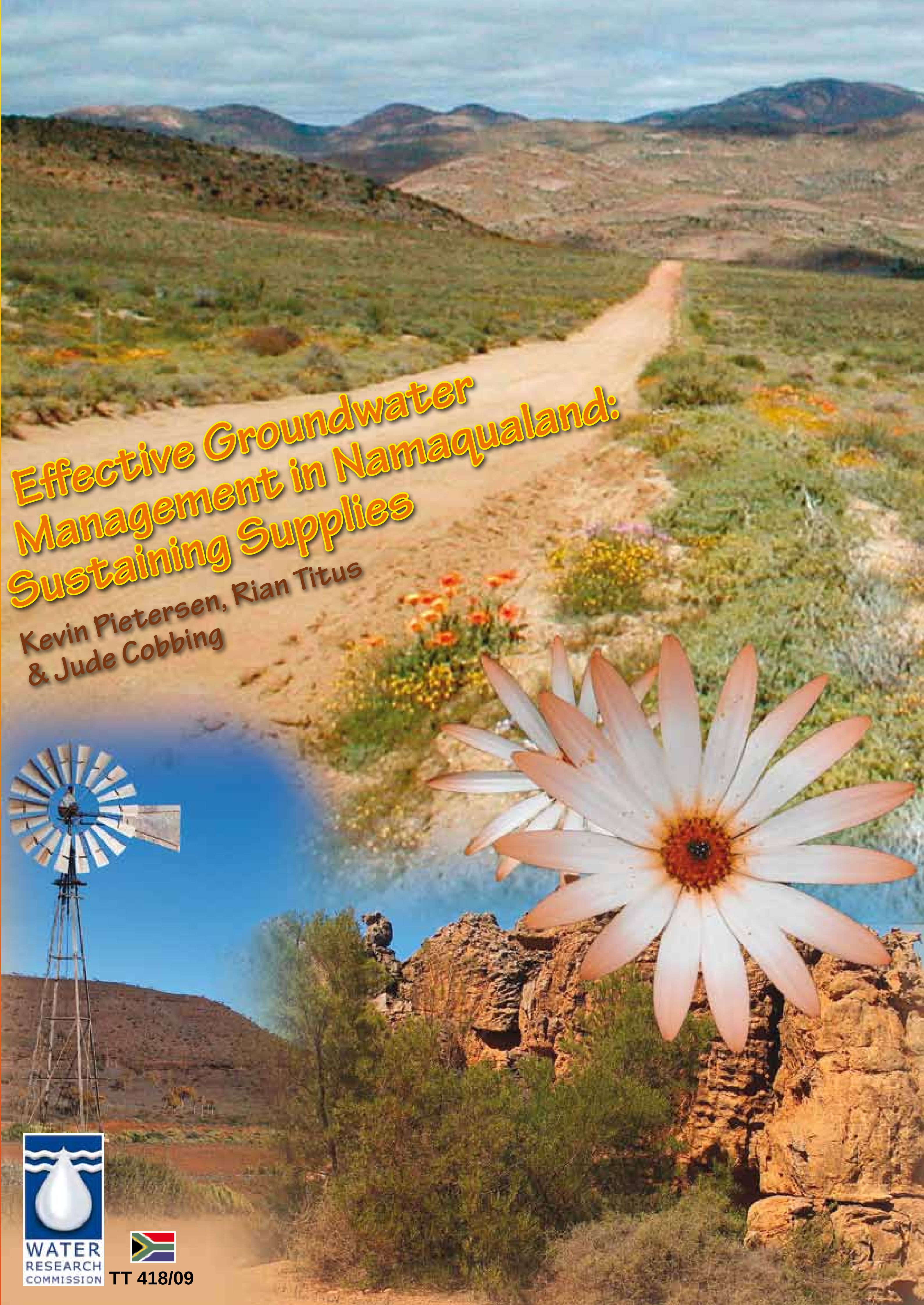

Effective Groundwater Management in Namaqualand: Sustaining Supplies

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& Jude Cobbing

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Report to the Water Research Commission

by

Kevin Pietersen, Rian Titus and Jude Cobbing

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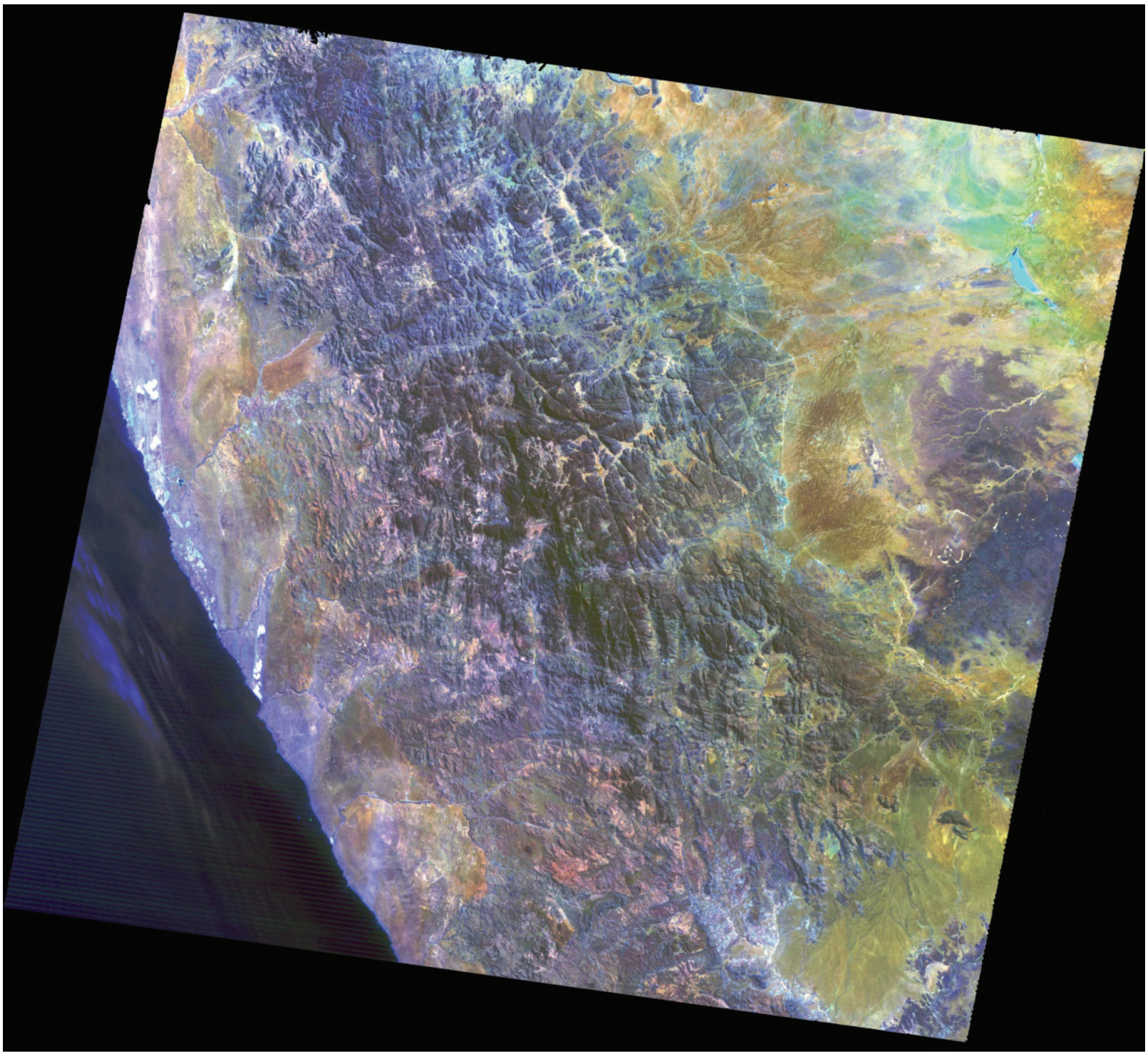


Landsat image of Namaqualand

A right to water

The rights to basic services are enshrined in the Constitution of South Africa through the adoption of a Bill of Rights. The Bill of Rights secures the right of people to have access to sufficient water and food.

