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Hydrogeological report for: Disaster Management, Rural Community Water Services, Resource Assessment and Resource Management for 21 Groundwater Production Boreholes within the Mtubatuba and Hlabisa Local Municipalities as part of the Umkhanyakude District Municipality

Version – Final

20 June 2016

Maragela Consulting Engineers

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EXECUTIVE SUMMARY

GCS (Water and Environmental Consultants) was contracted by Maragela Consulting Engineers (MCE) to undertake hydrogeological Consulting Services and contractor management for the Department of Water and Sanitation (DWS) rural water supply and resource management project. The project entailed the siting and drilling of 21 community water supply boreholes within the communities of Mtubatuba and Hlabisa local municipalities.

Objective

The main objective of this study was:

- To scientifically determine potential drilling targets for groundwater drought relief boreholes within the given communities as per the list supplied by the Department of Water and Sanitation (DW&S).
- To oversee drilling and test pumping and contractor management, and
- To equip boreholes with hand pumps.

Methodology

To archive the above mentioned objectives, the following methodology was applied:

- **Desk Study**:
    - A detailed desktop study of all hydrocensus boreholes, geohydrology, hydrology and geology in the study area was conducted. National Groundwater Database (NGDB) and the Hydrochemical databases were reviewed to establish existing groundwater users and groundwater availability.
- **Liaison and coordination**:
    - GCS applied a thorough and complete process of Liaison by considering heads of villages and local authority guidance. Project kick-off meetings were held in the Mtubatuba and Hlabisa local municipalities to make sure that all the local authorities and community members are aware of the project and to supply GCS with areas were they like the boreholes to be drilled.
- **Site assessment and borehole verification**:
    - When the local authorities and community members have indicated the site where they would like their borehole to be drilled, GCS undertook a detailed assessment on the site by looking at site topography, local geology from rock outcrops, and presence of springs and hydrocensus boreholes.

- **Borehole siting and drilling**:
    - Resistivity and magnetometer (Mag) geophysical methods were used to site all boreholes. The geology information gathered during desktop study, site walkover assessment and the structural information collected from the geophysical survey was used to decide on the final drilling position. Drilling was conducted by Drilling Africa.
- **Pump testing:**
    - A three hour step test and a 12 to 24 hour constant test were conducted on all successful boreholes to determine the aquifer properties and to work out the boreholes sustainable yields.
- **Water quality analysis:**
    - Water samples were collected from all pump tested boreholes and sent to Talbot & Talbot (Pty) Ltd and Yanka Laboratories (Pty) Ltd. Both laboratories are SANAS accredited.
- **Data processing, analysis and presentation:**
    - Data was assessed by applying dedicated hydrogeological and numerical software and presented in the form of graphs, tables and piper plots.
- **Pump installations**:
    - From the total of 21 drilled boreholes, 17 boreholes were equipped with mono hand pumps by Bay Side trading (Pty) Ltd. one borehole was equipped with a submersible electric pump by a 3rd party without any consultation. This was communicated to the client.
- **Handing over**:
    - After the installation of pumps the borehole were handed over to the community. Borehole handing over forms supplied by the DW&S were signed and are attached in the appendix section of this report.

Summary of report findings

- Data obtained through the desktop study indicates that ward 2, 6, 13, 14, 16, 12 and 7 are predominantly underlain by basalts and/or rhyolitic lava. Ward 17 is underlain by basalts, sandstone and shales. Ward 8, 9 and 10 occur on argillaceous sands.

- The hydrogeology for the entire study area is predominantly controlled by the underlying geology. The hydrogeology predominantly consist out of consolidated and unconsolidated sediments as well as basaltic and rhyolitic lava from the Karoo Supergroup.
- The aquifer present in the centre portion of the UMkhanyakude District Municipality (UKDM) can be classified as a confined aquifer system, with the remainder to the west and the east as unconfined to semi-confined aquifers. Groundwater recharge in the eastern coastal region is in the order of 5 to 18 % of the Mean Annual Rainfall (MAR). In the western region of the study area, groundwater recharge is estimated to be in the order of 1 to 5 % of the MAR. Groundwater throughout the entire study area is in the order of 5 to 40 meters below ground level (mbgl). The detailed hydrogeological setting is discussed in Section 3.5.

Field Work

- A review of the National Groundwater Archive database, indicated that there are a number of groundwater boreholes within the study area. A total number 30 boreholes were visited. The boreholes are scattered throughout the various wards. Visited boreholes are listed in Table 4-1 and Table 4-2.
- Geophysical investigations, by means of Electrical Resistivity Tomography (ERT) and Magnetic methods, were undertaken within each ward to identify drilling targets.
- A total of 21 boreholes were drilled in various wards. The boreholes were drilled using percussion methods in hard rocks and mud rotary methods in unconsolidated sands and clays.
- Subsequently after drilling, a 3 hour steps and 12-24 hour constant tests and recovery test were conducted by Bay Side Mode Trading (Pty) Ltd. The purpose of the pump tests were to establish well performance parameters as well as to determine the safe yield for each borehole drilled. Boreholes which were drilled and pump tested are listed in Table 5-1.
- Water quality samples were taken from the drilled boreholes. Samples were delivered to Talbot & Talbot Laboratories (Pty) Ltd and Yanka Laboratories (Pty) Ltd for analyses. Both inorganic and microbial constituents were analysed.

Hydrochemistry

- Initial hydrochemistry result from Talbot & Talbot indicated elevated iron concentration, above SANS 241 chronic limits, for boreholes in eight (8) communities. Therefore, additional samples were collected and submitted to Yanka Laboratories (Pty) Ltd to confirm the elevated iron concentrations. The results for the combined chemistry analysis are summarized as follows:
    - All boreholes, with the exception of KZN 15-0647 (Ward 7), exhibit neutral pH conditions.
    - Elevated turbidity above SANS 241-1:2015 aesthetic limits are observed at all boreholes, with the exception of KZN 15-0637, KZN 15-0647 and KZN 15-0646.
    - All boreholes, with the exception of boreholes KZN 15-0651, KZN 15-0653, KZN 15-0654, KZN 15-0655, KZN 15-0637, KZN 15-0635 and KZN 15-0649, exhibit elevated sodium (Na) and chloride (Cl) concentrations above SANS 241 aesthetic limits.
    - Nitrate (NO_3), nitrite (NO_2), sulphate (SO_4), fluoride (F), dissolved aluminium (Al), dissolved lead (Pb) and dissolved manganese (Mn) are elevated in some boreholes.
    - Dissolved iron (Fe) concentrations are elevated above SANS 241 chronic limits at KZN 15-0640 and KZN 15-0650.
    - Total coliforms and Escherichia coli (E. Coli) are elevated above aesthetic and chronic limits at borehole KZN 15-0651, KZN 15-0648, KZN 15-0653, KZN 15-0635 and KZN 15-0643.

Borehole sustainable yields

From the pump test conducted, as well as taking into consideration the physical construction of each borehole, the sustainable yields were determined. The table below summarises the sustainable yields as well as exploitation yields calculated.

Borehole exploitation and sustainable yields summary

Community	BH ID	Ward No	Sustainable Yield (l/s)	Water supply potential (people)
Hlambanyathi	KZN 15-0650	Ward 1	1.5	5184
Ngebeza	KZN 15-0651	Ward1	2	6912
Msane	KZN 15-0648	Ward 2	0.1	346
Nkanjini	KZN 15-0653	Ward 2	6	20736

Community	BH ID	Ward No	Sustainable Yield (l/s)	Water supply potential (people)
Macekeni	KZN 15-0654	Ward 2	1.5	5184
Emajikeni	KZN 15-0655	Ward 2	0.7	2419
Banzaneni	KZN 15-0637	Ward 3	1.5	5184
Nkodibe	KZN 15-0641	Ward 6	0.4	1382
Nkonjane	KZN 15-0647	Ward 7	0.08	276
Shikishela	KZN 15-0639	Ward 12	0.09	311
Madwaleni	KZN 15-0640	Ward 12	0.01	35
Nkombose	KZN 15-0643	Ward 13	0.5	1728
Ophaphasi	KZN 15-0644	Ward 13	0.01	35
kwaMshaya	KZN 15-0642	Ward 14	1.2	4147
Maswazini	KZN 15-0646	Ward 1	0.7	2419
Mapheleni	KZN 15-0649	Ward 16	0.2	691
Ogengele	KZN 15-0645	Ward 17	0.1	346
Nkundusi	KZN 15-0635	Ward 9	0.15	518

Risks and management

Boreholes used for drinking water abstraction can be exposed to external contamination if not properly constructed. Effective management can however, reduce the risk to allow for sustainable and prolonged use of the groundwater boreholes. The table below highlights some risks discussed in this report as well as a summary of management steps that can be taken to minimise risk and prolong the borehole life.

Summary of potential borehole risk and management plan

Preliminary Risks Identified	Preliminary Management Plan		
	Task	**Objectives**	**Proposed steps**
Over production from boreholes Poor borehole pump maintenance Poor borehole check-ups and routine water quality and quantity testing. Borehole vandalism. Urbanisation which could destroy unmarked or non-visible boreholes. Domestic waste disposal around or upstream of boreholes.	Community Awareness	The objective of community awareness is to inform water users of the sensitivity of the groundwater	Bi annual meetings with all residents situated around the abstraction boreholes. Informative sessions where water users are shown steps to improve borehole life and how to minimize impact on the groundwater aquifer (i.e. reduce waste stockpiles, do not construct pit latrines upstream of boreholes).
	Monitoring	The objective of the groundwater monitoring is to record groundwater levels and monitor groundwater quality to ensure that the impact on the underlying aquifer is kept at minimum or insignificant.	Monitoring on a routine basis. Bi-Annual borehole purging of boreholes with declining yields or deteriorating water quality. Quarterly water level measurements for borehole(s) fitted with a pump. Quarterly macro (inorganic and microbial) analyses of the borehole(s) that are being used to supply drinking water. Analysis should include, but is not limited to: pH, EC, Ca, Mg, Na, K, Cl, F, NO_3, NH_3, SO_4, Fe, Mn, Zn, Turbidity, Faecal coliforms, E-coli, Total coliforms, Heterotrophic plate count
	Maintenance	The objective is to ensure long term and regular maintenance of all boreholes supplying water by means of mechanical or electrical equipment.	Bi annual visits by the hand pump manufacturer to ensure that the installed equipment is functioning correctly without causing harm to its users or the groundwater aquifer.

Recommendations

- It is recommended that the preliminary water management plan be implemented to ensure prolonged use of the boreholes drilled in the different wards.
- Follow up water sampled be obtained from the boreholes that indicated high levels of iron concentrations. Other constituents like fluoride, sulphate and metals were also detected above the allowable drinking limits on boreholes. All boreholes shows above standard chloride and sodium concentrations.
- It is recommended that water obtained from all the boreholes be boiled before drinking use. Boiling the water will destroy any microbial organisms that may have established in the boreholes after water quality testing. The communities should be made aware of the risks that may follow if water is not prepared correctly before use.
- The alternative drilling targets in Ophaphase community (ward 13 in Mtubatuba) and Makopini need to be considered as the boreholes in these communities showed very small yields and deep water levels.
- It is recommended that more boreholes be drilled within the wards identified. Some residents will need to travel great distances to the boreholes that were drilled to get water. Increasing the number of groundwater boreholes within each ward, will help raise the water satisfaction level throughout the catchment.

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1 INTRODUCTION

GCS (Water and Environmental Consultants) was contracted by Maragela Consulting Engineers (MCE) to undertake hydrogeological Consulting Services and contractor management for the Department of water and Sanitation rural water supply and resource management project.

The objective of the rural water supply and resource management is to supply fresh water to the communities of Mtubatuba and Hlabisa local municipalities. This is an emergency response to drought conditions and water scarcity the region of uMkhanyakude District Municipality is currently experiencing. The project consist the drilling and pump testing of 14 boreholes in Mtubatuba and 7 boreholes in Hlabisa. These boreholes were equipped with hand pumps for usage by the community.

1.1 Scope of work

The scope of work for the project involved the following:

- Preparation of Project Execution Plans.
- Liaising and communication with the community and local authorities.
- Conducting a comprehensive hydrocensus survey to locate groundwater usage in the immediate vicinity of the site such as boreholes and springs.
- Scientifically siting 21 production boreholes.
- Drilling a total of 21 boreholes, 14 in Mtubatuba and 7 in Hlabisa local municipality areas.
- Managing and supervision of drilling and pump test contractors.
- Pump testing of all successful boreholes.
- Sampling of all successful production boreholes for water quality analysis.
- Allocation of numbers to un-numbered existing and newly drilled boreholes based on the implemented unique numbering system of KZN and subsequent planting of a pole with the engraved allocated number as specified.
- Project progress reporting, weekly or as required by the Employer.

2 METHODOLOGY

The following outlines the methodology in which the tasks were carried to achieve the objectives of the project. The project was done in phases as described below:

Phase 1: Desktop study.

The desktop assessment was carried out by evaluating all the available information regarding the geology and hydrogeology of the study area. The desktop study was broken down as follows:

- Site description and literature assessment on geographical setting of the study area such as site location, rain fall, topography and surface drainage geology and hydrogeology.
- Delineation of the target communities and generation of the site maps.
- Contact and communication with the District Municipality and Local Municipality.
- Preliminary household count.
- Planning and logistics
- team briefing meetings and client briefing meetings
- Contractor briefing meetings

Phase 2: Site Assessment

1. **Hydrocensus**

This included visual assessment of the sites look at the topography, surface drainage and accessibility to the sites. The verification of all hydrocensus boreholes was conducted and the GPS coordinates were taken at each borehole location to update the hydrocensus map. Data collected at boreholes include GPS positions, static water levels (where possible) and borehole utilization.

2. **Borehole siting**

Resistivity and magnetic methods were used to site all boreholes. The geology information gathered during desktop study, site walkover assessment and the structural information collected from the geophysical survey was used to decide on the final drilling position.

Phase 3: Drilling and testing

1. **Drilling**

Drilling of 21 boreholes, 14 in Mtubatuba area and 7 in Hlabisa area, was done by Drilling Africa. All boreholes in hard rock formations were drilled using percussion drilling method and those in unconsolidated sands were drilled using mud rotary drilling methods.

2. **Aquifer testing**

Testing of boreholes was done by Bay Side Mode Trading (Pty) Ltd. Pump tests were conducted on all successfully drilled boreholes. This was done to determine aquifer properties such as transmissivity (T) and the hydraulic conductivity (K).

3. **Sampling and Laboratory testing**

Water samples were collected from all pump tested boreholes and sent to Talbot & Talbot (Pty) Ltd and Yanka Laboratories (Pty) Ltd. Both are SANAS accredited laboratories.

4. **Data processing, analysis and presentation**

Data was assessed by applying dedicated hydrogeological and numerical software. This includes conceptualization of aquifers, hydrochemical interpretation and a brief risk assessment according to best practice guidelines and the Risk Assessment for Water Quality Management, WRC, TT90/97. All the data gathered is presented in the form of table, graphs and maps in this report.

Phase 4: Pump Installations and handing over

The installation of borehole hand pumps was undertaken by Bay Side Trading under supervision of GCS. The installation depths were supplier by GCS. Immediately after the installation of pumps, Maragela Consulting and GCS visited the boreholes to undertake the commissioning process. Commissioning forms were signed and included in the appendix section of this report.

3 PHASE 1: DESKTOP STUDY

The following data sources were used during the desktop assessment:

- Environmental Management Framework report for uMkhanyakude District Municipality prepared by the Council for Geoscience, 2012.
- 1:250 000 geology map of St Lucia
- 1:50 000 hydrogeology map of the Republic of Southern Africa.
- The Department of Water and Sanitation (DW&S) GRIP database.
- Google Earth images.
- Municipal Demarcation Board website.
- Statistic South Africa website

3.1 Description of the study area

The study area falls under UMkhanyakude District Municipality (UKDM) in the northern province of Kwazulu Natal. UKDM covers more than 12 818 km^2 in the north eastern part of KwaZulu-Natal province. The northern boundary is defined by the international border with Mozambique and the eastern boundary by the Indian Ocean shoreline extending southwards to St Lucia estuary. The western boundary extends to the Hlabisa area and incorporates the Hluhluwe-iMfolozi Park conservation area. The UKDM region includes the following Local Municipalities; uMhlabuyalingana, Jozini, The Big 5 False Bay, Hlabisa and Mtubatuba.

The drilling of 21 boreholes for rural water supply was undertaken in the Mtubatuba and Hlabisa local municipalities. Table 3-1 below lists the community names and ward numbers in which the boreholes were drilled. Figure 3-1 is a locality map of the study area displaying the geographical distribution of the Mtubatuba and the Hlabisa wards.

Table 3-1: Community names and ward numbers.

Community name	Ward number	Local Municipality	Number of boreholes Drilled
Msane	2	Mtubatuba	1
Nkodibe	6	Mtubatuba	1
Nkombose	13	Mtubatuba	1
Ophaphase	13	Mtubatuba	1
KwaMshaya	14	Mtubatuba	1
Ebaswazini	16	Mtubatuba	1
Mapheleni	16	Mtubatuba	1
Ogengele	17	Mtubatuba	1
Madwalwni	12	Mtubatuba	1
Shikishela	12	Mtubatuba	1
bazala	8	Mtubatuba	1
Mfekayi	10	Mtubatuba	1
Nkundusi	9	Mtubatuba	1
Nkonjaneni	7	Mtubatuba	1
Nkanjini	2	Hlabisa	1
Macekeni	2	Hlabisa	1
Emajikeni	2	Hlabisa	1
Makopini	2	Hlabisa	1
Hlambanyathi	1	Hlabisa	1
Ngebeza	1	Hlabisa	1
Banzaneni	3	Hlabisa	1

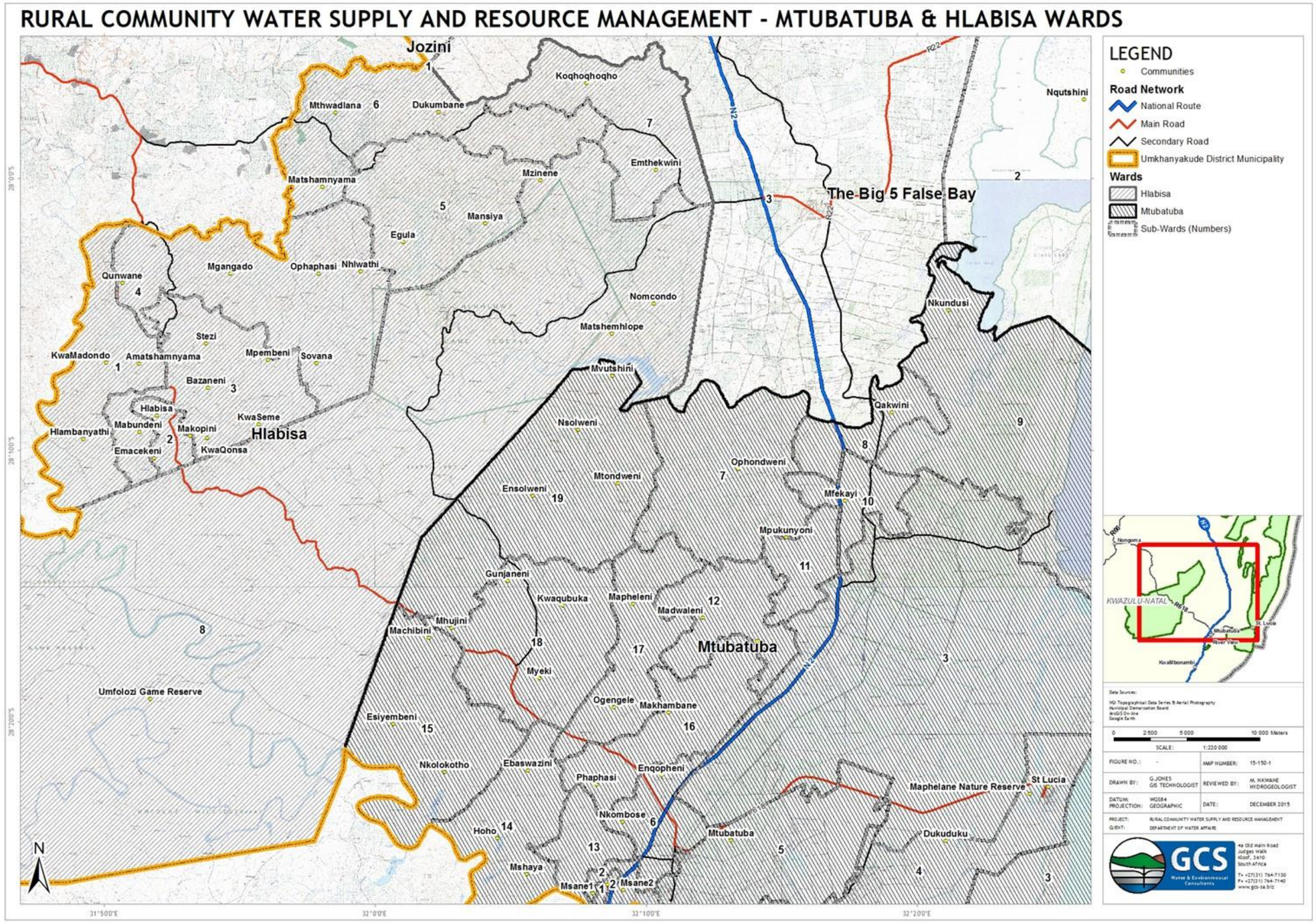

Figure 3-1: Locality map displaying the geographical locations of Mtubatuba and Hlabisa local municipality wards

3.2 Rainfall

Rainfall in the study area is strongly seasonal with rain occurring in the summer period. The mean annual rainfall (MAR) in the study area ranges between 700 and 800 millimetres per annum (mm/a). Groundwater recharge in the eastern coastal region of the study area is estimated to be in the order of 5 to 18 % of the MAR. In the western region of the study area, groundwater recharge is estimated to be in the order of 1 to 5 % of the MAR.

3.3 Topography and surface drainage

The topography in the Mtubatuba area is characterized by relatively flat terrain with low rolling hills with elevations ranging from 30 m to 250 m above mean sea level (mamsl). In the Hlabisa area, the topography is mountainous with elevations ranging between 400 mamsl to 600 mamsl. Drainage is predominantly from west to east across the length of the study area into the ocean.

3.4 Regional geology

The regional geology of the UMkhanyakude District Municipality is described by G.A. Botha and R.G. Sigh in the Environmental Management Framework (EMF) for uMkhanyakude District Municipality (UKDM). The oldest rocks in the UKDM are the 3.2 Ga Kaapvaal craton granites and the overlying Pongola Supergroup sedimentary and volcanic rocks deposited about 2.9 Ga ago. These basement rocks are unconformably overlain by the Permo-Triassic Karoo Supergroup sediments which are approximately 260-210 Ma old. The description of the basement rocks and the overlying rocks are further discussed below.

Figure 3-2 illustrates the regional geology of the study area. It can be seen that the rocks underlying ward 2, 6, 13, 14, 16, 12 and 7 predominantly consists out of basalts and/or rhyolitic lava. Ward 17 is predominantly underlain by basalts, sandstone and shales. Ward 8, 9 and 10 occur on argillaceous sands.

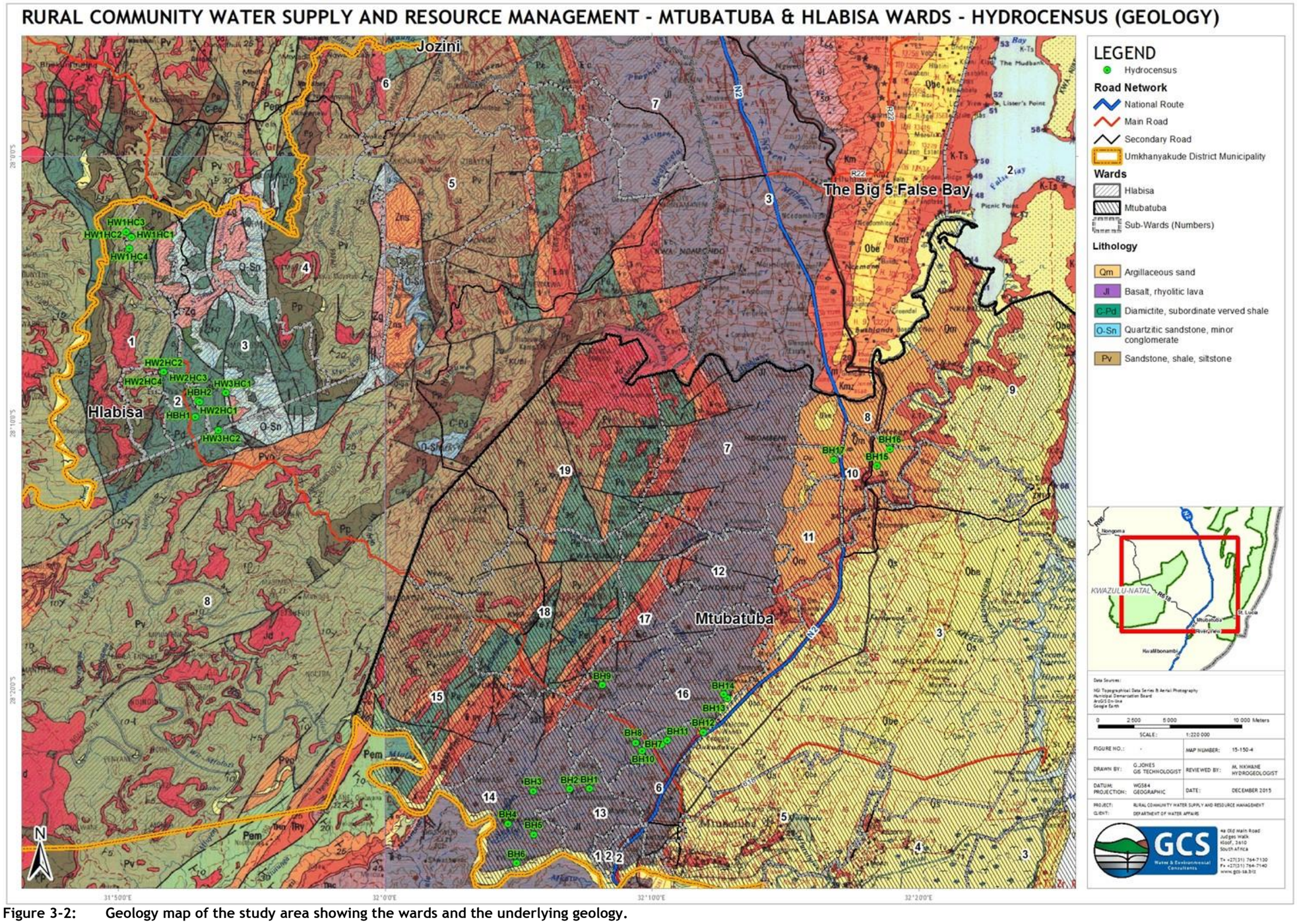

Figure 3-2: Geology map of the study area showing the wards and the underlying geology.

3.4.1 Basement rocks

The oldest Swazian basement rocks belonging to the Mandeva Formation (Mozaan Group, Pongola Supergroup) comprise the conglomerates, banded iron formation and shale. These rocks have been intruded by the more extensive coarse grained porphyritic biotite granite and tonalite of the Nzimane Granite. The distinctive Wela Formation quartzite, schist and banded Iron-formation are exposed in the Wela and Nzimane River valleys. These basement units are unconformably overlain by the Ordovician-Silurian sandstones of the Natal Group to the east and north of Hlabisa town. The distribution of these rocks is strongly influenced by north-south oriented block faulting (Botha and Singh, 2012).

3.4.2 The Karoo Supergroup

The Karoo Supergroup in UKDM region is represented by the rocks, from old to youngest, of the Dwyka and Ecca groups. The Permian to Triassic Emakwezeni, Ntabene, Nyoka and Clarens Formations form the high hills defining the eastern boundary of the park and extend northwards as irregular, steep hilly terrain. The Lebombo Group volcanic rocks form the low-lying area extending through Ngweni, Mhlosinga and Bayala and the prominent Lebombo mountains. The stratigraphy of the Karoo Supergroup in the UKDM region is summarised in Table 3-2.

Table 3-2: Rock types of the Karoo Supergroup stratigraphy within UKDM

	GROUP	FORMATION	ROCK TYPES	THICKNESS
Karoo Supergroup	Lebombo	Movene	Basalts	+2000m
		Jozini	Reddish Rhyodacites and Rhyolites	
		Letaba	Mafic pincritic/olivine-rich Basalts	
	Stormberg	Clarens	Very fine grained Sandstone	<45m
		Nyoka	Red & Purple mudstone Medium Grained sandstone Shale and Siltstone	250m
		Ntabene	Sandstones and mudrocks	100m
	Beaufort	Emakwezini	Mudstone Coal Medium to coarse grained sandstone	500-600m
	Ecca	Volksrust	Interbedded shales and siltstone	140m
		Vryheid	Medium to coarse grained Sandstones. Micaceous shales. Coal	500m
		Pitermaritzburg	Carbonaceous Siltstone and Shales	200m
	Dwyka	Elandsvlei	Massive Diamictites Conglomerates Pebbly Sandstones Mudrocks.	-
		Mbizane		

3.4.3 Maputaland Group

The Maputaland group sediments characterized the eastern part of the study area within Mtubatuba local municipality and comprise of unconsolidated to semi-consolidated sand deposits which are divided into six Formations, Uloa, uMkwelane, Port Durford, Kosi Bay, Kwambonambi and Sibayi Formations. Figure 3-3 illustrates a schematic diagram of the Maputaland stratigraphy. These sand deposits occur mainly to the east of the project area.

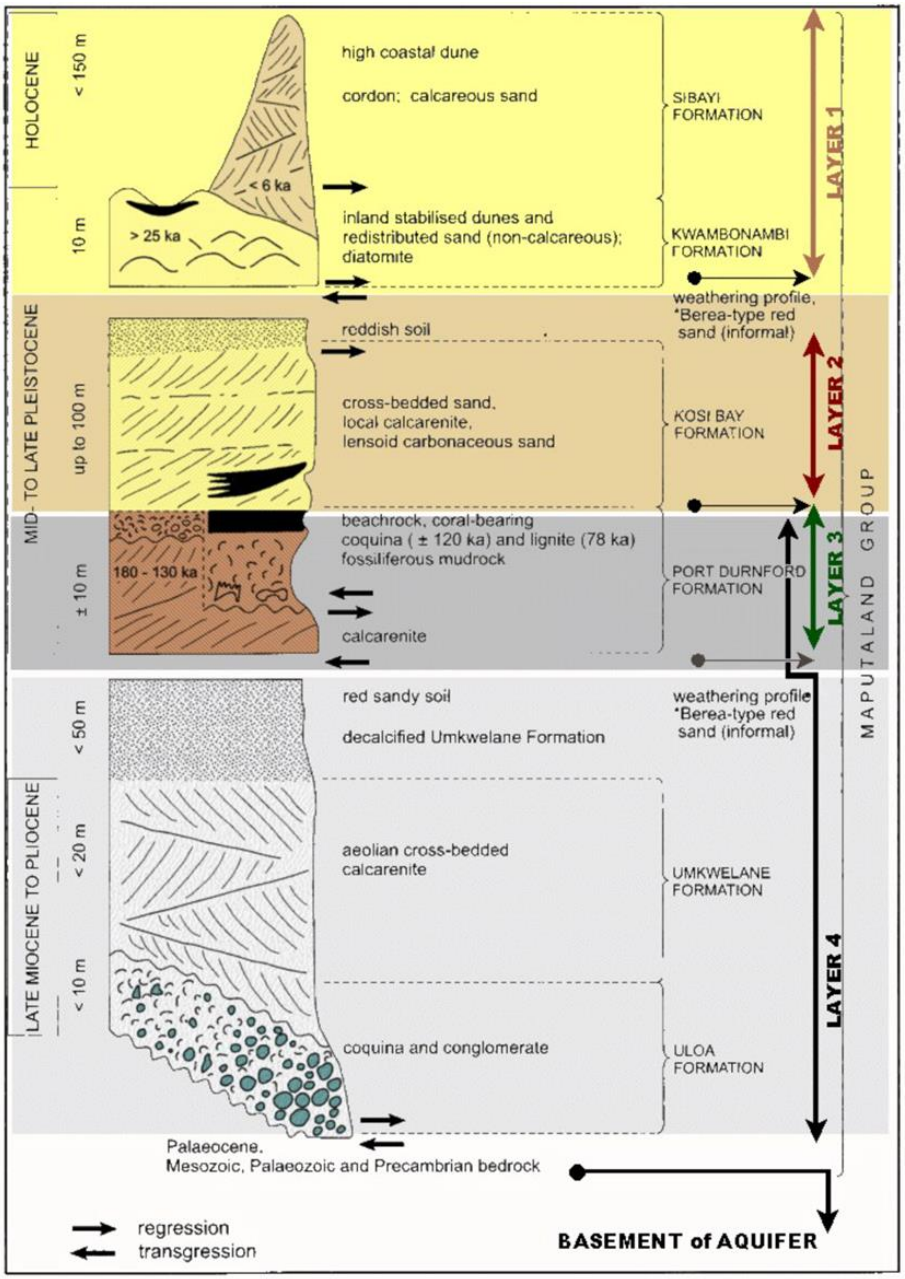

Figure 3-3: Maputaland Stratigraphy

3.5 General Hydrogeological setting

The groundwater associated with UKDM area is directly controlled by the underlying geology of the area as described above. The groundwater can be separated into the primary aquifer in the unconsolidated sediments from the secondary aquifers in the older fractured rock system. The rate of recharge to the groundwater and the storage and discharge from the aquifers is hydrologically different for the two aquifer systems. In the primary aquifer the groundwater is stored in the pore spaces (matrix porosity) between the unconsolidated sand particles while it is mainly stored in fractures and fissures in the secondary aquifers with little storage in the pore spaces of the consolidated rock material. The rate of surface water infiltration can be much quicker in unconsolidated sediments than in hard rocks.

