutes where the discharge was at 0.15 L/s with water level recovery monitoring thereafter occurring. The transmissivity was estimated in the order of 0.3 m²/day from the testing data.
- At Site B, a constant discharge test was undertaken for 24 hours where the discharge was at 0.2 L/s. Based on interpretation of the data using the FC Method, the recommended abstraction rate for the borehole is 0.03 L/s over an 8 hour pumping period. The transmissivity is estimated to be in the order of 0.2 m²/day.
- The parameters tested on the sample from Site A conforms to the SANS 241:2015 requirements for drinking water, with the exception of E. coli, nitrate, standard plate count, total coliforms, and the combined ratio of nitrate and nitrite. The presence of E Coli in the water sample could have been introduced into the borehole during the drilling process from the shallow zones. As the borehole was drilled to establish baseline conditions, in terms of water quality, and not intended for water supply purposes, the borehole was not disinfected.
- The analyses of the water sample retrieved from the borehole at Site B shows that the water shows elevated concentrations of Iron, Lead, Standard Plate Count, Total Coliforms and Turbidity when compared against SANS 241:2015 Drinking Water Standards and is therefore not suitable for human consumption. The elevated lead levels are not common with the geology in this area. Also, the borehole is positioned in an area where it is not likely to be impacted by any industrial activities that could have attributed to the lead in the sample.

Based on the above, the following is recommended:

- Diver equipment should be installed in the boreholes to record temporal groundwater level trends.

- The nearest rainfall gauging station (located within the catchment containing the monitoring borehole) should be identified to assist with understanding water level fluctuations in response to rainfall patterns. Should a gauging station not be located in close proximity, then a station should be installed close to the borehole.
- Regular monitoring of the borehole be undertaken to monitor parameters identified for SANS 241 (Abbrev.). It is further recommended that resampling of both these boreholes be undertaken as the water is deemed to be of inferior quality.
- Should the boreholes be considered for drinking water supply, the following treatment options can be considered to deem the water suitable for human consumption:
 - Methods to remove nitrate from water include ion-exchange, reverse osmosis, and biological reduction (denitrification) using a carbon source. The latter is normally used for treating large volumes of water. While effective, it is difficult to optimize and maintain and, requires advanced and intensive supervision (South African Water Quality Guidelines, 1996).
 - Where water is low in organic content, the iron is uncomplexed (such as in groundwater), aeration of the water may be effective in precipitating the iron from solution. Conventional coagulation and flocculation techniques, especially when coupled with the use of a strong oxidant and treatment, if necessary with lime, are usually effective in removing iron from water. Home treatment kits using iron exchange processes can be purchased, but these are expensive and treat only small volumes of water (South African Water Quality Guidelines, 1996).
 - For the presence of E.Coli., effective disinfection can be achieved either with chemical (e.g. chlorine) or physical methods (ultrafiltration or UV light). Home treatment may also be used, such as the addition of a teaspoon of bleach to 25 L of water, and allowing it to stand for 30 minutes before use, or boiling for at least 20 minutes (South African Water Quality Guidelines, 1996).
 - The choice of processes to be used to remove turbidity depends on the nature and degree of turbidity present. Typical processes include flocculation, settlement and filtration. Home treatment filtration kits are available, but these treat only small volumes of water (South African Water Quality Guidelines, 1996).

Prepared by

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A handwritten signature in black ink, appearing to read 'R Singh', written over the SRK Consulting logo.

R Singh, Pr.Sci.Nat.

Senior Engineering Geologist

Reviewed by

SRK Consulting - Certified Electronic Signature



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G Nel, Pr.Sci.Nat.

Principal Hydrogeologist/ Partner

All data used as source material plus the text, tables, figures, and attachments of this document have been reviewed and prepared in accordance with generally accepted professional engineering and environmental practices.

8 References

Department of Mineral and Energy Affairs, Extract of 1:250 000 Geological map sheet 2830 for Dundee, Government Printer, Pretoria, Republic of South Africa, (1988).

Department of Water Affairs and Forestry, (1996), South African Water Quality Guidelines, Volumes 1, 4 and 5, Second Edition. Pretoria.

Department of Water and Sanitation (2015), Extension of the KwaZulu-Natal Groundwater Monitoring Network- Terms of Reference for the Siting, Drilling and Test Pumping of 3 Boreholes in the Usuthu-Mhlathuze Water Management Area.

Directorate: Geohydrology, Extract of 1:500 000 Hydrologeological Map Series of the Republic of South Africa Durban 2928, Associated Printing, Cape Town, Republic of South Africa.