South African Constitution: Chapter 2 - Bill of Rights

Article 7 (1): This Bill of Rights is a cornerstone of democracy in South Africa. It enshrines the rights of all people in our country and affirms the democratic values of human dignity, equality and freedom.

Article 8 (1): The Bill of Rights applies to all law, and binds the legislature, the executive, the judiciary and all organs of state.

Article 27 (1): Everyone has the right to have access to -

a. health care services, including reproductive health care;

b. **sufficient food and water**; and

c. social security, including, if they are unable to support themselves and their dependants, appropriate social assistance.

Supplying sufficient water becomes difficult in arid environments with limited surface water and groundwater resources. This is particularly true in the region of Namaqualand, which is located in the western part of South Africa.

In response to this challenge, the Water Research Commission (WRC) has supported a number a groundwater research projects in the Namaqualand region over the last decade to build-up a knowledge base aimed at successfully exploiting the groundwater resources of the region.

The purpose of this guide

The purpose of this guide is translate the scientific and technical knowledge gained through research on the hydrogeology of basement aquifers into a user-friendly format for the Department of Water Affairs and Forestry (DWAF), local authorities and the end-users. The guide is not intended for operators of water supply schemes, but rather for water resource planners.

How to use this guide

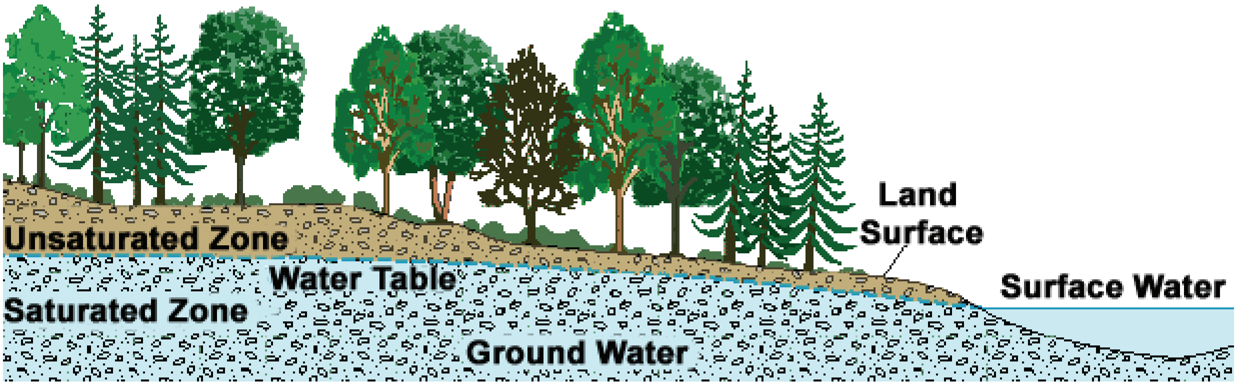
The guide has two overarching sections that deal with the issues of groundwater exploration and exploitation in a systematic manner. It is subdivided as follows:

1. What is groundwater?
2. The importance of groundwater in Namaqualand
3. Namaqualand aquifer systems
4. Locating groundwater resources in Namaqualand
5. Selecting drilling targets
6. Borehole design
7. The drilling process and the importance of data collection
8. Determining the sustainable yields
9. Understanding the water balance
10. Managing the water resource
11. Water quality considerations

1. What is groundwater?

Groundwater is generally all subsurface water as distinct from surface water; specifically, the part that is in the saturated zone. It naturally discharges as springs and as baseflow to rivers. It can also be accessed by people by means of wells and boreholes. Rainwater moves slowly downwards to replenish the groundwater resource, in a process called "recharge". It can take many years for infiltrating rainwater to reach the groundwater level in the aquifer.

Groundwater quality is usually good, and it can often be put into supply systems with little or no treatment. It is also resistant to droughts and can provide a water supply even when dams and rivers have dried up. For these reasons, groundwater is considered to be a very important resource. More than half of all South Africans depend on groundwater for their domestic water needs. Whilst groundwater can be found in most places, only aquifers generally yield enough water to be useful. In an aquifer, the ground is saturated with water below a level known as the "water table". This level of water is usually very similar to the level of water you will find in boreholes or wells in the aquifer.



Source: http://wwwrcamnl.wr.usgs.gov/uzf/unsatflow.html

Groundwater is part of the hydrological cycle, but the underground part of that cycle is constrained by geological controls. To study the physical hydrogeology or quantitative groundwater resources of an area three sets of factors have to be considered, requiring three different but interdependent fields of study: geological to investigate the framework in which the groundwater occurs; **hydrological**, to investigate the input and output of water to and from the framework; and **hydraulic** to investigate the way in which the framework constrains the water movement.

Source: Price (1996)

2. The importance of groundwater in Namaqualand

The Namaqualand region is situated mostly in the Orange Coastal sub-area of the Lower Orange Water Management Area (WMA). Studies conducted for DWAF estimate the available yield to be 3 million m^3/a for the Orange Coastal sub-area. The region has no surface water resources and this yield is mainly derived from groundwater resources.

The current and projected water demand for the Orange Coastal sub-area is estimated at 8 million m^3/a, which is significantly higher than the estimated available yield. This means that water needs to be imported from other catchments. This water is currently transferred from the Orange sub-area. However, these transfers are limited to the major urban and mining areas. In the rural areas, communities are dependent on local resources such as groundwater. As a result, efficient management of groundwater resources is necessary so that the water supply to communities in Namaqualand is optimised.

In order to utilise groundwater resources and make appropriate management decisions, the following need to be known:

- The imposed changes on the groundwater system. These are normally in the form of withdrawals, but can include artificial recharge.
- The groundwater system: geological framework, hydraulic properties and boundary conditions.

- The system response and impact on the broader environment.

Through research a reasonable understanding of the groundwater system has been developed (i.e. geological framework, hydraulic properties and boundary conditions). Currently a limited understanding of the stresses to the groundwater systems in Namaqualand exists. However, a serious information gap is the knowledge of groundwater responses and the environmental effects of the imposed stresses.

3. Namaqualand aquifer systems

The geometries of the aquifer systems in Namaqualand have been largely controlled and influenced by the underlying geology of igneous and metamorphic rocks (such as granites and gneisses) and its deformation history or structural evolution. Another influence on aquifer geometry has been the geomorphic development of the Namaqualand region, including weathering.