3.5.1 Primary Aquifers

Primary aquifers occur on the eastern coastal region of the study area. These primary aquifers are Quaternary sand deposits of the Maputaland Group. These deposits are characterised by shallow groundwater with moderate to good borehole yields ranging from > 0.5 to > 3 l/s. Perched aquifer conditions in these sand deposits often result in numerous freshwater pans and lakes which play an important role in the geohydrology of the coastal area. Groundwater recharge in these primary aquifers has been calculated between 5% and 18% of the mean annual rainfall. The groundwater associated Maputaland group is commonly of hydrochemical class “Type D” where the groundwater is cation-dominated by Na+ and/or K+ and anion-dominated by Cl- and/or SO_4. The porosity of the Maputaland Group sands is high with a storage coefficient of 0.1. The seasonal fluctuation of groundwater level requires deep drilling to at least 30-50m below the water table (Botha and Singh, 2012).

3.5.2 Secondary Aquifers

Fractured (secondary) aquifers occur in the western region of the study area. The boundary between the primary and the secondary aquifers is marked by N2 road. The secondary aquifers are mainly the volcanic rocks of the Letaba Formation and the sedimentary rocks of the Karoo Supergroup. The Letaba Formation volcanic rocks comprise a sequence of mafic picritic/olivine-rich basalts which have been classified as weathered and fractured aquifers with expected borehole yields up to 3 l/s. These volcanic rock aquifers are generally associated with groundwater that has fluoride concentration >1.5mg/l, storage coefficients of ≤0,001 and drilling depths that range from >20m to 30m below ground level (Botha and Singh, 2012).

The Ecca Group comprising shales and sandstones of the Pietermaritzburg, Vryheid and Volkrust Formations have expected borehole yields ranging from >0 to >3 l/s.

3.6 Delineation of target communities and generation of site maps.

The National Geospatial Information (NGI) database and the Municipal Demarcation Board (MDB) website were visited to obtain the geographic location of the target communities and ward delineations for Mtubatuba and Hlabisa local municipalities. A map displaying all the target communities and their respective ward boundaries was constructed using a GIS based software.

3.7 Contact and communication with DM and LM

Bheki of the uMkhanyakude District Municipality who is project contact person on the side of the UKDM was contacted to obtain a go ahead to meet with the local municipalities allocated to GCS. GCS then contacted the municipal managers of Mtubatuba and Hlabisa LM to arrange meetings with them and the ward councilors of the target communities. The Project kick-off Meeting in Mtubatuba local municipality was held on the 21 September 2015 at the Mtubatuba municipality council chamber at 09:00am. The project kick-off meeting in Hlabisa local municipality was held on the 12 October 2015 at the Hlabisa municipality council chamber. The attendance register for both meetings are available in Appendix E. In these meetings, all the ward councillors within the project area were invited in order for them to act as a medium of communication between GCS geologist onsite and the community as wells as traditional leaders.

After the meeting with ward councillors, a site visit to each community was undertaken to identify the preferred borehole location which will be accessible to community dwellers and with enough space to undertake geophysical survey and also looking at the potential for water based on, geology, topography and surface drainage. The locations were marked and GPS coordinates were taken for planning purposes.

3.8 Preliminary household count and need analyses.

According to the World Health Organisation (WHO), the quantity of safe water required is 20-40 litres per person per day, in SA, the Department of Water Affairs and Forestry (DWAF), now called Department of Water and Sanitation (DW&S), has set the minimum quantity at 25 litre per person per day. A typical South African household consists of 3 children and two parents. This means that each household will require 125 litre of water per day. to establish an approximate number of households within a 500m radius from the borehole, the household count was conducted using google earth images. The number of households in these communities were estimated by counting households on google earth. Table 3-3 below shows the information gathered from these sources as well as the amount of water required by the communities. It must be noted that the values supplied in the table are just an approximation and must only be taken as indicative.

Table 3-3: Need analysis table

Community	Municipality	Ward Number	Approximate No. of Households to be served	Approximate No. of people per household	Amount of water per person (Liters/day)	Amount of water required per household (liters/day)	Total amount of water required for the households (liters/day)
Nkanjini	Hlabisa	2	64	5	25	150	9600
Ngebeza	Hlabisa	1	32	5	25	150	4800
Banzaneni	Hlabisa	3	43	5	25	150	6450
Hlambanyathi	Hlabisa	1	35	5	25	150	5250
Mabhanoyini	Hlabisa	2	130	5	25	150	19500
Macekeni	Hlabisa	2	50	5	25	150	7500
Emajikeni	Hlabisa	2	127	5	25	150	19050
Nkodibe	Mtubatuba	6	145	5	25	150	21750
Nkombose	Mtubatuba	13	80	5	25	150	12000
Ophaphase	Mtubatuba	13	55	5	25	150	8250
KwaMshaya	Mtubatuba	14	35	5	25	150	5250
Msane	Mtubatuba	2	150	5	25	150	22500
Ebaswazini	Mtubatuba	16	45	5	25	150	6750
Mapheleni	Mtubatuba	16	41	5	25	150	6150
Madwaleni	Mtubatuba	12	37	5	25	150	5550
Shikishela	Mtubatuba	12	87	5	25	150	13050
Nkundisi	Mtubatuba	9	30	5	25	150	4500
Nkonjaneni	Mtubatuba	7	10	5	25	150	1500
Ogengele	Mtubatuba	17	32	5	25	150	4800

3.9 Outlay of proposed field geophysical survey lines

The coordinates of the preliminary borehole locations were plotted on the geology map to identify if there are any structural features nearby the proposed borehole locations and to determine what is the geology underlying the site. The information was then used to decide on the type of geophysical survey to be used and how the geophysical survey line should look like.

3.10 Planning and logistics

All planning and logistics involved in the project were undertaken by GCS to ensure that team is ready and all the things required for the commencement of the field work are in place.

3.11 Team briefing meetings and client briefing meetings

Meetings with Maragela Consulting engineers and the Department of water and sanitation were held at the DW&S offices in Durban to ensure that the everyone one is on the same understanding with anybody else and ensure the readiness of the team.

3.12 Contractor briefing meetings

Before the commencement of the field work, the drilling contractor was notified on the time frames and when to commence with drilling. The pumping test contractor was notified to commence with the testing when at least 6 boreholes were completed to ensure that they don't catch-up with the drilling.

4 PHASE 2: SITE ASSASSMENT

This section supplies the assessments conducted on the sites in preparation for drilling phase. These hydrogeological assessments were done in order to increase the probability of drilling successful boreholes. The assessments include site walkover assessment, hydrocensus and geophysical survey and are discussed below.

4.1 Hydrocensus

The Department of Water and Sanitation (DWS) supplied the National Groundwater Database (NGDB) and Hydrochemical databases boreholes for hydrocensus purposes. The boreholes visited in the study area as well as other boreholes in the database are indicated in Figure 4-1. A site verification of all hydrocensus boreholes was conducted and GPS coordinates and sites photo were taken from each borehole visited. Hydrocensus boreholes were located using the hydrocensus field map compiled from the DWA GRIP data as well as the Information collected by asking community members and ward Councillors. Table 4-1 supplies the coordinates and comments on the use and the status of the hydrocensus boreholes identified. A photo log for the hydrocensus boreholes is available in Appendix C.

Table 4-1: Hydrocensus boreholes visited in Mtubatuba

SITE ID	Latitude	longitude	Elevation (mamsl)	WL (mbgl)	Ward No	Community	Local municipality	Equipment	Functionality
BH1	28.39509	32.12765	87	-	13	Ophaphase	Mtubatuba	Hand Pump	In good working condition
BH2	28.39536	32.11518	69	-	13		Mtubatuba	Hand Pump	In good working condition
BH3	28.39664	32.09234	62	-	14	Kwamshaya	Mtubatuba	Hand Pump	No water
BH4	28.41713	32.0768		-	14	Nkatha	Mtubatuba	Hand Pump	In good working condition
BH5	28.42376	32.09296	57	-	14	Kwamshaya	Mtubatuba	Hand Pump	In good working condition
BH6	28.44161	32.08194	51	-	14	Kwamshaya	Mtubatuba	Hand Pump	In good working condition
BH7	28.37151	32.16043	75	-	16	Ebaswazini	Mtubatuba	-	Hand pump is destroyed. The borehole had a lot of water previously.
BH8	28.36644	32.15646	100	-	16	Ebaswazini	Mtubatuba	Hand Pump	In good working condition
BH9	28.33053	32.13562	124	-	17		Mtubatuba	Hand Pump	In good working condition
BH10	28.36754	32.17271	95	-	6	Ngqopheni	Mtubatuba	Hand Pump	In good working condition
BH11	28.36503	32.17619	86	-	6	Ngqopheni	Mtubatuba	Hand Pump	In good working condition
BH12	28.35971	32.19857	73	-	16	Mapheleni	Mtubatuba	Hand Pump	In good working condition
BH13	28.33878	32.21373	41	-	16	Mapheleni	Mtubatuba	Hand Pump	Pump handles are broken but the borehole has water.
BH14	28.33618	32.2115	80	-	16	Mapheleni	Mtubatuba	Hand Pump	Pump is broken
BH15	28.19341	32.30719		-	10	Mfekayi	Mtubatuba	Hand Pump	Pump is damaged and borehole is blocked.
BH16	28.18288	32.3153		-	10	Mfekayi	Mtubatuba	Hand Pump	Pump is damaged and borehole is blocked.
BH17	28.18955	32.28019		-	10	Mfekayi	Mtubatuba	Hand Pump	Pump is damaged and borehole is blocked.

W08-HBH1	28.1669	32.28654	52	-	8	Bazala	Mtubatuba	electric pump	Broken pump
W08-HBH2	28.16635	32.28243	61	-	8	Bazala	Mtubatuba	electric pump	Broken pump
W08-HBH3	28.1644	32.28289	61	-	8	Bazala	Mtubatuba	electric pump	Broken pump
W08-HBH4	28.17215	32.31718	36	-	8	Bazala	Mtubatuba	Hand Pump	In good working condition

Table 4-2: Hydrocensus boreholes visited in Hlabisa

SITE ID	Latitude	longitude	Elevation (mamsl)	WL (mbgl)	Ward No	Community	Local municipality	Equipment	Functionality
HBH1	28.15268	31.88298	509	94.8	2	Makopini	Hlabisa	-	Unused borehole
HBH2	28.15333	31.88395	515	37.75	2	Makopini	Hlabisa	electric pump	Pump is broken
HW1 HC 1	28.05038	31.8415	570		1		Hlabisa		
HW1 HC2	28.05045	31.84143	510		1		Hlabisa		
HW1 HC 3	28.04708	31.83812	548		1		Hlabisa		
HW1 HC4	28.05747	31.84027	520		1		Hlabisa		
HW2 HC 1	28.16270	31.88141	436		2		Hlabisa		
HW2 HC2	28.13469	31.86163	482		2		Hlabisa		
HW2 HC3	28.13474	31.86166	500		2		Hlabisa		
HW2 HC4	28.13457	31.86145	439		2		Hlabisa		
HW2 HC5	28.13458	31.86145	502		2		Hlabisa		
HW3 HC1	28.14791	31.90031	530		3		Hlabisa		
HW3 HC2	28.17125	31.89578	520		3		Hlabisa		

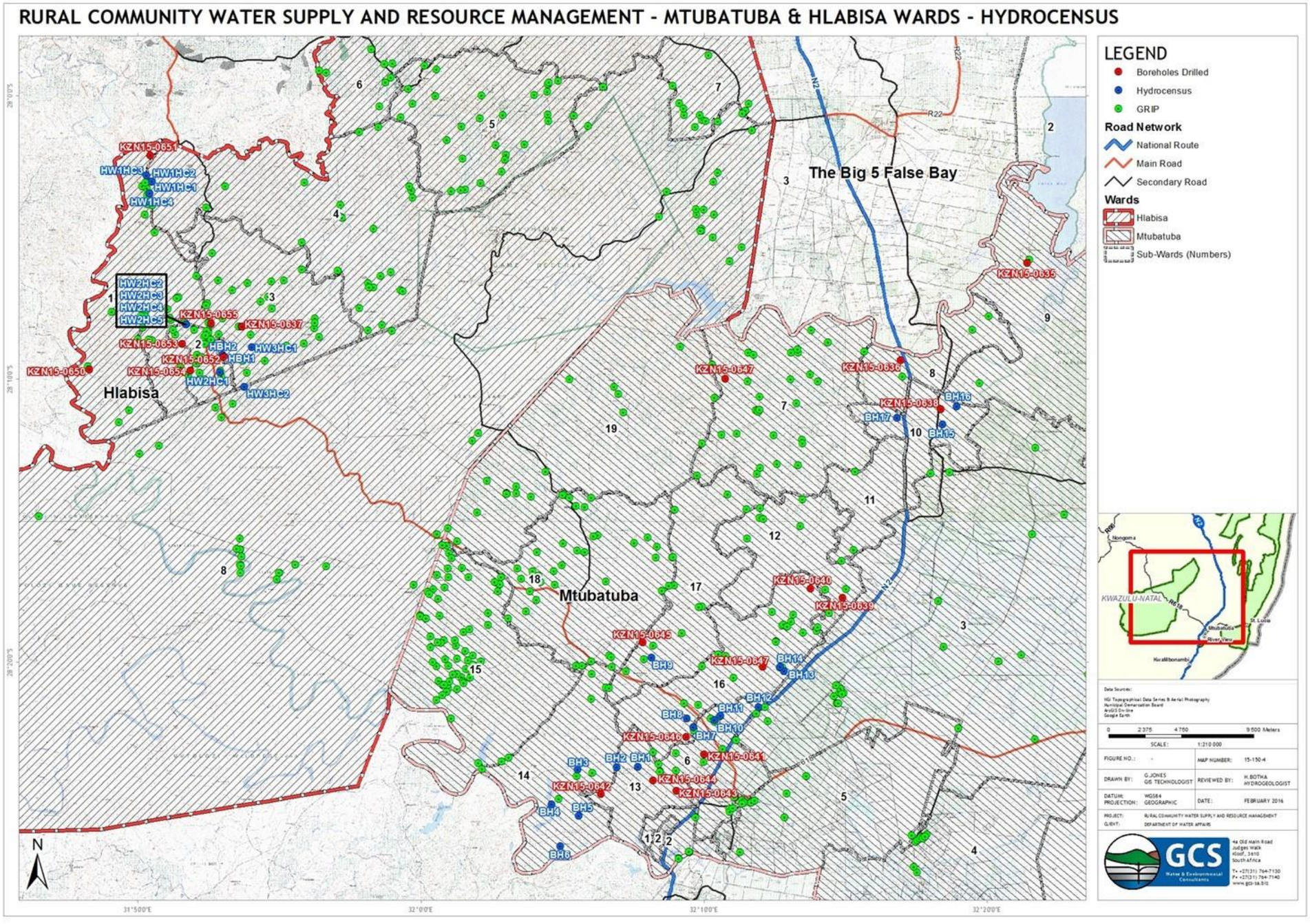

Figure 4-1: Hydrocensus borehole map

4.2 Borehole siting

Borehole siting was conduct using a number of tools and mediums. These included the study of available geological maps, aerial photographs, google images and topographical maps of the study area. This was done on a desktop study level to determine if there are geological structures such as faults and dykes in the area pre-selected for drilling. These geological structures are well known to be preferential pathways for groundwater movement.

During the field work phase, the pre-selected areas were surveyed for subsurface conditions using electrical resistivity and proton precession magnetometer (Mag) methods.

4.2.1 Electrical resistivity

In each community the resistivity data was recorded on two (2) transect lines (were possible) using Electrical resistivity Tomograph (ERT). The Electrical Resistivity Tomograph (ERT) technique uses a series of electrodes along a straight line attached to a multi-core cable. During the ERT survey, a DC or slowly varying AC current is artificially injected into the Earth through a series of grounded current electrodes and the resulting potential measurements made at a number of grounded potential electrode pairs. This information (injected current and the measured potential) is then used to subsurface apparent resistivity.

The ERT survey was undertaken using the standard Wenner (Wenner α) array. In the Wenner array, the vertical resolution of the subsurface resistivity is achieved by increasing the common distance between the electrodes while maintaining the location of the centre point of the array. Horizontal resolution is achieved by moving the electrodes laterally across the surface while maintaining a constant electrode separation. The ultimate result is a 2D collection of the raw resistivity measurements at different depths along a given survey traverse. The inversion of this 2D survey data results in a resistivity model which is then interpreted in terms of the subsurface properties associated with possible exploitable aquifer condition (e.g., dykes, saturated zone, dykes, weathered zones etcetera) along the surveyed line. The transect lines ranged between 400m and 700m long depending on the available space. The resistivity data was analysed using.

The resistivity data was appropriately edited, processed and ultimately modelled using the RES2Dinv inversion algorithm by Geotomo. The RES2Dinv models the raw resistivity data by automatically dividing the subsurface resistivity coverage (2D measured resistivity data) into rectangular blocks. Thereafter, it calculates the apparent resistivity values of the model blocks and compares these calculated apparent resistivity values with the measured apparent resistivity values using a standard deviation. The resistivity value of the model block is adjusted iteratively until the calculated apparent resistivity values of the model are in close agreement with the measured values. The final output is the 2D inverse model of true resistivity variation.

The inverted ERT models along the transect lines are presented in Appendix B. In the models, the horizontal (x) axis represents the position along the survey line, while the vertical (z) axis represents the depth below surface, given in metres and metres below ground level respectively. Table 4-3 lists the coordinates of the transect lines and the distance of each traverse.

Table 4-3: Geophysics coordinates.

	Community name	Ward Number	Local Municipality	Coordinates				Survey distance (m)
				Start		End		
				Lat	Lon	Lat	Lon	
Line 1	Nkodibe	6	Mtubatuba	-28.3868	32.164051	-28.38809	32.167818	400
Line 2	Nkodibe	6	Mtubatuba	-28.3866	32.168322	-28.38839	32.164827	400
Line 1	Nkombose	13A	Mtubatuba	-28.406	32.153077	-28.41098	32.148821	700
Line 2	Nkombose	13A	Mtubatuba	-28.409	32.153141	-28.40608	32.150863	400
Line 1	Nkombose	13B	Mtubatuba	-28.4031	32.13673	-28.3983	32.132661	700
Line 2	Nkombose	13B	Mtubatuba	-28.4043	32.135937	-28.40096	32.137471	400
Line 1	Kwamshaya	14	Mtubatuba	-28.4122	32.104276	-28.40821	32.108149	600
Line 2	Kwamshaya	14	Mtubatuba	-28.4121	32.107161	-28.40999	32.103895	400
Line 1	Msane	2	Mtubatuba	-28.447	32.143257	-28.44516	32.146412	400
Line 2	Msane	2	Mtubatuba	-28.4487	32.142882	-28.44529	32.143691	400
Line 1	Ebaswazini	16A	Mtubatuba	-28.3757	32.154165	-28.37787	32.157295	400
Line 2	Ebaswazini	16A	Mtubatuba	-28.3774	32.153413	-28.37582	32.156986	400
Line 1	Mapheleni	16B	Mtubatuba	-28.3357	32.20017	-28.33541	32.204023	400
Line 2	Mapheleni	16B	Mtubatuba	-28.3364	32.201823	-28.33287	32.202046	400
Line 1	Madwaleni	12A	Mtubatuba	-28.2913	32.2294	-28.28836	32.227089	400
Line 2	Madwaleni	12A	Mtubatuba	-28.2897	32.230363	-28.29022	32.226322	400
Line 1	Shikishela	12B	Mtubatuba	-28.2956	32.247638	-28.29435	32.249223	600
Line 2	Shikishela	12B	Mtubatuba	-28.2939	32.248424	-28.29562	32.248046	400
Line 1	Bazala	8	Mtubatuba	-28.1575	32.280567	-28.15575	32.284031	400
Line 2	Bazala	8	Mtubatuba	-28.1554	32.28123	-28.1562	32.284693	360
Line 1	Mfekayi	10	Mtubatuba	-28.1858	32.30517	-28.18264	32.307065	400
Line 2	Mfekayi	10	Mtubatuba	-28.1838	32.309261	-28.18286	32.305351	400
Line 1	Nkundusi	9	Mtubatuba	-28.0961	32.358903	-28.09908	32.356696	400
Line 1	Nkonjaneni	7	Mtubatuba	-28.1615	32.178085	-28.16674	32.178968	600
Line 1	Ogengele	17	Mtubatuba	-28.3227	32.129594	-28.31975	32.131703	400
Line 2	Ogengele	17	Mtubatuba	-28.3234	32.132088	-28.32053	32.12986	400
Line 1	Nkanjini	2A	Hlabisa	-28.1463	31.857872	-28.14503	31.861436	400
Line 2	Nkanjini	2A	Hlabisa	-28.1471	31.861253	-28.1436	31.861985	400
Line 1	Macekeni	2C	Hlabisa	-28.1637	31.862885	-28.16049	31.864566	400
Line 1	Hlambanyati	1A	Hlabisa	-28.1594	31.804322	-28.16299	31.804175	400
Line 2	Hlambanyati	1A	Hlabisa	-28.1624	31.803101	-28.15951	31.805536	400
Line 1	Ngebeza	1B	Hlabisa	-28.0371	31.841486	-28.03376	31.840692	400

4.2.2 Magnetic survey

Magnetic surveys were conducted over the transect lines of the electrical resistivity using a proton precession magnetometer (Mag). The aim was to study the subsurface geology in terms of its remnant magnetism caused by the Earth's magnetic field during the formation of the rock. This is recorded as the total magnetic field strength (in Nano Tesla). Changes or fluctuations in the data are observed as anomalies. These anomalies can indicate the presence of intrusive rocks (for example dykes, sills), geological contacts such as bedding planes and faults. The magnetic survey was done to supplement the resistivity data and to increase confidence in the information gathered.

5 PHASE 4: BOREHOLE DRILLING AND TESTING

5.1 Borehole drilling

The drilling of 21 boreholes in the communities of Mtubatuba and Hlabisa local municipalities was conducted from the 30th of September 2015 to the 2nd of November 2015. The drilling was undertaken by Drilling Africa drilling company. The boreholes were drilled using percussion methods in hard rocks and mud rotary methods in unconsolidated sands and clays. The details of the boreholes drilled are tabulated in Table 5-1. The geology logs are available in Appendix B.

5.1.1 Drilling outcomes

This section supplies a brief overview of the geology and hydrogeology of the study area based on the drilling results.

5.1.1.1 Geology

Drilling in Mtubatuba, ward 2, 6, 12, 13, 14 and 16 intersected the basalts of the Letaba formation. The basalts can be categorized into two types based on crystal size and the occurrence of olivine mineral. The basalt intersected near the surface is generally very fine grain (no crystals), dusky green to greyish in colour and is poor in olivine. The base of this basalt is normally defined by reddish rhyolitic bands. The second basalt is generally fine to medium crystals with greenish grey colour and is rich in olivine. The second basalt was intersected at depths ranging between 70 and 100 meters below ground level.

Drilling in ward 17 intersected sandstones and shales of the Emakwezini formation. Ward 8, 9 and 10 were drilled on the dunes sands and alluvium overlying the cretaceous rocks of the Zululand group.

Drilling in Hlabisa indicated a wide range of geology. The rocks intersected by the drilling range from sandstones, siltstones, Dwyka tillites/diamictites, granites and partially metamorphosed sandstones.

5.1.1.2 Hydrogeology

Groundwater in the basalts was mainly intersected in fractures at depth between 70 and 100 meters below ground level in the olivine-rich basalts. Blow yield in these basalts (based on the drilling results) ranges from 0.5 l/s to 4 l/s. The fine grain, olivine-poor basalt is massive with low porosity. Based on the drilling results it can be said that the olivine-rich basalt is the main fractured aquifer in the Mtubatuba areas which are underlain by Letaba formation basalts. The olivine-poor basalt act as a confining layer to the fractures aquifer underneath.

Groundwater in the Hlabisa area was intersected in fractures at depth between 40 and 100 meters below ground level. The blow yields were higher in most boreholes with the exception of Makopini and Emajikeni communities which had low blow yields. The blow yield ranges between 2 l/s to 10 l/s.

5.1.2 Drought relief boreholes

Base on the drilling results the following can be said about the drought relief boreholes:

Mtubatuba LM

- **Ward 8** borehole was only drilled to a depth of 20m from where loose boulders made it impossible to drill any deeper. To drill deeper in this area one need to apply a different drilling methodology (i.e. Odex or Symetrix).
- **Ward 10** borehole was drilled into cretaceous type rock with no water strike.
- The boreholes in **Ward 13B (Ophaphasi community)** indicates some water strike but when pumped the recovery was extremely slow. The 2nd drilling target needs to be considered.
- **Ward 12B** (Shikishela) borehole showed no clear water strike however, water seepage into the borehole after drilling was observed.
- Boreholes in **ward 2, 6, 7, 12A, 13A, 14, 16** and **17** indicate enough yields for the hand pumps.

Hlabisa LM

- The Borehole drilled in Makopini community shows a low yield and very deep water level. As a result the pumping test was not carried out in this borehole.
- Boreholes in at Emajikeni and Macekeni communities shows good yields for the hand pump.
- The boreholes in the community of Nkanjini, Hlambanyathi, Ngebeza and Banzaneni indicate high yields which could be used to supply lager communities.

5.2 Borehole pump testing

The objective of the pump test was to assess the yield potential of the boreholes drilled and the productivity of the groundwater resource in which the boreholes drilled draw water from. The recognition and understanding of the productivity of the borehole and the groundwater resource will help determine the suitable pumping rate for each borehole which will be sustainable for a longer period. This is done to avoid over pumping the boreholes which may lead to over exploitation of the groundwater resource. The pumping test was carried out as described below:

- Boreholes with sufficient yields were tested to establish aquifer parameters as well as to determine the sustainable yield of each borehole. Pump testing was undertaken by Bay Side Mode Trading (Pty) Ltd.
- Step-drawdown tests (step tests) were conducted prior to constant rate pump tests to establish the borehole performance under controlled variable discharge rates. The discharge rates were different for each borehole depending on the blow yield of the borehole. Based on the well performance under the variable discharge rates, a constant discharge rate was determined. A 24 hour constant discharge rate test was conducted for all boreholes with blow yield exceeding 1.5 l/s and a 12 hour constant discharge rate test for boreholes with blow yield less than 1.5 l/s.
- The water level within the borehole were monitored during the pumping. This data was used to determine the aquifer characteristics, such as transmissivity and storage.
- When the pump has been switched off, the water levels with the borehole were monitored to determine the recovery of the water levels with time. This allows for the evaluation of dewatering and pumping schedules. The aquifer test data was analysed to determine the following:
    - Sustainable yield;
    - Abstraction schedule;
    - Pump inlet depth; and
    - Management.

5.2.1 Pump test analysis

The Flow Characteristics (FC) program written by the Institute for Groundwater Studies (IGS) was used to analyse the all pump test results.

Various algorithms and methods within the software suite were applied to establish borehole safe yields, assess the borehole performance as well as to obtain critical aquifer parameters (T and K values).

Analyses results are listed in Table 5-1. Detailed interpretation graphs and summaries of the methods used is available in Appendix D.

Table 5-1: Borehole locations and testing Results

Community	Ward	BH number	Latitude (WGS 84)	Longitude (WGS 84)	BH Depth (mbgl)	Static WL (mbgl)	Pump depth (m)	Available Drawdown	Time pumped (min) constant rate	Pumping rate (l/s)	Total Drawdown (m)	Rec to (m)	Time rec (min)	% rec	T-Early (m^2/day)	T-Late (m^2/day)	Sustainable yield (l/s)	Step-Drawdown test				
																		1	2	3	4	Total drawdown
Nkundusi	9	KZN 15-0635	-28.09849	32.3570	49	14.91	33.00	33.85	90.00	0.15	32.22	5.11	720.00	95.18		0.5	0.15	0.20	0.41			30.30
Shikishela	12B	KZN 15-0639	-28.29548	32.2483	140	13.35	54.00	40.65	300.00	0.18	40.35	8.10	720.00	79.93	0	0.1	0.01	N/A	N/A	N/A	N/A	N/A
Madwaleni	12A	KZN 15-0640	-28.28995	32.2293	120	6.44	100.00	93.56	1440.00	0.81	78.31	7.12	1440.00	90.91	1	0.3	0.09	0.25	0.46	0.81	1.26	70.89
Nkodibe	6	KZN 15-0641	-28.38764	32.1666	110	2.45	72.00	69.55	1440.00	0.88	46.21	27.20	1440.00	41.14	1	0.9	0.4	2.70	0.50	1.08	2.00	46.40
kwaMshaya	14	KZN 15-0642	-28.41084	32.1058	120	33.80	100.00	66.20	1440.00	1.16	16.84	2.83	1440.00	83.19	6	3	1.2	0.34	0.60	1.16	2.20	65.12
Nkombose	13A	KZN 15-0643	-28.40908	32.1505	80	3.65	72.00	68.35	1440.00	1.01	46.70	0.51	1440.00	98.91	5	0.1	0.5	0.23	0.53	1.20	2.20	67.21
Ophaphasi	13B	KZN 15-0644	-28.40294	32.1365	120	71.30	100.00	28.70	N/A	N/A	N/A	25.10	360.00	11.15			0.01	0.11	0.20			28.25
Ogengele	17	KZN 15-0645	-28.32163	32.1305	120	16.45	100.00	83.55	720.00	0.61	54.12	1.74	720.00	97.12	1	0.3	0.1	0.20	0.41	0.81	1.15	60.40
Maswazini	16A	KZN 15-0646	-28.37744	32.1562	144	17.90	72.00	54.10	1440.00	1.51	39.76	15.34	1440.00	61.42	3	1	0.7	1.01	2.02	4.05		49.88
Nkonjane	7	KZN 15-0647	-28.16649	32.1790	132	33.00	100.00	67.00	720.00	0.32	62.30	6.46	720.00	89.63	0	0.1	0.08	0.21	0.43	0.78		66.21
Msane	2	KZN 15-0648	-28.447531	32.1431	120	7.17	100.00	92.83	720.00	0.32	22.31	0.83	720.00	96.28	1	0.02	0.1	0.22	0.43	0.76		67.59
Mapheleni	16B	KZN 15-0649	-28.33612	32.2011	140	20.34	100.00	79.66	1440.00	1.01	44.68	1.41	1440.00	96.84	2	0.2	0.2	0.34	0.64	0.96	1.41	49.96
Hlambanyathi	1 (A)	KZN 15-0650	-28.16123	31.8045	66	29.88	60.00	29.82	1440.00	2.50	10.80	0.48	1440.00	95.56	14	13.6	1.5	1.31	2.56	4.61	6.09	25.72
Ngebeza	1 (B)	KZN 15-0651	-28.03524	31.8405	90	22.24	72.00	49.38	1440.00	5.52	24.10	5.72	1440.00	76.27	20	5.1	2	2.32	4.05	6.41	8.19	19.01
Nkanjini	2 (A)	KZN 15-0653	-28.14606	31.8592	90	38.52	72.00	33.48	2880.00	5.12	7.38	0.19	60.00	97.43	579	40.6	6	2.08	4.36	6.46	8.12	11.11
Macekeni	2 (C)	KZN 15-0654	-28.16175	31.8641	72	19.08	60.00	40.35	1440.00	3.10	17.38	0.15	1440.00	99.14	9	7.4	1.5	1.44	2.51	4.30	6.32	28.62
Emajikeni	2 (D)	KZN 15-0655	-28.13406	31.8762	140	30.29	100.00	69.71	600.00	0.50	67.39	0.19	720.00	99.72	4	1.5	0.7	0.24	0.41	0.80		65.54
Banzaneni	3	KZN 15-0637	-28.13588	31.8944	120	62.43	81.00	18.18	1440.00	1.52	7.96	0.00	15.00	100	19	5.6	1.5	1.03	2.07	4.91		17.96

5.3 Sampling

Groundwater samples from all tested boreholes were collected and preserved in accordance with the groundwater sampling guidelines presented in the minimum standards and guidelines for groundwater resource development for the community water supply and sanitation programme and in the WRC Report No TT 303/07.