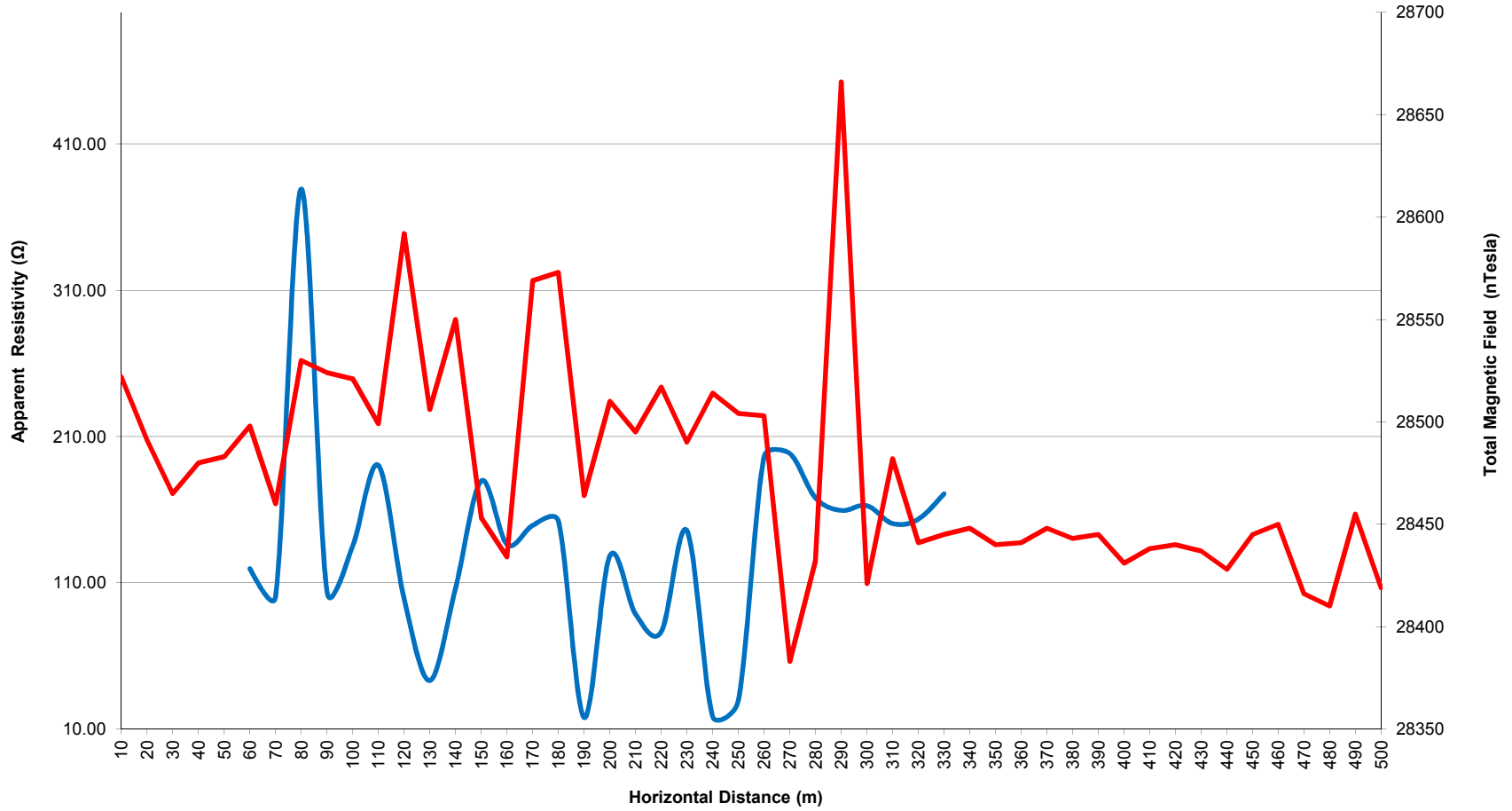
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Appendices

Appendix A: Field Geophysical Data

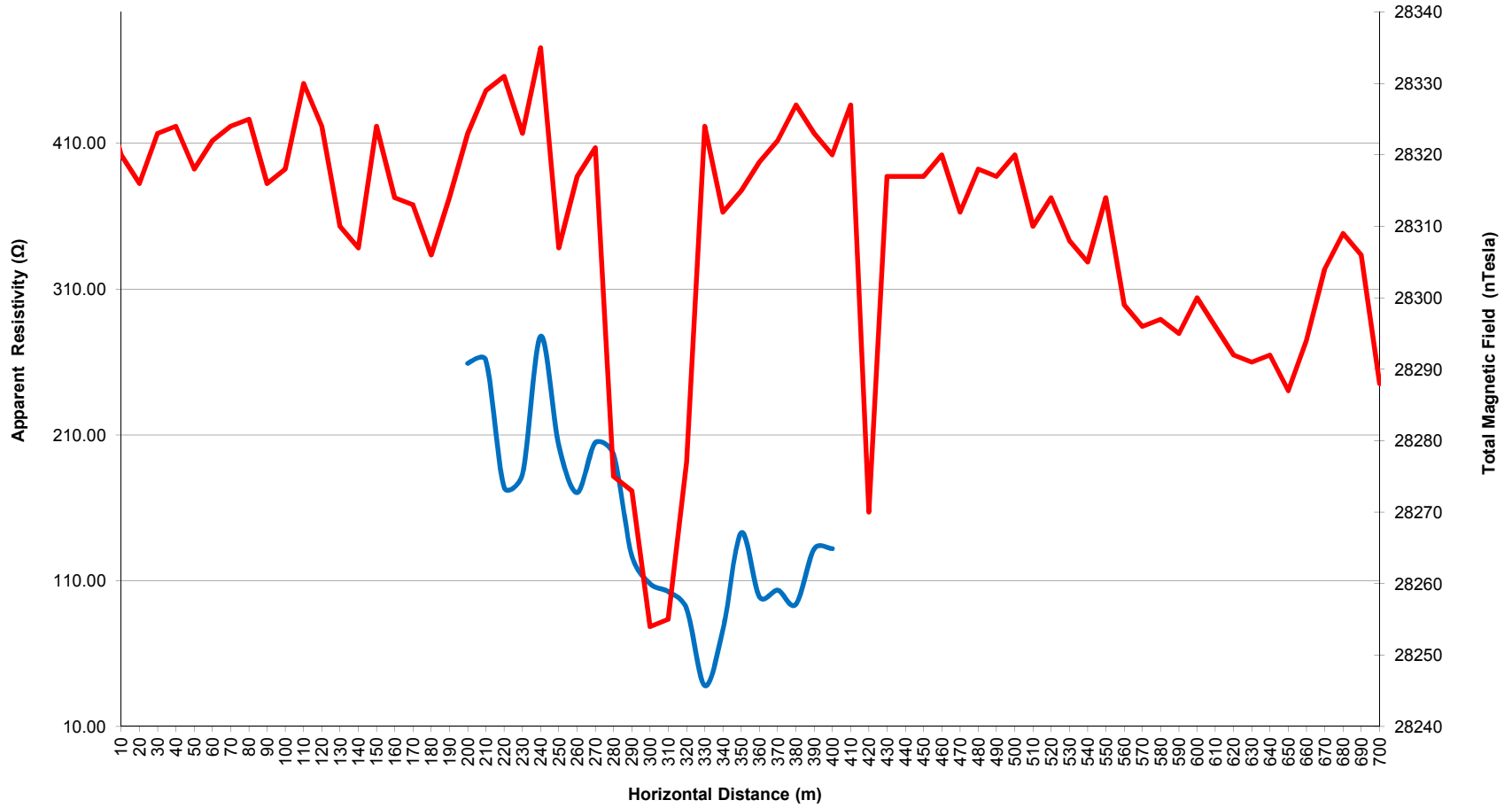
Site Details		Traverse Details			
Site ID	Ulundi		Latitude	Longitude	
Traverse number	1.0	Mag Traverse			
Farm name		Traverse start	-28.31098	31.38179	
Local Name	Tholwane	Traverse end	-28.31451	31.37871	
Farm owner details		Res Traverse			
Name	Nduna Ntombela (Hous	Traverse start	-28.31140	31.38142	
Cell	27.785,968,552	Traverse end	-28.31331	31.37976	
Potential Drilling Targets					
Date conducted	01/12/2015	Station number			
		190m	-28.31242	31.3807	
		240m	-28.31272	31.38033	
Resistivity Traverse - Electrodes at 40m spacing and readings collected at 10m intervals					
Magnetic Traverse - Data collected at 10m intervals					
Horizontal Distanc	Apparent Resistivity	Total Magnetic Field	Latitude	Longitude	Comment
		28499	-28.31098	31.38179	
10		28522	-28.31105	31.38173	
20		28491	-28.31112	31.38167	
30		28465	-28.31119	31.38161	
40		28480	-28.31126	31.38154	
50		28483	-28.31133	31.38148	
60	119.57	28498	-28.31140	31.38142	
70	100.61	28460	-28.31147	31.38136	
80	379.12	28530	-28.31154	31.38130	
90	103.99	28524	-28.31162	31.38124	
100	135.25	28521	-28.31169	31.38117	
110	190.20	28499	-28.31176	31.38111	
120	99.09	28592	-28.31183	31.38105	
130	43.15	28506	-28.31190	31.38099	
140	106.28	28550	-28.31197	31.38093	
150	179.64	28453	-28.31204	31.38087	Vandalized windmill (-28.31213 31.38106), has reservoir, rods fell dow
160	136.27	28434	-28.31211	31.38080	
170	149.15	28569	-28.31218	31.38074	
180	152.07	28573	-28.31225	31.38068	
190	17.88	28464	-28.31242	31.38070	Pegged
200	128.28	28510	-28.31239	31.38056	
210	88.63	28495	-28.31246	31.38050	
220	76.46	28517	-28.31253	31.38043	
230	145.55	28490	-28.31260	31.38037	
240	18.50	28514	-28.31272	31.38033	Pegged
250	29.47	28504	-28.31275	31.38025	
260	196.12	28503	-28.31282	31.38019	
270	198.49	28383	-28.31289	31.38013	15m from car
280	168.08	28432	-28.31296	31.38007	5m from car
290	159.39	28666	-28.31303	31.38000	Next to car
300	162.68	28421	-28.31310	31.37994	10m from car
310	150.39	28482	-28.31317	31.37988	outcrop dipping SW
320	153.40	28441	-28.31324	31.37982	
330	170.75	28445	-28.31331	31.37976	
340		28448	-28.31338	31.37970	
350		28440	-28.31345	31.37963	
360		28441	-28.31352	31.37957	
370		28448	-28.31359	31.37951	
380		28443	-28.31366	31.37945	
390		28445	-28.31373	31.37939	
400		28431	-28.31380	31.37933	
410		28438	-28.3138746	31.3792644	
420		28440	-28.3139452	31.3792028	
430		28437	-28.3140158	31.3791412	
440		28428	-28.3140864	31.3790796	
450		28445	-28.314157	31.379018	
460		28450	-28.3142276	31.3789564	
470		28416	-28.3142982	31.3788948	
480		28410	-28.3143688	31.3788332	
490		28455	-28.3144394	31.3787716	
500		28419	-28.31451	31.37871	

