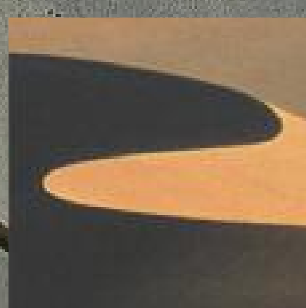
# Groundwater in Namibia

*an explanation to the Hydrogeological Map*



Claudia du Plessis

# Groundwater in Namibia

## *an explanation to the Hydrogeological Map*

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**(editors)**

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**under the supervision of the Steering Committee**
**of the Hydrogeological Map of Namibia Project**
**(Piet Heyns, Marina Coetzee, Karl-Heinz Hoffmann, John Mendelsohn,**
**Gabi Schneider, Wynand Seimons)**

**reviewed by Shirley Bethune**

This publication complements the Hydrogeological Map of Namibia
at scale 1:1 000 000 prepared as a Namibian – German technical cooperation project
of the Department of Water Affairs, Ministry of Agriculture, Water and Rural Development;
the Geological Survey of Namibia, Ministry of Mines and Energy;
the Namibia Water Corporation and
the Federal Institute for Geoscience and Natural Resources
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# Foreword

MAWRD

**Honorable Minister**
**Helmut K Angula**

Water is essential for the survival of mankind and the natural environment. Social welfare and economic development cannot be sustained without reliable water supplies, and this is particularly true of arid countries, such as Namibia, where water resources are extremely limited and highly valued as a social and economic good.

The early people who settled in Namibia migrated through the arid landscape in the interior of the country to graze their cattle. They found fountains, seeps and springs that provided them with open surface water, and also learned to dig shallow wells in the dry watercourses to find groundwater. Many of our towns, settlements, farms and special places bear the names of the waters that were available to sustain wildlife, man and his livestock.

The name of the town Gobabis is derived from a spring that was called "place of the elephants". In the south of Namibia, the towns of Karasburg, Warmbad and Keetmanshoop were founded at springs, respectively called "Nomsoros" (water between the lime stones), "Gei-ous" (big hot water source) and "Nugoeis" (black mud fountain). In the north, towns have been named after water features, for example Engela (wet place), Okatope (small well), Oshikango (place with many pans).

Although surface waters are available during the rainy season, these normally dry up very soon in the dry winter months. When these resources dried up, the people and their cattle even perished in the severe droughts that occur periodically in Namibia because they did not know about the hidden treasure of groundwater deep underground.

For more than a century, the technology to find and drill for groundwater continued to improve and brought additional benefits such as hydrogeological data collected in a systematic, scientific way. This now provides an excellent opportunity to produce a hydrogeological map for the country. The value of a hydrogeological map is that the available information about the occurrence and magnitude of the groundwater resources in the country can be presented to the general public in a simplified way, but more specifically, it can assist those that need accurate information to direct the development of the country according to the availability of sustainable groundwater resources.

Although the Geohydrology Division in the Department of Water Affairs in the Ministry of Agriculture, Water and Rural Development has long recognised the need for a hydrogeological map, a lack of resources was a major challenge to this objective. In 1996, the Namibian Government approached the German Government for support to prepare a national hydrogeological map. This request was thoroughly evaluated in terms of the availability of data and the need for such a map. A wealth of information already collected about the hydrogeological environment could be used to prepare the map. The need for a hydrogeological map to enhance the future development of a developing country like Namibia was also evident. This convinced the German Government to provide technical expertise to produce the Hydrogeological Map of Namibia.

After two years of close cooperation between staff of the Federal Institute of Geosciences and Natural Resources in Germany, the Ministry of Agriculture, Water and Rural Development, the Geological Survey of Namibia and the Namibia Water Corporation, the Hydrogeological Map of Namibia has become a reality.

In my view, the Hydrogeological Map of Namibia and this explanatory book "Groundwater in Namibia" that accompanies the Map, will assist planners, developers and entrepreneurs to direct their activities in such a way that our valuable, yet vulnerable, groundwater sources will be utilised sustainably to facilitate socio-economic development for the benefit of all the people in this country now and in the future.

**Helmut K Angula**
**Minister of Agriculture, Water and Rural Development**

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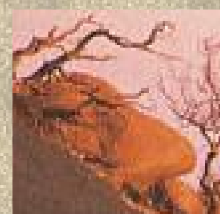
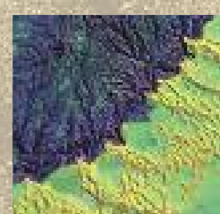
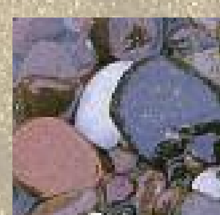
# Contents







# Executive Summary

Water is life, but in a country as dry as Namibia, water resources are often scarce and unreliable. Surface water availability is closely linked to a rainfall pattern that is extremely inconsistent in both time and space. Too much rain can cause floods that are difficult to master and during droughts surface waters evaporate quickly. Groundwater resources, a "hidden treasure" underground, are more reliable, widespread and naturally protected against evaporation. The groundwater stored in the pore spaces between sand grains and in voids of rocks has a regulating function: it can be abstracted during dry periods and filled up again by recharge during good rains.