5.4 Laboratory testing

Water samples were collected after the pumping tests. The samples were sent to Talbot and Talbot in Pietermaritzburg for water quality analysis. Results obtained where compared to SABS SANS 241 Drinking Water Standards to illustrate the status quo of the water resource quality.

The laboratory results indicated elevated iron concentration above the SANS chronic limit for boreholes in eight (8) communities. These boreholes were resampled and samples were sent to a different laboratory (Yanka laboratory) to confirm the iron concentrations. The results for the first batch of samples submitted to Talbot and Talbot are listed in Table 5-2 and Table 5-3. Results for the second batch of samples, to reconfirm iron concentrations, are presented in Table 5-4.

The following summarises the results obtained:

- All boreholes, with the exception of KZN 15-0647 (Ward 7), exhibit neutral pH conditions.
- Elevated turbidity above SANS 241-1:2015 aesthetic limits are observed at all boreholes, with the exception of KZN 15-0637, KZN 15-0647 and KZN 15-0646. It is anticipated that these elevated turbidity levels are the net result of unsettled suspended solids in the boreholes. Furthermore, it is anticipated that these levels will decrease with time.
- All boreholes, with the exception of boreholes KZN 15-0651, KZN 15-0653, KZN 15-0654, KZN 15-0655, KZN 15-0637, KZN 15-0635 and KZN 15-0649, exhibit elevated sodium (Na) and chloride (Cl) concentrations above SANS 241 aesthetic limits. Na and Cl concentrations above 600> mg/l will have a distinct salty taste as well as cause rapid corrosion in domestic appliances. Borehole water with Cl and Na concentrations >1200 mg/l is not suitable for infants where fatalities may occur as a result of dehydration (DWAF, 1996).
- Nitrate (NO_3), nitrite (NO_2), sulphate (SO_4), fluoride (F), dissolved aluminium (Al), dissolved lead (Pb) and dissolved manganese (Mn) are elevated in some boreholes (refer to Table 5-4).

- Dissolved iron (Fe) concentrations are elevated above SANS 241 chronic limits at KZN 15-0640 and KZN 15-0650. It is anticipated that the elevated iron concentrations are the net result of the natural water rock interaction in the areas where the boreholes were drilled. Furthermore, it is anticipated that these iron concentrations will decrease as oxidation of the water takes place. The water at these boreholes may become slightly acidic however, manganese and iron concentrations will subsequently be decreased.
- Total coliforms and Escherichia coli (E. Coli) are elevated above aesthetic and chronic limits at borehole KZN 15-0651, KZN 15-0648, KZN 15-0653, KZN 15-0635 and KZN 15-0643. The elevated faecal and e coli colony counts per 100ml implies that the water is not fit for human consumption. If water is consumed from these boreholes it will most likely cause infections in infants and adults (DWAF, 1996). It is imperative that water obtained from these boreholes be boiled before use. Boiling the water before use will break down the micro-organism strands.

Table 5-2: Water Quality Results (Talbot and Talbot)

Community	Ward Number	Borehole number	pH at 25°C	Electrical conductivity at 25°C	Total dissolved solids at 180°C	Total alkalinity	Total hardness*	Colour	Turbidity	Dissolved calcium	Dissolved magnesium	Sodium	Chloride
			pH units	mS/m	mg/l	mg $CaCO_3$/l	mg $CaCO_3$/l	mg Pt-Co/l	NTU	mg Ca/l	mg Mg/l	mg Na/l	mg Cl/l
Hlambanyathi	1 (A)	KZN 15-0650	7.1	222	990	380	314	<1	209.0	50	46	297	413
Ngebeza	1 (B)	KZN 15-0651	7.3	65	325	125	120	<1	26.5	32	10	66	98
Msane	2	KZN 15-0648	8.1	298	1730	24	374	<1	60.9	143	4	360	788
Nkanjini	2 (A)	KZN 15-0653	7.2	33	158	105	86	2	14.2	27	5	25	20
Macekeni	2 (C)	KZN 15-0654	7.8	20	82	42	24	<1	132.0	5	3	27	32
Emajikeni	2 (D)	KZN 15-0655	6.2	14	84	24	51	4	12.4	2	2	16	25
Banzaneni	3	KZN 15-0637	7.4	51	346	125	92	<1	4.7	17	12	56	58
Nkodibe	6	KZN 15-0641	7.4	166	878	251	240	1	10.2	40	34	241	335
Nkonjane	7	KZN 15-0647	10.0	137	722	40	28	5	1.8	11	<0.2	209	386
Nkundusi	9	KZN 15-0635	7.7	161	812	390	246	<1	32.4	36	38	197	204
Madwaleni	12A	KZN 15-0640	6.9	690	4310	636	1683	1	498.0	247	259	760	1810
Shikishela	12B	KZN 15-0639	7.9	494	2582	133	419	3	94.5	92	46	782	1223
Nkombose	13A	KZN 15-0643	7.4	263	1394	434	520	1	214.0	88	73	312	499
Ophaphasi	13B	KZN 15-0644	8.4	323	2034	28	451	7	531.0	176	3	420	910
kwaMshaya	14	KZN 15-0642	7.3	270	1544	189	435	<1	19.5	151	14	347	656
Maswazini	16A	KZN 15-0646	7.6	200	1108	332	186	<1	0.9	35	24	294	394
Mapheleni	16B	KZN 15-0649	7.6	128	730	380	180	4	6.0	36	22	178	157
Ogengele	17	KZN 15-0645	7.3	341	1684	464	506	6	5.2	79	75	440	744
SANS 241-1:2015 Drinking Water Standards			<5 <9.7	<170	<1200	n/s	n/s	<15	<1 Operational <5 Aesthetic	n/s	n/s	<200	<300

***** No sample taken; **<** Below detection limit; **RED** above SANS 241 chronic limits; **Orange** above SANS 241 aesthetic limits; **White** does not surpass any limits

Table 5-3: Water Quality Results (Talbot and Talbot) Continued

Community	Ward Number	Borehole number	Nitrate	Nitrite	Nitrate + Nitrate	Sulphate	Fluoride	Iron	Manganese	Aluminium	Lead	Total Coliforms	E. coli
			mg N/l	mg N/l	-	mg SO_4/l	mg F/l	mg Fe/l	mg Mn/l	mg Al/l	mg Pb/l	colonies per 100ml	colonies per 100ml
Hlambanyathi	1 (A)	KZN 15-0650	4.71	0.13	0.57	14.40	2.26	17.00	0.25	0.05	<0.001	0	0
Ngebeza	1 (B)	KZN 15-0651	<0.1	<0.1	<0.1	<0.3	0.35	1.75	0.28	0.03	<0.001	368	14
Msane	2	KZN 15-0648	<0.1	<0.1	<0.1	43.90	0.34	14.20	0.12	0.14	0.002	4	2
Nkanjini	2 (A)	KZN 15-0653	<0.1	<0.1	<0.1	3.86	2.14	0.85	0.21	0.26	<0.001	32	4
Makopini*	2 (B)	KZN 15-0652							0.00				
Macekeni	2 (C)	KZN 15-0654	1.38	<0.1	0.22	3.52	0.11	7.72	0.28	0.05	<0.001	0	0
Emajikeni	2 (D)	KZN 15-0655	0.15	<0.1	<0.1	2.08	0.16	1.94	0.05	0.19	<0.001	4	0
Banzaneni	3	KZN 15-0637	0.74	<0.1	0.17	7.53	0.81	0.31	0.01	0.02	<0.001	20	0
Nkodibe	6	KZN 15-0641	11.30	0.29	1.35	14.50	0.34	0.11	0.01	0.01	<0.001	2	0
Nkonjane	7	KZN 15-0647	<0.1	<0.1	<0.1	5.30	0.49	0.33	0.01	0.04	<0.001	0	0
Qwakwini*	8	KZN 15-0636							0.00				
Nkundusi	9	KZN 15-0635	4.36	<0.1	0.51	35.90	0.29	2.19	0.06	0.04	<0.001	800	240
Mfekayi*	10	KZN 15-0638							0.00				
Madwaleni	12A	KZN 15-0640	1.99	<0.1	0.27	37.80	0.46	32.70	0.60	0.09	0.003	0	0
Shikishela	12B	KZN 15-0639	<0.1	<0.1	<0.1	276.00	0.61	3.11	0.06	0.19	<0.001	0	0
Nkombose	13A	KZN 15-0643	16.30	<0.1	1.54	68.80	0.64	16.17	0.20	0.73	0.003	32	6
Ophaphasi	13B	KZN 15-0644	0.15	<0.1	<0.1	60.30	0.55	8.53	0.11	8.11	0.006	0	0
kwaMshaya	14	KZN 15-0642	1.72	<0.1	0.21	35.20	0.23	0.93	0.14	0.36	0.005	0	0
Maswazini	16A	KZN 15-0646	2.11	0.57	0.83	17.50	0.37	0.24	0.04	0.01	<0.001	38	0
Mapheleni	16B	KZN 15-0649	3.79	0.33	0.71	15.50	0.45	0.87	0.14	0.09	0.024	0	0
Ogengele	17	KZN 15-0645	2.52	0.16	0.41	39.00	0.43	0.36	0.10	0.07	<0.001	0	0
SANS 241-1:2011 Drinking Water Standards			<11	<0.9	<1	<500 Chronic <250 Aesthetic	1.5	<2 Chronic <0.3 Aesthetic	<0.4 Chronic <0.1 Aesthetic	<0.3	<0.01	<10	0

***** No sample taken; **<** Below detection limit; **RED** above SANS 241 chronic limits; **Orange** above SANS 241 aesthetic limits; **White** does not surpass any limits

Table 5-4: Water Quality Results (Yanka Laboratories - Reconfirmation of Iron)

Community	Ward Number	Borehole number	pH at 25°C	Electrical conductivity at 25°C	Total dissolved solids at 180°C	Total alkalinity	Total hardness*	Dissolved calcium	Dissolved magnesium	Sodium	Chloride	Nitrate + Nitrate	Sulphate	Fluoride	Iron	Manganese
			pH units	mS/m	mg/l	mg $CaCO_3$/l	mg $CaCO_3$/l	mg Ca/l	mg Mg/l	mg Na/l	mg Cl/l	-	mg SO_4/l	mg F/l	mg Fe/l	mg Mn/l
Msane	2	KZN 15 - 0648	7.03	238	1244	56	310	114	6.08	356	678	<0.35	49.2	<0.09	0.58	0.07
Nkombose	13	KZN 15 - 0643	7.8	236	1315	388	399	84	45.9	334	529	9.87	41.6	0.18	0.62	0.08
Ophaphase	13	KZN 15 - 0644	7.76	263	1308	24.6	340	132	2.41	349	733	0.91	70.9	<0.09	<0.01	<0.01
Madwaleni	12	KZN 15 - 0640	7.51	363	1866	210	447	72.5	64.7	561	992	<0.35	38.1	0.12	2.58	0.113
Shikishela	12	KZN 15 - 0639	7.76	418	2300	123	458	59.9	74.9	662	1034	<0.35	360	0.1	0.462	0.025
Nkundusi	9	KZN 15 - 0635	7.92	171	977	355	211	24.4	36.5	277	249	3.54	153	0.13	0.02	<0.01
Macekeni	2	KZN 15 - 0654	6.94	13.3	64.4	25	15.4	2.18	2.41	17.5	22.5	0.53	0.51	0.11	0.33	0.03
Hlambanyathi	1	KZN 15 - 0650	7.15	195	1042	347	307	53	42.3	280	406	5.44	20.8	1.78	3.09	0.05
Nkanjini	2	KZN 15 - 0653	7.51	29.6	165	116	112	38.4	3.87	18.8	18.5	2.28	1.63	1.75	1.27	0.19
Emajikeni	2	KZN 15 - 0655	6.86	12.3	56.9	24.8	15.8	1.63	2.85	14.8	19.7	<0.35	1.15	<0.09	0.126	0.022
Ngebeza	1	KZN 15 - 0651	7.06	53.7	262	96.4	86.9	19.4	9.34	68.2	100	<0.35	3.25	0.2	0.84	0.1
SANS 241-1:2015 Drinking Water Standards			<5	<170	<1200	n/s	n/s	n/s	n/s	<200	<300	<1	<500 Chronic	1.5	<2 Chronic	<0.4 Chronic
			<9.7										<250 Aesthetic		<0.3 Aesthetic	<0.1 Aesthetic

***** No sample taken; **<** Below detection limit; **RED** above SANS 241 chronic limits; **Orange** above SANS 241 aesthetic limits; **White** does not surpass any limits

6 PHASE 4: PUMP INSTALLATION

Table 6-1 below shows the list of boreholes that were equipped with mono hand pumps and the installation depths. The boreholes in the community of Mfekayi and Qakwini communities had no water strikes and were not equipped with pumps. These communities are marked red with (x*) indicating that no pump installed. The boreholes in Ophaphase and Nkundusi communities have low yield, however, the pumps were installed. These boreholes tend to dry after long pumping and peoples have to wait for the recovery. The recovery in the Ophaphase boreholes is very slow.

Table 6-1: Pump installation status (15 Feb 2016)

Community	Ward Number	Borehole number	Install pump	Pump Depth (m)	Final Depth (m)	Main Water Strikes (m)			WL
						1st	2nd	3rd	
Nkundusi	9	KZN 15-0635	√	40	49				14.91
Qwakwini	8	KZN 15-0636	X*		23				
Mfekayi	10	KZN 15-0638	X*		150				
Shikishela	12	KZN 15-0639	√	50	140	40	-	-	13.35
Madwaleni	12	KZN 15-0640	√	50	120	41	-	-	6.44
Nkodibe	6	KZN 15-0641	√	60	110	80	95	103	2.45
kwaMshaya	14	KZN 15-0642	√	60	120	81	102	110	33.8
Nkombose	13	KZN 15-0643	√	60	80	10	26		3.65
Ophaphasi	13	KZN 15-0644	√		120	75			71.3
Ogengele	17	KZN 15-0645	√	60	120	31	48	71	16.45
Maswazini	16	KZN 15-0646	√	60	144	142			17.9
Nkonjane	7	KZN 15-0647	√	60	132				33
Msane	2	KZN 15-0648	√	50	120	53	60		7.17
Mapheleni	16	KZN 15-0649	√	50	140	65	134		20.34
Hlambanyathi	1	KZN 15-0650	√		66	54	60		29.88
Ngebeza	1	KZN 15-0651	√	50	90	24	81		22.24
Makopini	2	KZN 15-0652	X*		149	54			
Nkanjini	2	KZN 15-0653	√	50	90	53	74		38.52
Macekeni	2	KZN 15-0654	√	50	72	32	41		19.08
Emajikeni	2	KZN 15-0655	√	60	140	36	108		30.29
Banzaneni	3	KZN 15-0637	√	80	120	95	105		62.43

* X: Pump not installed due to limited water supply, collapsed borehole or poor water quality.

6.1 Borehole commissioning

The commissioning of boreholes was undertaken from the 19 May 2016 to 20 May 2016 by GCS (Hydrogeological Consultants), Maragela Consulting Engineers (Project managers) and Bay Side Trading (contractor). The community and the ward councillors were invited during the commissioning. Thinus Kruger of the Umkhanyakude District Municipality (UKDM) could not participate in the commissioning of the boreholes due to commitments in UKDM. The signed borehole commissioning forms and pump photo logs are available in Appendix F and G respectively.

7 BOREHOLE UTILISATION AND MANAGEMENT

7.1 Borehole operational capacity

The boreholes fitted with pumps have the capacity to sustain the local communities with sustainable water yields for many years. Table 7-1 lists the estimated water quantities available for each drought relief borehole drilled. The estimated yield is based on the borehole safe yield as well as basic human water needs which is 25 litre/person/day (NWA, 1998).

Table 7-1: Estimated borehole water supply capacity for drought relief boreholes

Community	BH ID	Ward No	Potential abstraction quantities based on safe yield (m^3/month)	Water Supply Potential (people)
Hlambanyathi	KZN 15-0650	Ward 1a	3888	5184
Ngebeza	KZN 15-0651	Ward1b	5184	6912
Msane	KZN 15-0648	Ward 2	259.2	346
Nkanjini	KZN 15-0653	Ward 2a	15552	20736
Macekeni	KZN 15-0654	Ward 2c	3888	5184
Emajikeni	KZN 15-0655	Ward 2d	1814.4	2419
Banzaneni	KZN 15-0637	Ward 3	3888	5184
Nkodibe	KZN 15-0641	Ward 6	1036.8	1382
Nkonjane	KZN 15-0647	Ward 7	207.36	276
Shikishela	KZN 15-0639	Ward 12a	233.28	311
Madwaleni	KZN 15-0640	Ward 12b	25.92	35
Nkombose	KZN 15-0643	Ward 13a	1296	1728
Ophaphasi	KZN 15-0644	Ward 13b	25.92	35
kwaMshaya	KZN 15-0642	Ward 14	3110.4	4147
Maswazini	KZN 15-0646	Ward 16a	1814.4	2419
Mapheleni	KZN 15-0649	Ward 16b	518.4	691
Ogengele	KZN 15-0645	Ward 17	259.2	346
Nkundusi	KZN 15-0635	Ward 9	388.8	518

7.2 Preliminary borehole management risks

Though boreholes are reliable water sources, proper management and routine maintenance are key to their long term sustainable use. Risk associated with poor water management include, and are not limited to:

- Over production from a boreholes could potentially dry out the aquifer within the extent of the radius of influence. A borehole is over pumped if water is withdrawn at a faster rate than the aquifer is able to produce. A few net results from overproduction are:
    - Depletion of the groundwater aquifer;
    - Increase the rate of corrosion, incrustation and biofouling related problems;
    - Increases the rate of sediment particles moving toward the well, causing plugging of the perforated area where water flows into the well; and
    - Aquifer settlement and compactions which further restricts water flow to the borehole.
- Poor maintenance:
    - Water quantity obtainable is reduced due to mechanical failure;
    - Water quality can be influenced by corroding borehole screens, casings and mechanical components; and
    - Decline in water quality due to irregular check-ups and purging.
- Vandalism:
    - Vandalism to the headworks of any borehole could potentially have an impact on both the water quality and quantity. Vandalism often cause mechanical failure of hand pumps rendering groundwater unobtainable. Severe vandalism could cause cracks in the sanitary seal which could lead to the onsite pollution of a borehole.
- Anthropogenic influences:
    - Urbanisation in areas where boreholes aren't clearly marked could potentially render them destroyed; and
    - Waste disposal around the water abstraction boreholes; or upstream of the boreholes could effectively have an impact on the water quality. Though the impact will not be immediate it could eventually lead to the degradation of the water resource.

7.3 Preliminary water management and monitoring plan

The initial sampling and pump test conducted makes up the baseline conditions for each borehole. Deviations from this baseline should be monitored to ensure that the water abstracted is still of good quality. Water abstraction quantities are also important, for seasonal changes as well as water supply needs could influence the borehole life expectancy. A preliminary borehole water quality and quantity management programme and plan is outlined by Table 7-2.

Table 7-2: Preliminary groundwater management and monitoring plan

Task	Objectives	Proposed steps
Community Awareness	The objective of community awareness is to inform water users of the sensitivity of the groundwater	Bi annual meetings with all residents situated around the abstraction boreholes. Informative sessions where water users are shown steps to improve borehole life and how to minimize impact on the groundwater aquifer (i.e. reduce waste stockpiles, do not construct pit latrines upstream of boreholes).
Monitoring	The objective of the groundwater monitoring is to record groundwater levels and monitor groundwater quality to ensure that the impact on the underlying aquifer is kept at minimum or insignificant.	Monitoring on a routine basis. Bi-Annual borehole purging of boreholes with declining yields or deteriorating water quality. Quarterly water level measurements for borehole(s) fitted with a pump. Quarterly macro (inorganic and microbial) analyses of the borehole(s) that are being used to supply drinking water. Analysis should include, but is not limited to: pH, EC, Ca, Mg, Na, K, Cl, F, NO_3, NH_3, SO_4, Fe, Mn, Zn, Turbidity, Faecal coliforms, E-coli, Total coliforms, Heterotrophic plate count
Maintenance	The objective is to ensure long term and regular maintenance of all boreholes supplying water by means of mechanical or electrical equipment.	Bi annual visits by the hand pump manufacturer to ensure that the installed equipment is functioning correctly without causing harm to its users or the groundwater aquifer.

8 CONCLUSION

- A total of 21 boreholes were drilled for the Department of Water and Sanitation drought relief project in Umkhanyakude District municipality.
- 14 of these boreholes were drilled in the communities of Mtubatuba local municipality and 7 boreholes in the communities of Hlabisa local municipality.
- There are 10 boreholes in Mtubatuba which displayed relatively high yields that are sufficient for hand pump installation. Boreholes at Ophaphase (ward 13) and Nkundusi (ward 9) communities in Mtubatuba displayed low yields and sometimes these boreholes get dry after long pumping. The recovery in the Ophaphse borehole is very slow. Boreholes drilled in Mfekayi (ward 10) and Bazala (ward 8) communities in Mtubatuba were dry.
- There are 6 boreholes in Hlabisa with good yields sufficient for hand pumps. Some of these boreholes have yields of more than 5l/s and can be equipped with submersible pumps to supply even bigger communities. The borehole at Makopini (ward 2) in Hlabisa has a very low yield and deep water level.
- The pump test was conducted in all successful boreholes with clear water strikes to determine the aquifer parameters and to calculate the sustainable yields. The pump test results indicated good boreholes with sustainable yields ranging from 0.1 to 6 l/s in most boreholes with the exception of boreholes in ward 8, 10, 9 and 13 in Mtubatuba and Makopini community in Hlabisa.
- There are 11 hand pumps installed in the boreholes drilled in Mtubatuba. The borehole in Nkodibe (ward 6) community in Mtubatuba has a submersible electric pump and two JoJo tanks. The pump and the JoJo tanks were installed by Umngeni water. There are 6 hand pumps installed in the boreholes drilled in Hlabisa.

Hydrochemistry

- All boreholes, with the exception of KZN 15-0647 (Ward 7), exhibit neutral pH conditions.
- Elevated turbidity above SANS 241-1:2015 aesthetic limits are observed at all boreholes, with the exception of KZN 15-0637, KZN 15-0647 and KZN 15-0646.
- All boreholes, with the exception of boreholes KZN 15-0651, KZN 15-0653, KZN 15-0654, KZN 15-0655, KZN 15-0637, KZN 15-0635 and KZN 15-0649, exhibit elevated sodium (Na) and chloride (Cl) concentrations above SANS 241 aesthetic limits.
- Nitrate (NO_3), nitrite (NO_2), sulphate (SO_4), fluoride (F), dissolved aluminium (Al), dissolved lead (Pb) and dissolved manganese (Mn) are elevated in some boreholes.

- Dissolved iron (Fe) concentrations are elevated above SANS 241 chronic limits at KZN 15-0640 and KZN 15-0650.
- Total coliforms and Escherichia coli (E. Coli) are elevated above aesthetic and chronic limits at borehole KZN 15-0651, KZN 15-0648, KZN 15-0653, KZN 15-0635 and KZN 15-0643.

Borehole sustainable yields

- From the pump test conducted on each drought relief borehole, as well as taking into consideration the physical construction of each borehole, the sustainable yields were determined. The table below summarises the sustainable yields as well as exploitation yields calculated.

Table 8-1: Borehole exploitation and sustainable yields summary

Community	BH ID	Ward No	Sustainable Yield (l/s)	Water supply potential (people)
Hlambanyathi	KZN 15-0650	Ward 1	1.5	5184
Ngebeza	KZN 15-0651	Ward1	2	6912
Msane	KZN 15-0648	Ward 2	0.1	346
Nkanjini	KZN 15-0653	Ward 2	6	20736
Macekeni	KZN 15-0654	Ward 2	1.5	5184
Emajikeni	KZN 15-0655	Ward 2	0.7	2419
Banzaneni	KZN 15-0637	Ward 3	1.5	5184
Nkodibe	KZN 15-0641	Ward 6	0.4	1382
Nkonjane	KZN 15-0647	Ward 7	0.08	276
Shikishela	KZN 15-0639	Ward 12	0.09	311
Madwaleni	KZN 15-0640	Ward 12	0.01	35
Nkombose	KZN 15-0643	Ward 13	0.5	1728
Ophaphasi	KZN 15-0644	Ward 13	0.01	35
kwaMshaya	KZN 15-0642	Ward 14	1.2	4147
Maswazini	KZN 15-0646	Ward 16	0.7	2419
Mapheleni	KZN 15-0649	Ward 1	0.2	691
Ogengele	KZN 15-0645	Ward 17	0.1	346
Nkundusi	KZN 15-0635	Ward 9	0.15	518

8.1 Recommendations

- It is recommended that the preliminary water management plan be implemented to ensure prolonged use of the boreholes drilled in the different wards.
- Follow up water sampled be obtained from the boreholes that indicated high levels of iron concentrations. Other constituents like fluoride, sulphate and metals were also detected above the allowable drinking limits on boreholes. All boreholes shows above standard chloride and sodium concentrations.
- It is recommended that water obtained from all the boreholes be boiled before drinking use. Boiling the water will destroy any microbial organisms that may have established in the boreholes after water quality testing. The communities should be made aware of the risks that may follow if water is not prepared correctly before use.
- The alternative drilling targets in Ophaphase community (ward 13 in Mtubatuba) and Makopini need to be considered as the boreholes in these communities showed very small yields and deep water levels.
- It is recommended that more boreholes be drilled within the wards identified. Some residents will need to travel great distances to the boreholes that were drilled to get water. Increasing the number of groundwater boreholes within each ward, will help raise the water satisfaction level throughout the catchment.

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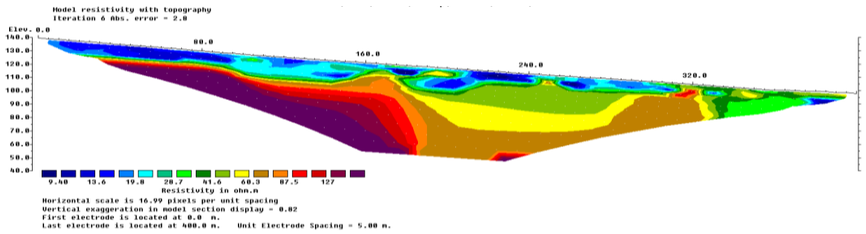
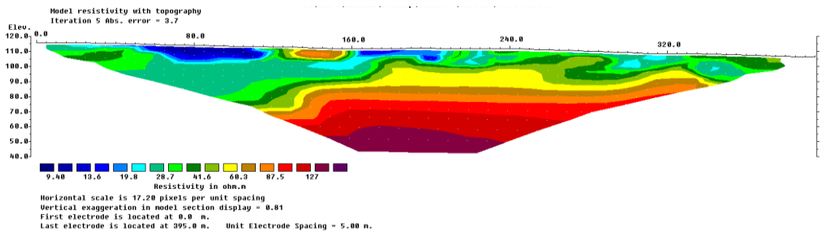
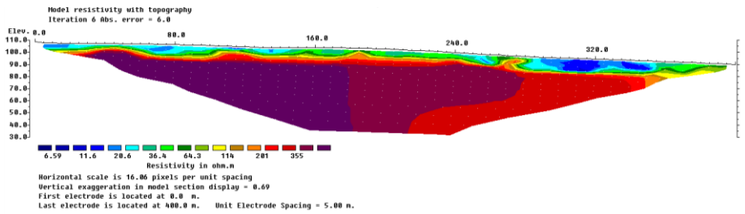
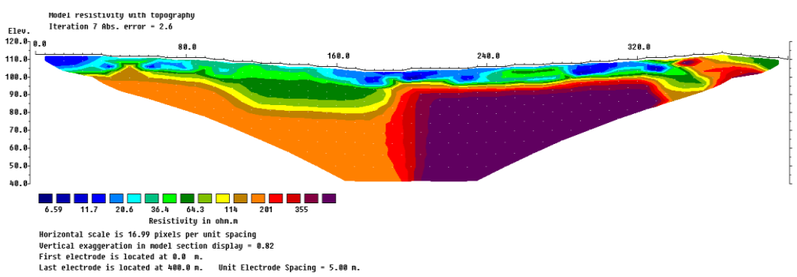
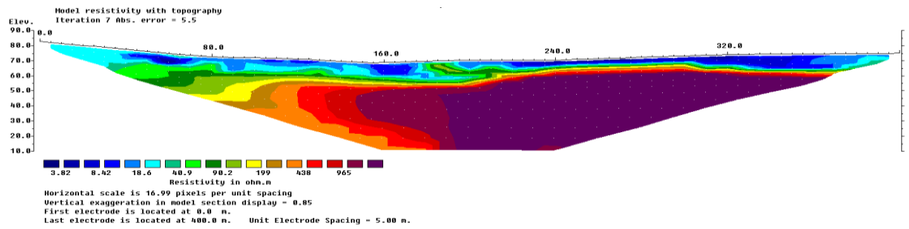
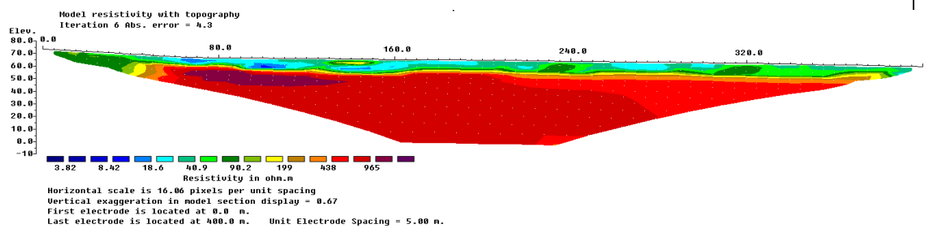
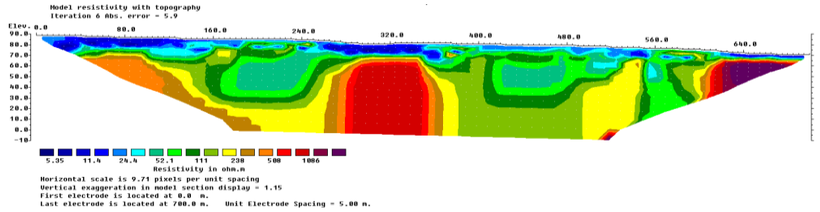
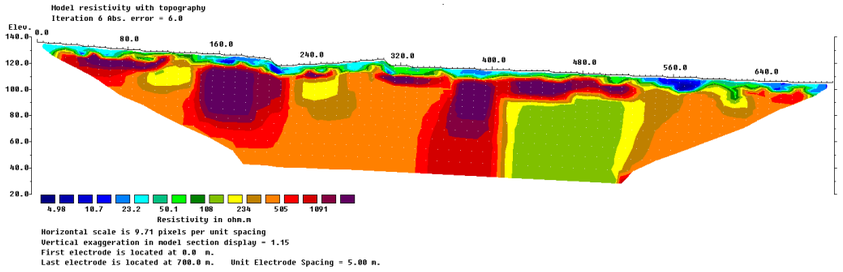
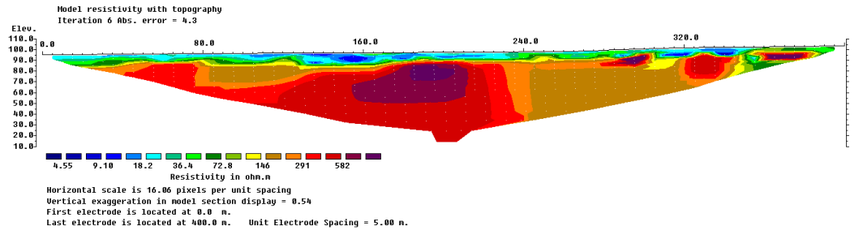
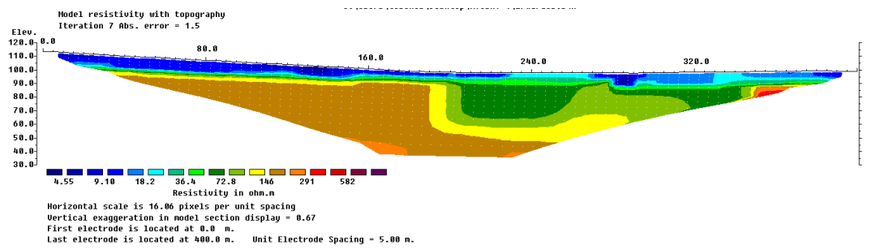
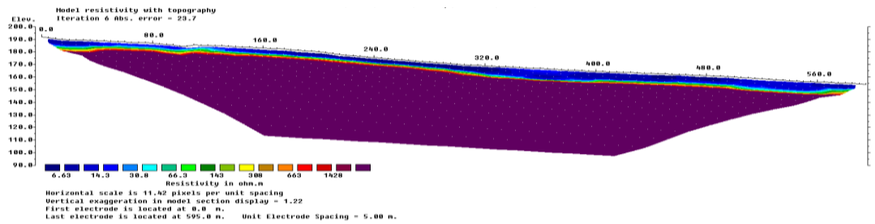
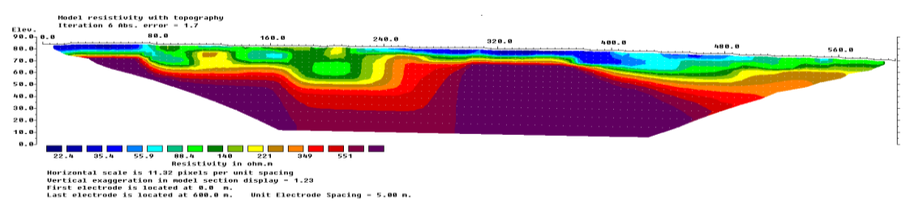
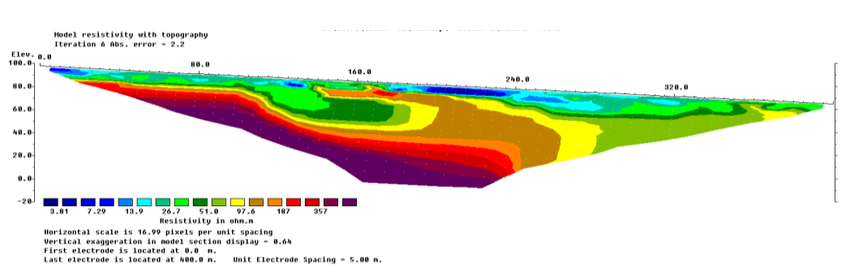
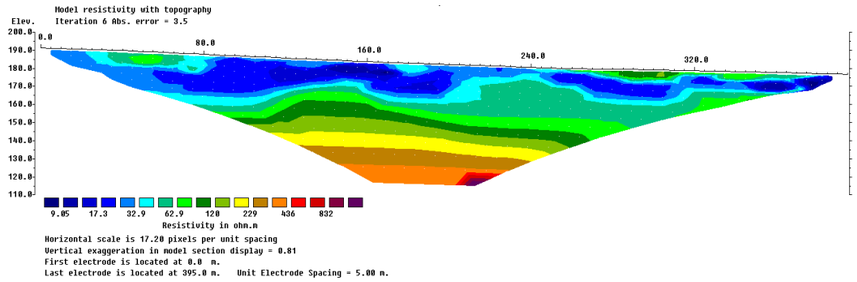
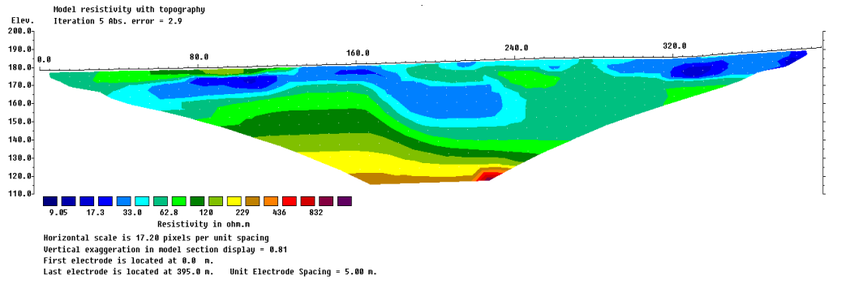
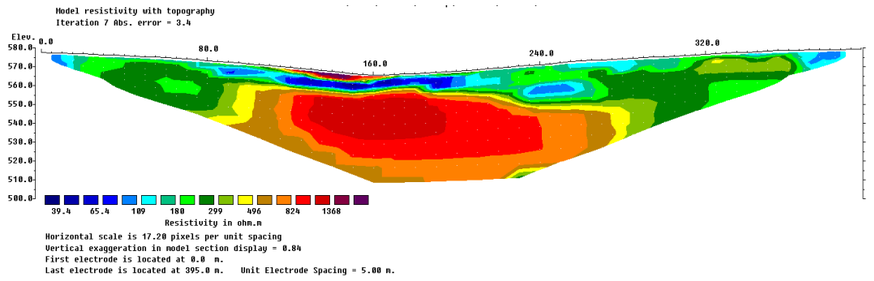
APPENDIX A: GEOPHYSICS DATA