Geophysical Traverse Data for Ulundi



Site Details		Traverse Details			
Site ID	Nquthu	Latitude	Longitude		
Traverse number	1.0	Traverse start	-28.18736	30.61127	
Farm name		Traverse end	-28.18172	30.60970	
Local Name	Mkhonjane				
Farm owner details		Res Traverse			
Name	Councillor Selepe	Traverse start	-28.18736	30.61127	
Cell	27.782,828,037	Traverse end	-28.18414	30.61037	
		Potential Drilling Targets			
Date conducted	02/12/2015	Station number			
		330m	-28.18506	30.60956	
Additional information		Working Mono Type T7 Handpump (-28.19020 30.61496)			
Resistivity Traverse - Electrodes at 40m spacing and readings collected at 10m intervals					
Magnetic Traverse - Data collected at 10m intervals					
Horizontal Distance	Apparent Resistivity	Total Magnetic Field	Latitude	Longitude	Comment
0		28329	-28.18736	30.61127	
10		28320	-28.18728	30.61125	
20		28316	-28.18720	30.61123	
30		28323	-28.18712	30.61120	
40		28324	-28.18704	30.61118	
50		28318	-28.18696	30.61116	
60		28322	-28.18688	30.61114	
70		28324	-28.18680	30.61111	
80		28325	-28.18672	30.61109	
90		28316	-28.18663	30.61107	
100		28318	-28.18655	30.61105	
110		28330	-28.18647	30.61102	
120		28324	-28.18639	30.61100	
130		28310	-28.18631	30.61098	
140		28307	-28.18623	30.61096	
150		28324	-28.18615	30.61093	
160		28314	-28.18607	30.61091	
170		28313	-28.18599	30.61089	
180		28306	-28.18591	30.61087	
190		28314	-28.18583	30.61084	
200	259.05	28323	-28.18575	30.61082	15m from fence
210	261.08	28329	-28.18567	30.61080	
220	174.00	28331	-28.18559	30.61078	
230	182.84	28323	-28.18551	30.61075	c. 50m downgradient of Pit Latrine, ,
240	277.59	28335	-28.18543	30.61073	
250	202.71	28307	-28.18535	30.61071	
260	170.45	28317	-28.18527	30.61069	
270	204.78	28321	-28.18518	30.61066	
280	196.56	28275	-28.18510	30.61064	Upgradient of drainage line
290	127.13	28273	-28.18502	30.61062	Upgradient of drainage line
300	108.03	28254	-28.18494	30.61060	Upgradient of drainage line
310	102.48	28255	-28.18486	30.61057	Upgradient of drainage line
320	90.94	28277	-28.18478	30.61055	Upgradient of drainage line
330	38.08	28324	-28.18506	30.60956	Upgradient of drainage line
340	76.70	28312	-28.18462	30.61051	
350	142.91	28315	-28.18454	30.61048	
360	98.96	28319	-28.18446	30.61046	
370	103.52	28322	-28.18438	30.61044	
380	93.89	28327	-28.18430	30.61042	
390	131.79	28323	-28.18422	30.61040	
400	132.00	28320	-28.18414	30.61037	
410		28327	-28.18406	30.61035	
420		28270	-28.18398	30.61033	
430		28317	-28.18390	30.61031	
440		28317	-28.18381	30.61028	
450		28317	-28.18373	30.61026	
460		28320	-28.18365	30.61024	
470		28312	-28.18357	30.61022	
480		28318	-28.18349	30.61019	
490		28317	-28.18341	30.61017	
500		28320	-28.18333	30.61015	
510		28310	-28.18325	30.61013	
520		28314	-28.18317	30.61010	
530		28308	-28.18309	30.61008	
540		28305	-28.18301	30.61006	
550		28314	-28.18293	30.61004	
560		28299	-28.18285	30.61001	
570		28296	-28.18277	30.60999	
580		28297	-28.18269	30.60997	
590		28295	-28.18261	30.60995	
600		28300	-28.18253	30.60992	
610		28296	-28.18245	30.60990	
620		28292	-28.18236	30.60988	
630		28291	-28.18228	30.60986	
640		28292	-28.18220	30.60983	
650		28287	-28.18212	30.60981	
660		28294	-28.18204	30.60979	
670		28304	-28.18196	30.60977	
680		28309	-28.18188	30.60974	20m from fence
690		28306	-28.18180	30.60972	10m from fence
700		28288	-28.18172	30.60970	At fence

