Groundwater Guidelines

Managing an unseen resource

July 2019

GROUNDWATER AND GIS CONSULTANTS
GEOSS
SOUTH AFRICA (Pty) Ltd

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Potatoes
Aartappels SA

FOREWORD

Dear Groundwater User,

Globally, groundwater makes up 12% of all fresh water on the Earth. Rivers and lakes only make up 1% and the rest is in our ice caps. This indicates the crucial importance of managing groundwater responsibly. Currently, there are 2 billion people in water-stressed countries. 50% of the world's population that drinks from unsafe water resources are in Africa. It is estimated that by 2030, Africa's population will increase by approximately 40%. So the big question is where will the food supply come from and where will the additional water for irrigation and potable supply come from?

The information above clearly highlights the need for increased agricultural output, yet for irrigated crops the access to volumes of water resources is finite. Thus, the water used for agriculture will have to be used more and more efficiently. Groundwater exploration will have to proceed with a strong emphasis on securing sustainable supplies. For these reasons, Potatoes South Africa has invested significantly in groundwater monitoring and research, especially in the Sandveld, Western Cape. The Sandveld potato industry is largely dependent on groundwater for irrigation and many lessons have been learnt from this work.

This booklet stems from this work and the intention is to provide a broad overview of groundwater resources in terms of how it occurs (its distribution across South Africa) as well as an overview of the complete "life cycle" of groundwater development projects (starting with drilling and on through yield testing; monitoring and all the way to the authorization of the use of groundwater). The National Government of South Africa is the custodian of all our water resources and, particularly since 1998, authorization is required prior to its use. A major objective of this booklet is to emphasize that sound science underpins the topic of groundwater and all associated aspects (exploration, development, monitoring and management). Another objective is to encourage all groundwater users to properly manage groundwater through water level, flow and rainfall monitoring. If, as a result of this publication, there is an increase in awareness and of groundwater monitoring, we will have met our objective.

There is a lot of text, literature and useful websites on groundwater. Please use this guideline and additional available information so as to ensure that your groundwater use is responsible and sustainable, particularly in light of the role that agriculture plays in South Africa and Africa, and to ensure its availability for future generations.

Conrad

Julian Conrad & Kes Murray

Geohydrologists

GEOSS South Africa

CONTENT

FIGURESNT

TABLES

INTRODUCTION

South Africa is a country with diverse climatic conditions and water resources are scarce in most parts of the country. Groundwater provides a crucial supply of water in the more arid regions.

Approximately 70% of all groundwater usage is for agricultural purposes. However, there is still a lot of uncertainty about how groundwater should be located, there is a lack of knowledge about how to determine the safe yield of a borehole and there are still very few instances of proper groundwater monitoring and management. In addition, there is a lot of confusion regarding the authorised use of groundwater. The current situation means that a lot of unnecessary expenditure occurs when groundwater is being developed and many irrigation schemes are built on very little scientific knowledge of borehole and groundwater characteristics. Groundwater must be used carefully as it is a finite resource and overuse can have long term effects on an aquifer.

To understand the presence of groundwater, it is best to think of it in terms of its place in the water cycle (Figure 1). At some point in time, almost all groundwater was once rainfall that landed on the earth's surface. Most of this rainfall then flowed down-gradient in small streams and rivers to eventually fill dams or reach the sea. Some of it evaporated back up into the atmosphere and a small amount infiltrated into the soil and rocks below the surface. The water that infiltrates below the surface accumulates becoming groundwater that flows slowly. Groundwater can accumulate either in fractures in the rock or within the weathered soils and sands above the bedrock. This is known as an aquifer.

As the flow of water is driven by pressure and gravity, most groundwater tends to flow from inland towards the coast, sometimes forming springs along the way. When the groundwater comes to surface, either from a spring or by joining the sea, it can evaporate to form clouds again, continuing the water cycle.

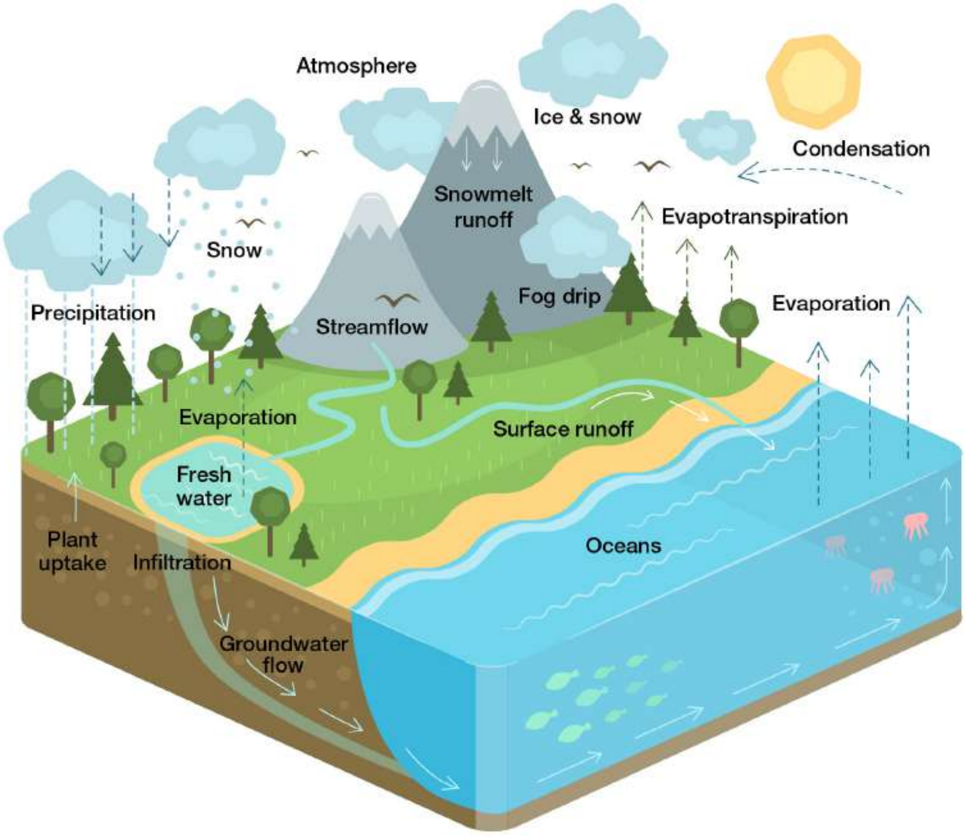

Figure 1: Water Cycle Diagram

Keeping the water cycle in mind, the amount of groundwater in different areas depends on a few simple questions. These are:

- How much rainfall occurs in the area (or in the nearest mountains)?
- How much of this rainfall can get into the ground without evaporating or flowing into streams?
- Once in the ground, how easily can the water flow or collect?