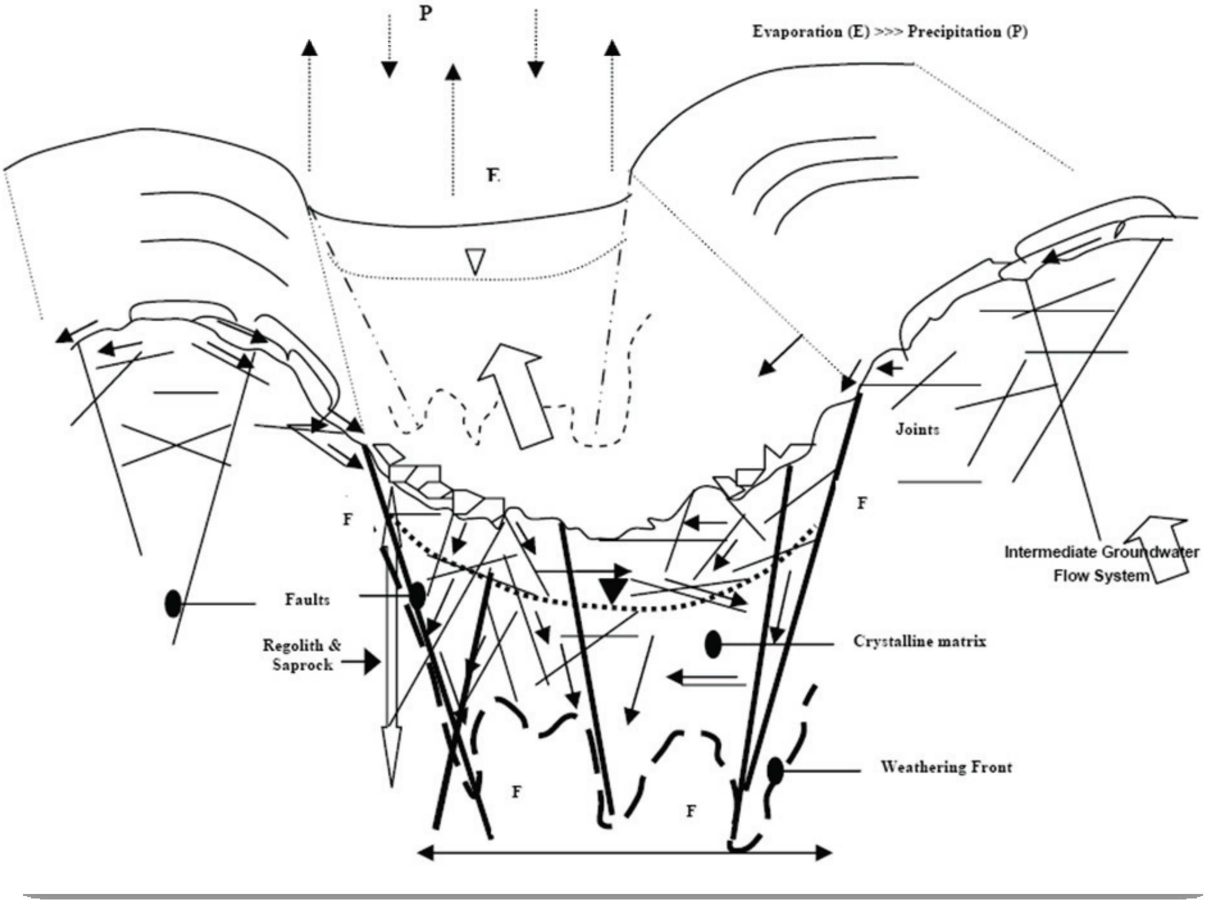
A **Fault** is a break or crack in the earth's crust, and can range from a few centimetres long to many kilometres. Faults can conduct groundwater in certain cases, whilst in others they can stop the flow of groundwater.

Regolith is a layer of loose, weathered material covering solid rock. It usually forms from the breakdown or weathering of the underlying solid rock and it can hold large amounts of groundwater.

In Namaqualand, groundwater occurs in three different aquifer systems

- fractured bedrock
- the weathered zone or regolith, and
- the sandy/alluvial aquifers

The fractured bedrock and regolith aquifer systems are normally linear systems associated with the structurally controlled valleys and may be laterally extensive depending on the nature of fault systems. These fault controlled valleys are especially prominent in the mountainous escarpment zone and are the traditional targets for the development of groundwater resources.



Superimposed on the basement aquifers are the alluvial aquifers associated with ephemeral rivers, paleochannels and the coastal plain. Alluvial aquifers associated with the river systems are usually very shallow (around 1 – 15 m), whereas alluvial depths of tens of metres are found in the coastal areas.

4. Locating groundwater resources in Namaqualand

The following analyses need to be done in order to locate groundwater resources in the region:

- Stress field analysis
- Geomorphic analysis
- Regolith analysis

Stress field analysis

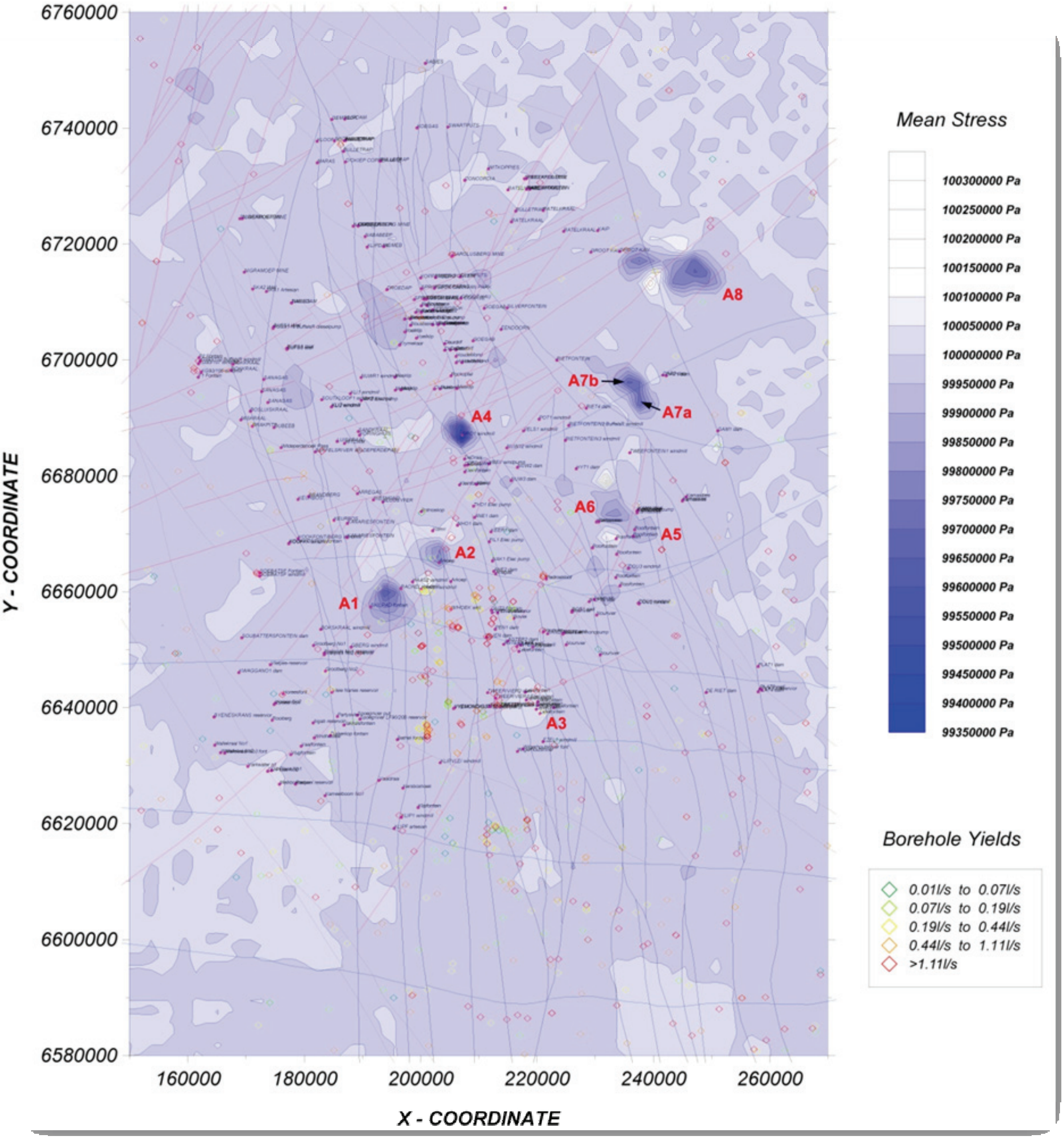
The Namaqualand region consists of mostly igneous and metamorphic rocks which have undergone a complex deformation history. An understanding of the structure can help hydrogeologists to find the best sites for boreholes – usually places where fractures in the rock are open and can transmit groundwater. Normally the most recent tectonic events have the most significant influence on the nature of the existing fracture network and subsequently on the regional flow characteristics. An understanding of the reactivation of older structures and the generation of new ones during neotectonics is also required.