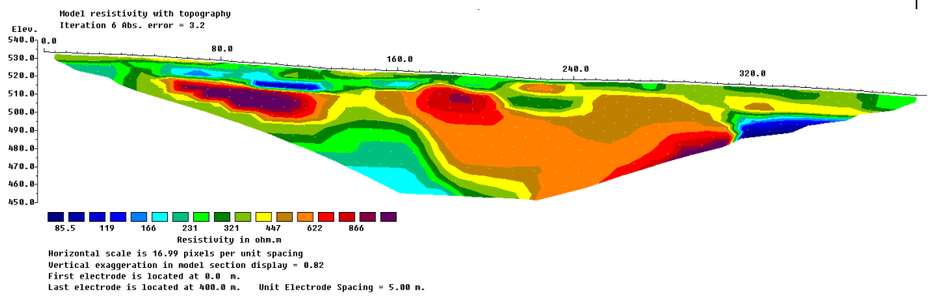
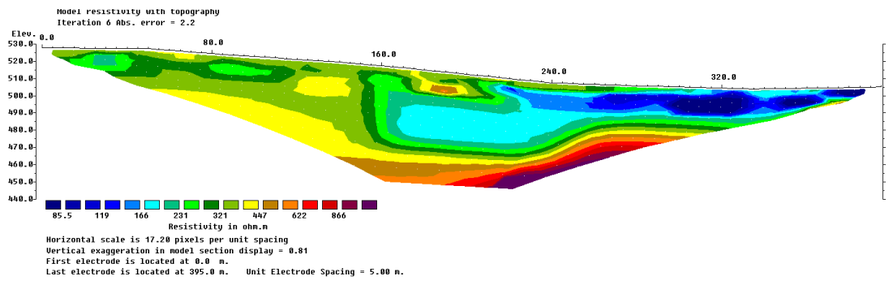
Table 9-1: Electrical resistivity 2D models.

Community Name	Ward number	Local Municipality	Models	Description
Ogengele	17	Mtubatuba	 Line 1  Line 2	Line 1: Line one has average resistivity highs of >88 Ωm at depth (135 mamsl) indicative of a substratum. The substratum is however interrupted, at $x \approx 190$ m, by the lithology of relatively suppressed resistivities values (29< x <88) indicative of weathering, prompting placement of a groundwater exploration borehole at $x \approx 105$ m along the survey line. Line 2: Line two is characterised by two distinct resistivity ranges; the first one being >88 Ωm interpreted as a substratum. Overtop the substratum is the second range (<60 Ωm) indicative of a shallow weathered lithology. If deep enough, the weathered zone is usually a good avenue for groundwater; however, it was, in this case, considered too shallow to place any groundwater exploration borehole along the survey line in question. As such, no groundwater exploration borehole was recommended in Line 2.
Ebaswazini	16	Mtubatuba	 Line 1  Line 2	Line 1: The inverted resistivity model for apparent resistivity data obtained along survey Line 1 indicate very shallow substratum revealed by relatively high resistivity values (>201 Ωm) overtop which is a shallow weathered zone as shown by relatively low resistivity (<64 Ωm). The weathered zone was considered too shallow to be deemed a good groundwater avenue medium; consequently, no groundwater exploration borehole was recommended along this survey line. Line 2: In Line 2, the model is characterised by relatively low resistivity values (<201 Ωm) from the start (0 m) before the model is interrupted by an area of resistivity highs (≥355 Ωm) at $x \approx 185$ m along the model. This characteristic (sharp contrast between resistivity lows and high to a greater depth) is typical of a fault; therefore, the contact between the resistivity high and lows were recommended as suitable area for placement of the groundwater production well

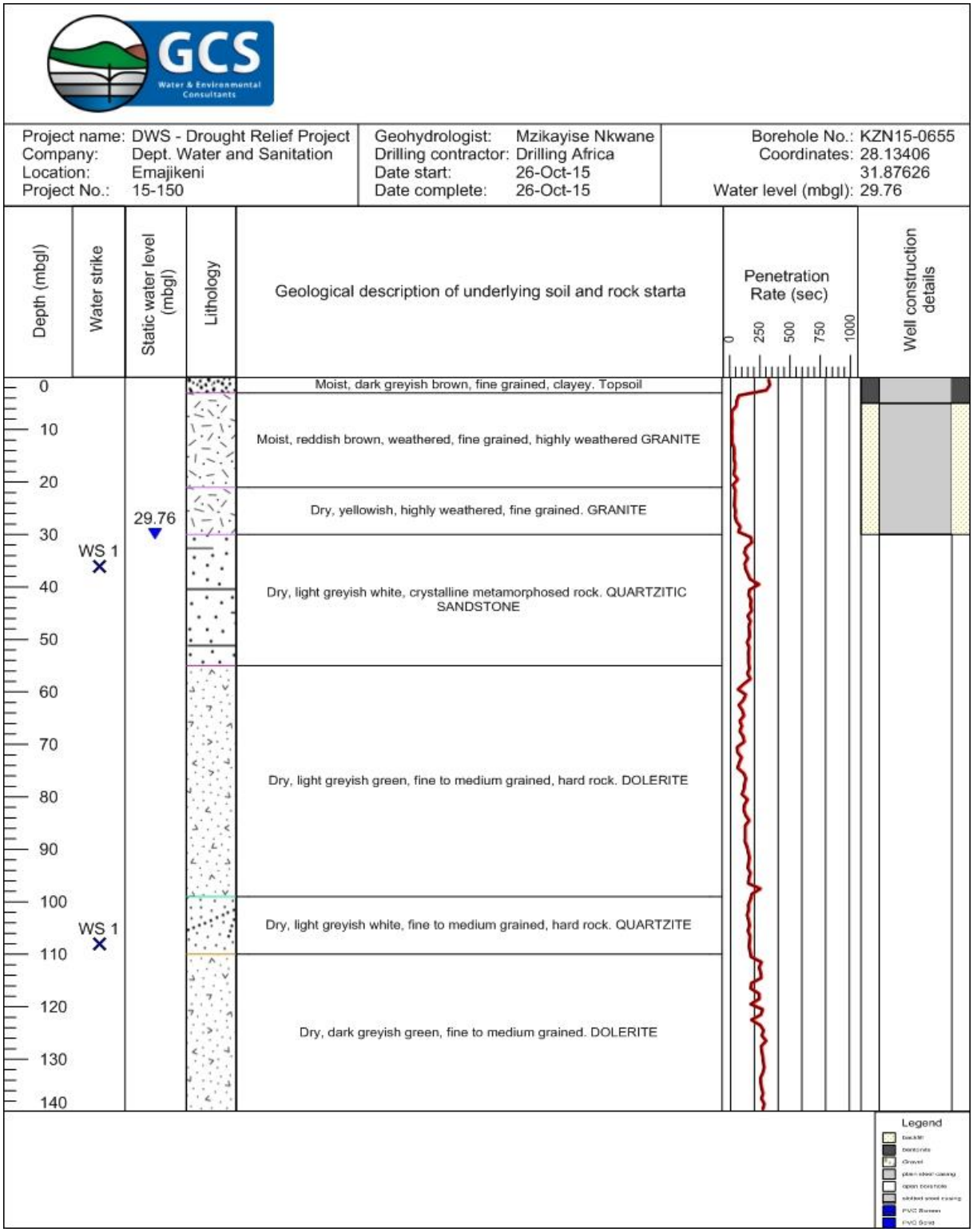
Community Name	Ward number	Local Municipality	Models	Description
apheleni	16	Mtubatuba	 Line 1  Line 2	Line 1: Line 1 has resistivity highs of >965 Ωm at depth (70 mamsl) indicative of a substratum. The substratum is however interrupted, at x≈125 m, by the lithology of relatively suppressed resistivities values (<438 Ωm) indicative of weathering, prompting placement of a groundwater exploration borehole at x≈110 m along the survey line. Line 2: The inverted resistivity model for resistivity data obtained along survey Line 2 indicate very shallow substratum revealed by relatively high resistivity values (>238 Ωm) overtop which is a shallow weathered zone as shown by relatively low resistivity (≤90 Ωm). The weathered zone was considered too shallow to be deemed a good groundwater avenue medium; consequently, no groundwater exploration borehole was recommended along this survey line.
Nkombose	13	Mtubatuba	 Line 1	Line 1: Using an interpretation from an inverted resistivity model for the data obtained from Line 1, no groundwater exploration borehole was recommended for there was no clear-cut anomalous resistivity distributions across the said model. Line 2: Line 2 was surveyed across Line 1 above and the results revealed clear resistivity contrasts in the subsurface; the model is characterised by high and shallow resistivity values (≈1461 Ωm) from the start (0 m). This zone of resistivity highs, however, deepens at x=200 m overtop which is a zone characterised by relatively low resistivity interpreted as deep weathering possibly facilitated by weathering by groundwater mobilisation; subsequently, a groundwater exploration borehole was recommended at x≈220 m along the survey line.
Ophaphase	13	Mtubatuba	 Line 1	Line 1: Beside the shallow weathered zone with resistivity values of 23 Ωm, the inversion model for Line 1 is characterised by average resistivity distributions of ≥504 Ωm indicative of a local country rock. However, the model is characterised further by an abrupt and localised area of relatively low resistivity values between x≈415 m and x≈520 m indicative of a localised weathering of the host rock which could potentially serve as a groundwater avenue zone thereby prompting placement of a groundwater exploration at x≈480 m. Line 2:

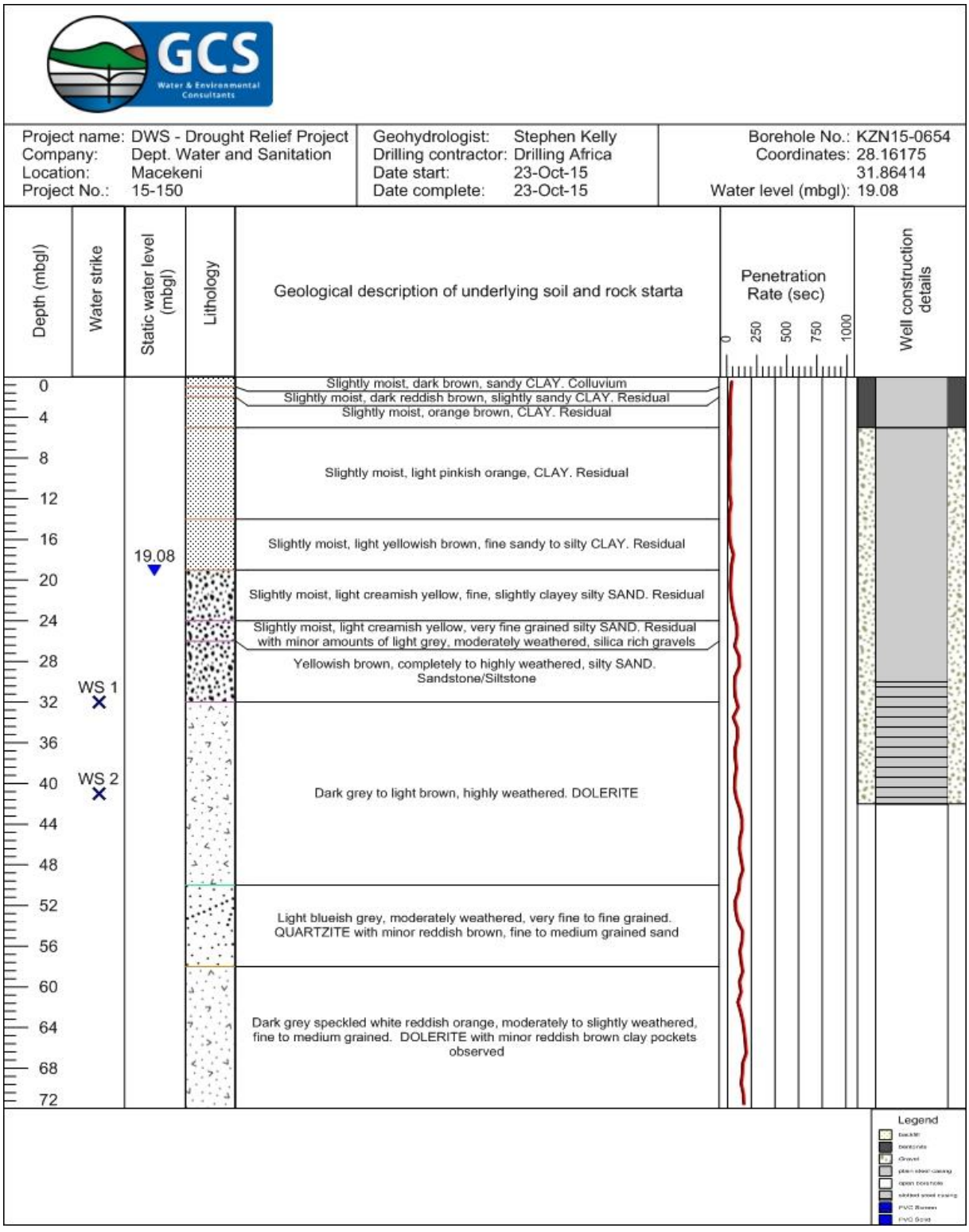
Community Name	Ward number	Local Municipality	Models	Description
Nkodibe	6	Mtubatuba	 Line 1  Line 2	Line 1: Using an interpretation from an inverted resistivity model for the data obtained from Line 1, no groundwater exploration borehole was recommended for there was no clear-cut anomalous resistivity distributions across the said model. Line 2: Line 2 was surveyed across Line 1 above and the results revealed clear resistivity contrasts in the subsurface; the model is characterised by high and shallow resistivity values (≈1461 Ωm) from the start (0 m). This zone of resistivity highs, however, deepens at x=200 m overtop which is a zone characterised by relatively low resistivity interpreted as deep weathering possibly facilitated by weathering by groundwater mobilisation; subsequently, a groundwater exploration borehole was recommended at x≈220 m along the survey line.
Nkonjaneni	7	Mtubatuba	 Line 1	The inverted resistivity model for the line surveyed in Nkonjaneni indicates very simple resistivity distribution with very shallow and competed substratum revealed by resistivity of over 663 Ωm. Overtop this shallow substratum is a weathered zone revealed resistivity values of ≤31 Ωm. The competent and shallow substratum is usually unfavourable for placement of groundwater production boreholes; nevertheless, a secondary (low confidence) groundwater exploration borehole was recommended at x≈360 m hoping for fracture interceptions across the substratum. The rationale is that, with long survey lines, the resolution tends to conceal highly localised and low intensity micro fractures
Kwamshaya	14	Mtubatuba	 Line 1  Line 2	Line 1: The inverted subsurface resistivity model of the ERT survey Line 1 is characterised by low apparent resistivity values ranging between 22 Ωm and 221 Ωm at shallow depth (approximately 80 mamsl). This (low resistivity range) is interpreted as a shallow weathered formation underlying a formation with relatively higher resistivity values (≥349 Ωm) interpreted as a competent substratum. A very important feature of the model is that the area with low resistivity extends to a deeper depth between x≈175 m and x≈2400 m. This characteristic (deepening of area of low resistivity values as a designated zone) may be interpreted as a weathering through. If deep enough, the weathering through would be targeted for placement of a groundwater exploration borehole; however, it was deemed not deep enough in this particular case.

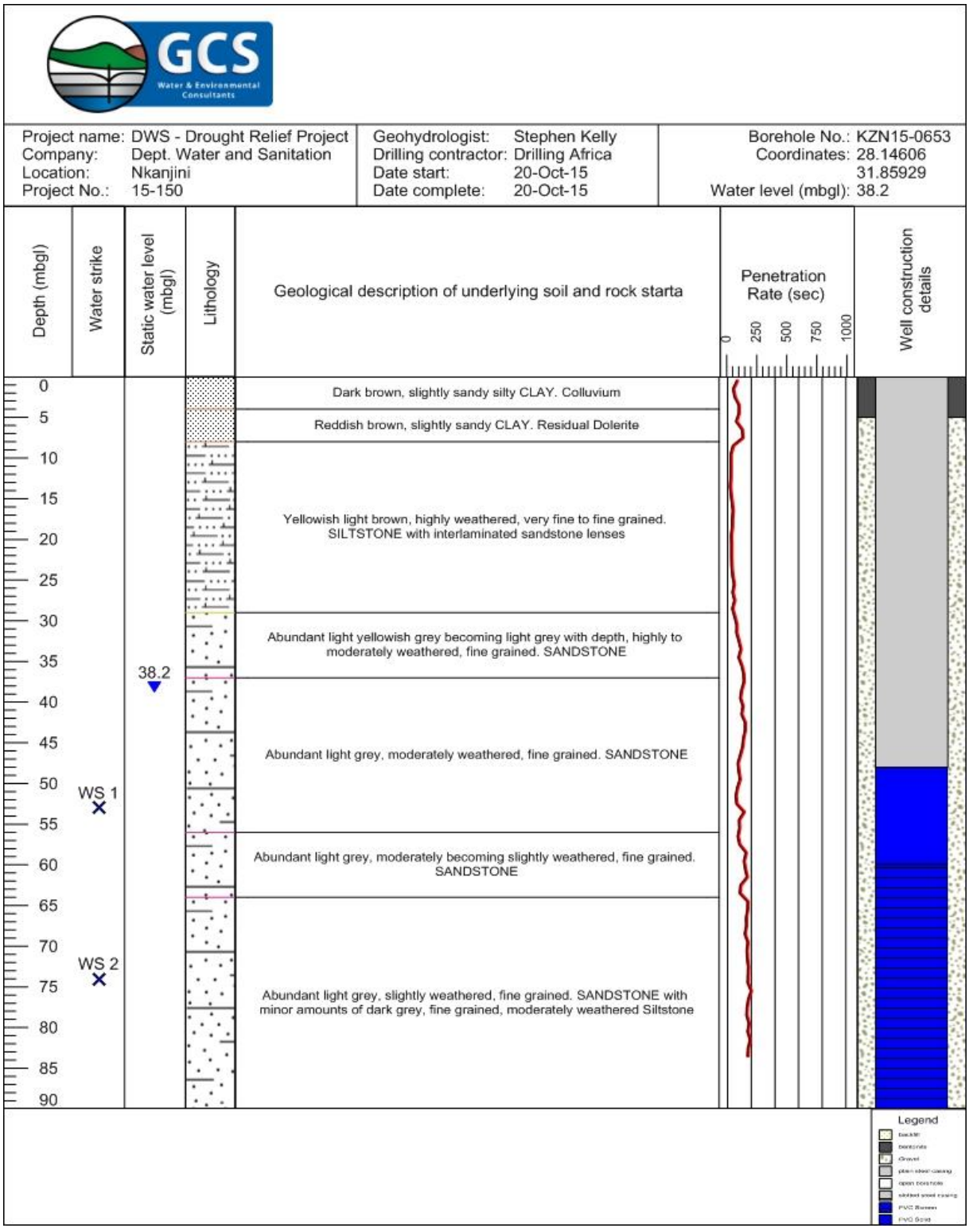
Community Name	Ward number	Local Municipality	Models	Description
Hlambanyathi	1	Hlabisa	 Line 1  Line 2	Line 1: The inverted resistivity data for both Line 1 and Line 2 in Hlambanyathi indicate almost near similar resistivity distributions; Line 1 is characterised by resistivity lows (<229 Ωm) at an approximate depth of z≈140 mamsl. This is interpreted as deep weathering below which is a zone with relatively increased resistivity values, interpreted as a weakened substratum perhaps due to fracturing and/or weathering. As such a groundwater exploration borehole was recommended at x=200 m along the survey line. Line 2: On Line 2, the weathering occurs relatively deeper compared to that identified in Line 1 prompting a primary (high confidence) groundwater exploration borehole at x≈220 m along the survey line.
Ngebeza	1	Hlabisa	 Line 1	Line 1: The resistivity model for the survey undertaken in Ngebeza shows relatively low resistivity (≤299 Ωm) zones in the peripheries of the model. Between x≈120 and x≈275 m, the model is characterised by relatively high resistivities (≥496 Ωm). Interesting is a much localised feature at x≈230, located at about 514 mamsl, with resistivity values ranging between 180 Ωm-496 Ωm. Since this line was surveyed upstream an active/flowing spring, this zone of low resistivities at greater depth was targeted for a primary groundwater production borehole.

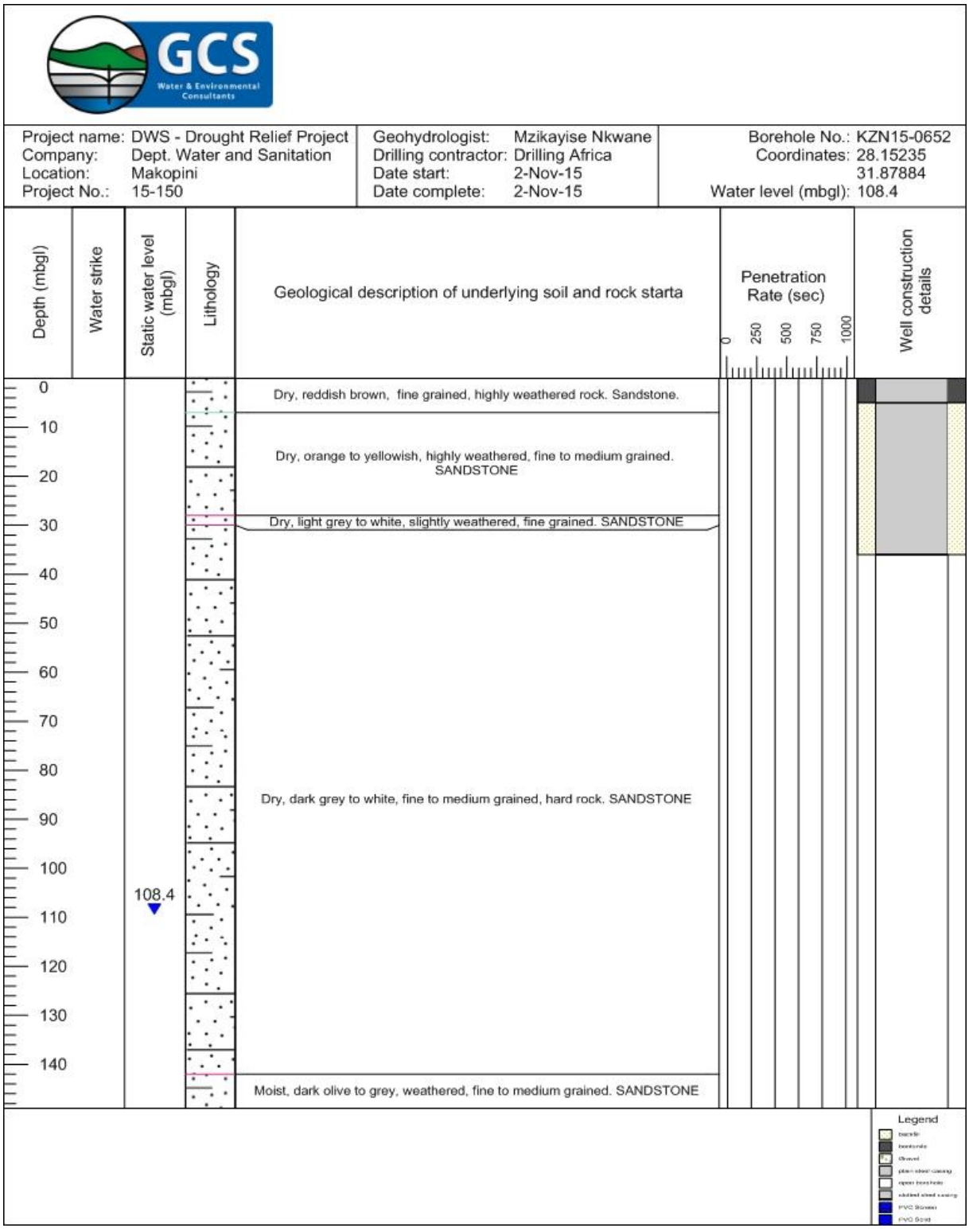
Community Name	Ward number	Local Municipality	Models	Description
Nkanjini	2	Hlabisa	 Line 1  Line 2	Line 1 and Line 2: While large variation in the resistivity of the subsurface materials is apparent across the inversion model area which gives a good insight on the possible area to place required groundwater exploration borehole on both lines, Line 1 was considered more favourable in terms of proximity to the target community. On Line 1, there is a deeper zone characterised by resistivity lows (166 Ωm-231 Ωm) relative to the ambient resistivity distributions and interpreted as comprehensive weathering. This zone appears to be connected to the recharge surface at $x \approx 120$ m as marked by a rift across the resistivity highs. As such a primary groundwater exploration borehole was recommended at $x \approx 120$