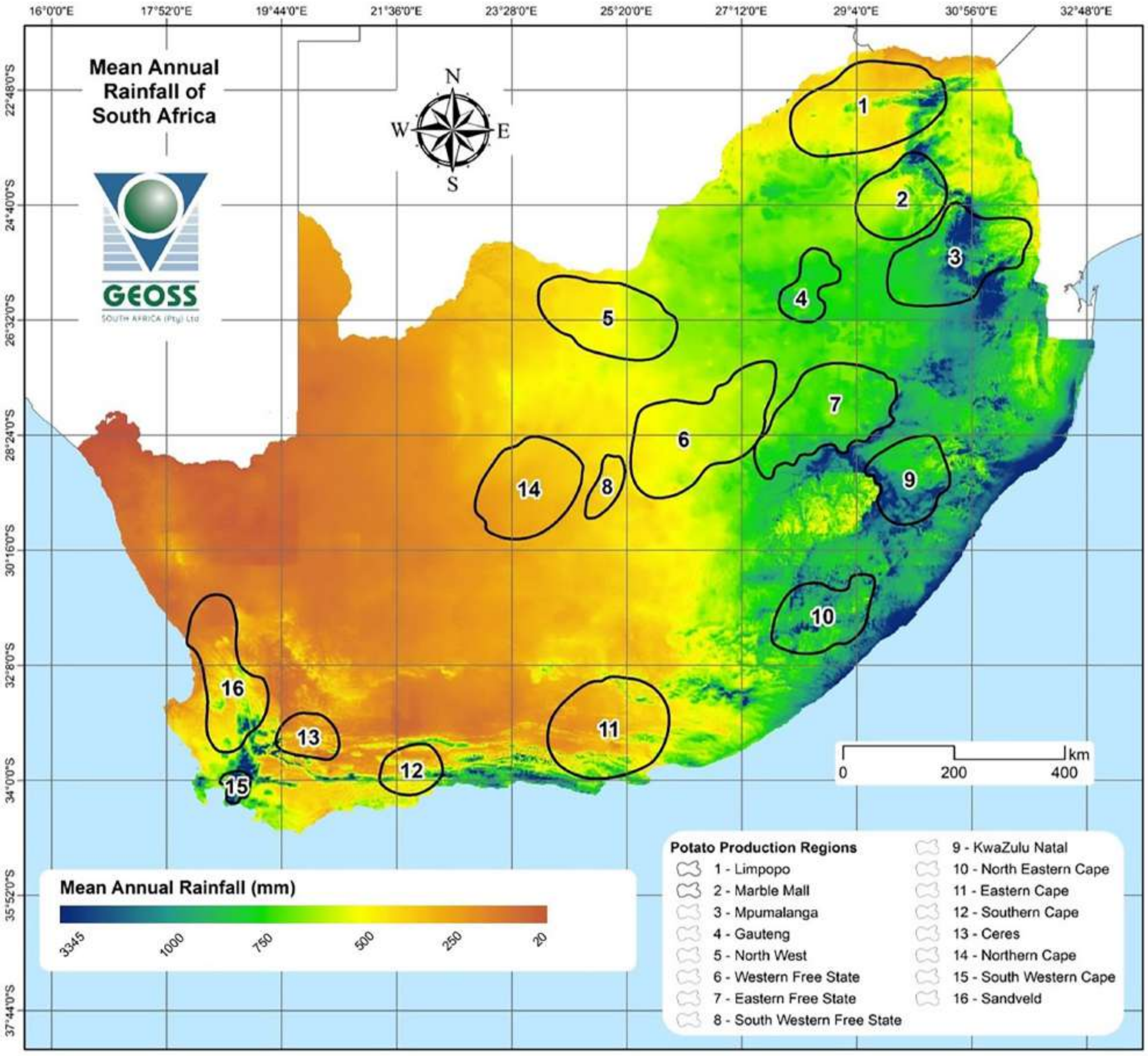

Figure 2: Rainfall of South Africa (Schulze, 2009)

The first question can be quite easily answered. Figure 2 gives an average yearly rainfall map of South Africa, showing places that have a lot of rainfall (darker blue) and little to no rainfall (orange) along with the potato production regions for reference. Thus, for a farm or town in South Africa it is already known whether there is a lot of rainfall in the area or not, and this can be the first step to understanding the groundwater of the area.

The second and third questions are a little more complicated, but both depend mostly on what type of rocks are below the surface (geology of the area). Different geological conditions will control whether the rainfall in an area can quickly seep below ground (coarse sands or very broken up rocks) or will pond at the surface and be evaporated (clays or solid rock with no fractures). The geology will also determine how difficult it is for the groundwater to flow through the subsurface. Groundwater that flows underground for a long time will start to pick up minerals and metals from the rocks that it travels through.

Groundwater can also be stored in the subsurface, in some cases accumulating slowly over decades, centuries or even millennia. In these areas, there may be very little rainfall, but given the correct geological conditions, drilling underground may intersect seemingly high yielding fractures. These boreholes may be recharged by better rainfall far away, in which case they will be sustainable if correctly yield tested and used. However, if they are intersecting high storage aquifers with low recharge, over time they will deplete faster than they can be recharged if the pumping rate is higher than the recharge rate. This can be determined during scientific yield tests, but ultimately requires very careful monitoring and informed management to prevent water level decline and boreholes becoming dry. An example of slow cumulative over-abstraction is in Mogwadi/Dendron, Limpopo, where large volumes of water were used for private farming in the 1970s and 1980s. Boreholes using groundwater from the fractured aquifers at depth were not correctly tested and were used unsustainably, resulting in the aquifer being depleted in some places (Food and Agricultural Organisation of the United Nations (FAO), 2004).

A simple geological map of South Africa (Figure 3) shows which different rock types or groups can be expected in different areas, and the potato production regions.

By using the rainfall and geological maps of South Africa, geohydrologists can estimate what types of aquifer (karst, fractured, intergranular or intergranular and fractured) are likely to be found and what the expected groundwater quality may be like for an area.

Karst aquifers are a special type of aquifer found specifically in limestones and sometimes dolomitic rock types. The acidity of the water dissolves the carbonate rock materials to form tunnels and caves. When these fill with groundwater they form karst aquifers. Fractured aquifers form in bedrock environments where groundwater flow is along the fracture planes and the storage is often in surrounding micro-fractures. These planes can be horizontal, vertical or anything in between, typically having widths of less than 1 mm which puts these planes under a great deal of pressure. Intergranular aquifers are found where the groundwater flow and storage are both between grainy particles, such as silts, sands and gravels.

The maps in Figures 4 & 5, used in conjunction with additional information on boreholes distributed throughout the country, are of great assistance to geohydrologists in predicting the type of aquifer expected in different areas and how best to use the groundwater in those areas.

However, these maps are very generalised and show the average expectations for different regional areas. In fractured bedrock aquifers it is important to understand that almost all the groundwater flows through cracks in the rock, thus random drilling will not necessarily yield good results.

While a geologist is someone who studies rocks (mineral and rock types, formation and deformation processes and mineralisation), a geohydrologist uses a geological understanding to study and understand the movement and storage of water in different geological settings.

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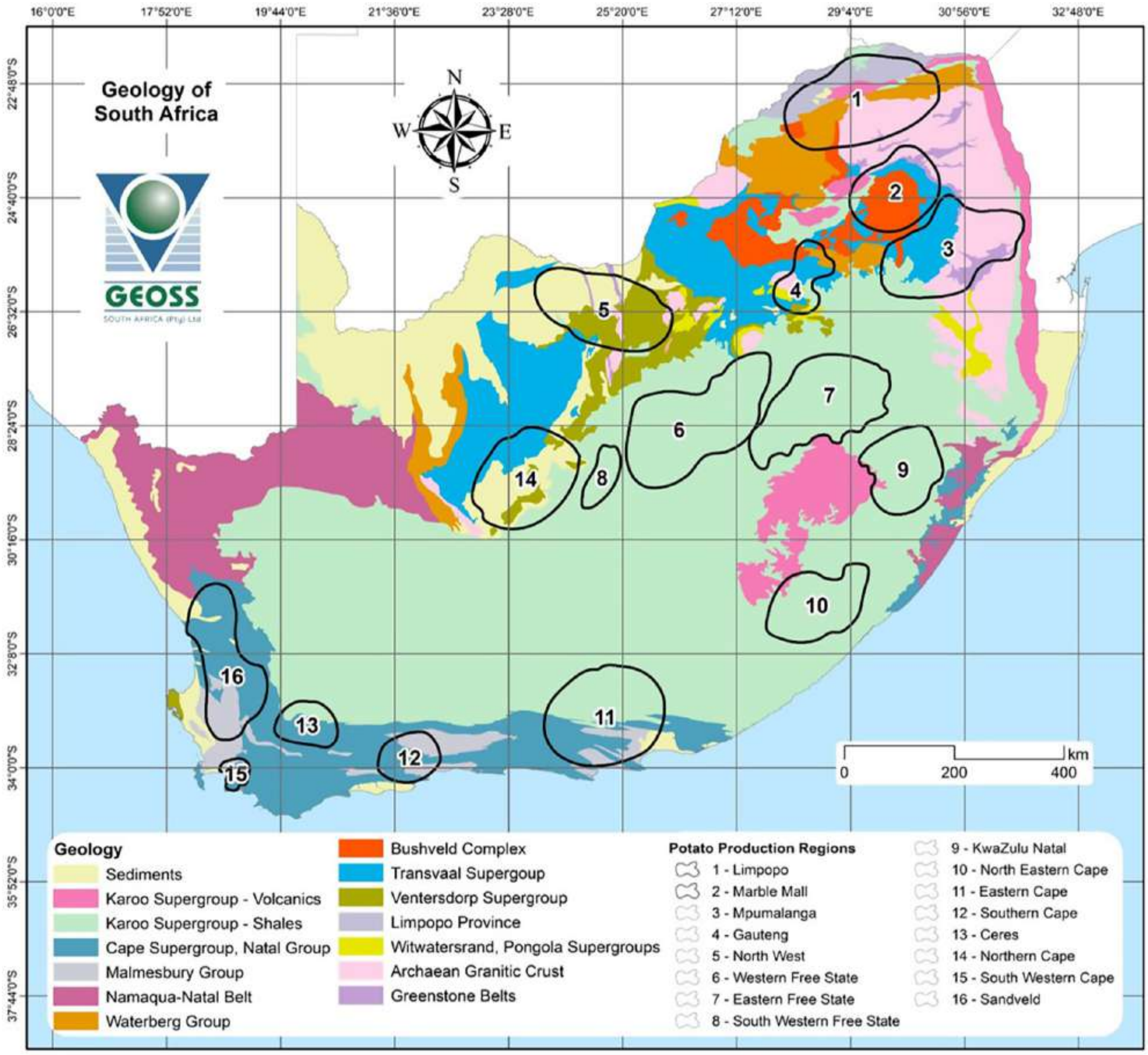