In Namaqualand, a strong correlation exists between known borehole positions and two prominent fault/fracture zone systems. In addition to the well-known NNW-SSE striking system of fault/fracture zones, a set of NNE-SSW fault/fracture zones exists which are oriented sub parallel to the direction of present day neotectonic crustal extension. It was found that both fracture systems represent zones where fractures are open and therefore make good borehole sites, especially close to where the fractures intersect.

Detailed studies by the Water Research Commission have examined the structure in detail and elaborate on the best sites for boreholes in the area. It has been shown that knowledge of the regional stress fields and fracture set orientations can be used as an effective tool for locating potentially higher yielding borehole locations in Namaqualand.

The use of remote sensing

Although remote sensing tools are excellent in predicting the characteristics of the groundwater system and understanding the geological framework, it is important to ground-truth these observations. Ground-truthing of certain areas can confirm and refine the structural interpretation carried out as a desktop study prior to the field visit.



Regional output map, showing mean high and low stress areas in relation to borehole yields and interpreted structures. Dr Andreas Friese

Geomorphic analysis

The more transmissive (i.e. which allow groundwater to flow more easily) and especially larger fault zones have been weathered and eroded more intensely to form open valley profiles in Namaqualand.

A description of the various anomalies identified through the structural interpretation confirms this finding (see regional output map for location of the anomalies):

Skilpadfontein (A1) anomaly is situated topographically on top of a plateau, forming the boundary between two catchments and structurally within the intersection area of a NNW- and NE-trending fracture zone, the latter giving rise to the development of the Voëlfontein se Kloof valley.

Skilpadfontein Spring (A2) anomaly, which is situated in the Voëlfontein se Kloof valley to the northeast of the Skilpadfontein (A1) anomaly along the same NE trending fracture zone, and where the latter is intersected by NNW-trending fracture zones. Numerous shallow boreholes (5-30 m in depth) aligned along the fault-controlled valley have confirmed a fairly reliable groundwater source, characterised by yields of 1 l/s, but with a fairly high salinity (just below drinking water standard upper limit of 230 mS/m).

The **Leliefontein (A3)** anomaly is topographically characterised by a trough-like depression, with its centre situated approximately 500 - 700m east of the village Leliefontein. The area is known for its unusually high groundwater yields, and the shallow water table gives rise to lush vegetation within the depression. Within the area of the anomaly several structural zones of different strike orientation intersect and are responsible for a high fracture frequency and intersection density forming subsidiary and major valleys.

The **DRO anomaly (A4)** is a prominent and circular shaped anomaly which coincides spatially and in shape with a circular depression or valley situated on a high plateau. It is structurally situated between two prominent NNW-trending fracture/fault zones and cross-cut by several NE-trending fracture/fault zones. Two boreholes (one positioned near the centre of the circular valley) provide sustainable groundwater supplies to a farm in this depression.

The **Rooifontein anomaly (A5)** is situated in the Buffelsriver valley in an area of high fracture frequency caused by intersecting NNW- and NE-trending fracture/fault zones. Numerous boreholes drilled to an average depth of 80m into bedrock are characterised by low yields. However, a single shallow borehole drilled to a depth of ~10m down to the interface between bedrock and overlying alluvium is the sole major domestic water supplier for the Rooifontein settlement.

The **Rietfontein anomaly (A7)** is positioned at the intersection of a prominent ~E-W striking shear zone with NNW-trending fault/fracture zones. The area represents the lowest lying area in the region with groundwater discharge occurring here. This area is characterised by the appearance of groundwater near/at surface that results in periodic flooding and lush vegetation and the formation of swamps ("Rietfontein Oasis"). Highly saline (300-350 mS/m), brackish groundwater is confined to the alluvium; whereas good quality water circulates along the NNW-trending fault/fracture zones within the crystalline basement down to depths of 60-70 metres.

The Rooifontein anomaly

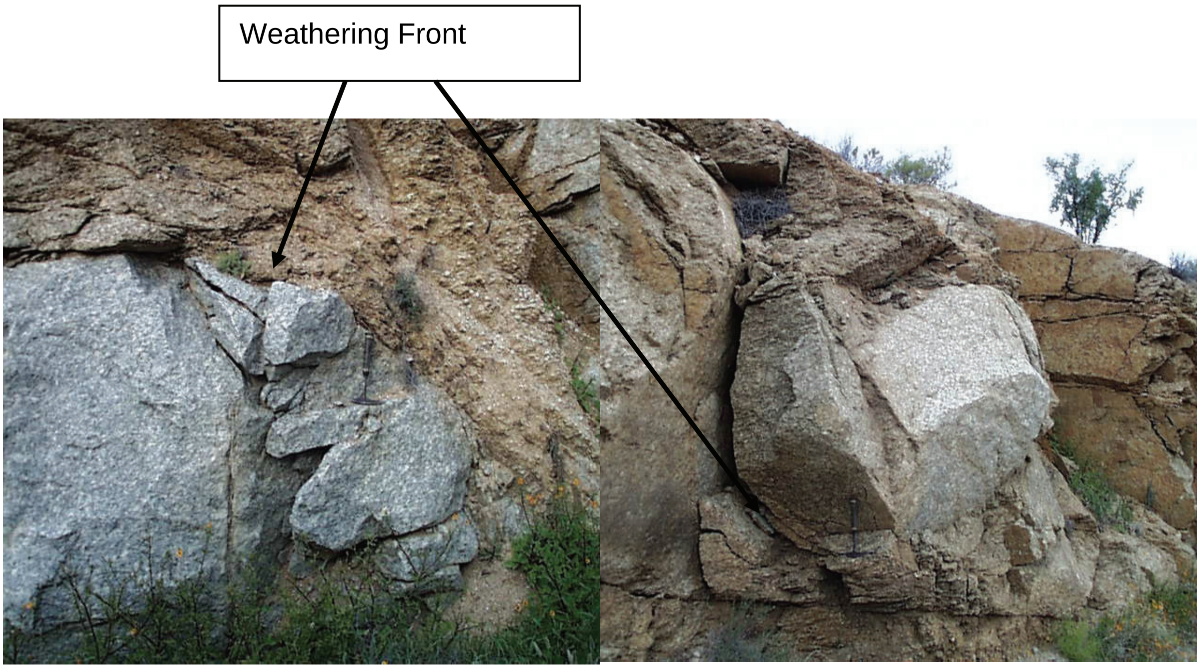
Within the weathered sections, core stones of fresh granite are present in a surrounding or “matrix” of weathered rock derived from in-situ weathering of the host rock. “Bornhardts” are therefore massive, compressionally stressed core zones in a matrix of highly weathered fractured rock.

Bornhardt (dome-like structure) in Namaqualand

Regolith analysis

Many studies have shown that the depth and extent of the weathered regolith is known to be important for groundwater yields in fractured crystalline aquifers. The regolith is a result from the reaction of acidic rainfall with the host minerals, with subsequent leaching of mobile elements and the accumulation of secondary clay minerals.

The weathered regolith is known to extend to greater depths in strongly fractured terrain. Arid regions, like Namaqualand, are characterized by relatively thin saturated regolith, which is generally present just above deeper groundwater levels. This scenario in arid regions necessitates the drilling of deep boreholes to intercept structural features and contact zones within the unweathered bedrock.



Geophysical methods such as multi-electrode resistivity profiling can be used to characterise this weathered profile. At the moment, inadequate published literature exists on the use of this geophysical method in the Namaqualand. Multi-electrode resistivity profiling has been successfully used in Zimbabwe to delineate weathering zones in crystalline aquifers and would be a suitable tool for further refinement of drilling targets for borehole or wellfield establishment.

5. Selecting drilling targets in Namaqualand

When the three analyses (as discussed above) are completed, target areas can be identified where further detailed investigations will take place.

The following are components of that investigation:

- Maps and reports
- Hydrocensus
- Geophysical analysis

Reports and Maps

Prior investigations and research provide useful insights into the groundwater resources of a region. A lot of previous work has been done in the region to support village water supply. This knowledge should be used to inform borehole target selection. Datasets that may have been collected as part of completed projects can also be useful.