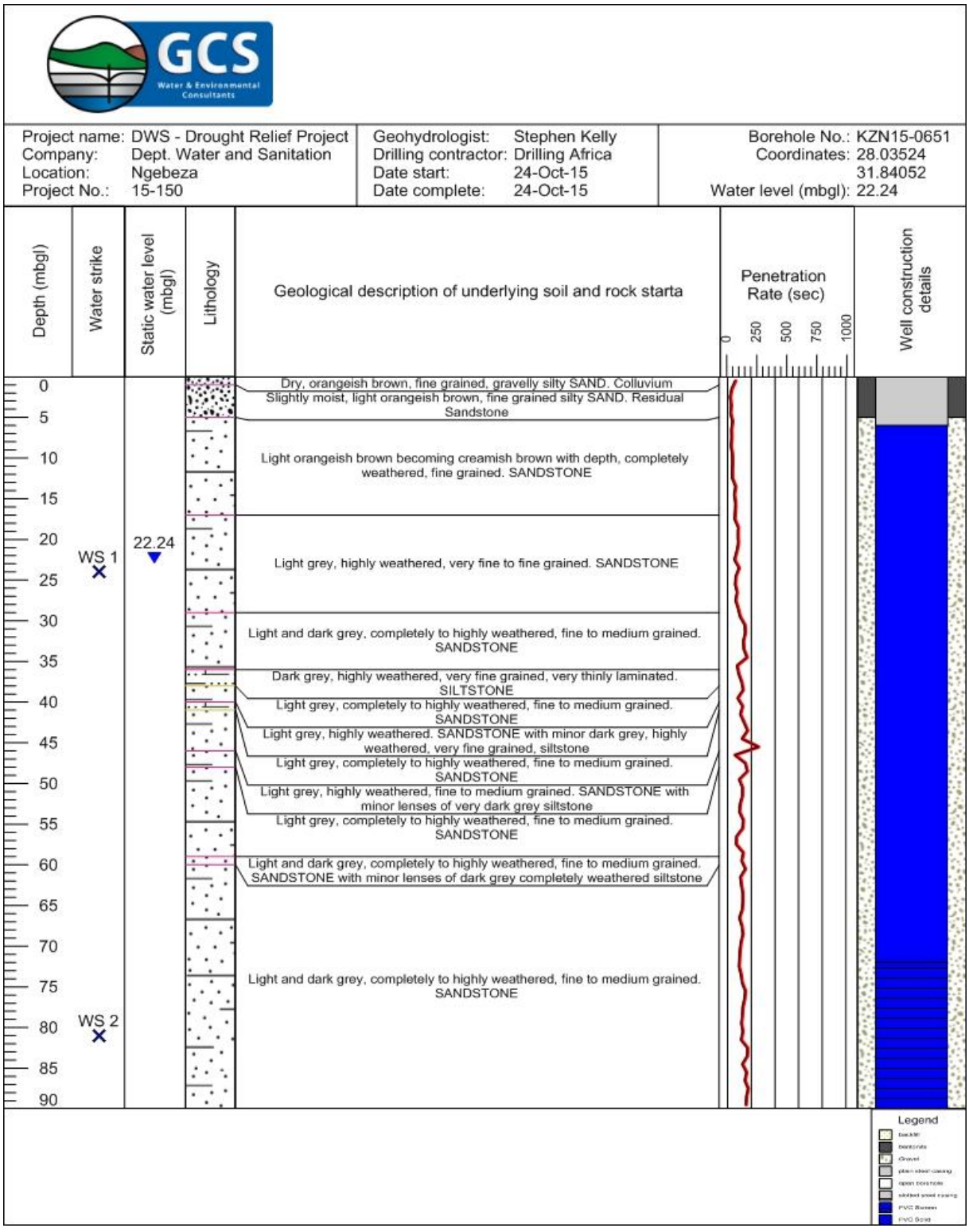
APPENDIX B: DRILLING LOGS



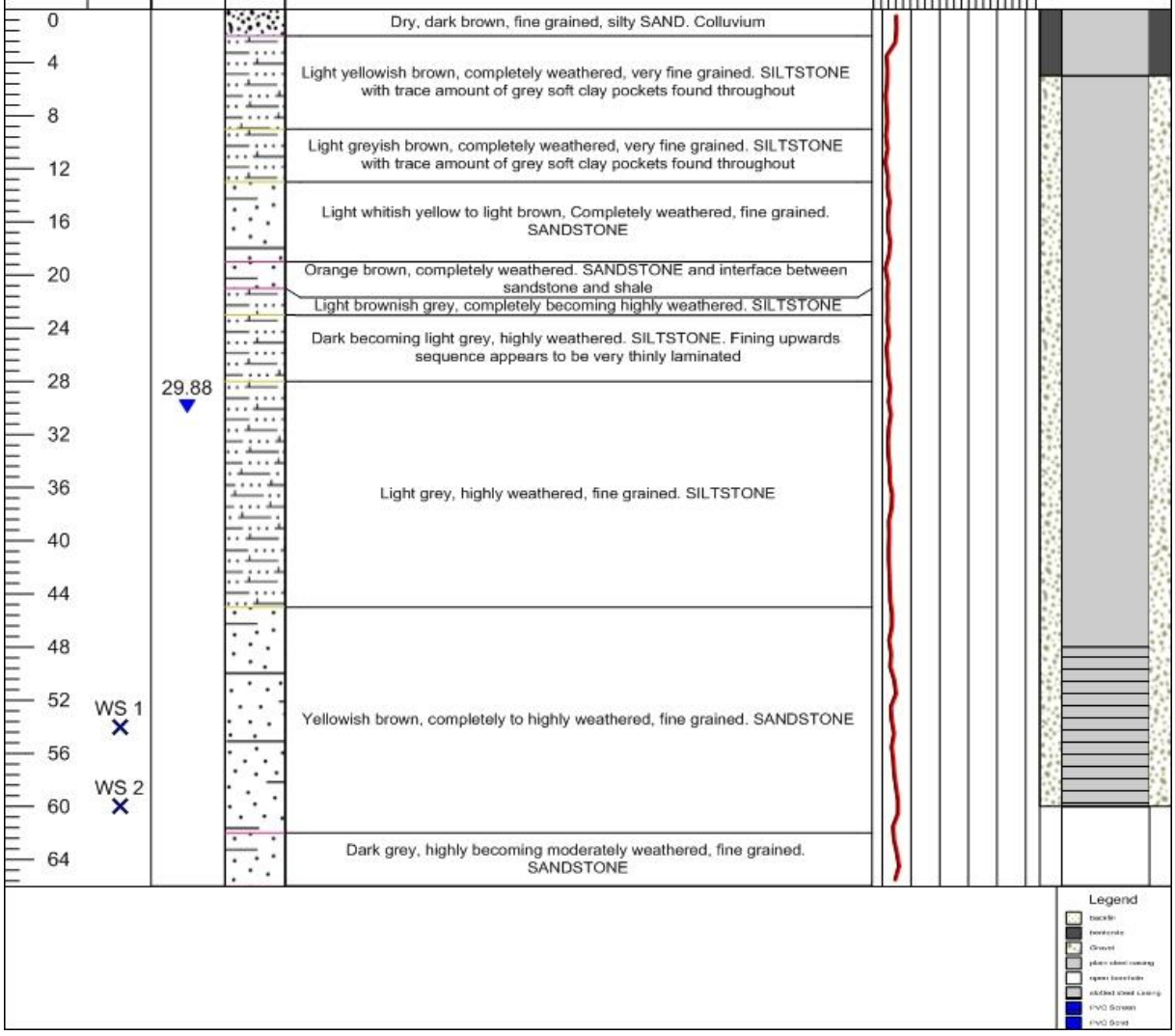

GCS
Water & Environmental Consultants
Project name: DWS - Drought Relief Project
Company: Dept. Water and Sanitation
Location: Macekeni
Project No.: 15-150
Geohydrologist: Stephen Kelly
Drilling contractor: Drilling Africa
Date start: 23-Oct-15
Date complete: 23-Oct-15
Borehole No.: KZN15-0654
Coordinates: 28.16175
31.86414
Water level (mbgl): 19.08
Depth (mbgl)
Water strike
Static water level (mbgl)
Lithology
Geological description of underlying soil and rock starta
Penetration Rate (sec)
0
250
500
750
1000
Well construction details
0
4
8
12
16
20
24
28
32
36
40
44
48
52
56
60
64
68
72
19.08
WS 1
WS 2
Slightly moist, dark brown, sandy CLAY. Colluvium
Slightly moist, dark reddish brown, slightly sandy CLAY. Residual
Slightly moist, orange brown, CLAY. Residual
Slightly moist, light pinkish orange, CLAY. Residual
Slightly moist, light yellowish brown, fine sandy to silty CLAY. Residual
Slightly moist, light creamish yellow, fine, slightly clayey silty SAND. Residual
Slightly moist, light creamish yellow, very fine grained silty SAND. Residual with minor amounts of light grey, moderately weathered, silica rich gravels
Yellowish brown, completely to highly weathered, silty SAND. Sandstone/Siltstone
Dark grey to light brown, highly weathered. DOLERITE
Light blueish grey, moderately weathered, very fine to fine grained. QUARTZITE with minor reddish brown, fine to medium grained sand
Dark grey speckled white reddish orange, moderately to slightly weathered, fine to medium grained. DOLERITE with minor reddish brown clay pockets observed
Legend

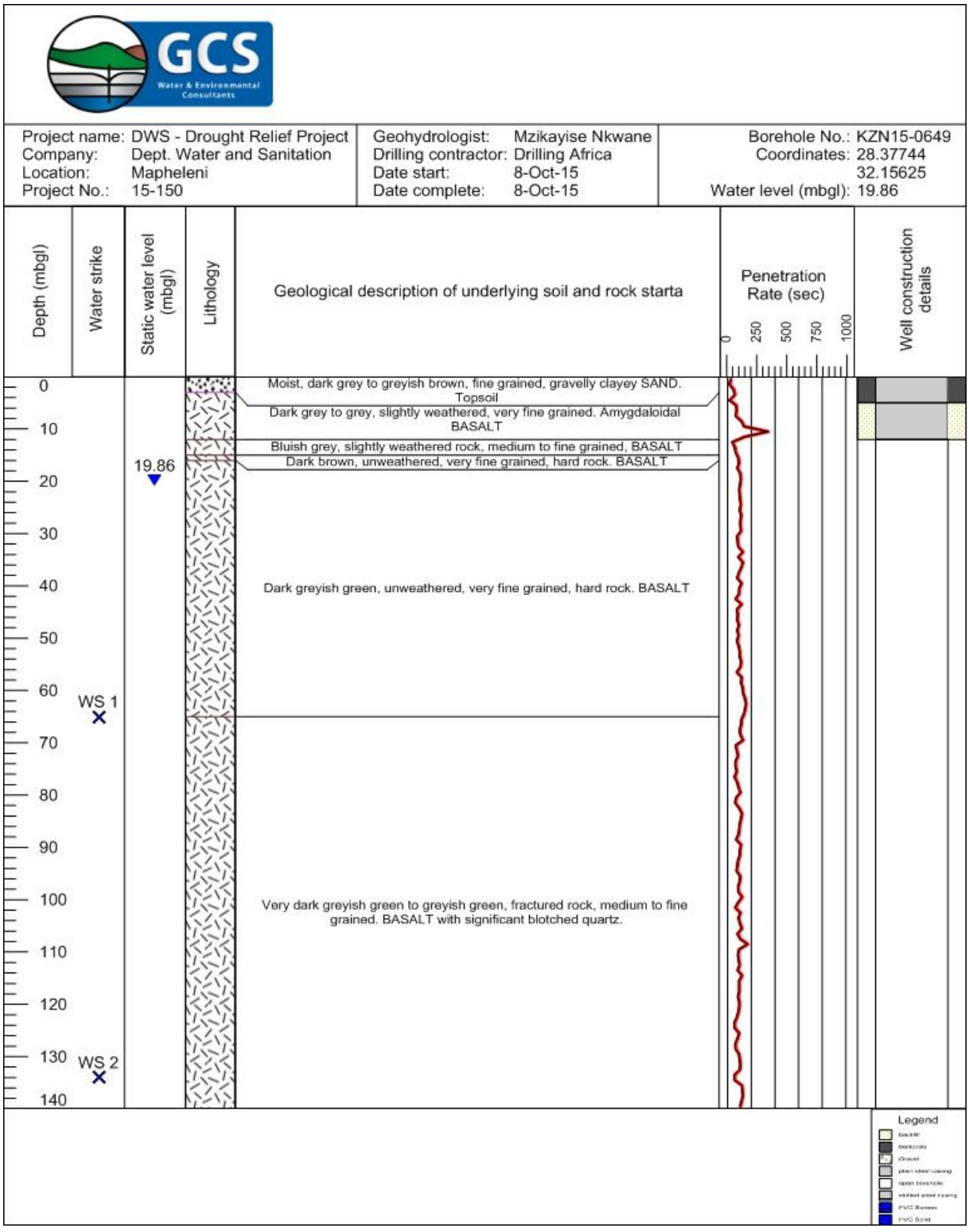

GCS
Water & Environmental Consultants
Project name: DWS - Drought Relief Project
Company: Dept. Water and Sanitation
Location: Nkanjini
Project No.: 15-150
Geohydrologist: Stephen Kelly
Drilling contractor: Drilling Africa
Date start: 20-Oct-15
Date complete: 20-Oct-15
Borehole No.: KZN15-0653
Coordinates: 28.14606
31.85929
Water level (mbgl): 38.2
Depth (mbgl)
Water strike
Static water level (mbgl)
Lithology
Geological description of underlying soil and rock starta
Penetration Rate (sec)
0
250
500
750
1000
Well construction details
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
38.2
WS 1
WS 2
Dark brown, slightly sandy silty CLAY. Colluvium
Reddish brown, slightly sandy CLAY. Residual Dolerite
Yellowish light brown, highly weathered, very fine to fine grained. SILTSTONE with interlaminated sandstone lenses
Abundant light yellowish grey becoming light grey with depth, highly to moderately weathered, fine grained. SANDSTONE
Abundant light grey, moderately weathered, fine grained. SANDSTONE
Abundant light grey, moderately becoming slightly weathered, fine grained. SANDSTONE
Abundant light grey, slightly weathered, fine grained. SANDSTONE with minor amounts of dark grey, fine grained, moderately weathered Siltstone
Legend

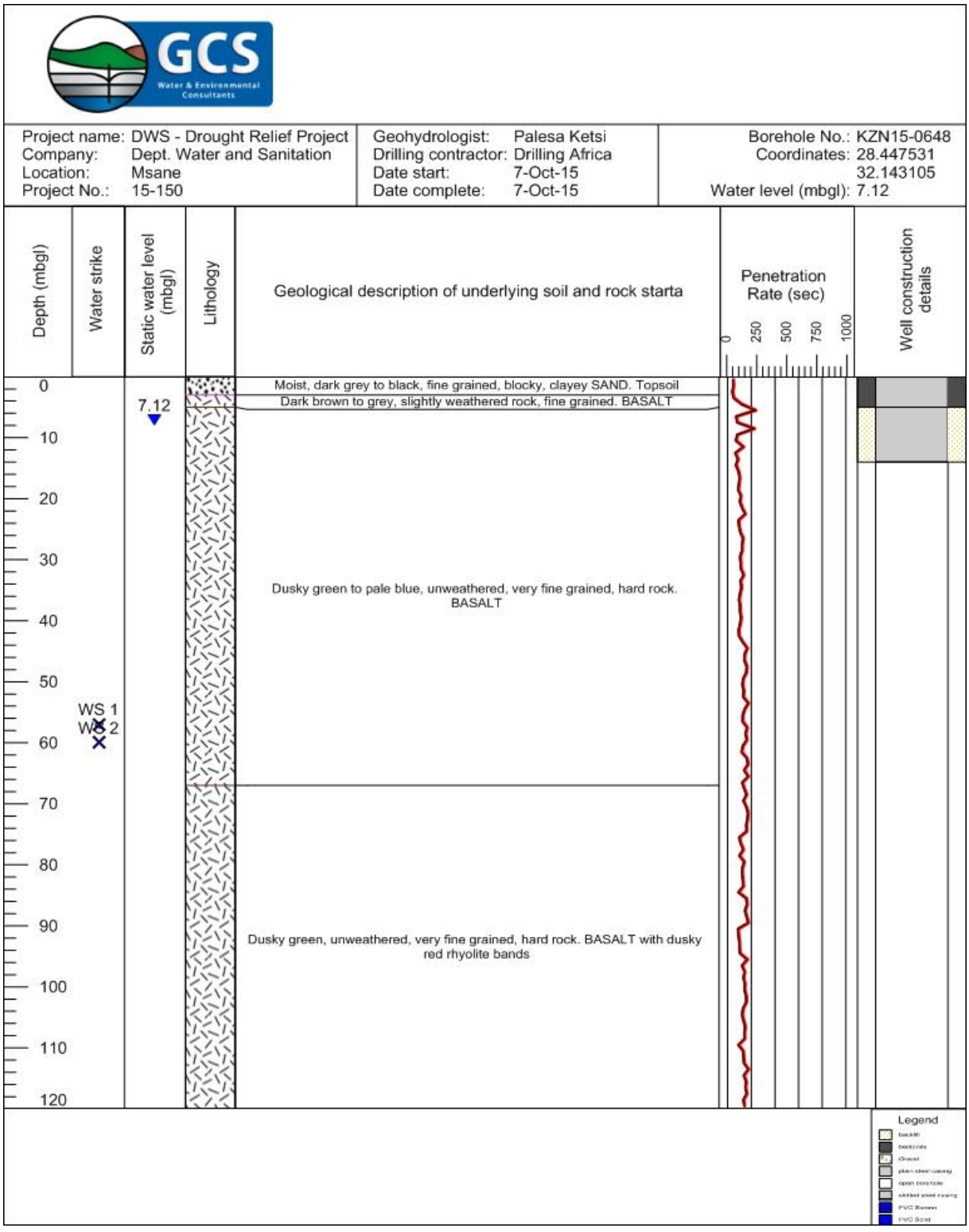

GCS
Water & Environmental Consultants
Project name: DWS - Drought Relief Project
Company: Dept. Water and Sanitation
Location: Makopini
Project No.: 15-150
Geohydrologist: Mzikayise Nkwane
Drilling contractor: Drilling Africa
Date start: 2-Nov-15
Date complete: 2-Nov-15
Borehole No.: KZN15-0652
Coordinates: 28.15235
31.87884
Water level (mbgl): 108.4
Depth (mbgl)
Water strike
Static water level (mbgl)
Lithology
Geological description of underlying soil and rock starta
Penetration Rate (sec)
0
250
500
750
1000
Well construction details
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
108.4
Dry, reddish brown, fine grained, highly weathered rock. Sandstone.
Dry, orange to yellowish, highly weathered, fine to medium grained. SANDSTONE
Dry, light grey to white, slightly weathered, fine grained. SANDSTONE
Dry, dark grey to white, fine to medium grained, hard rock. SANDSTONE
Moist, dark olive to grey, weathered, fine to medium grained. SANDSTONE
Legend

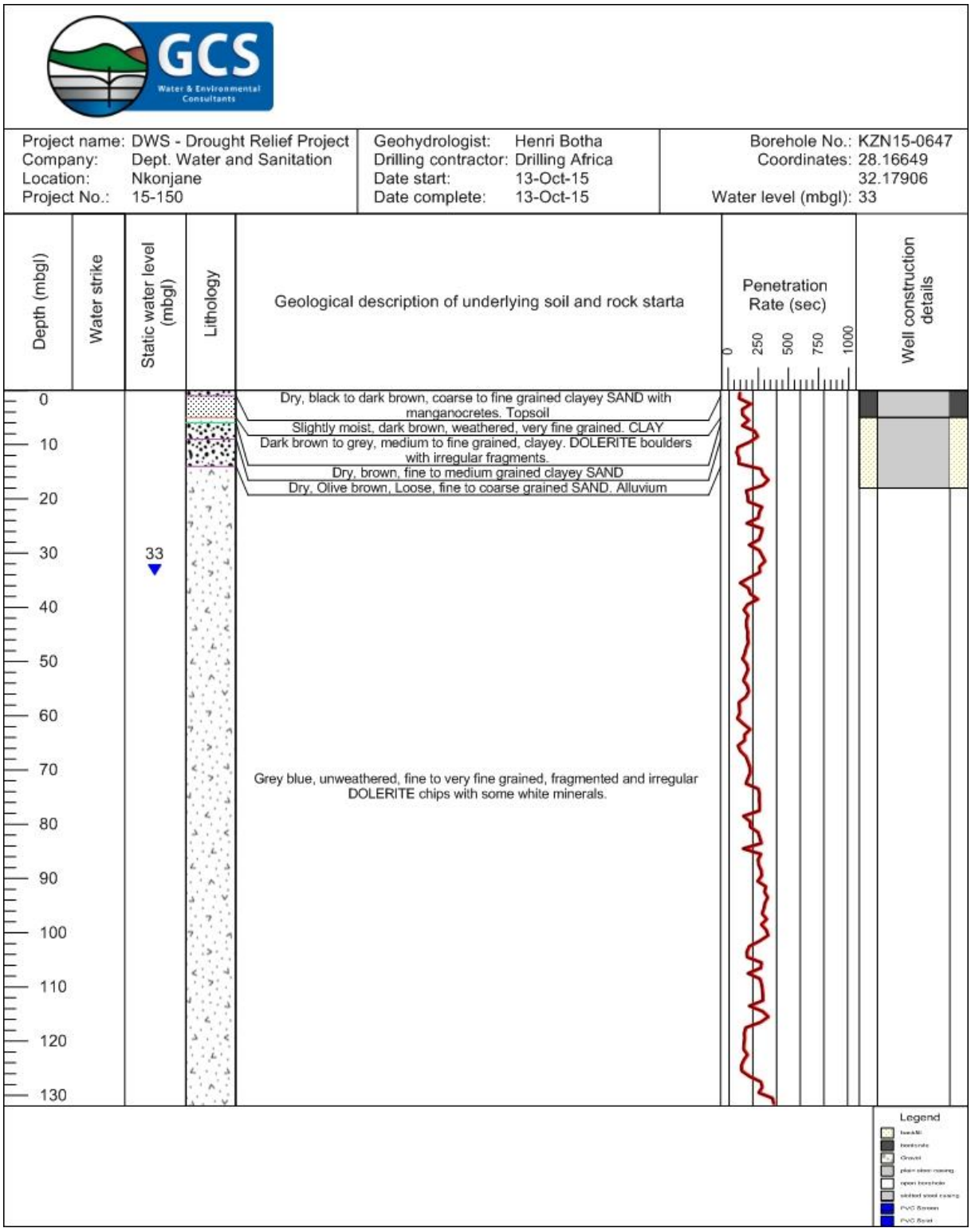

GCS
Water & Environmental Consultants
Project name: DWS - Drought Relief Project
Company: Dept. Water and Sanitation
Location: Ngebeza
Project No.: 15-150
Geohydrologist: Stephen Kelly
Drilling contractor: Drilling Africa
Date start: 24-Oct-15
Date complete: 24-Oct-15
Borehole No.: KZN15-0651
Coordinates: 28.03524
31.84052
Water level (mbgl): 22.24
Depth (mbgl)
Water strike
Static water level (mbgl)
Lithology
Geological description of underlying soil and rock starta
Penetration Rate (sec)
0
250
500
750
1000
Well construction details
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
WS 1
22.24
WS 2
Dry, orangeish brown, fine grained, gravelly silty SAND. Colluvium
Slightly moist, light orangeish brown, fine grained silty SAND. Residual Sandstone
Light orangeish brown becoming creamish brown with depth, completely weathered, fine grained. SANDSTONE
Light grey, highly weathered, very fine to fine grained. SANDSTONE
Light and dark grey, completely to highly weathered, fine to medium grained. SANDSTONE
Dark grey, highly weathered, very fine grained, very thinly laminated. SILTSTONE
Light grey, completely to highly weathered, fine to medium grained. SANDSTONE
Light grey, highly weathered. SANDSTONE with minor dark grey, highly weathered, very fine grained, siltstone
Light grey, completely to highly weathered, fine to medium grained. SANDSTONE
Light grey, highly weathered, fine to medium grained. SANDSTONE with minor lenses of very dark grey siltstone
Light grey, completely to highly weathered, fine to medium grained. SANDSTONE
Light and dark grey, completely to highly weathered, fine to medium grained. SANDSTONE with minor lenses of dark grey completely weathered siltstone
Light and dark grey, completely to highly weathered, fine to medium grained. SANDSTONE
Legend

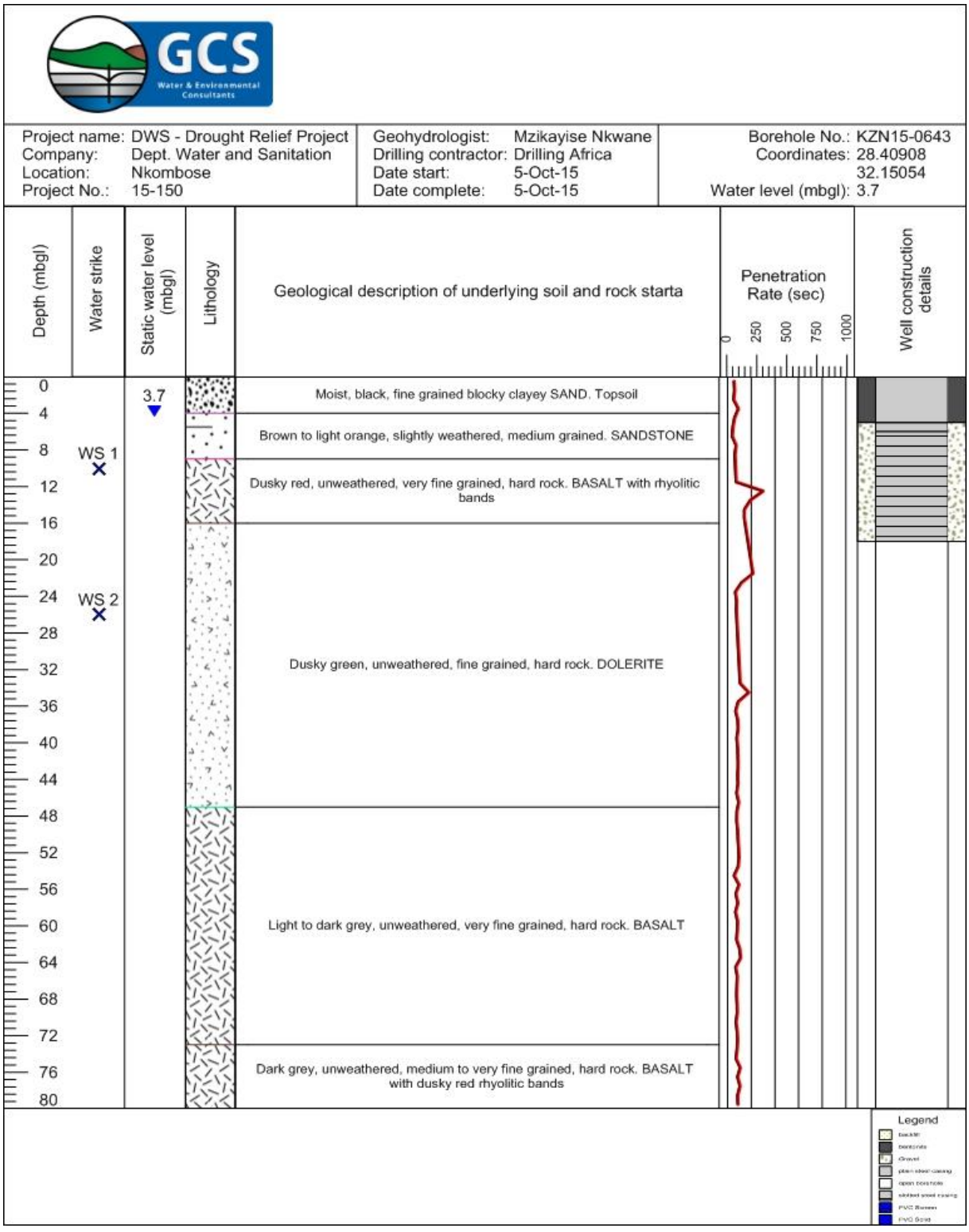
Project name:	DWS - Drought Relief Project	Geohydrologist:	Stephen Kelly	Borehole No.:	KZN15-0650
Company:	Dept. Water and Sanitation	Drilling contractor:	Drilling Africa	Coordinates:	28.16123
Location:	Hlambanyathi	Date start:	23-Oct-15		31.80454
Project No.:	15-150	Date complete:	23-Oct-15	Water level (mbgl):	29.88

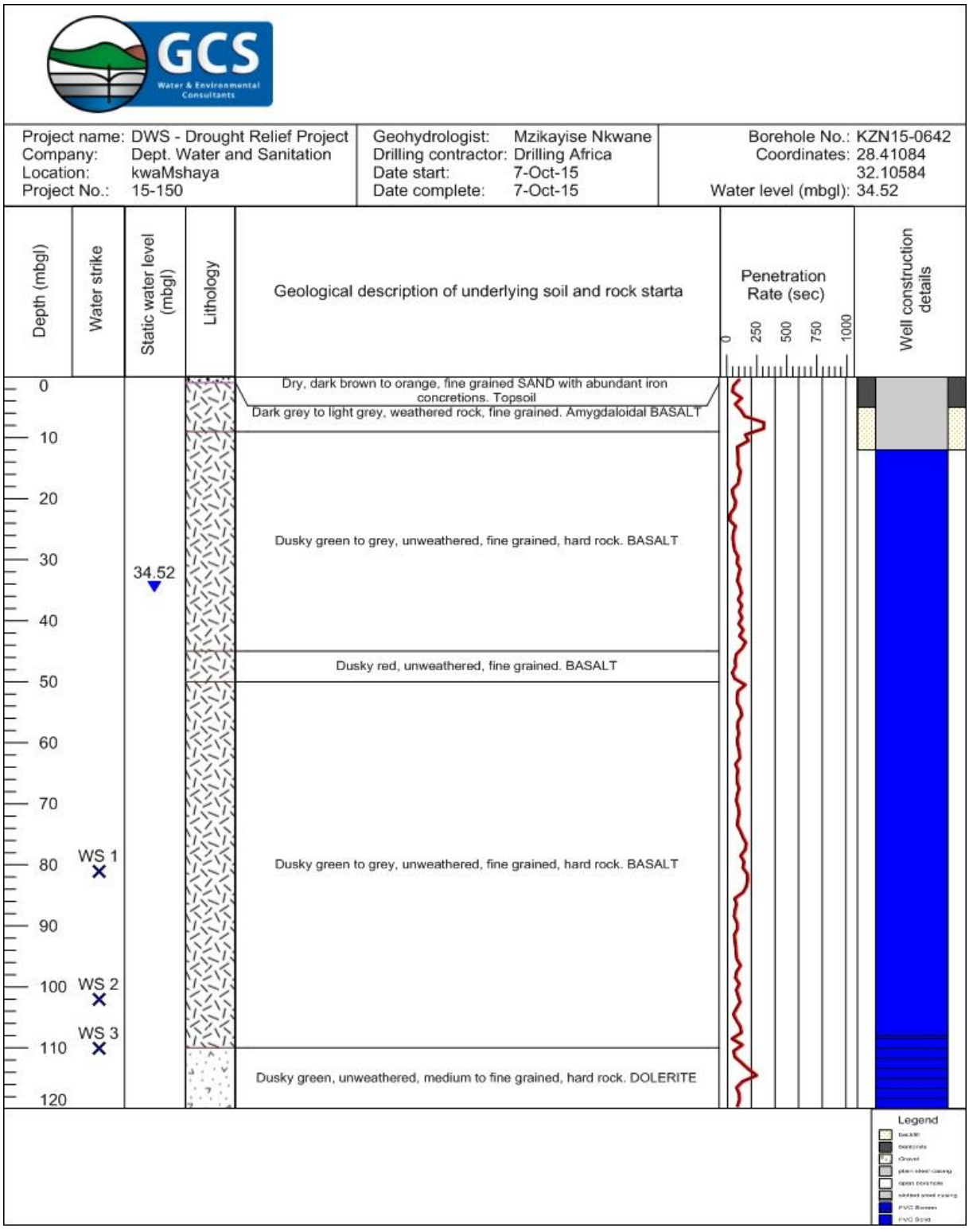


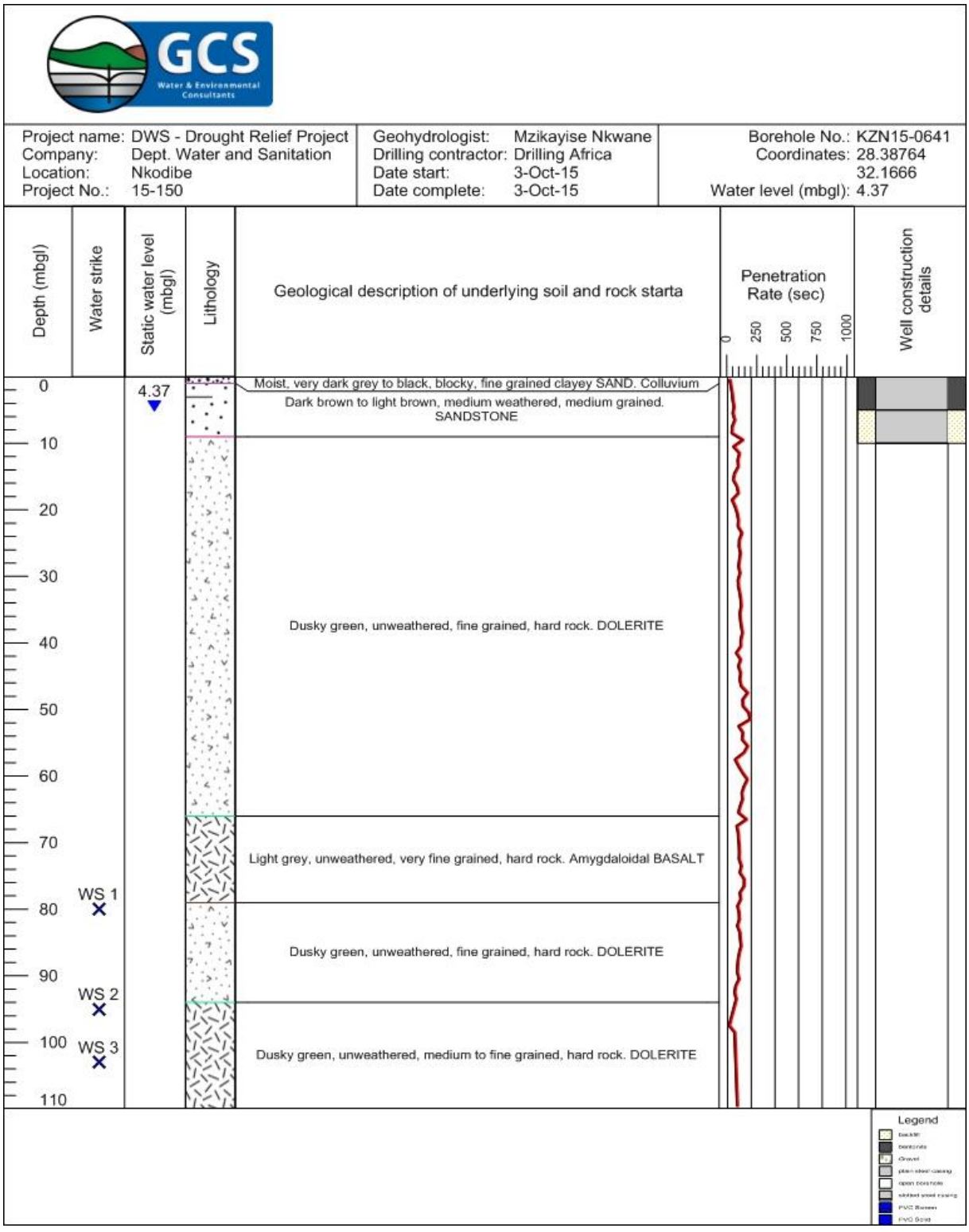

GCS
Water & Environmental Consultants
Project name: DWS - Drought Relief Project
Company: Dept. Water and Sanitation
Location: Mapheleni
Project No.: 15-150
Geohydrologist: Mzikayise Nkwane
Drilling contractor: Drilling Africa
Date start: 8-Oct-15
Date complete: 8-Oct-15
Borehole No.: KZN15-0649
Coordinates: 28.37744
32.15625
Water level (mbgl): 19.86
Depth (mbgl)
Water strike
Static water level (mbgl)
Lithology
Geological description of underlying soil and rock starta
Penetration Rate (sec)
0
250
500
750
1000
Well construction details
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
19.86
WS 1
WS 2
Moist, dark grey to greyish brown, fine grained, gravelly clayey SAND. Topsoil
Dark grey to grey, slightly weathered, very fine grained. Amygdaloidal BASALT
Bluish grey, slightly weathered rock, medium to fine grained, BASALT
Dark brown, unweathered, very fine grained, hard rock. BASALT
Dark greyish green, unweathered, very fine grained, hard rock. BASALT
Very dark greyish green to greyish green, fractured rock, medium to fine grained. BASALT with significant blotched quartz.
Legend