Figure 3: Simplified Geology of South Africa (adapted from CGS, 2008)

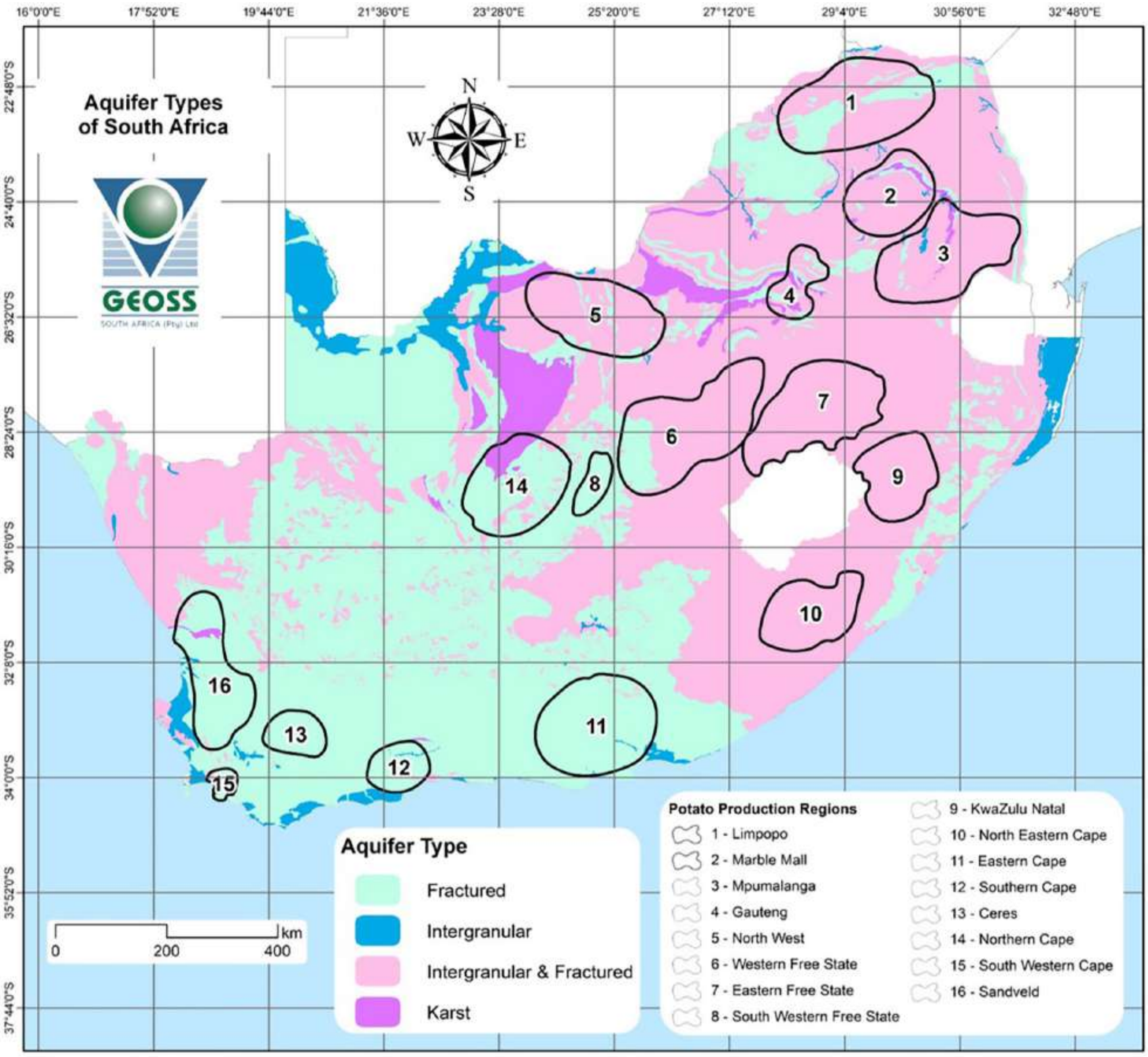

Figure 4: Aquifer Types of South Africa (1:500 000) (DWAF, 2000)

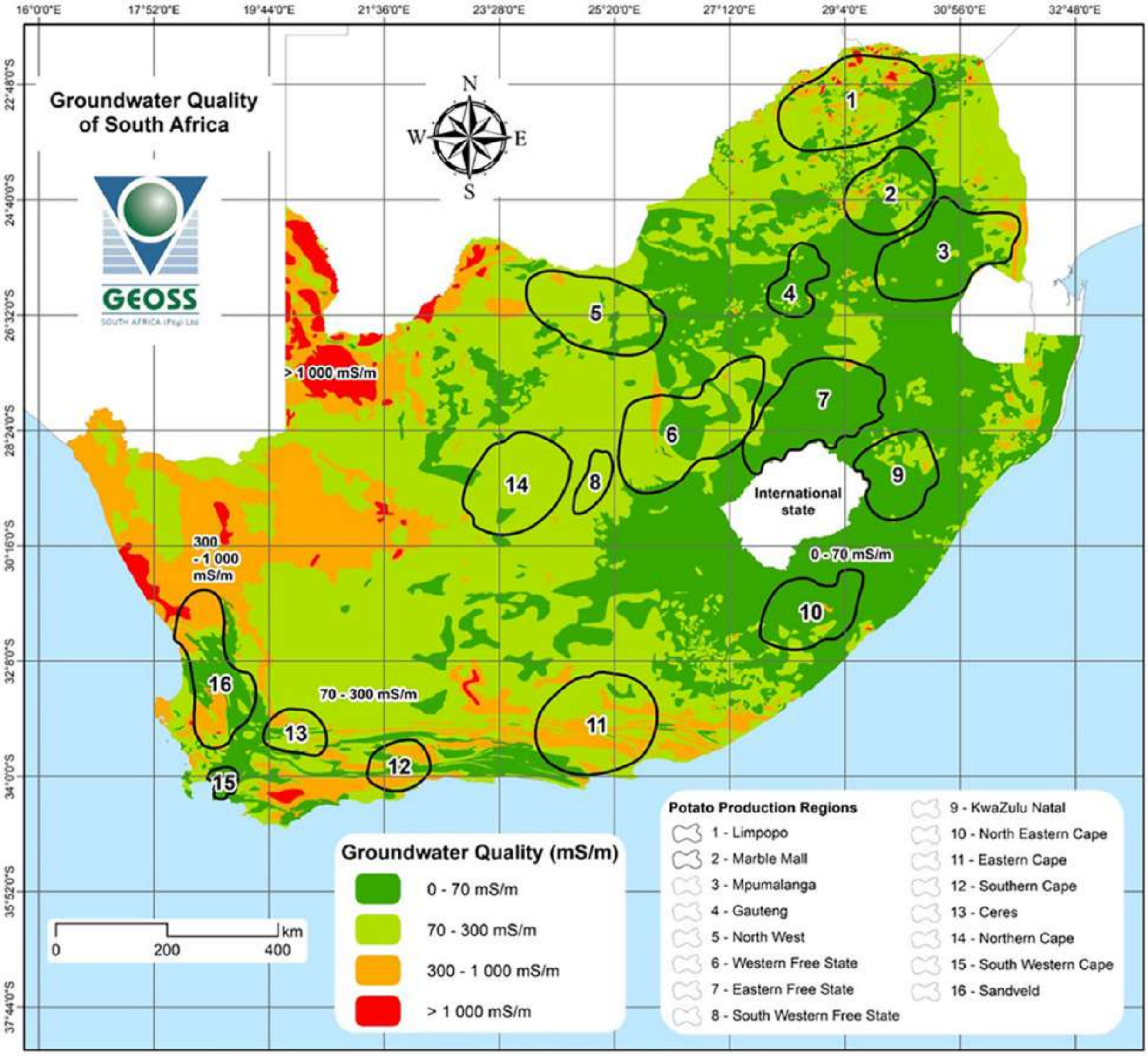

Figure 5: Groundwater Quality of South Africa (1:500 000) (DWAF, 2005)