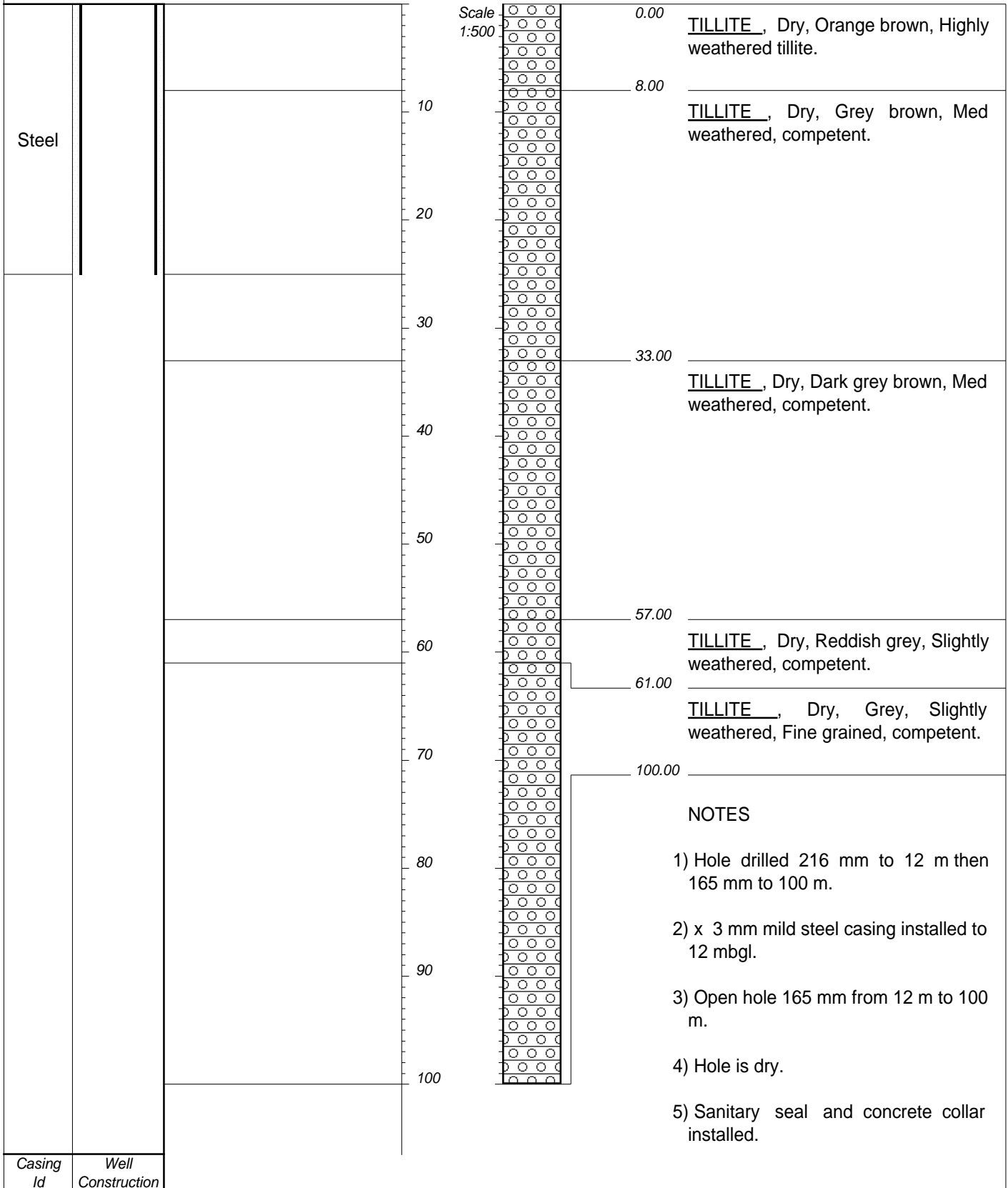
Geophysical Traverse Data for Nquthu



— Apparent Resistivity (Ω) 40m Electrode Spacing

— Total Magnetic Field (nTesla)