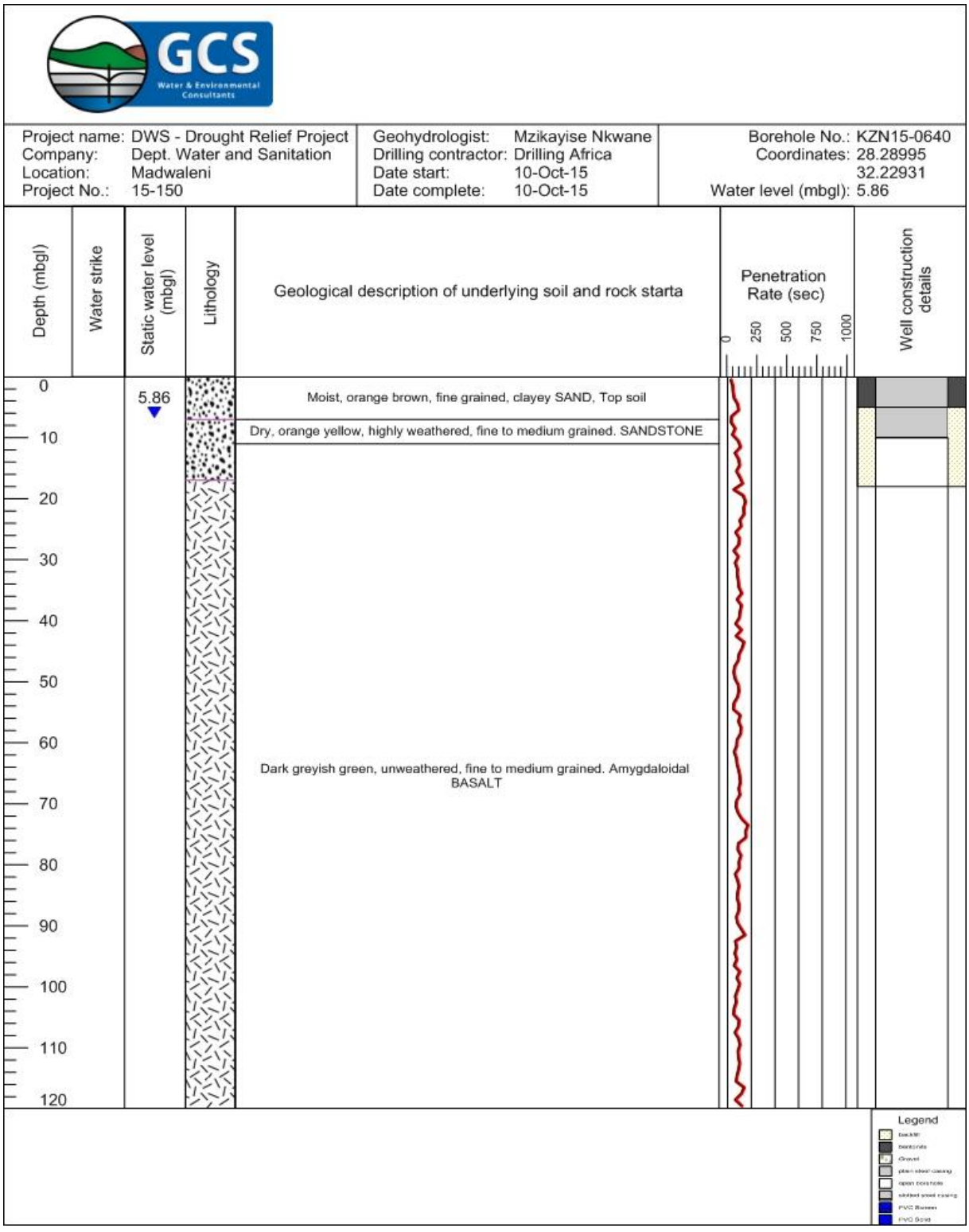

GCS
Water & Environmental Consultants
Project name: DWS - Drought Relief Project
Company: Dept. Water and Sanitation
Location: Msane
Project No.: 15-150
Geohydrologist: Palesa Ketsi
Drilling contractor: Drilling Africa
Date start: 7-Oct-15
Date complete: 7-Oct-15
Borehole No.: KZN15-0648
Coordinates: 28.447531
32.143105
Water level (mbgl): 7.12
Depth (mbgl)
Water strike
Static water level (mbgl)
Lithology
Geological description of underlying soil and rock starta
Penetration Rate (sec)
0
250
500
750
1000
Well construction details
7.12
WS 1
WS 2
Moist, dark grey to black, fine grained, blocky, clayey SAND. Topsoil
Dark brown to grey, slightly weathered rock, fine grained. BASALT
Dusky green to pale blue, unweathered, very fine grained, hard rock. BASALT
Dusky green, unweathered, very fine grained, hard rock. BASALT with dusky red rhyolite bands
Legend

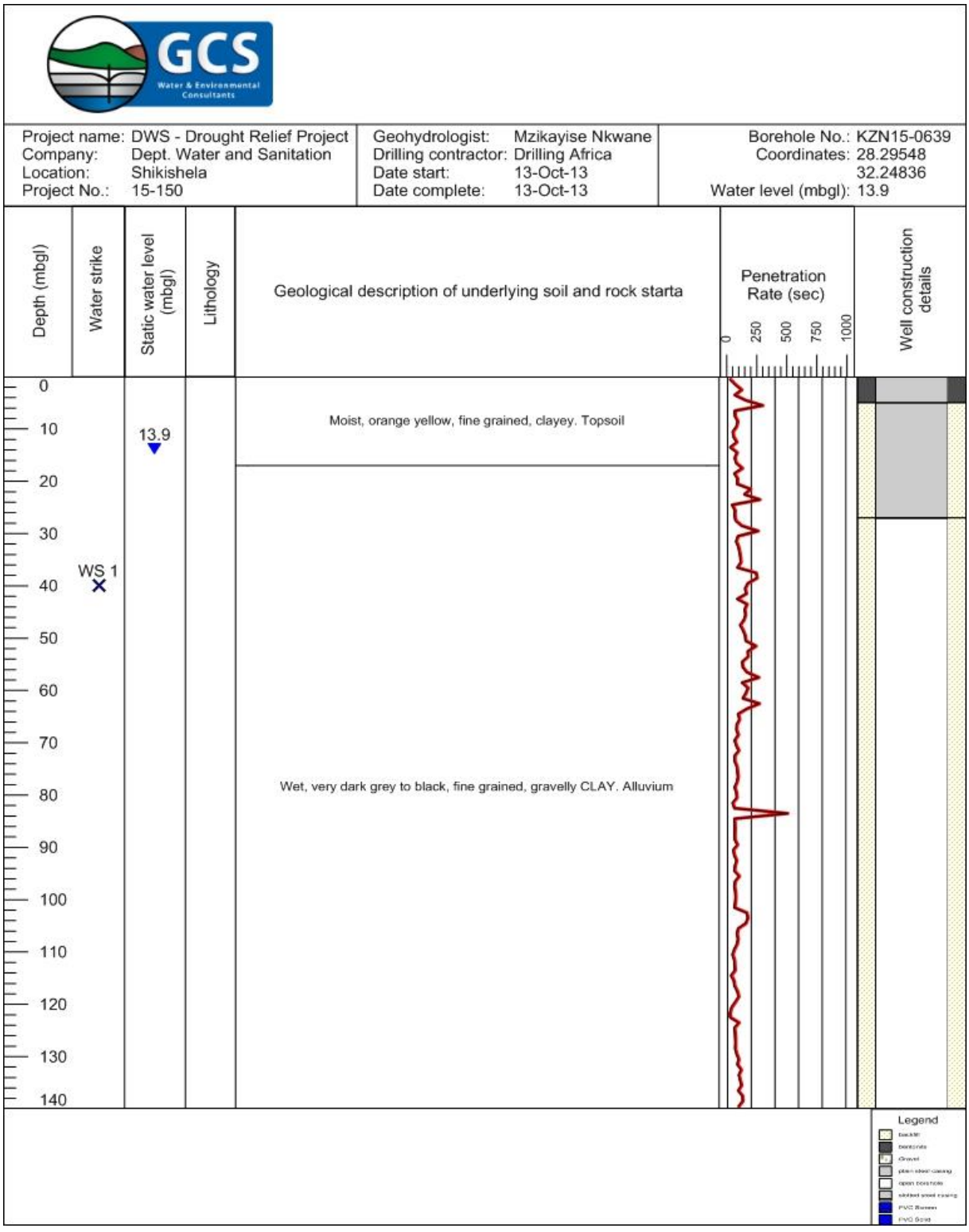

GCS
Water & Environmental Consultants
Project name: DWS - Drought Relief Project
Company: Dept. Water and Sanitation
Location: Nkonjane
Project No.: 15-150
Geohydrologist: Henri Botha
Drilling contractor: Drilling Africa
Date start: 13-Oct-15
Date complete: 13-Oct-15
Borehole No.: KZN15-0647
Coordinates: 28.16649
32.17906
Water level (mbgl): 33
Depth (mbgl)
Water strike
Static water level (mbgl)
Lithology
Geological description of underlying soil and rock starta
Penetration Rate (sec)
0
250
500
750
1000
Well construction details
0
10
20
30
40
50
60
70
80
90
100
110
120
130
33
Dry, black to dark brown, coarse to fine grained clayey SAND with manganocretes. Topsoil
Slightly moist, dark brown, weathered, very fine grained. CLAY
Dark brown to grey, medium to fine grained, clayey. DOLERITE boulders with irregular fragments.
Dry, brown, fine to medium grained clayey SAND
Dry, Olive brown, Loose, fine to coarse grained SAND. Alluvium
Grey blue, unweathered, fine to very fine grained, fragmented and irregular DOLERITE chips with some white minerals.
Legend

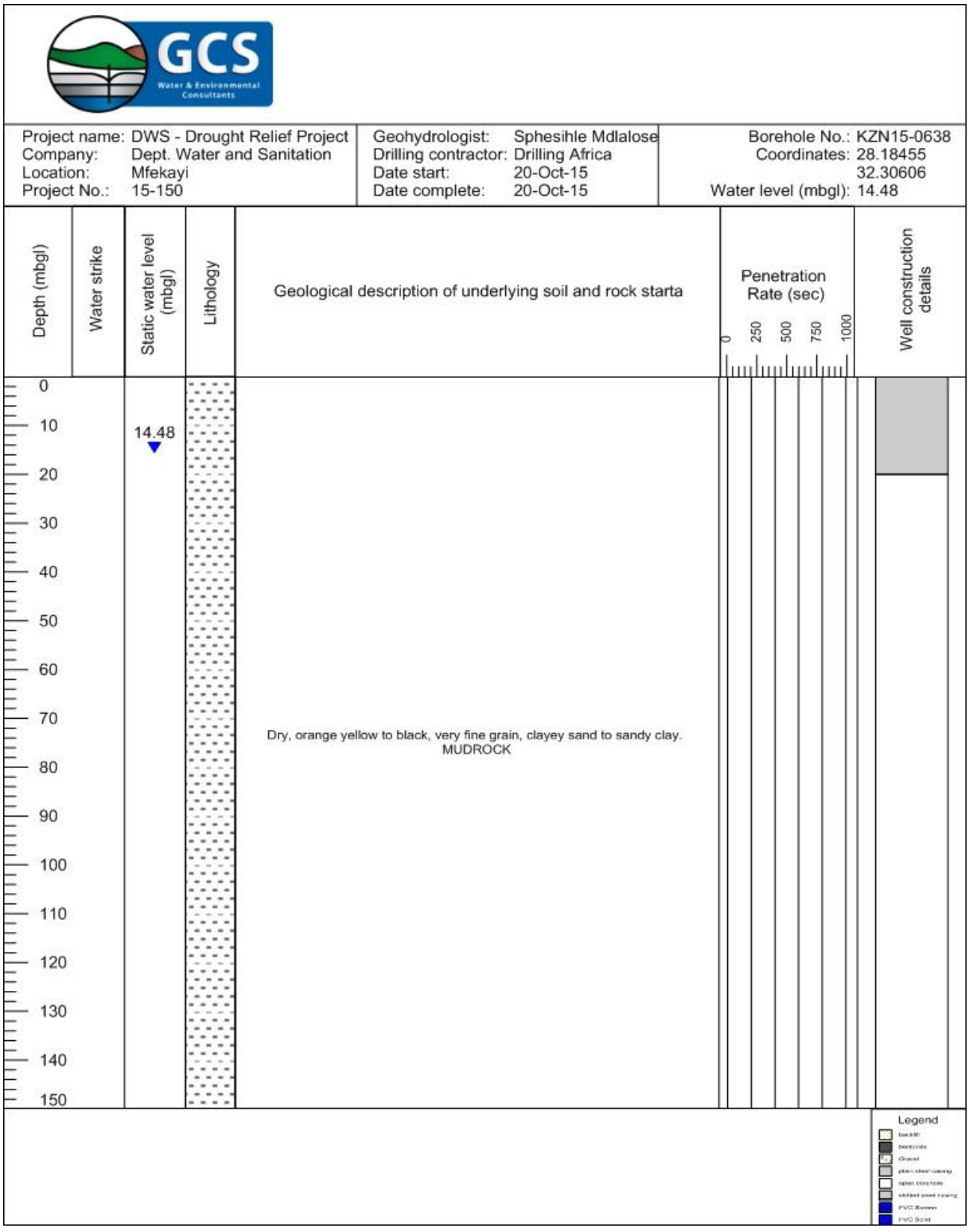

GCS
Water & Environmental Consultants
Project name: DWS - Drought Relief Project
Company: Dept. Water and Sanitation
Location: Nkombose
Project No.: 15-150
Geohydrologist: Mzikayise Nkwane
Drilling contractor: Drilling Africa
Date start: 5-Oct-15
Date complete: 5-Oct-15
Borehole No.: KZN15-0643
Coordinates: 28.40908
32.15054
Water level (mbgl): 3.7
Depth (mbgl)
Water strike
Static water level (mbgl)
Lithology
Geological description of underlying soil and rock starta
Penetration Rate (sec)
0
250
500
750
1000
Well construction details
3.7
WS 1
WS 2
Moist, black, fine grained blocky clayey SAND. Topsoil
Brown to light orange, slightly weathered, medium grained. SANDSTONE
Dusky red, unweathered, very fine grained, hard rock. BASALT with rhyolitic bands
Dusky green, unweathered, fine grained, hard rock. DOLERITE
Light to dark grey, unweathered, very fine grained, hard rock. BASALT
Dark grey, unweathered, medium to very fine grained, hard rock. BASALT with dusky red rhyolitic bands
Legend

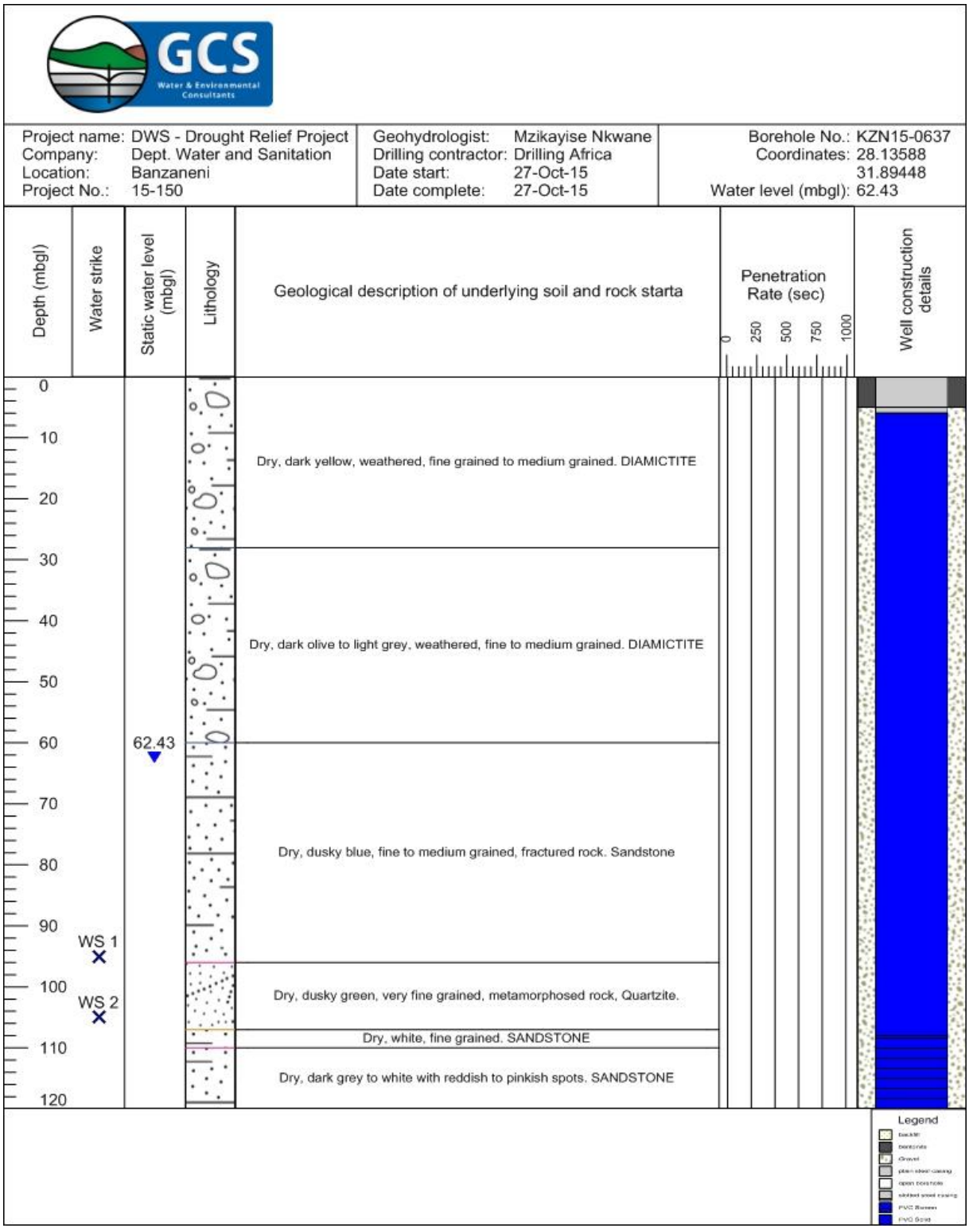

GCS
Water & Environmental Consultants
Project name: DWS - Drought Relief Project
Company: Dept. Water and Sanitation
Location: kwaMshaya
Project No.: 15-150
Geohydrologist: Mzikayise Nkwane
Drilling contractor: Drilling Africa
Date start: 7-Oct-15
Date complete: 7-Oct-15
Borehole No.: KZN15-0642
Coordinates: 28.41084
32.10584
Water level (mbgl): 34.52
Depth (mbgl)
Water strike
Static water level (mbgl)
Lithology
Geological description of underlying soil and rock starta
Penetration Rate (sec)
0
250
500
750
1000
Well construction details
0
10
20
30
40
50
60
70
80
90
100
110
120
34.52
WS 1
WS 2
WS 3
Dry, dark brown to orange, fine grained SAND with abundant iron concretions. Topsoil
Dark grey to light grey, weathered rock, fine grained. Amygdaloidal BASALT
Dusky green to grey, unweathered, fine grained, hard rock. BASALT
Dusky red, unweathered, fine grained. BASALT
Dusky green to grey, unweathered, fine grained, hard rock. BASALT
Dusky green, unweathered, medium to fine grained, hard rock. DOLERITE
Legend


GCS
Water & Environmental Consultants
Project name: DWS - Drought Relief Project
Company: Dept. Water and Sanitation
Location: Nkodibe
Project No.: 15-150
Geohydrologist: Mzikayise Nkwane
Drilling contractor: Drilling Africa
Date start: 3-Oct-15
Date complete: 3-Oct-15
Borehole No.: KZN15-0641
Coordinates: 28.38764
32.1666
Water level (mbgl): 4.37
Depth (mbgl)
Water strike
Static water level (mbgl)
Lithology
Geological description of underlying soil and rock starta
Penetration Rate (sec)
0
250
500
750
1000
Well construction details
4.37
Moist, very dark grey to black, blocky, fine grained clayey SAND. Colluvium
Dark brown to light brown, medium weathered, medium grained. SANDSTONE
Dusky green, unweathered, fine grained, hard rock. DOLERITE
Light grey, unweathered, very fine grained, hard rock. Amygdaloidal BASALT
Dusky green, unweathered, fine grained, hard rock. DOLERITE
Dusky green, unweathered, medium to fine grained, hard rock. DOLERITE
WS 1
WS 2
WS 3
0
10
20
30
40
50
60
70
80
90
100
110
Legend

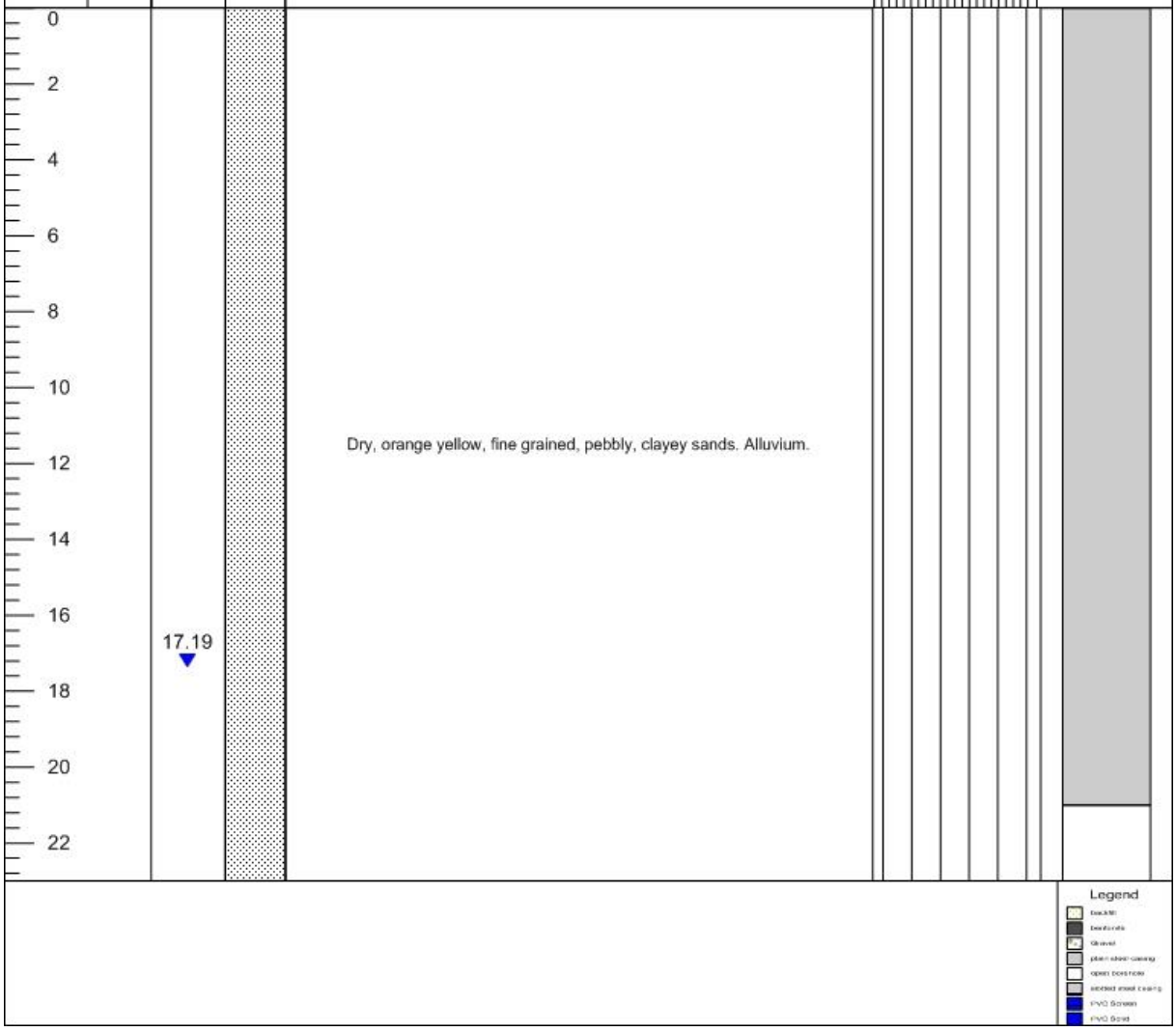

GCS
Water & Environmental Consultants
Project name: DWS - Drought Relief Project
Company: Dept. Water and Sanitation
Location: Madwaleni
Project No.: 15-150
Geohydrologist: Mzikayise Nkwane
Drilling contractor: Drilling Africa
Date start: 10-Oct-15
Date complete: 10-Oct-15
Borehole No.: KZN15-0640
Coordinates: 28.28995
32.22931
Water level (mbgl): 5.86
Depth (mbgl)
Water strike
Static water level (mbgl)
Lithology
Geological description of underlying soil and rock starta
Penetration Rate (sec)
0
250
500
750
1000
Well construction details
5.86
Moist, orange brown, fine grained, clayey SAND, Top soil
Dry, orange yellow, highly weathered, fine to medium grained. SANDSTONE
Dark greyish green, unweathered, fine to medium grained. Amygdaloidal BASALT
Legend

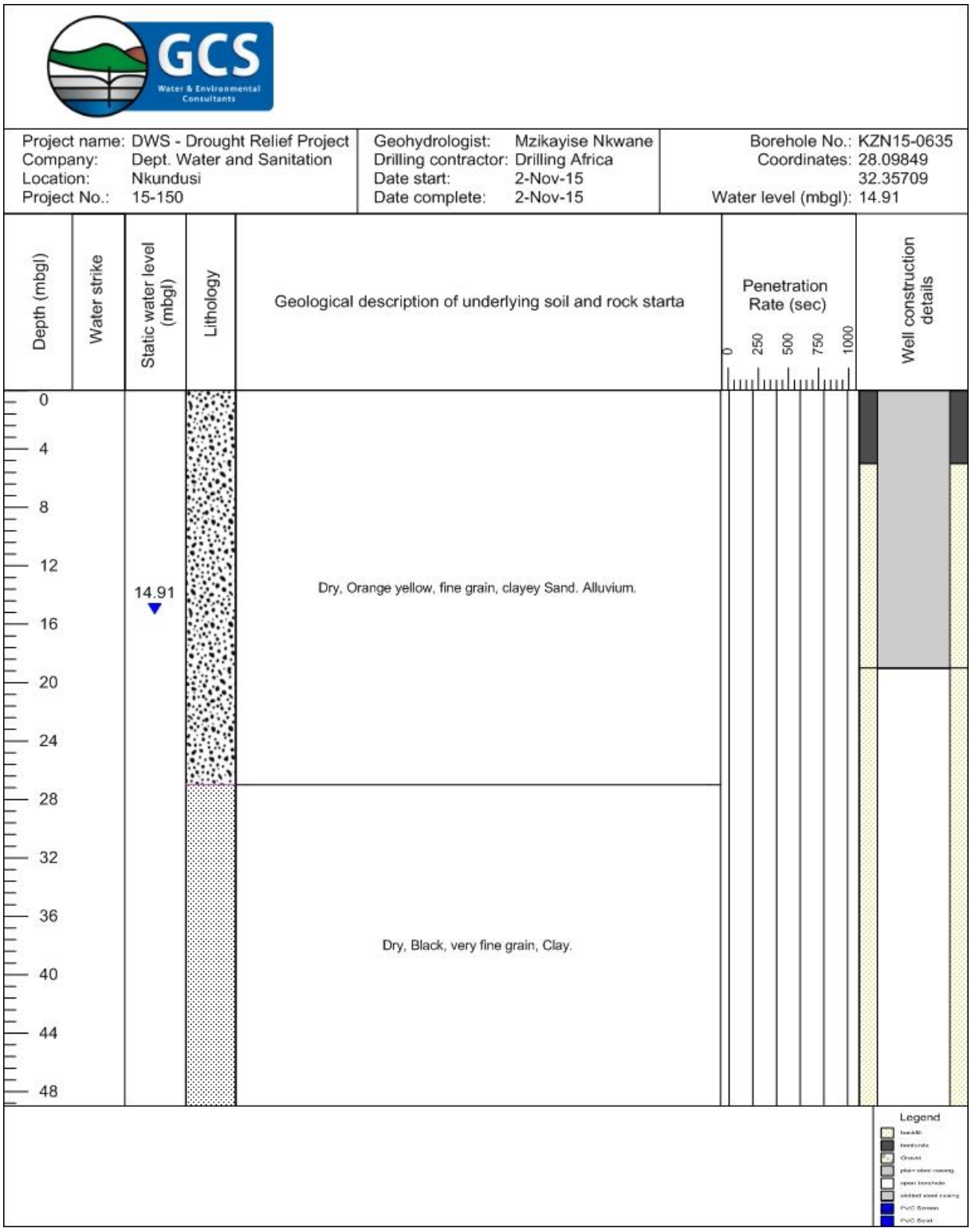

GCS
Water & Environmental Consultants
Project name: DWS - Drought Relief Project
Company: Dept. Water and Sanitation
Location: Shikishela
Project No.: 15-150
Geohydrologist: Mzikayise Nkwane
Drilling contractor: Drilling Africa
Date start: 13-Oct-13
Date complete: 13-Oct-13
Borehole No.: KZN15-0639
Coordinates: 28.29548
32.24836
Water level (mbgl): 13.9
Depth (mbgl)
Water strike
Static water level (mbgl)
Lithology
Geological description of underlying soil and rock starta
Penetration Rate (sec)
0
250
500
750
1000
Well construction details
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
13.9
WS 1
Moist, orange yellow, fine grained, clayey. Topsoil
Wet, very dark grey to black, fine grained, gravelly CLAY. Alluvium
Legend