DRILLING BOREHOLES

Before a borehole is drilled, and especially for large study areas such as farms or municipalities, a decision has to be made as to where a borehole (or boreholes) should be drilled. In some cases there are several areas on a single property where groundwater development can successfully occur, in other cases there are none. While the general geology and average rainfall in an area will provide an indication of groundwater conditions, even on a single property the geology can be fairly uniform or can change dramatically within a few meters. The flow direction of groundwater in the area can also play an important role in choosing where to drill. Simply drilling deeper is also not necessarily the best solution. Many shallow fresh water aquifers have been contaminated by drilling deeper and finding very saline water deeper down which mixes into the shallow aquifer after drilling. Another factor worth considering, especially on a large property, is the presence of existing power supply and water pipes as these installations can have a significant impact on the cost of a borehole.

In most cases, deciding where to drill a borehole should be done based on a geological understanding of a study area. This includes an understanding of the geology at surface, as well as deeper below the surface. To understand what the geological setting of an area is, detailed geological maps can be purchased from the Council for Geoscience. Earth scientists with a background in geology can conduct field surface mapping and in addition – and not as a replacement – conduct a geophysical survey.

Geophysical science is the study of how the different materials of the earth (sands, clays, dense rocks, light rocks, etc) interact with different electrical or magnetic signals. In South Africa, the most common forms of geophysical surveys in connection with groundwater studies are electrical resistivity methods, electromagnetic methods and magnetic methods. Understanding these methods can be very complex and they should be used carefully and interpreted by someone who has studied geophysics and is familiar with the geology of the area. Typically geophysical surveys are used to improve understanding of geology rather than groundwater. The geophysicist's task is to use a geophysical survey of an area to assist the geohydrologist in understanding the subsurface geology better.

The geohydrologist should also spend time visiting other boreholes in the area and mapping these in relation to the local geology map. By collating all this information (surface geology, underground geology, flow directions and any other information attained from other boreholes in the area) a geohydrologist can make a recommendation as to where to drill a borehole that is likely to contain high groundwater flow rates.

In South Africa (and around the globe) boreholes are often drilled based on the suggestions of a water diviner. Water diviners claim to locate underground water based on the way a divining rod (often a wire or branch) moves in their hand as they walk around an area where they expect to find water. While this method may be near and dear to many groundwater users' hearts, time, experience and controlled testing have shown that a scientific approach using geological mapping, geophysical surveys and sound geohydrological conceptual modelling is more likely to be successful.

Irrespective of how someone chooses to do so, drilling a borehole is not a simple operation. There are many questions that should be asked of a drilling contractor before a borehole is drilled. Here are some of the most important ones:

- What is the estimated depth of drilling?
- How much casing will be needed?
- What type of geology will be drilled through?
- What method will be used to drill to this depth, and can it go deeper if necessary?
- What is the expected cost to drill this borehole? (Important note – the answers to questions 3 and 4 can have a dramatic effect on the price!)
- Can the driller develop (i.e. flush with compressed air) the borehole after drilling and for how long?

Once again, the answers to these questions can be estimated from the geology of the area but can also be answered by drillers who are familiar with the area. Drilling a 165 mm diameter borehole 20 m into sand is very different to drilling a 305 mm diameter borehole 150 m into rock. For groundwater drilling in South Africa there are two main drilling methods which are used, depending on the geology. These are air percussion and mud rotary.

Air percussion involves drilling with a pneumatic hammer drill bit to break up the rock, while blowing air into the bottom of the borehole to blow out the rock chips. This method is typically used in hard rock geologies which will not collapse easily while drilling. An advantage to this is that it is relatively fast, the drill chips can be collected every meter to log the geology and water strike depths are quite easy to note and measure. Disadvantages are that in softer formations the open rock can collapse onto the drill bit during rod changes, risking the loss of equipment and even losing the borehole in some situations.

Mud rotary drilling is typically used to drill through soft, saturated formations, such as sands or clays. A thick, sticky additive (known as a "drilling mud") is pumped into the borehole while being slowly drilled, which coats the wall of the hole and holds it open during drilling. After drilling a flush-threaded, factory perforated uPVC casing with centralisers should be installed with a suitably sized gravel pack to filter out the aquifer materials (fine sands will require a different filter pack to coarse sands). The drilling mud will degrade and dissolve in time (depending on how much water is in the area).

Once drilling has been successfully completed (whether air percussion or mud rotary), a borehole should be developed by the driller. The purpose of this is to lift the groundwater out the borehole and to flush out any drilling fluids or fine material in the process. While this is happening (typically a minimum of 2 – 4 hours) the driller can measure the airlift yield of the borehole (how much water is being blown out the borehole). This is NOT the sustainable yield of a borehole and many boreholes have been overused (and sometimes underused) by putting the wrong size pump in the boreholes based on the airlift yield. In most cases this means that the pump burns out and has to be replaced, but in some cases the actual borehole can be damaged by over pumping.

The final task a driller has is to give their client a borehole log. The log records the date drilled, name of the borehole, where the borehole is, what materials they drilled through (geological log), where they intersected a water strike and how the borehole was constructed (drilling diameters and depths, steel casing depths, PVC inner casing depths, gravel pack sizes, etc). An example of this is provided in Figure 6 and this information is used by a yield test contractor to decide at what rate to scientifically test a borehole. A pump should not be selected until a geohydrologist has carefully analysed the results of a scientific yield test.

> *"Choosing where to drill a borehole should be based on the underground geology, not on wishful thinking".*

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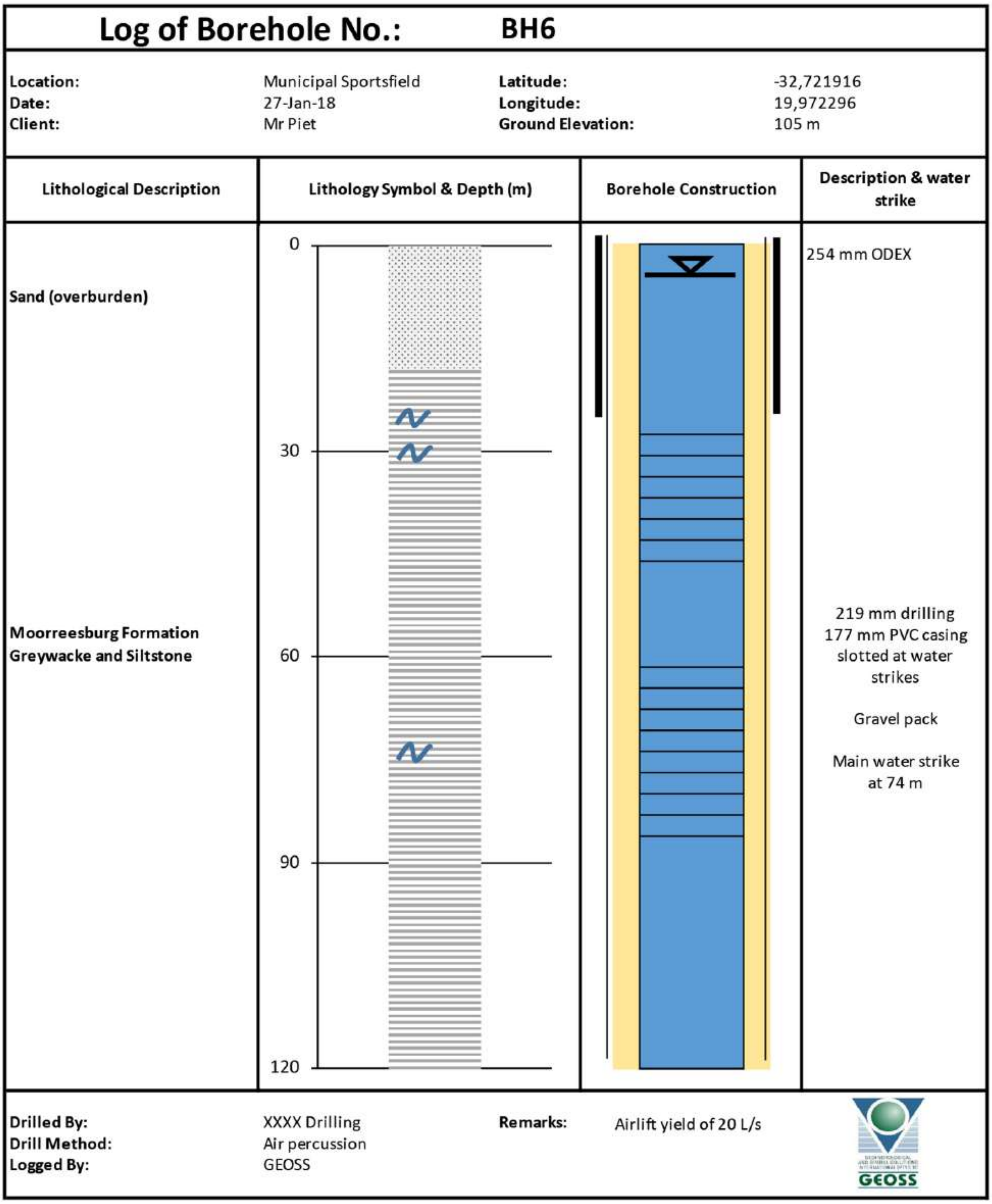