Appendix B: Borehole Logs



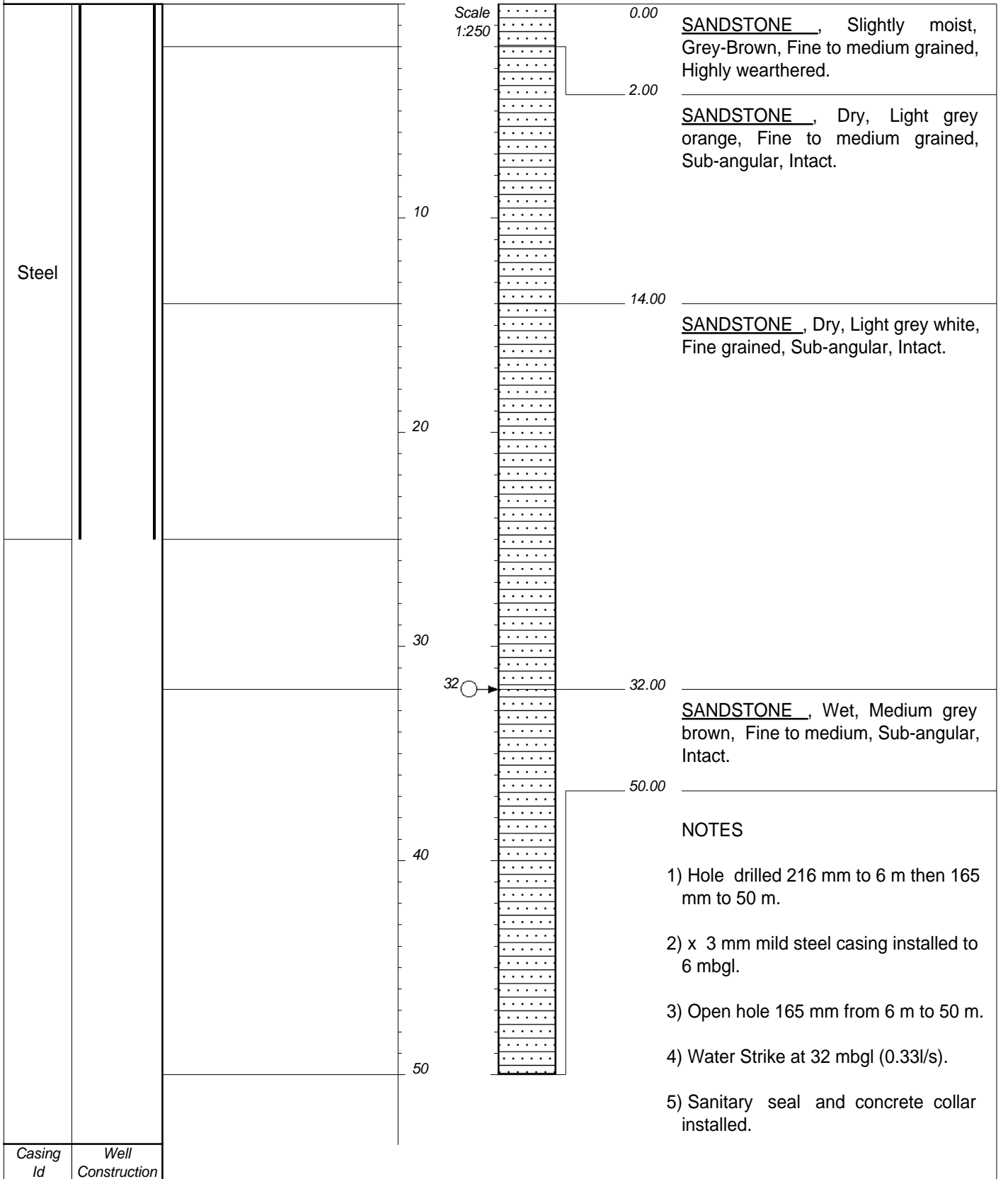
CONTRACTOR : National Drilling
MACHINE : Rotary Percussion
DRILLED BY :
PROFILED BY : L Goosen

INCLINATION : Vertical
DIAM : 165 mm
DATE : 29 February 2016
DATE :

ELEVATION : 607
X-COORD : 3138183
Y-COORD : -2831099

TYPE SET BY :
SETUP FILE : BH1PG-A4.SET

DATE : 22/06/2016 14:30
TEXT : ..UlundiBHLogs20160229.txt



CONTRACTOR : KwaManzi
 MACHINE : Rotary Percussion
 DRILLED BY :
 PROFILED BY : L Goosen
 TYPE SET BY :
 SETUP FILE : BH1PG-A4.SET

INCLINATION : Vertical
 DIAM : 165 mm
 DATE : 2 March 2016
 DATE :
 DATE : 22/06/2016 14:28
 TEXT : ..8NqutuBHLogs20160302.txt

ELEVATION : 1379
 X-COORD : 3061129
 Y-COORD : -2818734

Appendix C: Aquifer Testing Data

ATP PUMPS cc t/a AQUATEC PUMPS

P. O. Box 13634
 Cascades - 3202 Pietermaritzburg
 Phone 033-3455986 Fax 033-3949109

Constant Discharge & Recovery

Date Started **4/5/2016**

Project: Ulundi	Borehole Number:
Project No:	Observation on Borehole No:
Consultant: SRK	Distance to Observation Hole:
Pump Type: Sub Pump	Pumped Borehole Depth: 97 Diameter: 165mm
Pump inlet Depth: 90m	Static Water Level: 33.18m
Datum (above ground level): 0.65m	Available/Pumpable Drawdown: 56.82