Geological maps, structural information and other remote sensing information also provide valuable baseline information regarding the characteristics of local conditions and will be useful in initial target identification.

Hydrocensus

A reconnaissance survey of existing groundwater sources or "hydrocensus" is needed to obtain information about existing boreholes in an area, as well as possible impacts of new abstraction. Field forms are critical to this task in order to collect quality data in a systematic manner. Experienced hydrogeologists are able to design a practical form; alternatively DWAF has standard forms which are used to populate the National Groundwater Archive. Community discussions can also yield very valuable information about local conditions.

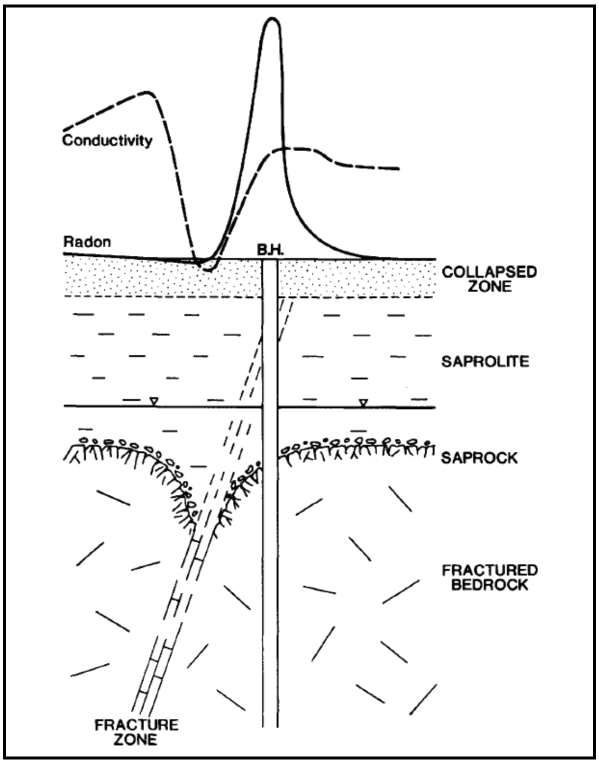
Geophysical analysis

Geophysical investigations have been done at selected sites in Namaqualand. Three techniques (electromagnetic induction, resistivity and magnetics) have been studied, and electromagnetic induction (EM) proved to be the most appropriate. The magnetic data did not correlate particularly well with known reservoirs, while the resistivity tool was difficult to employ in areas where soils were thin to absent and/or sandy.

Electromagnetic induction is a technique used to determine the electrical conductivity of the ground. A transmitter coil induces electrical currents in the subsurface. These electrical currents give rise to an electromagnetic field, which is then picked up by a receiver coil. The ground conductivity can then be calculated, depending on the strength of these induced electromagnetic fields. In practice, two operators (one with the transmitter coil and one with the receiver coil) can cover several kilometres of ground per day, making the technique relatively cheap and efficient. Different frequencies, coil spacings and orientations give different depths of penetration.

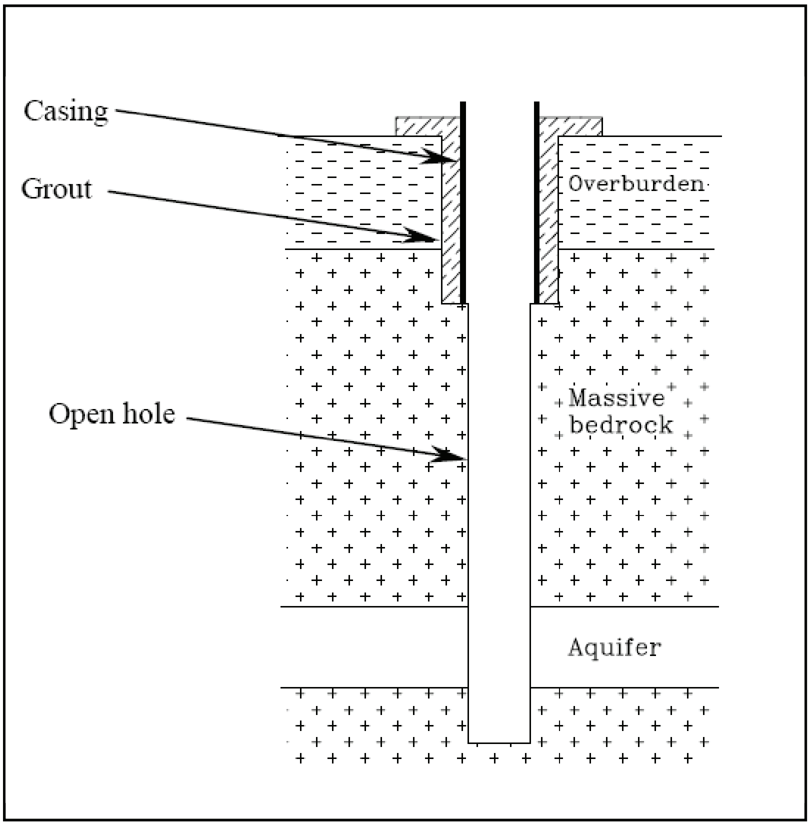
Interpretation of geophysical data (e.g. electromagnetic data) is a specialised task, and depends on the area under investigation. For example, in Namaqualand, areas of higher conductivity, such as slightly saline saturated zones, will produce stronger secondary fields than surrounding drier areas. Therefore areas of higher water content should appear as a distinct contrast to surrounding drier areas.

The intention of geophysics is to locate fractures with the most weathering and thickest overburden. This is because aquifers benefit from the storage available in overlying or adjacent saturated regolith, or other suitable formations such as alluvium. In areas of complex hydrogeology such as Namaqualand, the siting of boreholes based on geophysical anomalies without a good conceptual understanding of the geological framework, can lead to unsuccessful boreholes. For example, in the figure below, the influence of dipping strata was not taken into account and this resulted in the borehole placed in the wrong position.



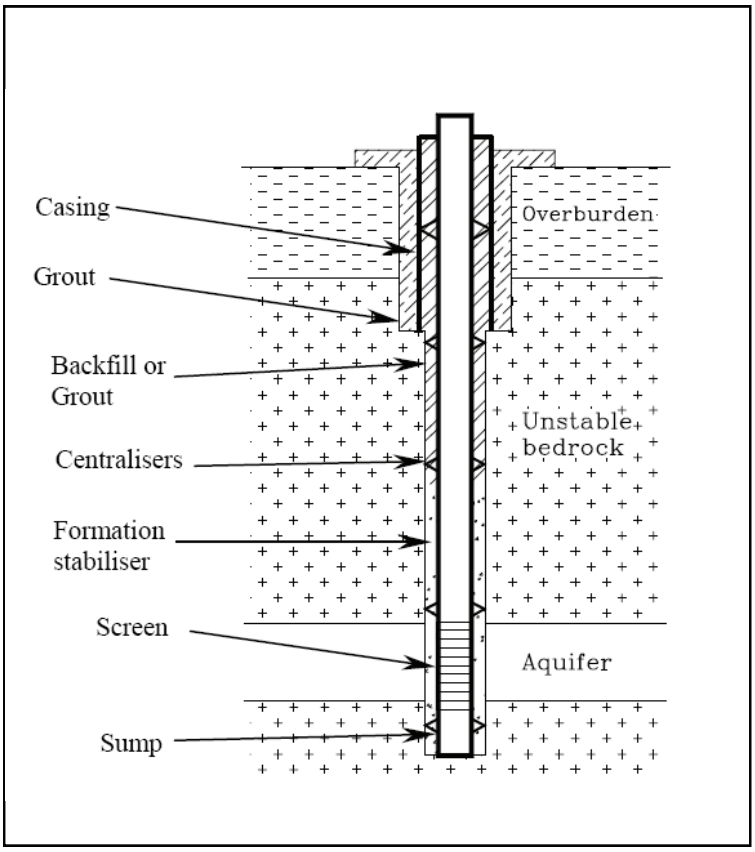
6. Borehole design

Poor borehole design can result in inefficient boreholes and frequent borehole failure/collapse, whilst good design can ensure longer use and a good borehole yield. It is usual for standard borehole designs to be used, but in many cases designs can be tailored to an individual location by a hydrogeologist. In Namaqualand boreholes are typically cased, and are only left open when in extremely stable formations. The casing and screens used are mostly PVC with a diameter of 4” (100/110mm), but 5” was used on very few occasions. Gravel packing of the borehole is common, since in most cases boreholes tap the relatively shallower aquifers within the unstable weathered zone.