Log of Borehole No.: BH6

Location:	Municipal Sportsfield	**Latitude:**	-32,721916
Date:	27-Jan-18	**Longitude:**	19,972296
Client:	Mr Piet	**Ground Elevation:**	105 m

Lithological Description	Lithology Symbol & Depth (m)	Borehole Construction	Description & water strike
Sand (overburden)			254 mm ODEX
Moorreesburg Formation Greywacke and Siltstone			219 mm drilling 177 mm PVC casing slotted at water strikes Gravel pack Main water strike at 74 m

Drilled By:	XXXX Drilling	**Remarks:**	Airlift yield of 20 L/s
Drill Method:	Air percussion		
Logged By:	GEOSS		

Figure 6: Drilling Log Example

YIELD AND PUMP SELECTION

In order to CHOOSE the correct pump for a borehole the following must be known: pumping rate, pumping water level (dynamic water level), pump depth and borehole inner diameter. This information can then be used by an irrigation manager to purchase and install the correct pump for the borehole, based on different pump curves. An example of a pump curve is shown in Figure 7 for the Grundfos SP 30-8, which would work for pumping 8.3 L/s (30 m3/h) when the water is 60 m below surface. If the water dropped to 85 m below surface it would only deliver 3.5 L/s (12.6 m3/h). This would also be too high yielding if the borehole can only yield 2 L/s ,and would pump the borehole dry very quickly instead of being able to pump for an extended period of time (12 hours or longer per day). Accurately knowing the yield of the borehole is important in selecting the correct pump size.

In order to determine the yield of a borehole, it is necessary to conduct a scientific yield test. From this test the pumping water level and sustainable yield can be determined. A scientific test for the yield of a borehole requires someone to pump a borehole at a controlled constant rate while the water level is accurately measured as it lowers in the borehole. This is first done with a Step Test, where the borehole is pumped at a constant rate for an hour with the water level measured. The pumping rate is then increased to a higher rate for another hour and monitored again. This is repeated another two times for a total of four or more Steps.

Once the water level has returned to pre-test levels, a Constant Discharge Test (CDT) can be conducted. During this test the borehole is pumped at a fixed rate for several hours (minimum 24 hours for farms, often 48 hours or 72 hours).

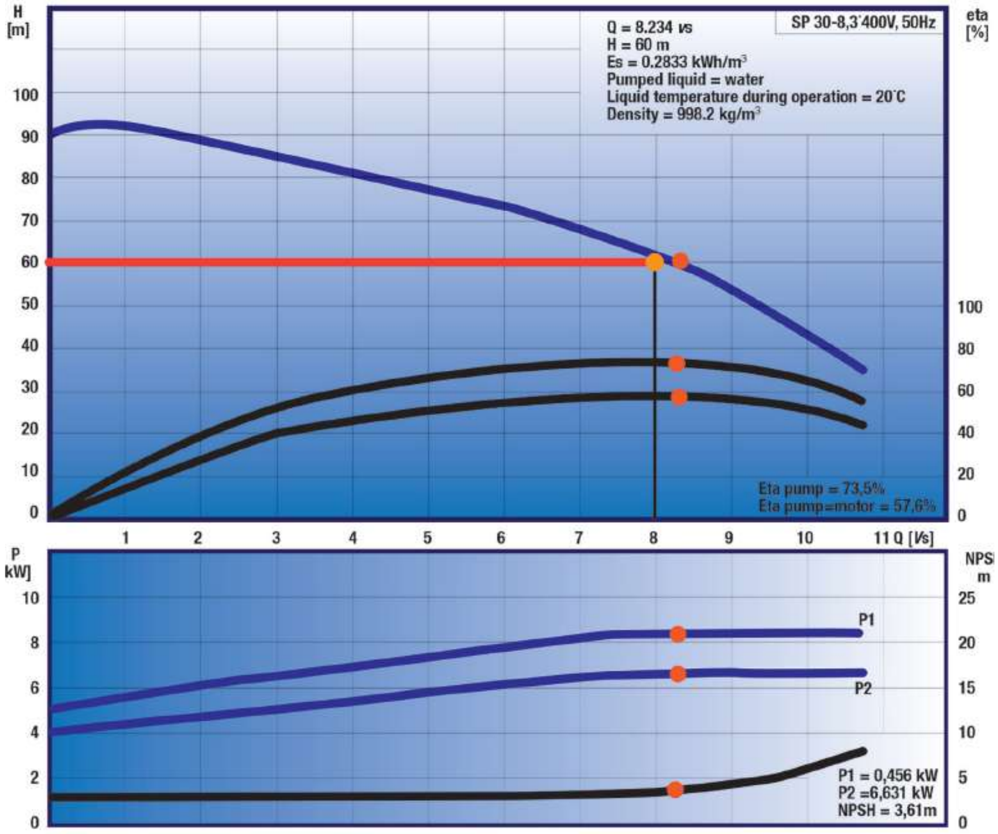

Figure 7: Pump Curve Example - Grundfos

During this test it is extremely important that the flow rate is not changing and that the water level is measured throughout the test. It is also important to choose a pumping rate for this test that will drop the water level as much as possible during the test, but not to reach the pump too quickly (ideally if the water level reaches the pump it should take at least 75% of the test time to get there). Once the water level reaches the pump or once the CDT time has finished, the pump is turned off and the water level must again be measured and recorded as it comes back up. This can sometimes take an hour or two and sometimes up to a few days, but must be monitored as it comes back, which is called a Recovery Test.

This test is a National Standard test (SANS 10299-4:2003, Part 4 – Test pumping of water boreholes) and is acceptable for licensing a borehole with the Department of Human Settlement, Water and Sanitation (DHSWS). A graphical example of the test is shown in Figure 8.

There is also a traditional borehole testing method, commonly known as a Constant Head Test or Farmer Test (Table 1). This is done unscientifically and is insufficient for determining a borehole's sustainable yield and what the pumping water level will be.

The test is typically done by dropping a pump close to the bottom of the borehole and pumping the borehole at maximum pumping rate. Once the water level reaches the pump and the pump starts "sucking air" the pump is throttled back slowly until it stops sucking air. The flow rate is then monitored, usually for about 8 – 12 hours and the pump contractor then instructs the client to either use the borehole at 2/3 of this capacity or ½, depending on what they feel is best. Unfortunately, this test reveals almost nothing about how a borehole can be pumped in the long term. Sometimes the borehole can be used at a higher rate, sometimes much lower. This can have small cost implications (just buying the wrong pump or using too much electricity with a throttled pump) or very high cost implications (when an entire irrigation scheme is put into a new farm and the borehole dries up in a few weeks or months).