Time			Drawdown (m)	Water Q/lph	Recovery Water Level (m)	TIME			Drawdown (m)	Water Q/lph	Recovery Water Level (m)
Date	Elapsed Time min	Time Hours				Date	Elapsed Time min	Time Hours			
	0						800				
	0.5		1.48		55.37		900	15:00			
	1		1.94		54.60		1000	16:40			
	1.5		2.60		54.03		1100	19:00			
	2		3.08		53.49		1200	20:00			
	2.5		3.57		53.46		1300	21:40			
	3		4.11		53.44		*1440	24-00			
	4		4.63		53.41		1500	24-00			
	5		5.15		53.38		1600	26-40			
	6		5.60		53.35		1700	28-20			
	7		6.11	0.15	53.31		1800	30-00			
	8		6.68		53.27		1900	31-40			
	9		6.94		53.24		2000	33-20			
	10		7.41		53.20		2100	35-00			
	12		8.00		53.14		2200	36-40			
	15		8.86	0.15	52.97		2300	38-20			
	20		10.45		52.73		2400	40-00			
	25		12.33		52.52		2500	41-40			
	30		14.08		52.39		2600	43-20			
	40		18.30	0.15	52.16		2700	45-00			
	50		21.43		51.78		2800	46-40			
	60	1:00	24.74		51.40		2900	48-20			
	70		28.65		51.22		3000	50-00			
	80		31.06		50.88		3100	51-40			
	90		34.43	0.15	50.57		3200	53-20			
	100		38.11		50.26		3300	55-00			
	120	2:00	42.15		49.66		3400	56-40			
	150	2:30	46.02		49.17		3500	58-20			
	200	3:20	52.1	0.15	48.7		3600	60-00			
	250	4:10	56.82		48.24		3700	61-40			
	300	5:00					3800	63-20			
	400	6:40					3900	65-00			
	500	8:20					4000	66-40			
	600	10:00					4100	68-20			
	700	12:00					4200	70-00			
	800						4320	72-00			

ATP PUMPS cc t/a AQUATEC PUMPS

P. O. Box 13634
 Cascades - 3202 Pietermaritzburg
 Phone 033-3455986 Fax 033-3949109

Constant Discharge & Recovery

Date Started **5/6/2016**

Project:	Borehole Number:
Project No:	Observation on Borehole No:
Consultant: SRK-Nquthu	Distance to Observation Hole:
Pump Type: Sub Pump	Pumped Borehole Depth: 49.10m Diameter: 165mm
Pump inlet Depth: 47m	Static Water Level: 10.55m
Datum (above ground level): 0.47m	Available/Pumpable Drawdown: 36.45m

Time			Drawdown (m)	Water Q/lph	Recovery Water Level (m)	TIME			Drawdown (m)	Water Q/lph	Recovery Water Level (m)
Date	Elapsed Time min	Time Hours				Date	Elapsed Time min	Time Hours			
	0						800				
	0.5		1.15		30.93		900	15:00			
	1		1.53		29.80		1000	16:40			
	1.5		1.91	0.2	29.15		1100	19:00			
	2		2.13		28.63		1200	20:00			
	2.5		2.38		28.02		1300	21:40			
	3		2.63		27.61		*1440	24-00			
	4		2.90		27.35		1500	24-00			
	5		3.20	0.2	26.42		1600	26-40			
	6		3.53		26.00		1700	28-20			
	7		3.87		25.68		1800	30-00			
	8		4.10		25.11		1900	31-40			
	9		4.49		24.53		2000	33-20			
	10		4.93	0.2	23.98		2100	35-00			
	12		5.30		22.40		2200	36-40			
	15		5.92		20.80		2300	38-20			
	20		6.58		18.47		2400	40-00			
	25		7.41		16.21		2500	41-40			
	30		8.34	0.2	14.30		2600	43-20			
	40		10.01		12.53		2700	45-00			
	50		11.45		10.49		2800	46-40			
	60	1:00	12.63	0.2	8.63		2900	48-20			
	70		14.40		7.20		3000	50-00			
	80		15.9		5.84		3100	51-40			
	90		17		3.85		3200	53-20			
	100		18.53		2.5		3300	55-00			
	120	2:00	19.42	0.2	1.74		3400	56-40			
	150	2:30	21.63		1.13		3500	58-20			
	200	3:20	23.2		0.65		3600	60-00			
	250	4:10	24.98	0.2	0.27		3700	61-40			
	300	5:00	26.04		0.00		3800	63-20			
	400	6:40	27.59				3900	65-00			
	500	8:20	29.2				4000	66-40			
	600	10:00	30.83	0.2			4100	68-20			
	700	12:00	32.05				4200	70-00			
	800						4320	72-00			

Appendix D: Laboratory Certificates

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20 Pentrich Road, PO Box 3391, Pietermaritzburg, 3200, KwaZulu-Natal, South Africa • S 29°37.934, E 30°22.685
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2016/06/02

ANALYTICAL REPORT

OUR REF: SRK CONSULTING DURBAN 4718/16
(O/N: Q42293)

COMPANY NAME: SRK CONSULTING DURBAN

CONTACT ADDRESS: SECTION A, 2ND FLOOR, IBM HOUSE, 54 NORFOLK TERRACE
OFF BLAIR ATHOLL, WESTVILLE, 4001

CONTACT PERSON: RIONA SINGH

SAMPLE TYPE: WATER SAMPLE

DATE SUBMITTED: 2016/04/08

Determinand	Units	Method No	SANS 241-1:2015 RECOMMENDED LIMITS	Results
				4718/16 SRK ULUNDI 08.04.16
Chloride	mg Cl/l	16	< 300	177
Colour*	mg Pt-Co/l	48	< 15	<1
Copper	µg Cu/l	83	< 2000	5.60
Dissolved calcium	mg Ca/l	8A	Not specified	62
Dissolved magnesium	mg Mg/l	9A	Not specified	55
<i>E. coli</i>	colonies per 100ml	31	0	8
Electrical conductivity at 25°C	mS/m	2	< 170	138
Fluoride	µg F/l	18A	< 1500	740
Iron	µg Fe/l	83	Chronic ≤2000 Aesthetic ≤300	1 457
Lead	µg Pb/l	83	< 10	1.94
Manganese	µg Mn/l	83	Chronic ≤400 Aesthetic ≤100	66
Nitrate*	mg N/l	Calc.	< 11	15.2
Nitrite*	mg N/l	65	< 0.9	<0.1
Combined Nitrate + Nitrite (sum of Ratios)*	-	-	<1	1.40
pH at 25°C	pH units	1A	5.0 - 9.7	7.7
Sodium	mg Na/l	6A	< 200	107
Standard plate count	colonies per ml	31	<1000	>10 000
Sulphate	mg SO ₄ /l	67	Acute Health ≤500 Aesthetic ≤250	16.1
Total alkalinity	mg CaCO ₃ /l	10	Not specified	290
Total coliforms	colonies per 100ml	31	<10	260
Total hardness*	mg CaCO ₃ /l	Calc.	Not specified	383
Turbidity	NTU	4	Operational ≤1 Aesthetic ≤5	1 060

Directors: Dr MMJ-F Talbot, Mr FD Urbaniak- Hedley (British), Mrs VR Talbot, Mr CA Haycock
Talbot & Talbot (Pty) Ltd • Company Registration Number: 2000/021732/07

Comments:

The parameters tested on the sample submitted (lab number 4718/16) conform to the SANS 241:2015 requirements for drinking water, with the exception of *E. coli*, nitrate, standard plate count, total coliforms, and the combined ratio of nitrate and nitrite.