Type 1: Basic open borehole construction:

This is perhaps the most common design found in SADC (Southern African Development Community) countries, and is appropriate in consolidated formations where the rock is stable and will not collapse. Surface casing is set through the overburden and sealed with grout, and the remainder of the hole is left open. Advantages of this design include low cost, maximum efficiency, and various choices for pump location. However, collapse or sand pumping may occur in unstable formations.



Type 2: Cased borehole in consolidated formation:

This design is common where formations are unstable. In addition to the sanitary seal, an assembly with the screened interval set adjacent to the primary aquifer horizon is installed in the borehole. Gravel pack (formation stabiliser) is installed surrounding the screens, with the upper section of the annular space backfilled or grouted. Centralisers may be installed above and below the screen and at intervals to the surface.

7. The drilling process and the importance of data collection

Borehole drilling is a specialised business. Most boreholes need to be drilled using a motorised drilling rig, which is a machine with a mast, a motor and other equipment to allow the drill bit and drill rods to be rotated into the ground. Because geological conditions are so diverse, there are many different types and sizes of drilling rigs, ranging from small units which can be towed behind a bakkie to heavy, very powerful machines mounted on large truck bodies. Most drilling rigs also need a compressor, which supplies air at very high pressures to blow the rock fragments or “drill cuttings” out of the hole, and to cool the drill bit. Sometimes water or other fluids are used along with the air to help suspend the drill cuttings and stabilise the borehole during drilling. A drilling rig must be operated by a specialist driller and his crew, who ideally should be experienced in drilling in the rock types which are expected. Boreholes take anything from a few hours to several days or even weeks to drill, depending on the borehole depth and diameter, the type of rig and on the type of rock. It is common practise to examine various quotes from drilling companies before deciding on the final contractor.

A borehole can be thought of as a “window” on the subsurface, and the opportunity to learn as much as possible about the aquifer should not be lost. During drilling, it is possible to collect a huge amount of very valuable information, which can inform further drilling in the same area and guides decisions about how to equip and operate the borehole.

At the very minimum, this information should include:

- the exact location of the borehole,
- the types of rock penetrated,
- the presence of any fractures,
- the penetration rate of the drill bit,
- the locations of water strikes and estimates of “blow yields”,
- the final depth of the hole, and
- the way the hole has been constructed (screen and casing details).

Samples of rock are usually taken every metre, and these are often carefully stored for later logging and analysis. It is common and preferred practice that a hydrogeologist supervises the collection of data during drilling operations, particularly where the borehole is intended for long-term water supply.

It can be surprising to learn that the value of the data gathered during drilling can often exceed the value of the borehole itself. Even dry boreholes are valuable, since they help hydrogeologists to understand exactly why conditions were not right for a good yield of water. Groundwater data, built up by collecting detailed information from boreholes, is the basis of groundwater management. Such data can be used to construct hydrogeological maps, to predict the correct yields for boreholes, to give early warning of any problems, and generally to make the process of utilising groundwater efficient and cost-effective.

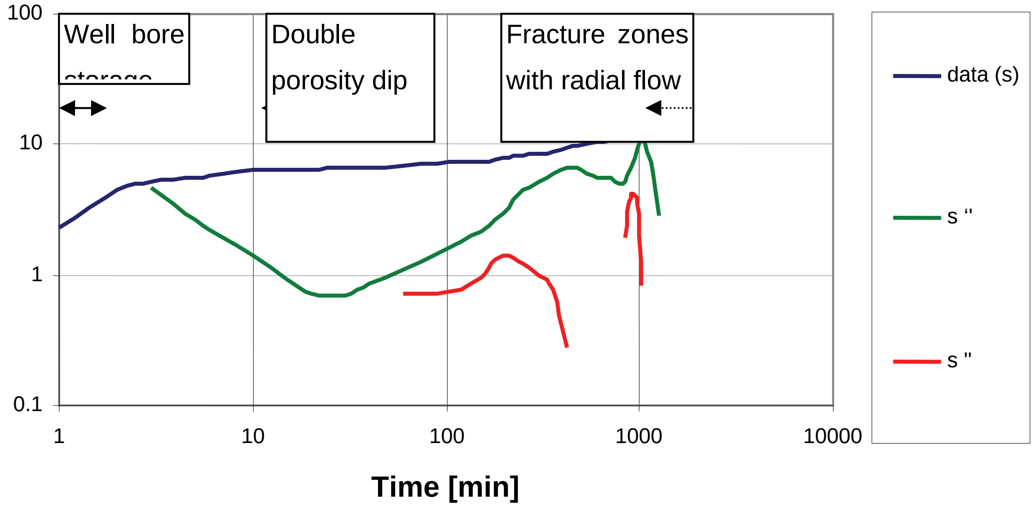
8. Determining the sustainable yields

No two boreholes are the same, mainly because there is a huge variation in the types of aquifers they penetrate. Most groundwater managers try to estimate a “sustainable yield” for the boreholes that they are responsible for. This is an estimate of the amount of groundwater that can be extracted without any undesirable consequences, such as boreholes “drying up” or the flow to rivers or springs being disrupted. The sustainable yield of a borehole -or series of boreholes (wellfield) - depends both on the characteristics of the boreholes themselves, as well as on the properties of the aquifer which they penetrate. For example, a “strong” borehole in a small aquifer with little recharge may be able to yield a lot of water initially, but will eventually run dry because the source of the water is limited. Hydrogeologists need to take all the various factors into account before recommending a sustainable yield. It is preferable that data collection continues during borehole operation, since this allows the estimated sustainable yield to be revised as time goes on. Pumping rates can then be adjusted, if proven necessary.

The most common technique for analysing the hydraulic properties of boreholes and aquifers is to carry out a “pumping test”. A pumping test establishes the response of the system to pumping, via careful measurements of water levels and pumping rates. There are several different types of pumping tests, and they can last anything from a few hours to several weeks or even months. Pumping tests are normally carried out by a specialist contractor, who has the equipment necessary to install the pump, regulate pumping volumes, and measure water levels in the pumping borehole and any nearby observation boreholes. Pumping test data must be interpreted by a hydrogeologist, who then makes estimates of aquifer properties such as transmissivity (T) and storativity (S), and the “specific capacity” of the borehole. This information helps in estimating the sustainable yield for individual boreholes, and for a wellfield as a whole.

Sometimes an airlift test is done by the driller as a substitute for a pumping test. This is a test in which compressed air is used to blow water out of a borehole and it can be used to make very rough estimates of borehole yield. Airlift tests are not, however, substitutes for pumping tests. Like other forms of data collection, pumping tests usually repay the investment needed many times over when it comes to efficiently and sustainably managing a groundwater resource.

The figure below is an example of a pump test result, which observes drawdown in a borehole observed over time. Diagnostic plots, i.e. the logarithmic derivatives of the drawdown as a function of time, are used to identify the flow regime, fracture intersections and boundary conditions. In this case the derived plots typically explain aquifer systems as found in Namaqualand. The double porosity behaviour of the aquifer becomes apparent in the derivative plot as a so-called double porosity dip of the drawdown curve (s') after initial borehole storage effects. At later times of the pumping test radial flow regimes are observed (s'' not visible) before the fracture zones are dewatered (dip in s').