On the opposite page is an example of a Constant Head Test (Table 1) which would be used to recommend 2.3 – 3 L/s (8 – 11 m3/h). A scientific test of this same borehole done a few months later indicated that the borehole could only yield 1 L/s (3.6 m3/h).

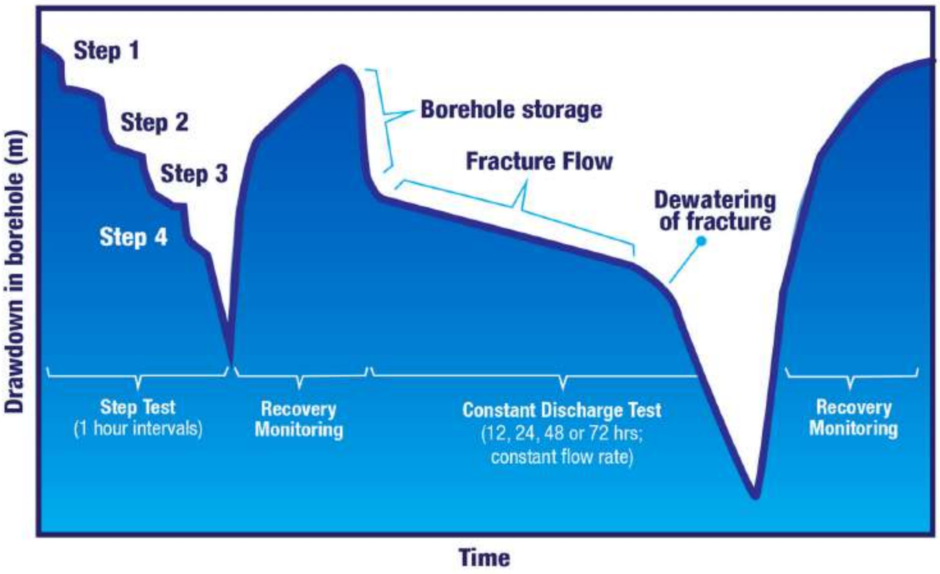

Figure 8: Yield Test Data and Graph Example

Depth of borehole: 120 m
Rest water level before test: 10 m
Installation depth: 100 m

Time	Dynamic	Reading	Flow
Minutes	**WL**	**Seconds**	**L/H**
7H00	11 m	18,33	41243,86
8H00	70 m	22,59	33466,13
9H00	100 m	26,18	28877,00
10H00	100 m	39,05	19359,79
11H00	100 m	42,10	17957,24
12H00	100 m	42,75	17684,21
13H00	100 m	43,37	17431,40
14H00	100 m	45,43	16640,98
15H00	100 m	45,42	16644,64
16H00	100 m	46,46	16630,00
17H00	100 m	45,51	16611,73
18H00	100 m	45,49	16619,03
19H00	100 m	45,58	16586,22
20H00	100 m	45,44	16637,32
21H00	100 m	45,46	16630,00
22H00	100 m	45,44	16637,32
23H00	100 m	45,37	16662,99
24H00	100 m	45,41	16648,31
1H00	100 m	45,44	16637,32
2H00	100 m	45,43	16640,98
3H00	100 m	45,46	16630,00
4H00	100 m	45,49	16619,07
5H00	100 m	45,45	16633,66
6H00	100 m	45,43	16640,98
7H00	100 m	45,44	16637,32

Table 1: Example of the Unacceptable Constant Head Test / Farmer Test

MONITORING AND MANAGING A BOREHOLE

Once the yield of a borehole is known and the correct pump has been bought and installed, it is still strongly recommended that a borehole be monitored continuously in order to manage it correctly. Proper management of a borehole ensures that even though seasons and climate changes occur, the borehole can be used to maximize current supply without sacrificing future supply. Returning to the introduction of this brochure, we remember that rainwater is the originator of borehole water and thus long-term rainwater trends (drought years and higher rainfall years) will eventually impact the groundwater in an area. Using a borehole can also cause sediment or iron to build up on the pump or in the borehole. These can reduce the yield of the borehole or cause the water level to drop to the pump level, causing the pump to overheat. In the same way that the water level in a dam is important for how much gets used, the water level in a borehole should also be monitored and managed. To understand what causes changes in the water level, a flow meter should be attached to the outlet of the borehole to monitor the flow.

This can be done in different ways and at different costs, but as with most equipment, the more information there is to record, the more expensive it can be. At the most basic level, the water level in a borehole should be measured before a pump is turned on and before it is turned off every time the pump is used, and the flow meter read and recorded with the date and time. The data can be saved in a simple spreadsheet to keep a record the borehole's performance.

Over time the readings taken will clearly indicate that the aquifer is either coping or being over-abstracted. The level to which the borehole drops each time it is pumped will provide an indication of how effectively the borehole is being pumped and if the pump is at risk of burning out.

A dip meter can be used to manually measure borehole water levels. A dip meter is a portable battery operated instrument with a sensor at one end of a calibrated cable which winds onto a reel and accurately measures the water level. The sensor is lowered into the borehole via an observation tube (usually installed alongside the riser pipe as shown in Figure 9).

As shown in Figure 9, a water level pressure transducer with logging capacity (also called a water level logger) can be installed in the observation pipe. The sensor electronically measures and records the water level above it. The sensor is hung on a thin (1 mm) stainless steel cable so that it can be retrieved and the latest data downloaded to be stored in a data base together with hand readings of the water levels.

Having a logger allows a much more detailed understanding of the borehole, for example "when the pump turns on the water level drops 10 m in the first 30 min and then slows down to drop another 5 m in the next 2 hours after which the water level drops slowly for another 1 m until the pump is switched off after 12 hours of pumping. After rainfall events the water level drops less, but when the nearby neighbouring borehole is used it drops much faster". The logger enables a frequent groundwater user such as a farmer or municipal manager to understand how much water they are likely to have at different times of the year and to make sure they don't run out unexpectedly.

An example of a monitoring graph from logger data is shown in Figure 10. It clearly shows that the borehole is used sustainably and if needed it could be pumped at a higher rate or for longer periods of time. Figure 11 shows an example of an overused borehole. There is a risk of burning out the pump and / or causing iron to build up in the groundwater fractures and /or resulting in aquifer collapse.

The logger can also be installed on a direct read cable, which allows users to read the logger from the surface, instead of having to pull it up each time. The logger can be part of an online telemetry system, allowing clients or consultants to view the daily water levels from any internet enabled device. Of course, each improvement in the monitoring system incurs an additional cost. Table 3 summarises estimated costs for the different options, as well as a short description of the purpose they serve.