- The presence of *E. coli* shows faecal contamination and renders this water unsuitable for human consumption unless properly disinfected.

Effective disinfection can be achieved either with chemical (eg. chlorine) or physical methods (ultrafiltration or UV light). Home treatment may also be used, such as the addition of a teaspoon of bleach to 25l of water, and allowing to stand for 30 minutes before use, or boiling for at least 20 minutes.

- The nitrate result on this sample is higher than the SANS specification of 11 mg N/l but lower than 20mg/l where we would see slight chronic risk to some babies. High nitrate causes methaemoglobanaemia, which reduces the oxygen carrying capacity of the blood. This especially affects young children and the aged.

Methods to remove nitrate from water include ion-exchange, reverse osmosis, and biological reduction (denitrification) using a carbon source. The latter is normally used for treating large volumes of water. While effective, it is difficult to optimize and maintain and, requires advanced and intensive supervision.

Nitrate stimulates algal growth, and thus may indirectly lead to secondary treatment problems. Home treatment kits using ion exchange processes can be purchased, but these are expensive and treat only small volumes of water.

- The turbidity of the water exceeds the SANS limit of <5 NTU and is one of the indirect indicators of microbiological water quality and of inefficient water treatment. The presence of turbidity in water results in a cloudy or muddy appearance, and may also affect taste and colour of the water.

The choice of processes to be used to remove turbidity depends on the nature and degree of turbidity present. Typical processes include flocculation, settlement and filtration. Home treatment filtration kits are available, but treat only small volumes of water.

- The total hardness indicates that this water is very hard where one would experience severe impairment of lathering of soap and severe scaling of appliances. Health and aesthetic effects include possible chronic effects in sensitive groups and an effect on the taste of the water.

In order to deem the water suitable for drinking, the complete SANS 241:2015 suite needs to be tested.

Note 1: All comments were made on the assumption that sampling was performed correctly.

Note 2: Standard Plate Count: >10 000 CFU/ml result equates to Too Numerous to Count (TNTC) and therefore out of specification limit.

Technical Signatory: Chemistry _____ Bacteriology _____

- This report relates only to the samples tested. This report shall not be reproduced, except in full, without the written approval of **TALBOT LABORATORIES**.
- Tests marked with an asterisk (*) in this report are not SANAS accredited and are not included in the Schedule of Accreditation for our laboratory.
- Opinions and interpretations expressed herein are outside the scope of SANAS accreditation.
- Note: Results marked with a double asterisk (**) have been sub-contracted to a peer laboratory.
- Note: Estimates of Uncertainty of Measurement may be obtained from the laboratory if required.

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2016/05/18

ANALYTICAL REPORT

OUR REF: SRK CONSULTING DURBAN 6566/16
 COMPANY NAME: SRK CONSULTING DURBAN
 CONTACT ADDRESS: SECTION A, 2ND FLOOR, IBM HOUSE, 54 NORFOLK TERRACE
 OFF BLAIR ATHOLL, WESTVILLE, 4001
 CONTACT PERSON: RIONA SINGH
 SAMPLE TYPE: POTABLE WATER
 DATE SUBMITTED: 2016/05/09

Determinand	Units	Method No	SANS 241-1:2015 RECOMMENDED LIMITS	Results
				6566/16 SRK NQUTU 08.05.16
Chloride	mg Cl/l	16	< 300	19
Colour*	mg Pt-Co/l	48	< 15	<1
Copper	µg Cu/l	83	< 2000	6.96
Dissolved calcium	mg Ca/l	8A	Not specified	22
Dissolved magnesium	mg Mg/l	9A	Not specified	19
<i>E. coli</i>	colonies per 100ml	31	0	0
Electrical conductivity at 25°C	mS/m	2	< 170	37
Fluoride	µg F/l	18A	< 1500	410
Iron	µg Fe/l	83	Chronic ≤2000 Aesthetic ≤300	2 193
Lead	µg Pb/l	83	< 10	14.6
Manganese	µg Mn/l	83	Chronic ≤400 Aesthetic ≤100	77
Nitrate*	mg N/l	Calc.	< 11	0.27
Nitrite*	mg N/l	65	< 0.9	<0.1
Combined Nitrate + Nitrite (sum of Ratios)*	-	-	<1	< 0.1
pH at 25°C	pH units	1A	5.0 - 9.7	7.6
Sodium	mg Na/l	6A	< 200	19
Standard plate count	colonies per ml	31	<1000	>10 000
Sulphate	mg SO ₄ /l	67	Acute Health ≤500 Aesthetic ≤250	5.00
Total alkalinity	mg CaCO ₃ /l	10	Not specified	133
Total coliforms	colonies per 100ml	31	<10	236
Total hardness*	mg CaCO ₃ /l	Calc.	Not specified	132
Turbidity	NTU	4	Operational ≤1 Aesthetic ≤5	92.6

Directors: Dr MMJ-F Talbot, Mr FD Urbaniak- Hedley (British), Mrs VR Talbot, Mr CA Haycock
 Talbot & Talbot (Pty) Ltd • Company Registration Number: 2000/021732/07

Comments:

The parameters tested on the sample submitted (lab number 6566/16) conform to the SANS 241:2015 requirements for drinking water, with the exception of iron, lead, standard plate count, total coliforms and turbidity.