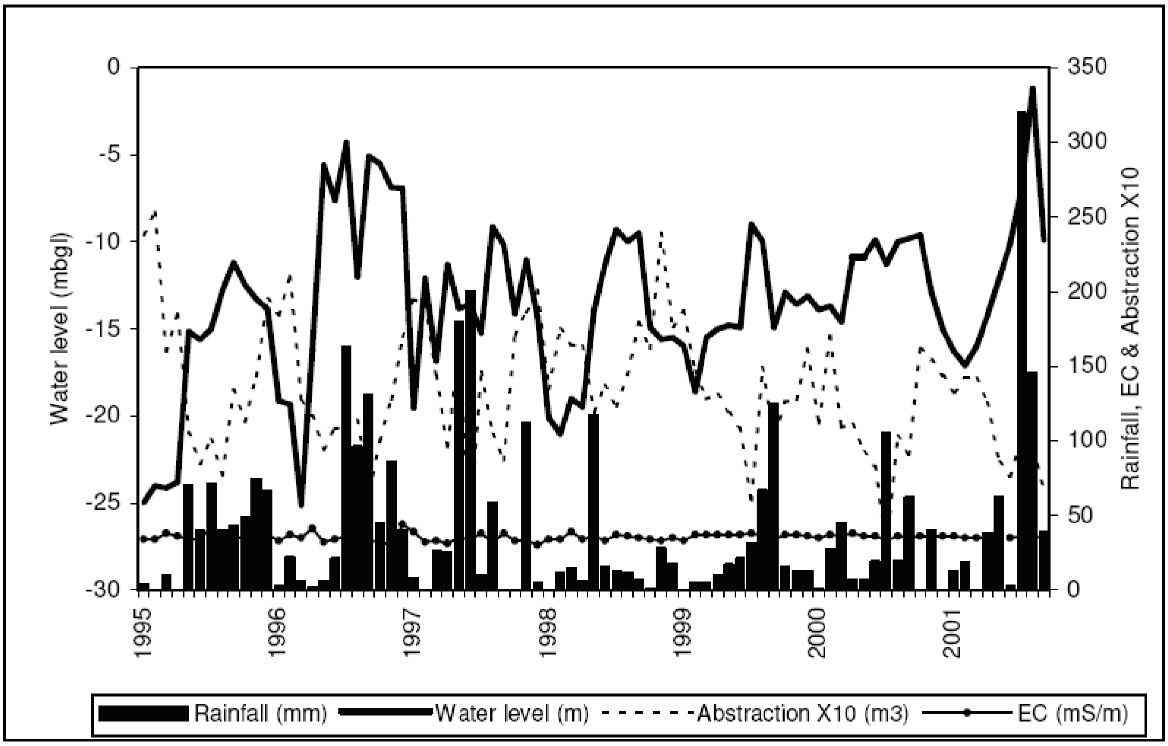


9. Understanding the water balance

In some ways, an aquifer can be thought of as system in which water leaving the aquifer via springs, boreholes and other discharges must be “balanced” by water recharging it. If withdrawals exceed recharge, then water levels in the aquifer and its boreholes will drop. Over-abstraction can be serious: boreholes may run dry, or poorer quality water may be drawn into the aquifer from adjacent areas. A hydrogeologist will usually estimate a water balance for a particular aquifer or catchment, in which he or she tries to determine all the losses and gains to the system. This information is extremely important in deciding on borehole sustainable yields, and can also assist with determining parameters such as recharge more accurately.

Water balances should be adjusted or updated as new information becomes available. Therefore it is important to continue collection of groundwater information also after boreholes have been drilled and supply has started. This information is then used to update the understanding of the system or “conceptual model” that the hydrogeologist develops and refines as work continues. Combining the updated information with the model, it is possible to detect early warning signs of system problems such as over-abstraction. In some cases, water balance data along with other information is used to create a digital computer model of the aquifer system. This model aims to simulate the groundwater system and can be used to test various scenarios such as the movement of pollutants or the effects of higher pumping rates. Computer models can be very useful, but they are not always necessary, particularly where relatively small abstractions are involved.

The importance of continued data collection and proper analysis is illustrated in hydrographs from production and observation boreholes in Namaqualand. These indicate that the water levels in the boreholes fluctuate in response to recharge, abstraction, hydraulic properties of the aquifer and aquifer configuration. Research could categorise four types of hydrograph responses. For example, the figure below represents a situation where boreholes were drilled in topographically high areas, with little soil cover and a high rainfall. There is a strong relationship between the amount of rainfall, groundwater abstraction and aquifer (water level) response. A steep drawdown during pumping and the fast recovery thereafter is an indication of a low storativity and a high transmissivity. The electrical conductivity (EC) of the water remains constant, thus indicating a short groundwater flow path within an actively recharged aquifer system. These observations could not have been made without a proper time series record.



10. Managing the water resource

Management decisions about groundwater are driven by the demands to abstract groundwater at a given location and rate. This imposes stresses on the groundwater system which modifies groundwater levels, discharge rates and water quality which in turn may affect the surrounding environment.

The research done here concluded that the aquifer flow system consists of a stacked, multiple flow system. This consists of a shallow, circulating and relatively young groundwater system overlying a relatively older, deeper and slower circulating groundwater system.