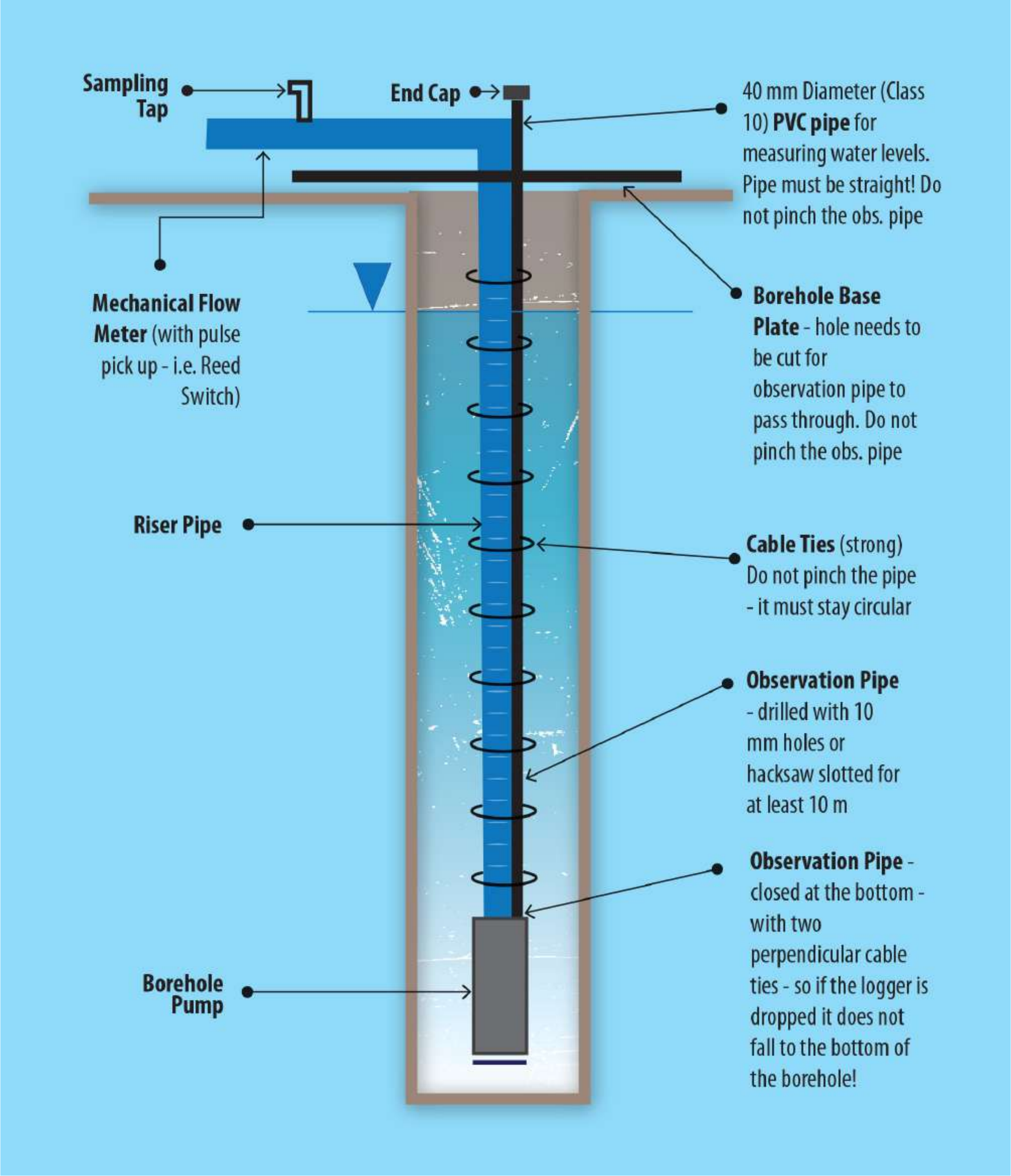

Figure 9: Monitoring Infrastructure

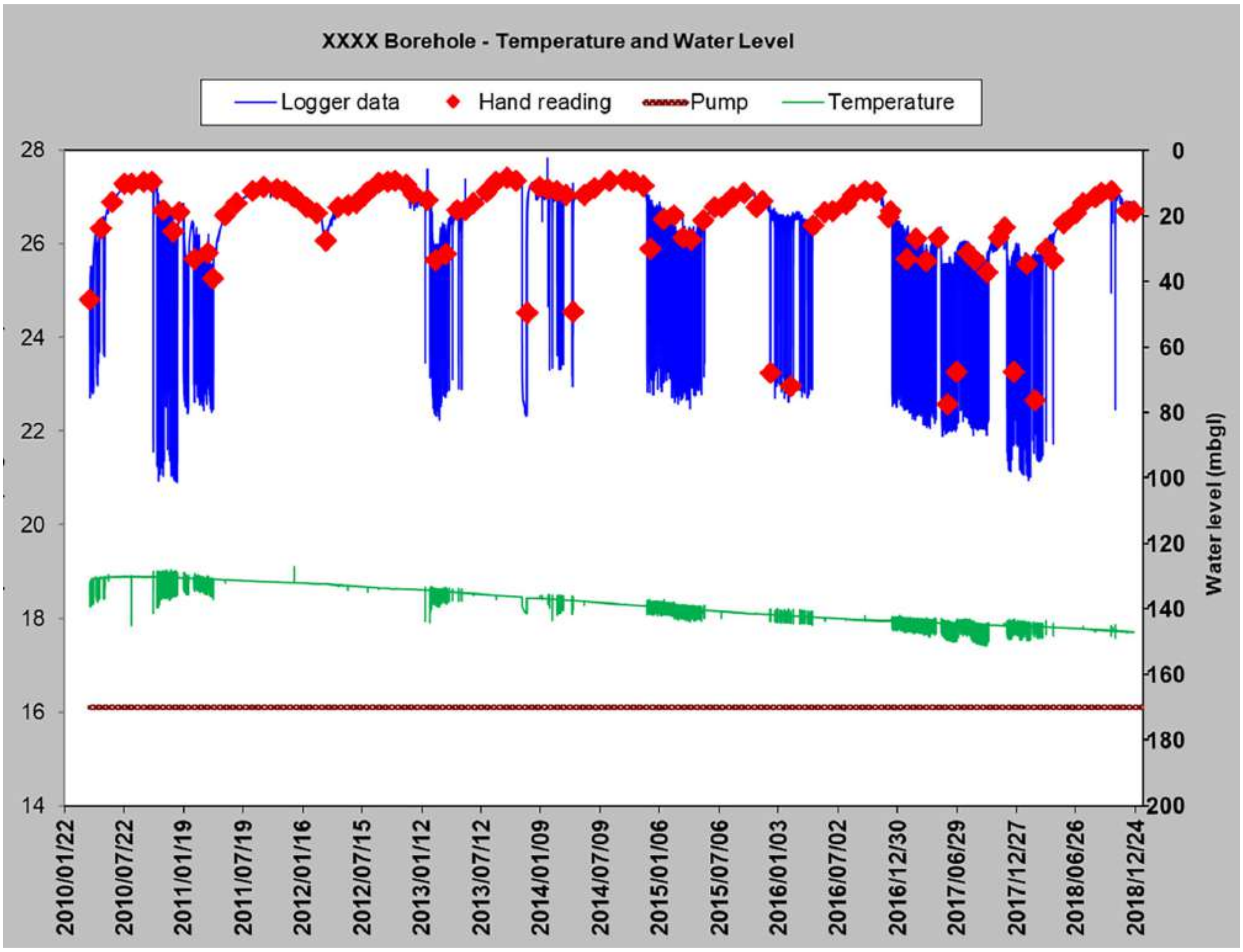

Figure 10: Example of a Well Monitored Borehole

Date	Time	Date and Time	Flow meter reading (cubes)	Flow rate (L/s)	Pumping (Yes/ No)	Water Level (mbgl)	Comments
2018/05/03	8:00	2018/05/03 8:00	19325	4.2	Yes	43.26	All fine
2018/06/10	9:00	2018/06/10 9:00	23927	0	No	12.20	All fine
2018/07/02	10:00	2018/07/02 10:00	28503	4.1	Yes	41.60	All fine
2018/08/19	11:00	2018/08/19 11:00	33124	4.2	Yes	42.90	All fine
2018/09/16	12:00	2018/09/16 12:00	38167	0	No	13.60	All fine
2018/10/20	13:00	2018/10/20 13:00	42629	0	No	12.12	All fine
2018/11/12	14:00	2018/11/12 14:00	48836	4.2	Yes	43.86	All fine
2018/12/03	15:00	2018/12/03 15:00	53641	4.1	Yes	43.15	All fine