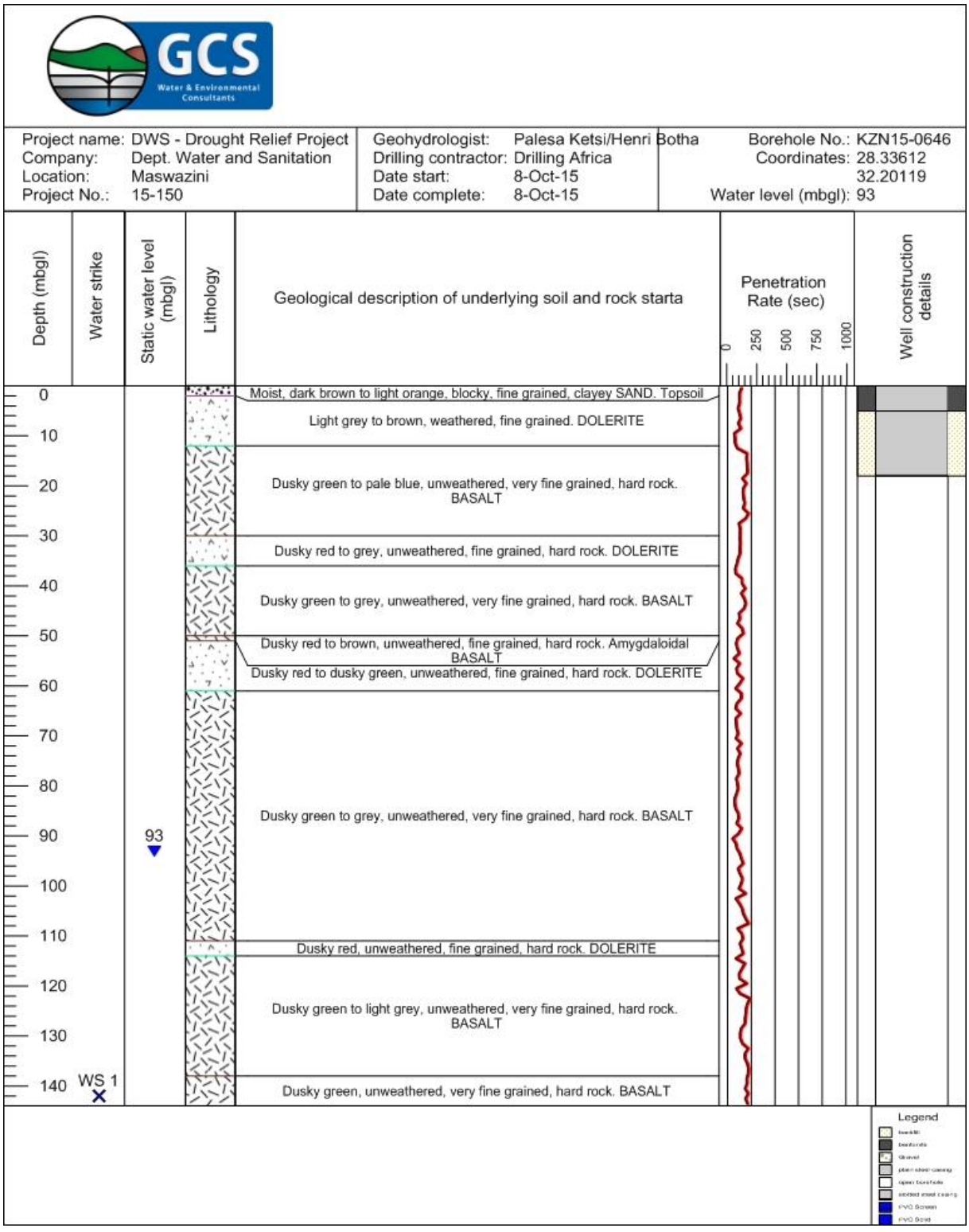

GCS
Water & Environmental Consultants
Project name: DWS - Drought Relief Project
Company: Dept. Water and Sanitation
Location: Mfekayi
Project No.: 15-150
Geohydrologist: Sphesihle Mdlalose
Drilling contractor: Drilling Africa
Date start: 20-Oct-15
Date complete: 20-Oct-15
Borehole No.: KZN15-0638
Coordinates: 28.18455
32.30606
Water level (mbgl): 14.48
Depth (mbgl)
Water strike
Static water level (mbgl)
Lithology
Geological description of underlying soil and rock starta
Penetration Rate (sec)
0
250
500
750
1000
Well construction details
14.48
Dry, orange yellow to black, very fine grain, clayey sand to sandy clay.
MUDROCK
Legend

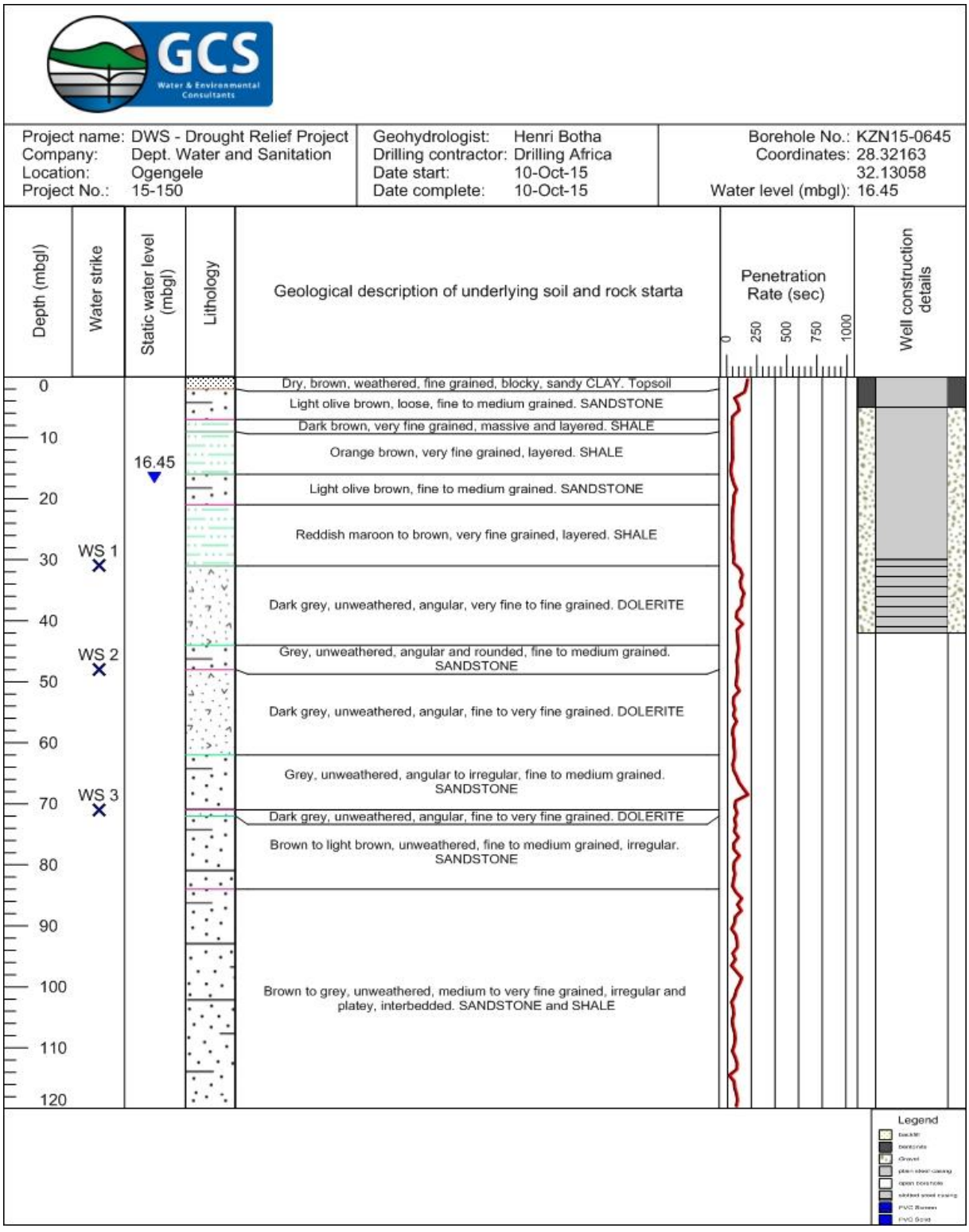

GCS
Water & Environmental Consultants
Project name: DWS - Drought Relief Project
Company: Dept. Water and Sanitation
Location: Banzaneni
Project No.: 15-150
Geohydrologist: Mzikayise Nkwane
Drilling contractor: Drilling Africa
Date start: 27-Oct-15
Date complete: 27-Oct-15
Borehole No.: KZN15-0637
Coordinates: 28.13588
31.89448
Water level (mbgl): 62.43
Depth (mbgl)
Water strike
Static water level (mbgl)
Lithology
Geological description of underlying soil and rock starta
Penetration Rate (sec)
0
250
500
750
1000
Well construction details
0
10
20
30
40
50
60
70
80
90
100
110
120
62.43
WS 1
WS 2
Dry, dark yellow, weathered, fine grained to medium grained. DIAMICTITE
Dry, dark olive to light grey, weathered, fine to medium grained. DIAMICTITE
Dry, dusky blue, fine to medium grained, fractured rock. Sandstone
Dry, dusky green, very fine grained, metamorphosed rock, Quartzite.
Dry, white, fine grained. SANDSTONE
Dry, dark grey to white with reddish to pinkish spots. SANDSTONE
Legend

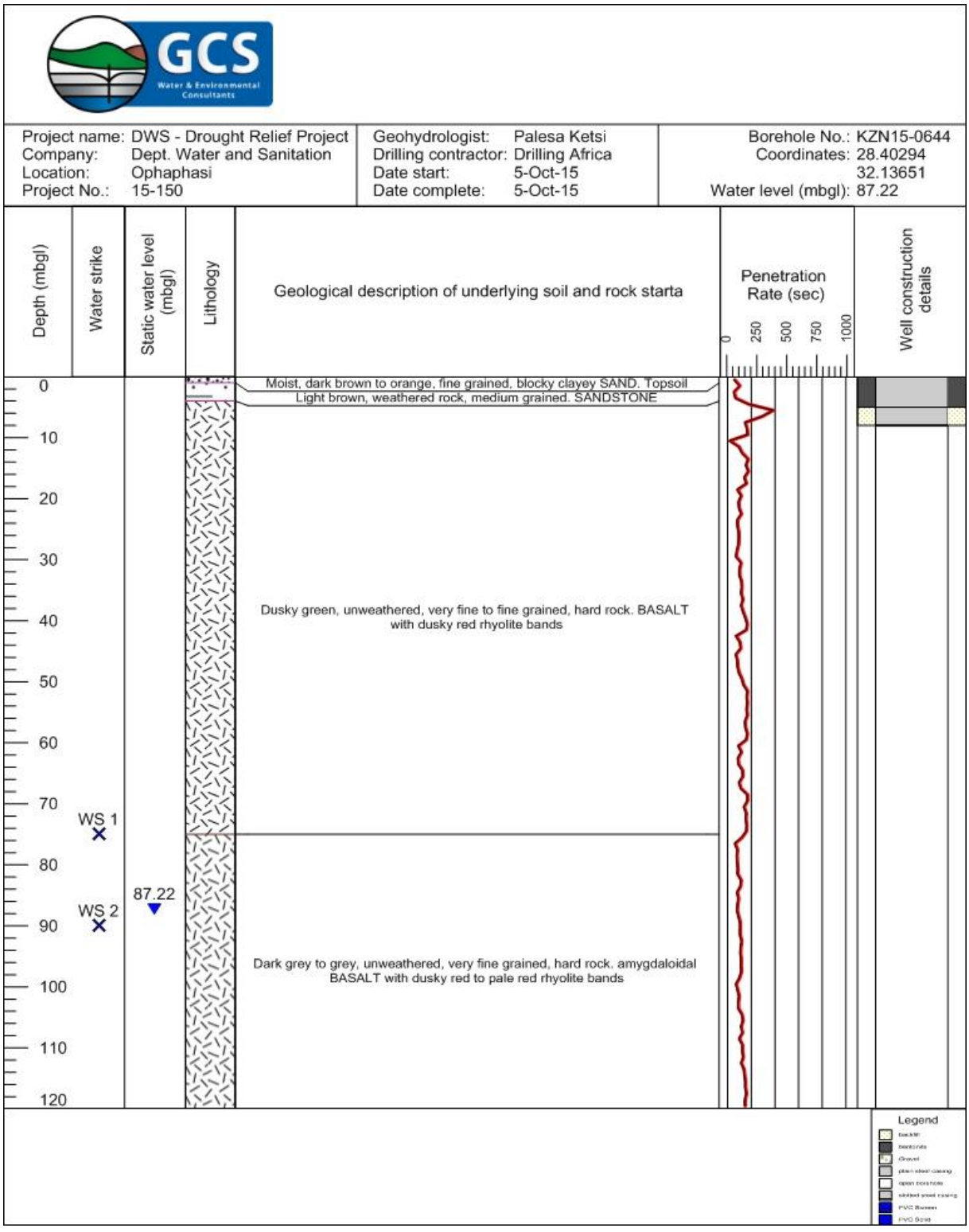
Project name:	DWS - Drought Relief Project	Geohydrologist:	Mzikayise Nkwane	Borehole No.:	KZN15-0636
Company:	Dept. Water and Sanitation	Drilling contractor:	Drilling Africa	Coordinates:	28.1557
Location:	Bazala	Date start:	17-Oct-15		32.28265
Project No.:	15-150	Date complete:	17-Oct-15	Water level (mbgl):	17.19




GCS
Water & Environmental Consultants
Project name: DWS - Drought Relief Project
Company: Dept. Water and Sanitation
Location: Nkundusi
Project No.: 15-150
Geohydrologist: Mzikayise Nkwane
Drilling contractor: Drilling Africa
Date start: 2-Nov-15
Date complete: 2-Nov-15
Borehole No.: KZN15-0635
Coordinates: 28.09849
32.35709
Water level (mbgl): 14.91
Depth (mbgl)
Water strike
Static water level (mbgl)
Lithology
Geological description of underlying soil and rock starta
Penetration Rate (sec)
0
250
500
750
1000
Well construction details
0
4
8
12
16
20
24
28
32
36
40
44
48
14.91
Dry, Orange yellow, fine grain, clayey Sand. Alluvium.
Dry, Black, very fine grain, Clay.
Legend


GCS
Water & Environmental Consultants
Project name: DWS - Drought Relief Project
Company: Dept. Water and Sanitation
Location: Maswazini
Project No.: 15-150
Geohydrologist: Palesa Ketsi/Henri Botha
Drilling contractor: Drilling Africa
Date start: 8-Oct-15
Date complete: 8-Oct-15
Borehole No.: KZN15-0646
Coordinates: 28.33612
32.20119
Water level (mbgl): 93
Depth (mbgl)
Water strike
Static water level (mbgl)
Lithology
Geological description of underlying soil and rock starta
Penetration Rate (sec)
0
250
500
750
1000
Well construction details
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
WS 1
93
Moist, dark brown to light orange, blocky, fine grained, clayey SAND. Topsoil
Light grey to brown, weathered, fine grained. DOLERITE
Dusky green to pale blue, unweathered, very fine grained, hard rock. BASALT
Dusky red to grey, unweathered, fine grained, hard rock. DOLERITE
Dusky green to grey, unweathered, very fine grained, hard rock. BASALT
Dusky red to brown, unweathered, fine grained, hard rock. Amygdaloidal BASALT
Dusky red to dusky green, unweathered, fine grained, hard rock. DOLERITE
Dusky green to grey, unweathered, very fine grained, hard rock. BASALT
Dusky red, unweathered, fine grained, hard rock. DOLERITE
Dusky green to light grey, unweathered, very fine grained, hard rock. BASALT
Dusky green, unweathered, very fine grained, hard rock. BASALT
Legend


GCS
Water & Environmental Consultants
Project name: DWS - Drought Relief Project
Company: Dept. Water and Sanitation
Location: Ogengele
Project No.: 15-150
Geohydrologist: Henri Botha
Drilling contractor: Drilling Africa
Date start: 10-Oct-15
Date complete: 10-Oct-15
Borehole No.: KZN15-0645
Coordinates: 28.32163
32.13058
Water level (mbgl): 16.45
Depth (mbgl)
Water strike
Static water level (mbgl)
Lithology
Geological description of underlying soil and rock starta
Penetration Rate (sec)
0
250
500
750
1000
Well construction details
16.45
WS 1
WS 2
WS 3
Dry, brown, weathered, fine grained, blocky, sandy CLAY. Topsoil
Light olive brown, loose, fine to medium grained. SANDSTONE
Dark brown, very fine grained, massive and layered. SHALE
Orange brown, very fine grained, layered. SHALE
Light olive brown, fine to medium grained. SANDSTONE
Reddish maroon to brown, very fine grained, layered. SHALE
Dark grey, unweathered, angular, very fine to fine grained. DOLERITE
Grey, unweathered, angular and rounded, fine to medium grained. SANDSTONE
Dark grey, unweathered, angular, fine to very fine grained. DOLERITE
Grey, unweathered, angular to irregular, fine to medium grained. SANDSTONE
Dark grey, unweathered, angular, fine to very fine grained. DOLERITE
Brown to light brown, unweathered, fine to medium grained, irregular. SANDSTONE
Brown to grey, unweathered, medium to very fine grained, irregular and platey, interbedded. SANDSTONE and SHALE
Legend


GCS
Water & Environmental Consultants
Project name: DWS - Drought Relief Project
Company: Dept. Water and Sanitation
Location: Ophaphasi
Project No.: 15-150
Geohydrologist: Palesa Ketsi
Drilling contractor: Drilling Africa
Date start: 5-Oct-15
Date complete: 5-Oct-15
Borehole No.: KZN15-0644
Coordinates: 28.40294
32.13651
Water level (mbgl): 87.22
Depth (mbgl)
Water strike
Static water level (mbgl)
Lithology
Geological description of underlying soil and rock starta
Penetration Rate (sec)
0
250
500
750
1000
Well construction details
Moist, dark brown to orange, fine grained, blocky clayey SAND. Topsoil
Light brown, weathered rock, medium grained. SANDSTONE
Dusky green, unweathered, very fine to fine grained, hard rock. BASALT with dusky red rhyolite bands
Dark grey to grey, unweathered, very fine grained, hard rock. amygdaloidal BASALT with dusky red to pale red rhyolite bands
WS 1
WS 2
87.22
0
10
20
30
40
50
60
70
80
90
100
110
120
Legend

APPENDIX C: HYDROCENSUS BOREHOLES PHOTO LOG

Table 9-2: Mtubatuba hydrocensus photolog

Client Name: Maragela Consulting Engineers	Site Location: DWA Rural Water Supply and resource Management	Project No. 15-150
Hydrocensus boreholes in Mtubatuba District		

Photo No. 1	Date:	
Direction Photo Taken: N		
Description: Photo of BH1 in Ward 13.		

Photo No. 2	Date:	
Direction Photo Taken: S		
Description: Photo of BH2 in Ward 13.		

Photo No. 3	**Date:**
Direction Photo Taken: S	
Description Photo of BH3 in Ward 14.	

Photo No. 4	**Date:**
Direction Photo Taken: N	
Description Photo of BH4 in Ward 14.	

Photo No. 5	**Date:**
Direction Photo Taken: S	
Description Photo of BH5 in Ward 14.	

Photo No. 6	**Date:**
Direction Photo Taken: S	
Description Photo of BH6 in Ward 14.	

Photo No. 7	**Date:**
Direction Photo Taken: N	
Description Photo of BH7 in Ward 16.	

Photo No. 8	**Date:**
Direction Photo Taken: N	
Description Photo of BH8 in Ward	

Photo No. 9	**Date:**
Direction Photo Taken: S	
Description Photo of BH9 in Ward 17.	

Photo No. 10	**Date:**
Direction Photo Taken: E	
Description Photo of BH10 in Ward 6.	

Photo No. 11	**Date:**
Direction Photo Taken: E	
Description Photo of BH11 in Ward 6.	

Photo No. 12	Date:	
Direction Photo Taken: S		
Description Photo of BH12 in Ward 16.		

Photo No. 13	Date:	
Direction Photo Taken: E		
Description Photo of BH13 in Ward 16.		

Photo No. 14	Date:	
Direction Photo Taken: E		
Description Photo of BH14 in Ward 16.		

Photo No. 15	Date:	
Direction Photo Taken: S		
Description Photo of BH15 in Ward 10.		

Photo No. 16	Date:	
Direction Photo Taken: S		
Description Photo of BH16 in Ward 10.		

Photo No. 17	Date:	
Direction Photo Taken: E		
Description Photo of BH17 in Ward 10.		

Table 9-3: Hlabisa hydrocensus photo log

Client Name: Maragela Consulting Engineers	Site Location: DWA Rural Water Supply and resource Management	Project No. 15-150
Hydrocensus boreholes in Hlabisa District		

Photo No. 1	Date:	
Direction Photo Taken: N		
Description: Photo of borehole HBH1 in Ward 2.		

Photo No. 2	Date:	
Direction Photo Taken: E		
Description: Photo of borehole HBH2 in Ward 2.		

Photo No. 3	Date:	
Direction Photo Taken: E		
Description Photo of borehole HW1 HC_1 in Ward 1.		

Photo No. 4	Date:	
Direction Photo Taken:		
Description Photo of borehole HW1 HC_12 in Ward 1.		

Photo No. 5	Date:	
Direction Photo Taken: E		
Description Photo of borehole HW1 HC_3 in Ward 1.		

Photo No. 6	Date:	
Direction Photo Taken: E		
Description Photo of borehole HW1 HC_4 in Ward 1.		

Photo No. 7	Date:	
Direction Photo Taken: E		
Description Photo of borehole HW2 HC_1 in Ward 2.		

Photo No. 8	Date:	
Direction Photo Taken: N		
Description Photo of borehole HW2 HC_2 in Ward 2.		

Photo No. 9	Date:	
Direction Photo Taken:		
Description Photo of borehole HW2 HC_3 in Ward 2.		

Photo No. 10	Date:	
Direction Photo Taken: S		
Description Photo of borehole HW2 HC_4 in Ward 2.		

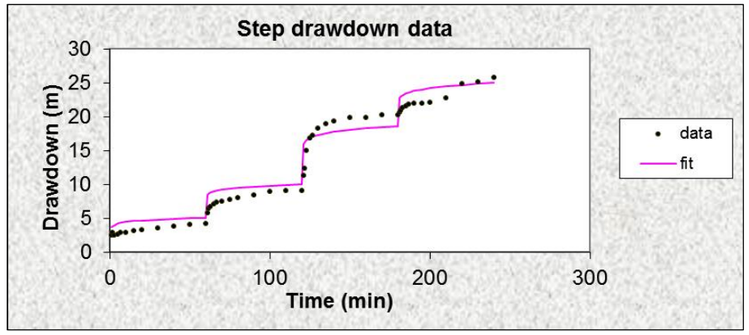
Photo No. 11	Date:	
Direction Photo Taken: E		
Description Photo of HW2 HC_5 in Ward 2.		

Photo No. 12	Date:	
Direction Photo Taken: E		
Description Photo of borehole HW3 HC_1 in Ward 3.		

Photo No.	Date:	
13		
Direction Photo Taken: S		
Description Photo of borehole HW3 HC_2 in Ward 3.		

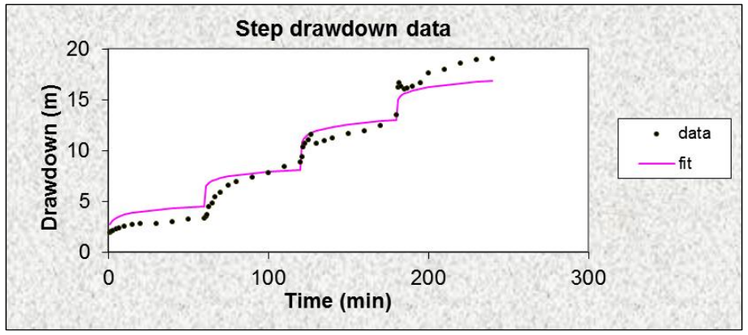
APPENDIX D: PUMP TESTS ANALYSES SUMMARY

Ward 1a



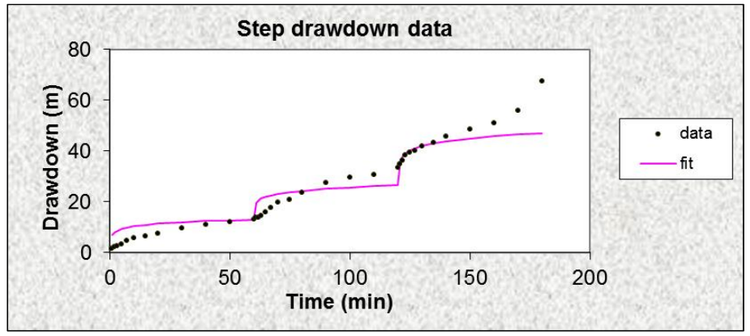
Method	Sustainable yield (l/s)	Std. Dev	Early T (m^2/d)	Late T (m^2/d)	S
Basic FC	1.83	0.90	14	13.6	1.10E-03
Cooper-Jacob	1.67		1.08		1.00E-06

Ward 1b



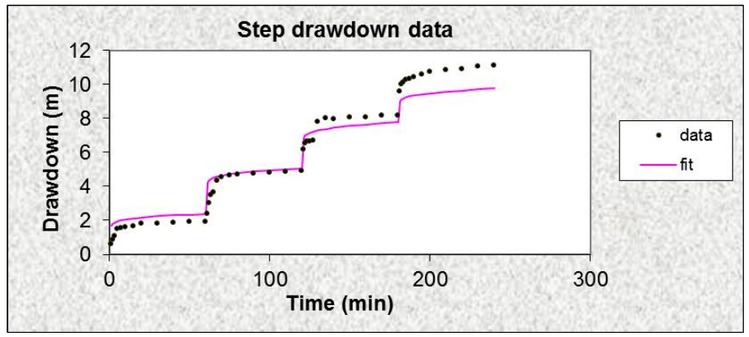
Method	Sustainable yield (l/s)	Std. Dev	Early T (m^2/d)	Late T (m^2/d)	S
Basic FC	2.17		1.44	20	1.10E-03
Cooper-Jacob	8.57		5.55		1.00E-06

Ward 2



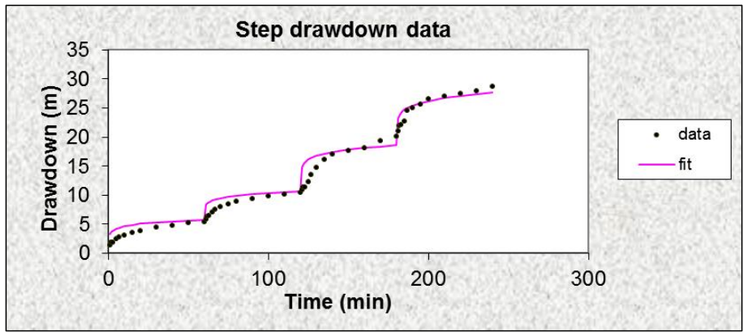
Method	Sustainable yield (l/s)	Std. Dev	Early T (m^2/d)	Late T (m^2/d)	S
Basic FC	0.09	0.06	1	0.2	1.10E-03
Cooper-Jacob	0.29	0.19		1.0	1.00E-06

Ward 2a



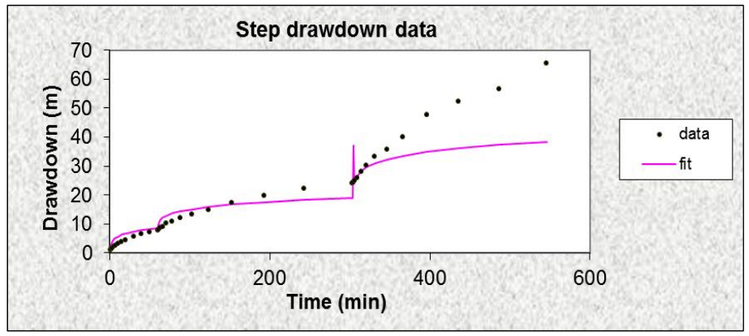
Method	Sustainable yield (l/s)	Std. Dev	Early T (m^2/d)	Late T (m^2/d)	S
Basic FC	8.56		3.97	579	1.10E-03
Cooper-Jacob	17.69		11.45		1.00E-06

Ward 2c



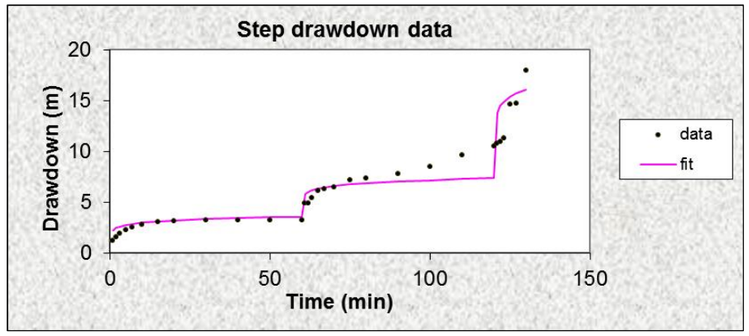
Method	Sustainable yield (l/s)	Std. Dev	Early T (m^2/d)	Late T (m^2/d)	S
Basic FC	1.43	0.80	9	7.4	1.10E-03
Cooper-Jacob	1.66	1.07		11.2	1.00E-06

Ward 2d



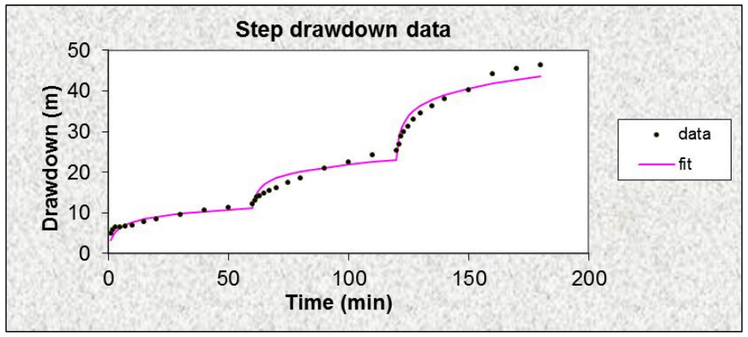
Method	Sustainable yield (l/s)	Std. Dev	Early T (m^2/d)	Late T (m^2/d)	S
Basic FC	0.78	0.55	4	1.5	1.10E-03
Cooper-Jacob	2.07	1.34		4.2	5.00E-05

Ward 3



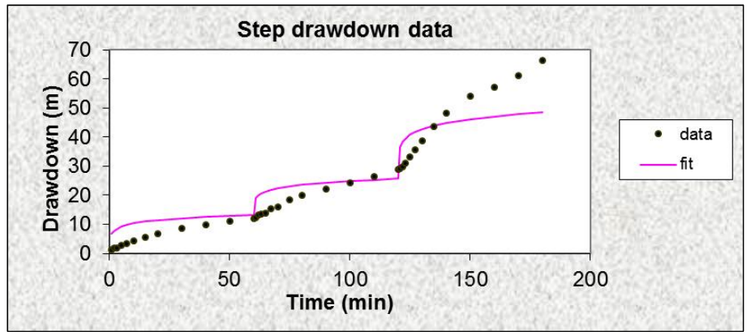
Method	Sustainable yield (l/s)	Std. Dev	Early T (m^2/d)	Late T (m^2/d)	S
Basic FC	1.61	0.98	19	5.6	1.10E-03
Cooper-Jacob	2.24	1.45		11.1	1.00E-06

Ward 6



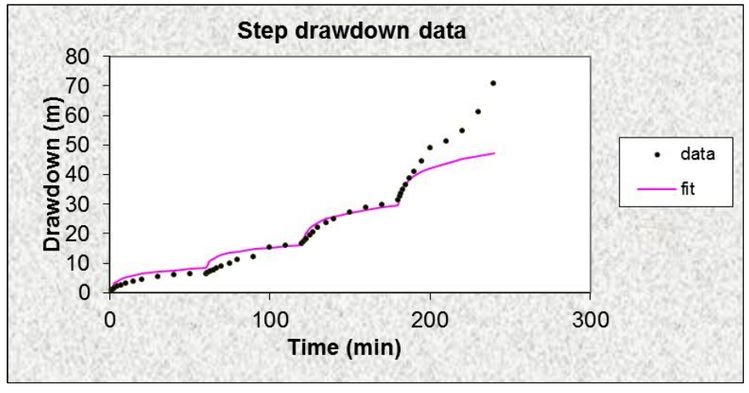
Method	Sustainable yield (l/s)	Std. Dev	Early T (m^2/d)	Late T (m^2/d)	S
Basic FC	0.49	0.26	1	0.9	1.10E-03
Cooper-Jacob	0.67	0.44		1.4	1.00E-06

Ward 7



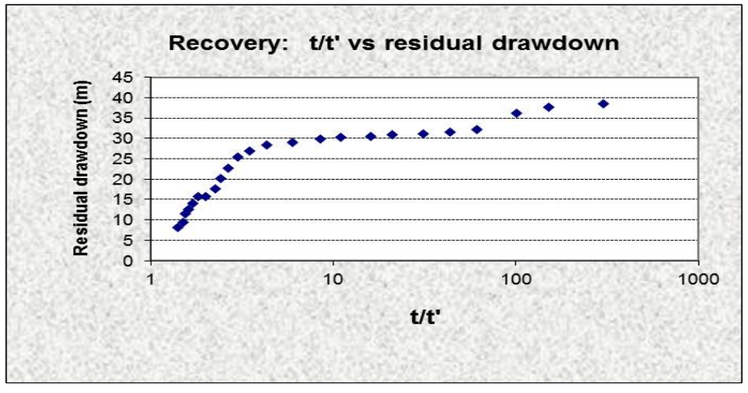
Method	Sustainable yield (l/s)	Std. Dev	Early T (m^2/d)	Late T (m^2/d)	S
Basic FC	0.03	0.02	0	0.1	1.10E-03
Cooper-Jacob	0.12	0.08		0.3	1.00E-06

Ward 12a



Method	Sustainable yield (l/s)	Std. Dev	Early T (m^2/d)	Late T (m^2/d)	S
Basic FC	0.07	0.04	1	0.3	1.10E-03
Cooper-Jacob	0.11	0.07		0.7	7.00E-05

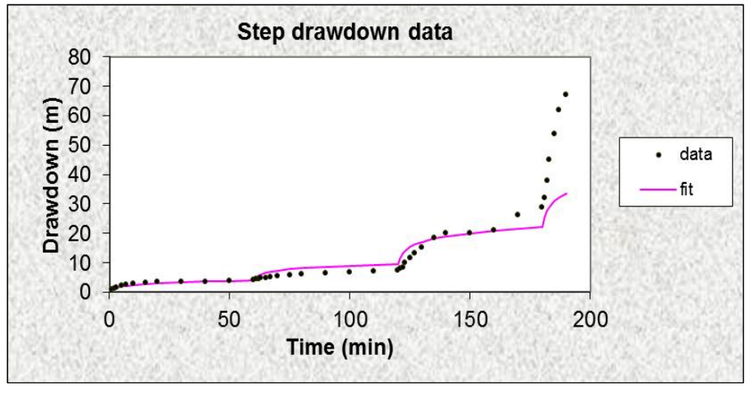
Ward 12b



No Step test was done on this borehole. Only Constant drawdown and recovery.