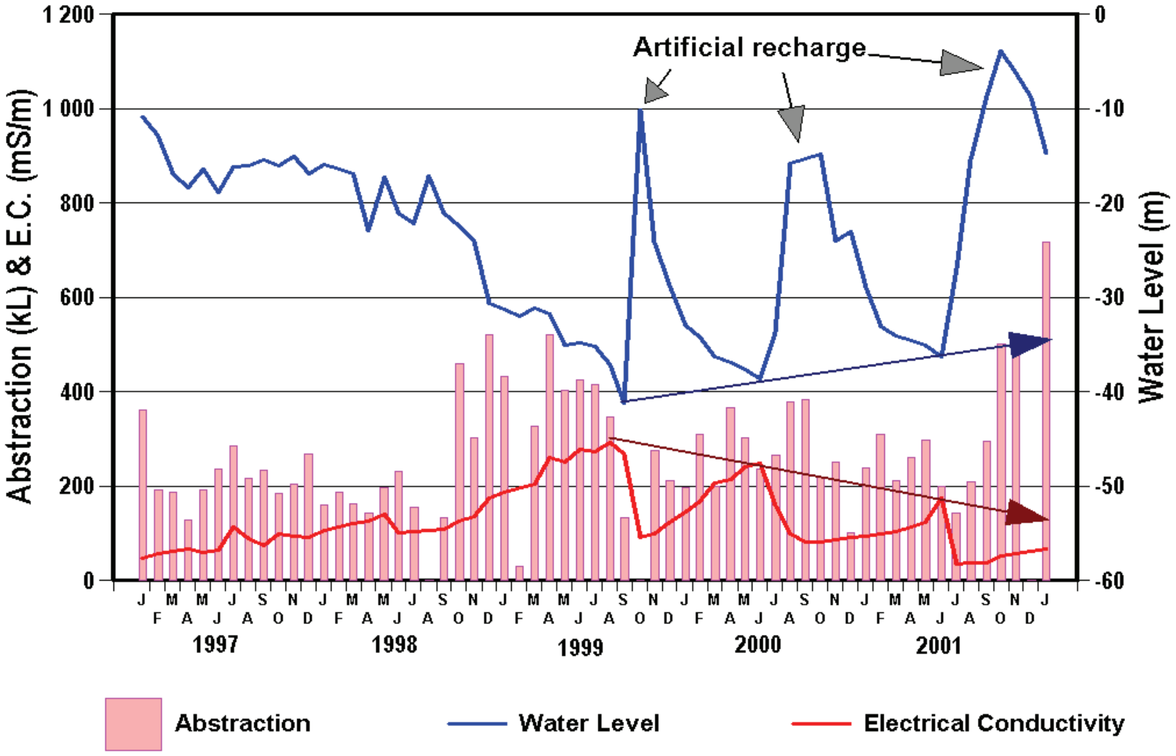
Abstraction

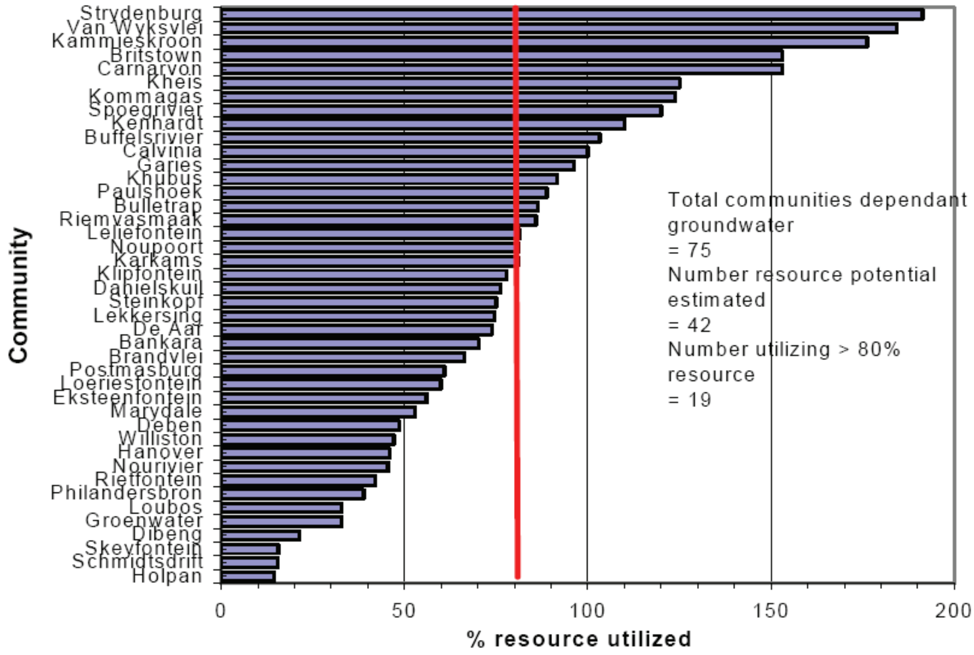
The abstraction of groundwater resources in Namaqualand is limited by available yield and water quality.

In many cases, aquifers are stressed due to over-abstraction despite the use of recommended pumping rates for boreholes. Reasons for borehole failure include:

- The high ratio of people to a borehole – in some cases, more than 300 people per borehole.
- The misuse of pumps.
- The drop in groundwater levels during dry periods.
- The poor rate of payment for services.
- Many of the pumps are located in remote and scattered places, complicating access and leading to irregular maintenance.
- Maintenance costs differ from place to place depending on the availability of spare parts and technicians, which results in irregular maintenance.
- Community participation is poor and those residents who are dissatisfied with water regulations often damage water systems and ignore the rules formulated by leaders.

The figure below illustrates the decline of water levels due to excessive abstraction of groundwater in Karkams. The village of Karkams in Namaqualand, with a mean annual rainfall of 250 mm and a population of 1700, depends solely on groundwater. Natural groundwater recharge is very low and as a result of abstraction since the mid 1990s, groundwater levels have dropped tens of metres and the water quality (salinity) has deteriorated significantly (Murray and Tredoux, 2005). The water levels recovered through the introduction of an artificial recharge scheme. Declining water levels are common to many water supply boreholes in the region and are mainly due to pumping rates that are set too high, in order to meet demand.





Percentage of water resource utilised by communities in the Northern Cape (Van Dyk and Peters, 2005).

Strategies to improve the situation:

Import of water

The available yield of water resources in the year 2000 for the Orange Coastal sub-area was estimated at 3 million m^3/a. The region has no surface water resources and this yield is derived from groundwater resources. The above estimated available groundwater resources needs to be reconciled with work done in the Groundwater Resource Assessment Phase 2 for DWAF.

The current and projected water demand for the Orange Coastal sub-area is estimated at 8 million m^3/a, which means that water needs to be transferred from the Orange sub-area as is currently the case. However, these transfers are limited to the major urban and mining areas. Rural communities are still dependant on local resources.

Changing pumping rates or spatial distribution of supply boreholes

The current pumping regimes of community water supply boreholes in Namaqualand need to be reviewed to ensure pumping rates are not “mining” (i.e. unsustainable abstraction) the aquifers. This includes a change in the spatial distribution of abstraction boreholes to minimise its existing or potential unwanted impacts.

Where recommendations for pumping rates are not followed, regulation needs to be promoted through cooperative governance and user education.

DWAF, with the support of the Norwegian Agency for Development Cooperation (NORAD) has developed guidelines for groundwater monitoring by pump operators (DWAF, 2004). Amongst others, the following training is required (Murray, 2005):

- Water level, water quality and abstraction monitoring;
- Data capturing;
- Data analysis (and operational changes based on data analysis); and
- Reporting.

This kind of training will enhance water user knowledge of groundwater resources and promote self-regulation and protection of the resource.

Artificial recharge and water conservation

Artificial recharge schemes need to be developed to supplement poorly naturally recharged groundwater resources. Murray and Tredoux (2002) have demonstrated the usefulness of artificial recharge in the region. Borehole yields improved considerably with the additional benefit of enhancing water quality. Other conservation practices include:

- Harvesting water in rainfall tanks and building structures and channelling overland flow to reservoirs;
- Leakage reduction of infrastructure through proper operation and maintenance systems; and
- Reuse of wastewater (grey water) for non-potable purposes such as for household gardens.

11. Water quality considerations

The groundwater in the area can be broadly characterised as relatively saline, with the lower salinity groundwater limited to the higher lying regions of the catchment. High fluoride concentrations tend to occur where fluorine-bearing minerals (particularly fluorite, apatite and micas) are abundant in aquifer rocks, which is the case in Namaqualand. The most common consequence of exposure to excess fluoride is dental fluorosis (“mottled enamel”), a condition involving interaction of fluoride with tooth enamel, and causing staining or blackening, weakening and possible loss of teeth. With more extreme exposure to fluoride, skeletal fluorosis can result.

Further water quality problems arise as a result of the pollution of groundwater from anthropogenic activities such as on-site sanitation.

Strategies to improve the situation:

Appropriate technologies

The region has natural water quality problems which will require the use of technologies to improve water quality for potable purposes. Examples include in situ groundwater remediation and desalination technologies such as solar distillation. Certain still need to be developed to a commercial level.

Improved understanding and management of groundwater resources in Namaqualand will lead to a more reliable and sustainable resource, and result in better environmental conditions.

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Price, M (1996). Introducing groundwater. 2nd Edition. Chapman and Hall.
Van Dyk, G, and R Peters. “Water Provision from Groundwater in the Northern Cape: Balancing demand and supply.” Groundwater 2005. Pretoria, 2005.

Useful reports (available from the WRC)

Report Number: TT 285/06
Hydrogeology of groundwater region 26 Bushmanland
Vegter Johannes Roelf

Report Number: TT 219/03
Artificial Groundwater Recharge: Wise water management for towns and cities
Ricky Murray

Report Number: 1117/1/06
Geomechanical modeling as tool for groundwater exploration of fractured rock aquifers in the Namaqualand region, South Africa.
Friese, A, Swartz H, Titus R, Fielies A, Davids S, and Domoney R

Report Number: 1093/1/04
Groundwater recharge assessment of the basement aquifers of central Namaqualand.
Adams S; Titus R; Xu Y

Report Number: 966/1/02
Groundwater exploration in geologically complex and problematic terrain - Guidelines (Volume 1)
Sami K; Neumann I; Gqiba D; De Kock G, Grantham G

Report Number: 966/2/02
Groundwater exploration in geologically complex and problematic terrain - Case studies (Volume 2)
Sami K; Neumann I; Gqiba D; De Kock G, Grantham G

Report Number: 721/1/02
Groundwater assessment and strategies for sustainable resource supply in arid zones – The Namaqualand case study
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