Table 2: Example of a Borehole Monitoring Record

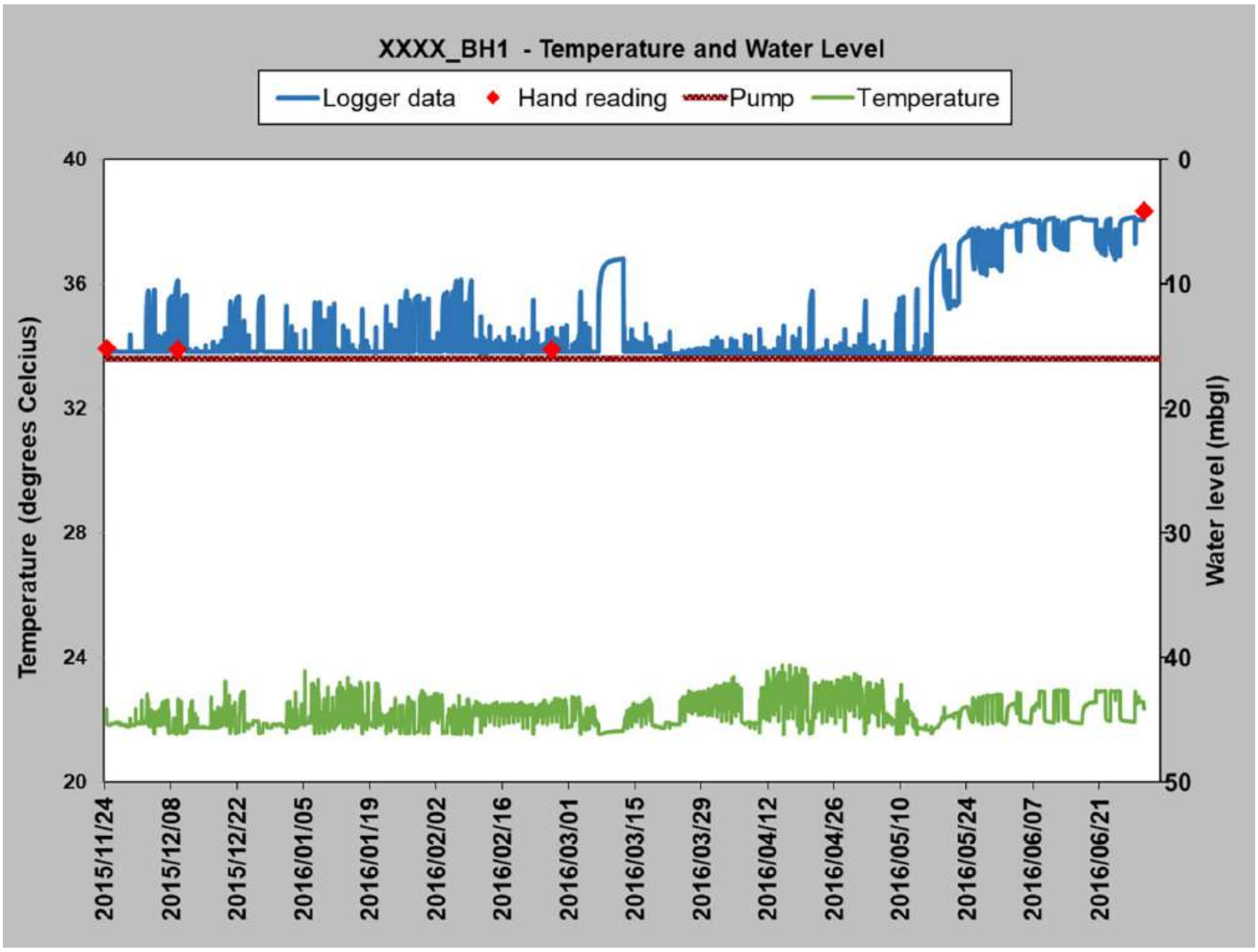

Figure 11: Example of Over Abstraction.

Item	Estimate Cost	Description/Comments	Use/Benefit
Observation pipe	R5 000 – R10 000	32 mm OD, 28 mm ID, cable tied at bottom, from surface to pump.	Keeps logger or dipmeter safe from tangling with pump.
Flow meter	R7 000	Built in close to borehole.	Required to monitor flow. Compulsory.
Dipmeter	R3 000 – R10 000	Can be a simple wire, marked every meter on a reel, or more complex to measure temperature and EC if required. Must be at least as long as pump depth.	Measuring the water level depth in the borehole at dif¬ferent times is key to proper management.
Solinst Logger	R10 000 per logger	Must be suited to instal¬lation depth (pressure capability of the logger).	Records water levels (and temperature, pH and EC if necessary) at pre-set intervals. More continuous data than dipmeter readings, better management.
GeoTel Telemetry	R50 000 per borehole	Requires power source, direct read cable to logger and flow meter.	Logger and flow meter data can be uploaded online from a borehole, to enable mon-itoring/ management from anywhere without visiting the site.
Automated Pump Switch	R1 000 – R4 000 per borehole, depending on depth and specifications.	Linked to logger or set to timer.	If a borehole's abstraction is well understood, or if the borehole is used on a top up system, the pump can be programmed to a schedule or to switch on at a certain water level and switch off at a critical water level. Protects the pump from burning out and protects the aquifer from over abstraction.
Management Report	R1 000 per borehole report if telemetry installed. R 5 000 – R20 000 per report if driving to site and visiting boreholes is required.	An analysis of abstraction data (flow rates, water levels, temperatures, ECs, etc) by a geohydrologist to scientifically assess the borehole's sustainability.	Allows the user to receive regular updates on whether they are over abstracting or optimise their borehole abstraction. Typically done on a monthly, quarterly or bi-annual basis.

Table 3: Estimate Costs of Monitoring Infrastructure

GROUNDWATER LEGISLATION

The final step in having a fully operational groundwater supply is the legalisation of the source. The Department of Human Settlement, Water and Sanitation (DHSWS) is the custodian of all water resources in South Africa, and legal use of water from the surface or underground must be approved by the DHSWS. This is important as it ensures that a legal user of groundwater is protected from new groundwater users impacting their boreholes. Areas near to mines or new water intensive farms can often experience groundwater depletion as the mines dewater the mining area and lower the water level of an area. Groundwater can also be polluted by surface contaminants such as oils, brines or other contaminants produced by industry, if these are allowed to seep into the ground.

To license groundwater use, the quality and yield must be scientifically tested and documented. Doing so allows a legal groundwater user who starts losing water or whose water becomes contaminated, to investigate the cause thereof. If the cause is anthropogenic (caused by humans) it can be taken up as a legal matter. A legal groundwater use may not be impacted by new users, but proving what an owner's use is can be tricky and simply saying that "we have used this borehole for 30 years with no problems" isn't considered legal proof. An approved license is required, and a monitoring record can help greatly in ensuring that a groundwater or surface water source is protected.

In order to license a groundwater use, a scientific study has to be conducted to ensure that the borehole water use is sustainable; the aquifer must be sustainable, the water use may not impact other groundwater users in the vicinity, and the owner must use the resource responsibly. By ensuring that these conditions are met, the DHSWS makes sure that the groundwater aquifers in our country are used sustainably and will be available for future generations.

> *"To legalise groundwater abstraction one must apply to the Department of Human Settlement, Water and Sanitation. This application must contain scientifically tested borehole yields and quality as well a geohydrological study of the area to determine any potential impacts"*

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CONCLUSION

While groundwater is a sustainable and economic answer to many of South Africa's water supply problems, the success of groundwater projects is usually dependent on careful planning and discussion before drilling boreholes. These discussions should include what the required vs expected yield and qualities are, and what the full process to becoming operational will entail. In a nutshell this is: geohydrological siting, informed drilling, scientific yield and quality testing, licensing with the correct authorities, equipping informed by yield testing, yield and quality informed treatment and storage if necessary, and finally management informed by monitoring. Each one of these steps can be the make or break in successfully securing groundwater as a viable solution to a water supply problem, or an expensive and misinformed failure. While all these steps are closely interlinked, most companies and contractors will only specialise in one to three of the steps, thus it is advisable to arrange smaller meetings between the different parties to ensure clear communication. The various steps that need to be taken are outlined below and also listed are the specialists and contractors that should be involved:

- Borehole Siting – Geohydrologist (along with geophysicist and geologist).
- Drilling – Drilling contractor and geohydrologist (possibly environmentalist as well, depending on the area and scale of the project).
- Yield and Quality Testing – Yield testing contractor, geohydrologist and water chemistry laboratory (potentially environmentalist as well, depending on the area and scale of the project).
- Licensing – Geohydrologist and Department of Human Settlement, Water and Sanitation.
- Equipping – Local/regional supplier of borehole pumps (who will require the drilling log/report and the yield and quality report), with monitoring infrastructure and equipment.
- Treatment and Storage – Water treatment specialist (who will require the yield and quality report, as well as the specifications of the equipment to be installed).
- Long-term Monitoring and Management – Geohydrologist.

Depending on the size of the project some of these steps may be simple and quick to address, which can lead groundwater users to overlook them completely. Whether simple or complicated, it is strongly recommended that each of these steps is discussed before going ahead with the project. Groundwater is a precious resource and should be respected and protected as such by all. Borehole drilling is not a simple once-off exercise. Users need to remember that boreholes require on-going care and maintenance.

> *Whether simple or complicated, it is strongly recommended that each of these steps are discussed before going ahead with the project.*

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