- The iron content of the water exceeds the limit of 2 000µg Fe/l recommended by the SANS 241 specifications for drinking water. This concentration of iron in water has increasing effects in sensitive groups and can cause objectionable taste and appearance.

Where water is low in organic content, the iron is uncomplexed (such as in groundwater), aeration of the water may be effective in precipitating the iron from solution. Conventional coagulation and flocculation techniques, especially when coupled with the use of a strong oxidant and treatment, if necessary with lime, are usually effective in removing iron from water. Home treatment kits using iron exchange processes can be purchased, but these are expensive and treat only small volumes of water.

- The lead content of the water does not impose any adverse health effects except for a slight risk of behavioural changes and possibility of neurological impairment, if the exposure to lead from other sources, such as food, is not minimise.
- The presence of coliforms shows contamination from soil or vegetation which may become more serious after rain. The water is of doubtful quality and cannot be recommended for drinking unless properly disinfected.

Effective disinfection can be achieved either with chemical (eg. chlorine) or physical methods (ultrafiltration or UV light). Home treatment may also be used, such as the addition of a teaspoon of bleach to 25l of water, and allowing to stand for 30 minutes before use, or boiling for at least 20 minutes.

- The turbidity of the water exceeds the SANS limit of <5 NTU and is one of the indirect indicators of microbiological water quality and of inefficient water treatment. The presence of turbidity in water results in a cloudy or muddy appearance, and may also affect taste and colour of the water.

The choice of processes to be used to remove turbidity depends on the nature and degree of turbidity present. Typical processes include flocculation, settlement and filtration. Home treatment filtration kits are available, but treat only small volumes of water.

- The total hardness indicates that this water is slightly hard where lathering of soap would become slightly impaired. Further to this, slight scaling of kettles will also occur at these levels.

In order to deem the water suitable for drinking, the complete SANS 241:2015 suite needs to be tested.

Note 1: All comments were made on the assumption that sampling was performed correctly.

Note 2: Standard Plate Count: >10 000 CFU/ml result equates to Too Numerous to Count (TNTC) and therefore out of specification limit.

Technical Signatory: Chemistry_____ Bacteriology_____

- This report relates only to the samples tested. This report shall not be reproduced, except in full, without the written approval of **TALBOT LABORATORIES.**
- Tests marked with an asterisk (*) in this report are not SANAS accredited and are not included in the Schedule of Accreditation for our laboratory.
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- Note: Results marked with a double asterisk (**) have been sub-contracted to a peer laboratory.
- Note: Estimates of Uncertainty of Measurement may be obtained from the laboratory if required.

**APPENDIX
UNCERTAINTY OF MEASUREMENT**

Determinand	Method No	Uncertainty of Measurement (%)	Determinand	Method No	Uncertainty of Measurement (%)
Ammonia	64	± 4.80	Mercury (ICP-MS)	83	± 12.00
Aluminium (ICP-MS)	83	± 13.23	Molybdenum (ICP-MS)	83	± 9.50
Antimony (ICP-MS)	83	± 11.16	Nickel (AAS)	55A	± 3.80
Arsenic (ICP-MS)	83	± 10.56	Nickel (ICP-MS)	83	± 10.63
Barium (ICP-MS)	83	± 9.81	Nitrate/Nitrite	65	± 4.79
Beryllium (ICP-MS)	83	± 9.07	Orthophosphate	66	± 4.80
Boron (ICP-MS)	83	± 12.93	Oxygen Absorbed	39	± 4.40
Cadmium (ICP-MS)	83	± 10.10	Potassium (AAS)	7A	± 5.60
Calcium (AAS)	8A	± 2.56	pH at 25°C (Radiometer)	1	± 1.36
Chromium (ICP-MS)	83	± 8.96	pH Value 25°C (Eutech)	1A	± 1.12
Cobalt (ICP-MS)	83	± 8.91	Selenium (ICP-MS)	83	± 14.60
Copper (AAS)	24A	± 4.20	Silver (ICP-MS)	83	± 18.59
Copper (ICP-MS)	83	± 12.79	Sodium (AAS)	6A	± 5.08
Chemical Oxygen Demand	3	± 3.71	Strontium (ICP-MS)	83	± 8.18
Chloride	16	± 2.80	Sulphate	67	± 3.87
Electrical Conductivity at 25°C	2	± 2.74	Suspended Solids at 105°C	5	± 4.08
Fluoride (Lovibond)	18	± 4.82	Thallium (ICP-MS)	83	± 9.33
Fluoride (MultiDirect)	18A	± 4.10	Tin (ICP-MS)	83	± 10.21
Hexavalent Chromium	68	± 6.67	Titanium (ICP-MS)	83	± 15.52
Iron (AAS)	20A	± 6.20	Total Alkalinity	10	± 2.36
Iron (ICP-MS)	83	± 15.42	Total Dissolved Solids at 180°C	41	± 1.25
Lead (AAS)	26A	± 3.80	Total Solids at 105°C	59	± 0.44
Lead (ICP-MS)	83	± 10.06	Turbidity	4	± 1.70
Lithium (ICP-MS)	83	± 11.86	Uranium (ICP-MS)	83	± 7.95
Magnesium (AAS)	9A	± 5.15	Vanadium (ICP-MS)	83	± 11.15
Manganese (AAS)	19A	± 5.20	Zinc (AAS)	23A	± 4.63
Manganese (ICP-MS)	83	± 9.38	Zinc (ICP-MS)	83	± 15.13

Note: The Uncertainty of Measurement is calculated as a percentage and should be applied to the respective results.

For ICP elements, the UoM applies to total, dissolved and acid soluble metals.

Estimates of Uncertainty of Measurement for microbiological analyses can be provided on request.

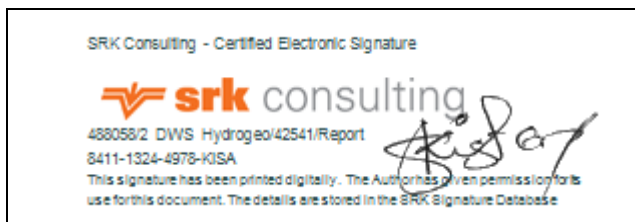
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