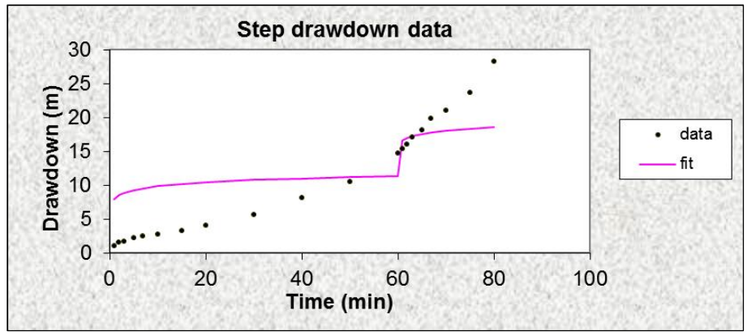
Method	Sustainable yield (l/s)	Std. Dev	Early T (m^2/d)	Late T (m^2/d)	S
Basic FC	0.01	0.01	0	0.1	1.10E-03

Ward 13a



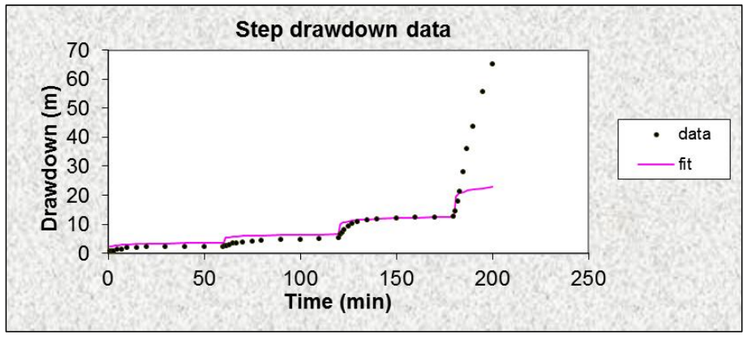
Method	Sustainable yield (l/s)	Std. Dev	Early T (m^2/d)	Late T (m^2/d)	S
Basic FC	0.03	0.02	5	0.1	1.10E-03
Cooper-Jacob	1.00	0.65		7.2	2.80E-05

Ward 13b



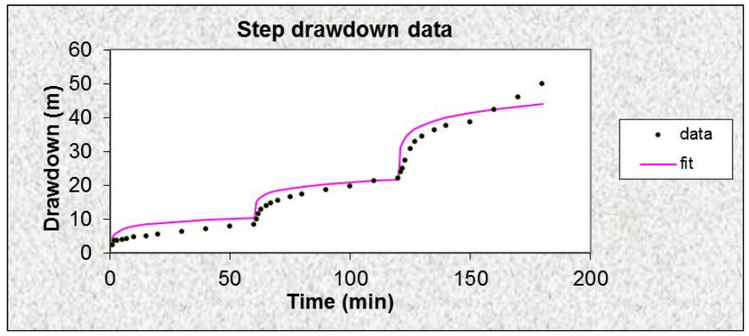
Method	Sustainable yield (l/s)	Std. Dev	Early T (m^2/d)	Late T (m^2/d)	S
Basic FC	0.00	0.00	0	0.0	1.10E-03
Cooper-Jacob	0.02	0.01		1.1	1.00E-06

Ward 14



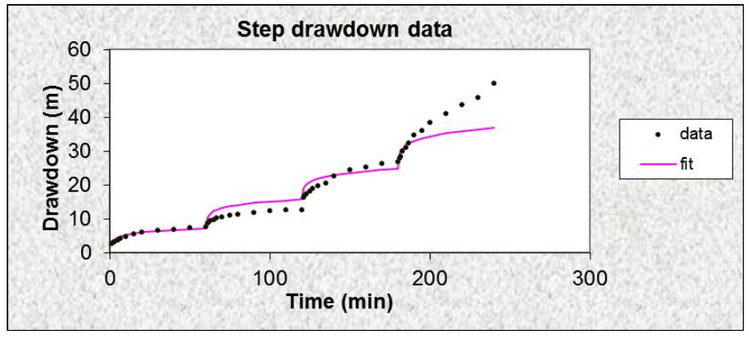
Method	Sustainable yield (l/s)	Std. Dev	Early T (m^2/d)	Late T (m^2/d)	S
Basic FC	1.26	0.69	6	3.0	1.10E-03
Cooper-Jacob	1.30	0.84		3.9	1.00E-06

Ward 16



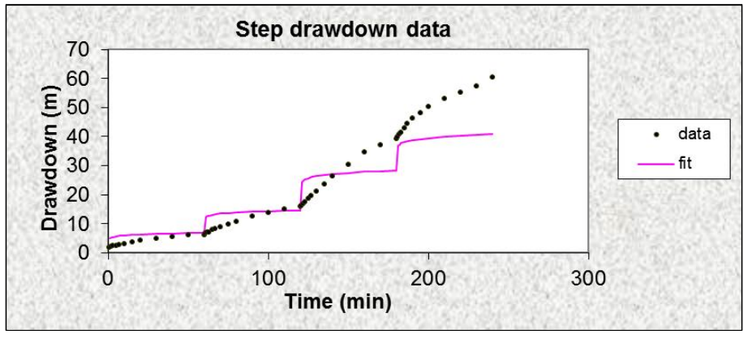
Method	Sustainable yield (l/s)	Std. Dev	Early T (m^2/d)	Late T (m^2/d)	S
Basic FC	0.91	0.57	3	1.0	1.10E-03
Cooper-Jacob	1.94	1.26		2.6	8.00E-03

Ward 16b



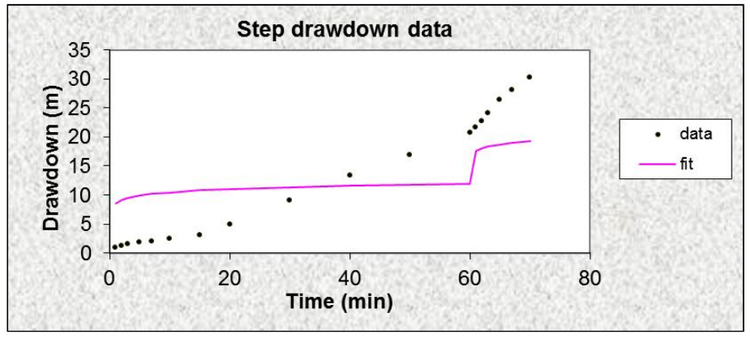
Method	Sustainable yield (l/s)	Std. Dev	Early T (m^2/d)	Late T (m^2/d)	S
Basic FC	0.21	0.16	2	0.2	1.10E-03
Cooper-Jacob	3.49	2.26		6.2	1.00E-06

Ward 17



Method	Sustainable yield (l/s)	Std. Dev	Early T (m^2/d)	Late T (m^2/d)	S
Basic FC	0.10	0.07	1	0.3	1.10E-03
Cooper-Jacob	0.20	0.13		0.5	1.50E-05

Nkundisi



Method	Sustainable yield (l/s)	Std. Dev	Early T (m^2/d)	Late T (m^2/d)	S
Cooper-Jacob	0.09	0.06		0.5	1.00E-06

APPENDIX E: COMMUNITY PARTICIPATION REGISTERS

Community Liaison - Mtubatuba

DEPARTMENT OF WATER AND SANITATION: DROUGHT RELIEF PROJECT DISTRICT MUNICIPALITY: UMKHANYAKUDE

DATE : 21 SEPTEMBER 2015

VENUE : MTUBATUBA MUNICIPALITY COUNCIL CHAMBER

TIME : 09H00

No.	Name & Surname	Ward number/Comp	Contact/Cell	Signature
	Pieta Lubuschagne	GCS	0828023116	
	Sphesihle Mdlalose	GCS	0824255156	
	Thomas Gumede	CLLR 2	0722067496	
	Victor Ndlazi	CLLR 10	0792270435	
	Vincent Madonsela	Cllr 9	0718860459	
	Mbongiseni Ndlovu	CLLR	0798720721 (17)	
	S'Busiso S'biya	CLLR 13	072 311 6862	
	Bheki Dumede	CLLR 6	0790844458	
	Mkhumbuzi Tlokozani	PMU Manager	082 9572383	
	Mbuduzi F. Mahlinza	Communications Manager	071 885 0516	

No.	Name & Surname	Ward number	Contact/Cell	Signature
	M.A. Gina	08 speaker	079 733 5440	
	I.F. Nyawo	Mayor	076 158 6344	
	Aishika Roy	Deputy Mayor	083 4297347	
	M.E Shobede	16 (CLLR)	073 390 8255	
	S.J. Khoza	08	082 2658826	wenzileas@gmail.com
	D.R Ntuli	07 Chairperson Technical	0827340523	

Community Liaison - Hlabisa

Meeting Held at Hlabisa on 12 October 2015 - District Municipality: Umkhanyakude - Attendance Register

Name and Surname	Ward No	Community	Contact	Signature
Pieta Lubuschagne			0828023116	GCS
Mzikayise Nkwanne			0832571409	GCS
Thulani Kunene	Cllr		0720732305	
Zama P. Ndlovu	Cllr	Hlabisa L.M.	0797491542	Z.P. Ndlovu
B.T. Zungu	Cllr	Ward 8	0828991656	
B.T. Langa	Cllr	Ward 7	0721807594	BL
P.P. Mhlenyama	Cllr	Ward 2	0725102988	PPM
T.H. Zungu	Cllr	Ward 6	0792536768	
LM Mthembeni	Senior Manager		082 446 7704	
M.B. Shange	KZ274	Official	0822803723	
L.M.V Cele	KZ274	official	0834845207	
M.W Khumalo	KZ274	OFFICIAL	0829069584	
Dr KJ Mthembu	mm	Official	0609821858	

APPENDIX F: BOREHOLE COMMISSIONING FORMS

water & sanitation
Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

Department of Water and Sanitation, 9th Floor, Southern Life Building, 88 Joe Slovo Street (cnr Joe Slovo & Monty Naicker), Durban, Tel No: 031 336 2700

Drought Project Borehole Handover Form

Community/site Name: KWAMSHAYA **Borehole Name:** KZN-15-0642 **Date:** 19/05/2016

Organization representative	Name	Designation	Contact details	Signature of acceptance
Maragela Consulting Engineers: Project managers	GIFT KGOEDIE	PROJECT MANAGER	081 024 1657	
Contractor	H. Venter Welltech	Contractor	071 031 5086	
Consultant	Mzikayise Nkwane	Geologist	0317647130	
Community	JOBE P.R.	WARD 14 COUNCILLOR	082 724 7185	
Municipality				
Other:				

Check List	Good	Fair	Bad
Condition of the borehole Structure	✓		
Borehole providing water	✓		
Visual condition of water (smell & colour)	✓		
Overall status of work done	✓		

General Comments:

water & sanitation
Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

Department of Water and Sanitation, 9th Floor, Southern Life Building, 88 Joe Slovo Street (cnr Joe Slovo & Monty Naicker), Durban, Tel No: 031 336 2700

Drought Project Borehole Handover Form

Community/site Name: OPhaPhase **Borehole Name:** KZN15-0644 **Date:** 19/05/2016

Organization representative	Name	Designation	Contact details	Signature of acceptance
Maragela Consulting Engineers: Project managers	GIFT KGOEDIE	PROJECT MANAGER	081 024 1657	
Contractor	H. Venter Welltech	Project Administrator	071 031 5086	
Consultant	GCS	Geologist	0317647130	
Community	S'busiso Sibiya	Clr Ward 13	072 311 6862	
Municipality				
Other:				

Check List	Good	Fair	Bad
Condition of the borehole Structure	✓		
Borehole providing water			✓
Visual condition of water (smell & colour)		✓	
Overall status of work done	✓		

General Comments: water level is deep & poor borehole recovery.

water & sanitation
Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

Department of Water and Sanitation, 9th Floor, Southern Life Building, 88 Joe Slovo Street (cnr Joe Slovo & Monty Naicker), Durban, Tel No: 031 336 2700

Drought Project Borehole Handover Form

Community/site Name: Nkombose **Borehole Name:** KZN15-0643 **Date:** 19/05/2016

Organization representative	Name	Designation	Contact details	Signature of acceptance
Maragela Consulting Engineers: Project managers	Glen Mashabela	Project Engineer	082 2174558	
Contractor	Wellfield	Driver	071 073 [illegible]	
Consultant	GCS/M21	Geologist	0	
Community	S'busiso S'biya	Cllr Ward 13	072 311 6862	
Municipality				
Other:				

Check List	Good	Fair	Bad	General Comments:
Condition of the borehole Structure	✓			
Borehole providing water	✓			
Visual condition of water (smell & colour)	✓			
Overall status of work done	✓			

water & sanitation
Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

Department of Water and Sanitation, 9th Floor, Southern Life Building, 88 Joe Slovo Street (cnr Joe Slovo & Monty Naicker), Durban, Tel No: 031 336 2700

Drought Project Borehole Handover Form

Community/site Name: Msane **Borehole Name:** KZN15-0648 **Date:** 19/05/2016

Organization representative	Name	Designation	Contact details	Signature of acceptance
Maragela Consulting Engineers: Project managers	Gift Ngobeni	Project Manager	081 824 1657	
Contractor	Wellfield	Driver	071 073 5096	
Consultant	N21 Kayise	Geology	0317647130	
Community	N.T. Gumede	Ward 12	0722067496	
Municipality				
Other:				

Check List	Good	Fair	Bad	General Comments:
Condition of the borehole Structure	✓			
Borehole providing water	✓			
Visual condition of water (smell & colour)	✓			
Overall status of work done	✓			

water & sanitation
Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

Department of Water and Sanitation, 9th Floor, Southern Life Building, 88 Joe Slovo Street (cnr Joe Slovo & Monty Naicker), Durban, Tel No: 031 336 2700

Drought Project Borehole Handover Form

Community/site Name: Nkodibe **Borehole Name:** KZN15-0641 **Date:** 19/05/2016

Organization representative	Name	Designation	Contact details	Signature of acceptance
Maragela Consulting Engineers: Project managers	Mr Gift Kgoesane	Project Manager	081 024 1657	
Contractor	Wellkit Investments	Owner	0710315246	
Consultant	M2ikayise	Geologist	0317647130	
Community	Sibu Gumede	Ward C/lr	0794564458	
Municipality				
Other:				

Check List	Good	Fair	Bad
Condition of the borehole Structure			
Borehole providing water			
Visual condition of water (smell & colour)			
Overall status of work done			

General Comments: Two tanks & electric pump installed by Umngeni Water without consultation

water & sanitation
Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

Department of Water and Sanitation, 9th Floor, Southern Life Building, 88 Joe Slovo Street (cnr Joe Slovo & Monty Naicker), Durban, Tel No: 031 336 2700

Drought Project Borehole Handover Form

Community/site Name: Ebaswazini **Borehole Name:** KZN15-0646 **Date:** 19/05/2016

Organization representative	Name	Designation	Contact details	Signature of acceptance
Maragela Consulting Engineers: Project managers	Given Mashabela	Project Engineer	0822174558	
Contractor	Wellkit Investments	Owner	0710315246	
Consultant	GCS	Hydrogeologist	0317647130	
Community	Shobede M.Z	Clr	0733508255	
Municipality				
Other:				

Check List	Good	Fair	Bad
Condition of the borehole Structure	✓		
Borehole providing water	✓		
Visual condition of water (smell & colour)	✓		
Overall status of work done	✓		

General Comments:

water & sanitation
Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

Department of Water and Sanitation, 9th Floor, Southern Life Building, 88 Joe Slovo Street (cnr Joe Slovo & Monty Naicker), Durban, Tel No: 031 336 2700

Drought Project Borehole Handover Form

Community/site Name: Mapheleni **Borehole Name:** KZN15-0649 **Date:** 19/05/2016

Organization representative	Name	Designation	Contact details	Signature of acceptance
Maragela Consulting Engineers: Project managers	[illegible]	Project Engineer	0822174558	
Contractor	Wellfield	[illegible]	0710315086	
Consultant	GCS	hydrogeologist	0317647130	
Community	SHOREDE M.T	CLLR	073 3908 255	
Municipality				
Other:				

Check List	Good	Fair	Bad	General Comments:
Condition of the borehole Structure	✓			
Borehole providing water	✓			
Visual condition of water (smell & colour)	✓			
Overall status of work done	✓			

water & sanitation
Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

Department of Water and Sanitation, 9th Floor, Southern Life Building, 88 Joe Slovo Street (cnr Joe Slovo & Monty Naicker), Durban, Tel No: 031 336 2700

Drought Project Borehole Handover Form

Community/site Name: Madwaleni **Borehole Name:** KZN15-0640 **Date:** 19/05/2016

Organization representative	Name	Designation	Contact details	Signature of acceptance
Maragela Consulting Engineers: Project managers	GIFT VOORBAAD	PROJECT MANAGER	081 024 1657	
Contractor	Wellfield Services	[illegible]	0710315086	
Consultant	GCS	hydrogeologist	0317647130	
Community	[illegible]	WARD CLLR	0782936542	
Municipality				
Other:				

Check List	Good	Fair	Bad	General Comments:
Condition of the borehole Structure				
Borehole providing water				
Visual condition of water (smell & colour)				
Overall status of work done				

water & sanitation
Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

Department of Water and Sanitation, 9th Floor, Southern Life Building, 88 Joe Slovo Street (cnr Joe Slovo & Monty Naicker), Durban, Tel No: 031 336 2700

Drought Project Borehole Handover Form

Community/site Name: Shikishela **Borehole Name:** KZN15-0639 **Date:** 19/05/2016

Organization representative	Name	Designation	Contact details	Signature of acceptance
Maragela Consulting Engineers: Project managers	GIFT KGOBAPANE	PROJECT MANAGER	081 026 1657	
Contractor	WELLFIELD	OWNER	0710315036	
Consultant	GCS	HYDROGEOLOGIST	0317647130	
Community	LUCIA	WARD CLLR	0782936597	
Municipality				
Other:				

Check List	Good	Fair	Bad
Condition of the borehole Structure	✓		
Borehole providing water		✓	
Visual condition of water (smell & colour)	✓		
Overall status of work done	✓		

General Comments:

water & sanitation
Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

Department of Water and Sanitation, 9th Floor, Southern Life Building, 88 Joe Slovo Street (cnr Joe Slovo & Monty Naicker), Durban, Tel No: 031 336 2700

Drought Project Borehole Handover Form

Community/site Name: Nkundusi **Borehole Name:** KZN15-0635 **Date:** 19/05/2015

Organization representative	Name	Designation	Contact details	Signature of acceptance
Maragela Consulting Engineers: Project managers	GIFT KGOBAPANE	PROJECT MANAGER	081 026 1657	
Contractor	Wellfield Services	Owner	0710315036	
Consultant	GCS	Hydrogeologist	0317647170	
Community	V. MADONSELA	COUNCILLOR	0722943849	
Municipality				
Other:				

Check List	Good	Fair	Bad
Condition of the borehole Structure	V		
Borehole providing water		✓	
Visual condition of water (smell & colour)	V		
Overall status of work done	V		

General Comments: Gets dry sometimes but Recovers in an hours time.

water & sanitation
Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

Department of Water and Sanitation, 9th Floor, Southern Life Building, 88 Joe Slovo Street (cnr Joe Slovo & Monty Naicker), Durban, Tel No: 031 336 2700

Drought Project Borehole Handover Form

Community/site Name: Nkonjaneni **Borehole Name:** KZN15-0647 **Date:** 19/05/2016

Organization representative	Name	Designation	Contact details	Signature of acceptance
Maragela Consulting Engineers: Project managers	Craven Mashabela	Project Engineer	0822194558	
Contractor	Wellbed Services	Owner	0710315086	
Consultant	GCS	hydrogeologist	0317647130	
Community				
Municipality	Shezi S.J.	Ward Councillor	0728496949	
Other:				

Check List	Good	Fair	Bad
Condition of the borehole Structure	✓		
Borehole providing water	✓		
Visual condition of water (smell & colour)	✓		
Overall status of work done	✓		

General Comments:

water & sanitation
Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

Department of Water and Sanitation, 9th Floor, Southern Life Building, 88 Joe Slovo Street (cnr Joe Slovo & Monty Naicker), Durban, Tel No: 031 336 2700

Drought Project Borehole Handover Form

Community/site Name: Ogengele **Borehole Name:** KZN15-0645 **Date:** 19/05/2016

Organization representative	Name	Designation	Contact details	Signature of acceptance
Maragela Consulting Engineers: Project managers	Gift Kgoebane	Project Manager	081 074 1657	
Contractor	Wellbed Services	Owner	0710315086	
Consultant	Mzikayise	Geologist	0317647130	
Community	CLLR MP Ndlovu	Ward 17 CLLR	0798720721	
Municipality				
Other:				

Check List	Good	Fair	Bad
Condition of the borehole Structure	✓		
Borehole providing water	✓		
Visual condition of water (smell & colour)	✓		
Overall status of work done	✓		

General Comments:

water & sanitation
Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

Department of Water and Sanitation, 9th Floor, Southern Life Building, 88 Joe Slovo Street (cnr Joe Slovo & Monty Naicker), Durban, Tel No: 031 336 2700

Drought Project Borehole Handover Form

Community/site Name: EMAJIKENI **Borehole Name:** KZN15-0655 **Date:** 20/05/2016

Organization representative	Name	Designation	Contact details	Signature of acceptance
Maragela Consulting Engineers: Project managers	Gift Ksoebane	Project Manager	081024 1657	
Contractor	Welltek Services		0710315086	
Consultant	GCS	Hydrogeologist	0317647130	
Community	Phumzile Mhlengwa	Ward Cllr	0725102988	
Municipality				
Other:				

Check List	Good	Fair	Bad	General Comments:
Condition of the borehole Structure	✓			
Borehole providing water	✓			
Visual condition of water (smell & colour)	✓			
Overall status of work done	✓			

water & sanitation
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Drought Project Borehole Handover Form

Community/site Name: Nkanyini **Borehole Name:** KZN15-0653 **Date:** 20/05/2016

Organization representative	Name	Designation	Contact details	Signature of acceptance
Maragela Consulting Engineers: Project managers	Gift Ksoebane	Project Manager	081 024 1657	
Contractor	Welltek Services		0710315086	
Consultant	GCS	Geologist	0317647130	
Community	Phumzile Mhlengwa	Ward Cllr	0725102988	
Municipality				
Other:				

Check List	Good	Fair	Bad	General Comments:
Condition of the borehole Structure				
Borehole providing water				
Visual condition of water (smell & colour)				
Overall status of work done				

water & sanitation
Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

Department of Water and Sanitation, 9th Floor, Southern Life Building, 88 Joe Slovo Street (cnr Joe Slovo & Monty Naicker), Durban, Tel No: 031 336 2700

Drought Project Borehole Handover Form

Community/site Name: Macekeni **Borehole Name:** KZN15-0654 **Date:** 20/05/2016

Organization representative	Name	Designation	Contact details	Signature of acceptance
Maragela Consulting Engineers: Project managers	GIFT KGOEBANE	PROJECT MANAGER	081 024 1657	
Contractor	WELLTECH [illegible]	OWNER	0710315086	
Consultant	GCS	Geologist	0317647130	
Community	PHUMZILE MALENJAMS	WARD CLLR	0725102988	
Municipality				
Other:				

Check List	Good	Fair	Bad
Condition of the borehole Structure	✓		
Borehole providing water	✓		
Visual condition of water (smell & colour)	✓		
Overall status of work done	✓		

General Comments:

water & sanitation
Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

Department of Water and Sanitation, 9th Floor, Southern Life Building, 88 Joe Slovo Street (cnr Joe Slovo & Monty Naicker), Durban, Tel No: 031 336 2700

Drought Project Borehole Handover Form

Community/site Name: Hlambanyathi **Borehole Name:** KZN 15 - 0650 **Date:** 20/05/2016

Organization representative	Name	Designation	Contact details	Signature of acceptance
Maragela Consulting Engineers: Project managers	[illegible]	Project Engineer	0827174855	
Contractor	Wellfield Services	Driver	071 531 5996	
Consultant	GCS	Geologist	0317647130	
Community	George R Mchunu	Councillor	0768108455	
Municipality				
Other:				

Check List	Good	Fair	Bad
Condition of the borehole Structure	✓		
Borehole providing water	✓		
Visual condition of water (smell & colour)	✓		
Overall status of work done	✓		

General Comments:

water & sanitation
Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

Department of Water and Sanitation, 9th Floor, Southern Life Building, 88 Joe Slovo Street (cnr Joe Slovo & Monty Naicker), Durban, Tel No: 031 336 2700

Drought Project Borehole Handover Form

Community/site Name: NGebeZA **Borehole Name:** KZN15-0651 **Date:** 20/05/2016

Organization representative	Name	Designation	Contact details	Signature of acceptance
Maragela Consulting Engineers: Project managers	SIFT KGOEBANE	PROJECT MANAGER	0510241657	
Contractor	[illegible]	[illegible]	0117655586	
Consultant	GCS	Geologist	0317647130	
Community	George Ramchum	Councillor	0768108455	
Municipality				
Other:				

Check List	Good	Fair	Bad	General Comments:
Condition of the borehole Structure	√			
Borehole providing water	√			
Visual condition of water (smell & colour)	√			
Overall status of work done	√			

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Drought Project Borehole Handover Form

Community/site Name: BANZANENI **Borehole Name:** KZN15-0637 **Date:** 20/05/2016

Organization representative	Name	Designation	Contact details	Signature of acceptance
Maragela Consulting Engineers: Project managers				
Contractor	[illegible]	[illegible]	0710315246	
Consultant	GCS	Geologist	0317647130	
Community	M.B. SITHOLE	COUNCILLOR	0839897214	
Municipality				
Other:				

Check List	Good	Fair	Bad
Condition of the borehole Structure			
Borehole providing water			
Visual condition of water (smell & colour)			
Overall status of work done			

General Comments: pump to be checked Tommorow (21/05/2016)

APPENDIX G: BOREHOLE PHOTO LOG WITH HAND PUMPS

		PHOTOGRAPH
Borehole ID	KZN15-0635	
Ward number	9	
Community name	**Nkundusi**	
Municipality	Mtubatuba	
Depth (mbgl)	49 (m)	
Pump Type	Hand Pump	
Pump installation depth	40 (m)	

		PHOTOGRAPH
Borehole ID	KZN15-0639	
Ward number	12	
Community name	**Shikishela**	
Municipality	Mtubatuba	
Depth (mbgl)	140 (m)	
Pump Type	Hand Pump	
Pump installation depth	50 (m)	
		PHOTOGRAPH
Borehole ID	KZN15-0640	
Ward number	12	
Community name	Madwaleni	
Municipality	Mtubatuba	
Depth (mbgl)	120 (m)	
Pump Type	Hand Pump	
Pump installation depth	50 (m)	
		PHOTOGRAPH
Borehole ID	KZN15-0641	
Ward number	6	
Community name	Nkodibe	
Municipality	Mtubatuba	
Depth (mbgl)	110 (m)	
Pump Type	Electric Pump	
Pump installation depth	60 (m)	

		PHOTOGRAPH
Borehole ID	KZN15-0642	
Ward number	14	
Community name	kwaMshaya	
Municipality	Mtubatuba	
Depth (mbgl)	120(m)	
Pump Type	Hand Pump	
Pump installation depth	60 (m)	
		PHOTOGRAPH
Borehole ID	KZN15-0643	
Ward number	13	
Community name	Nkombose	
Municipality	Mtubatuba	
Depth (mbgl)	80 (m)	
Pump Type	Hand Pump	
Pump installation depth	60 (m)	
		PHOTOGRAPH
Borehole ID	KZN15-0644	
Ward number	13	
Community name	Ophaphase	
Municipality	Mtubatuba	
Depth (mbgl)	120 (m)	
Pump Type	Hand Pump	
Pump installation depth	100 (m)	
		PHOTOGRAPH
Borehole ID	KZN15-0645	
Ward number	17	
Community name	Ogengele	
Municipality	Mtubatuba	
Depth (mbgl)	120 (m)	
Pump Type	Hand Pump	
Pump installation depth	60 (m)	
		PHOTOGRAPH
Borehole ID	KZN15-0646	

Ward number	16
Community name	Ebaswazini
Municipality	Mtubatuba
Depth (mbgl)	144 (m)
Pump Type	Hand Pump
Pump installation depth	60 (m)

	PHOTOGRAPH
Borehole ID	KZN15-0647
Ward number	97
Community name	Nkonjaneni
Municipality	Mtubatuba
Depth (mbgl)	132 (m)
Pump Type	Hand Pump
Pump installation depth	60 (m)

	PHOTOGRAPH
Borehole ID	KZN15-0649
Ward number	16
Community name	Mapheleni
Municipality	Mtubatuba
Depth (mbgl)	140 (m)
Pump Type	Hand Pump
Pump installation depth	50 (m)

	PHOTOGRAPH
Borehole ID	KZN15-0650
Ward number	1
Community name	Hlambanyathi
Municipality	Hlabisa
Depth (mbgl)	66 (m)
Pump Type	Hand Pump
Pump installation depth	60 (m)

	PHOTOGRAPH
Borehole ID	KZN15-0651
Ward number	1
Community name	Ngebeza
Municipality	Hlabisa
Depth (mbgl)	90 (m)
Pump Type	Hand Pump
Pump installation depth	50 (m)

	PHOTOGRAPH
Borehole ID	KZN15-0653
Ward number	2
Community name	Nkanjini
Municipality	Hlabisa
Depth (mbgl)	90 (m)
Pump Type	Hand Pump
Pump installation depth	50 (m)

	PHOTOGRAPH
Borehole ID	KZN15-0654
Ward number	2
Community name	Macekeni
Municipality	Hlabisa
Depth (mbgl)	72 (m)
Pump Type	Hand Pump
Pump installation depth	50 (m)

	PHOTOGRAPH
Borehole ID	KZN15-0637
Ward number	3
Community name	Banzaneni
Municipality	Hlabisa
Depth (mbgl)	120 (m)
Pump Type	Hand Pump

Pump installation depth	80 (m)	
		PHOTOGRAPH
Borehole ID	KZN15-0655	
Ward number	2	
Community name	Emajikeni	
Municipality	Hlabisa	
Depth (mbgl)	140 (m)	
Pump Type	Hand Pump	
Pump installation depth	60 (m)	