Namibia, the driest country in Africa south of the Sahara, depends largely on groundwater. Over the past century, more than 100 000 boreholes have been drilled. Half of these are still in operation and produce groundwater for industrial, municipal and rural water supply. They provide drinking water to man, livestock and game, irrigation water for crop production and supply distant mines. The advantage of using groundwater sources is that even isolated communities and those economic activities located far from good surface water sources like mining, agriculture and tourism, can be supplied from groundwater over nearly 80 % of the country.

Despite considerable investment in drilling, borehole design and construction as well as pumping and maintenance, groundwater is usually the most economical way of supplying water. However, groundwater resources, being closely associated with underground rock types that vary with the geological situation, are unevenly distributed across the country. There are only a few favourable places where high volumes of groundwater can be sustainably abstracted, but fortunately there are also few places where no groundwater is found at all. But even if there is enough groundwater in a region, it might be unfit for human use because of its poor quality. The north-western part of the Cuvelai-Etosha Basin and the south-eastern part of the Stampriet Basin, the so-called salt block, are prominent examples.

This book "Groundwater in Namibia" and the attached "Hydrogeological Map of Namibia" at a 1:1 000 000 scale, are the result of a two years' technical cooperation project of the Republic of Namibia and the Federal Republic of Germany. The Map and Book synthesise the groundwater related data, information and knowledge available in Namibia. The project enjoyed the cooperation of experts from the Department of Water Affairs (DWA) in the Ministry of Agriculture, Water and Rural Development; from the Geological Survey of Namibia (GSN) in the Ministry of Mines and Energy; from the Namibia Water Corporation Ltd. (NamWater); from the Federal Institute for Geosciences and Natural Resources (BGR) on behalf of the German Ministry for Economic Cooperation and Development (BMZ), and many other hydrogeological and geological experts in the country.

The groundwater situation in Namibia is outlined in detail in the chapter "Hydrogeological Framework". Compilers of the Map identified twelve main hydrogeological units based on their coherent geological and hydrogeological conditions. The chapter presents the status of the groundwater resources in these groundwater basins or units, their quantitative and qualitative aspects, and their present-day use.

Good data were usually available for the Groundwater Supply Schemes (109 sites) run by NamWater and certain Municipalities listed in Annex 1. In other areas, boreholes representative of the hydrogeological situation in their vicinity were added (see Annex 2). The rest of the country was classified into aquifers, aquitards and aquicludes using the data available in the databases of DWA, GSN and NamWater, records and documentation as well as the local expertise of numerous groundwater experts, most of whom contributed voluntarily to the Map and the Book. Despite this wealth of information, knowledge about groundwater is still sparse or insufficient for some areas. Here the Map and the Book can help focus future investigations and programmes.

Whether or not groundwater can be stored and the way it flows is largely determined by the types of rocks underground. About half (48 %) of the country is covered by unconsolidated deposits that are potential porous aquifers and the rest is made

DWA Archive

**Windpump and borehole installation**

up of hard rocks, more or less fractured. Fractured hard rocks and porous unconsolidated rocks are regarded as aquifers, only if they store extractable groundwater in an appreciable quantity. Only groundwater-producing rock bodies, in which borehole yields generally exceed 3 $m^3/h$, are classified as aquifers and are shown in blue or green on the Map. Those with borehole yields between 3 and 0.5 $m^3/h$ are aquitards, and are shown in light brown, while rocks in which very little groundwater is found (borehole yields less than 0.5 $m^3/h$) are shown as dark brown aquicludes. Only 42 % of the country overlies aquifers, of which 26 % of the area contains porous aquifers and 16 % fractured aquifers. Within these aquifers, the borehole yields exceed 15 $m^3/h$ only over some 14 000 $km^2$ or 3 % of the total territory, making these highly productive aquifers and strategic targets for groundwater supply. Not surprisingly, most of these areas are already declared groundwater control areas.

Wherever known, quantitative information about aquifer parameters, groundwater volumes and water balance figures have been provided in the text. However, detailed figures exist only in a few places where groundwater models have been established, e.g. in the Grootfontein and Tsumeb areas and in the Stampriet Artesian Basin.

Although Namibia is an arid country, its finite water resources are sufficient to sustain continuous growth and steady development of the Nation. There are however great variations in the availability of water. At the southern, northern and north-eastern borders where surface water is available throughout the year from perennial rivers, there is an excess rather than a shortage of water, although this is shared with neighbouring countries. The rest of the country either relies on dams constructed in ephemeral rivers that have low safe yields in comparison to their total volume, because of drought and high evaporation losses, or on groundwater. The total, overall groundwater resources are sufficient to assure long-term water supply if used sustainably, yet there are great regional variations. In many areas, groundwater conditions are unfavourable due to limited water availability, little and unreliable recharge, low borehole yields, great depths, poor groundwater quality and high risks of contamination. Other areas are favourable, sitting on high-yielding, very productive aquifers that contain more water than farmers and communities presently need. Numerous small springs, fountains and seeps throughout the country sustain wildlife, man and livestock in an otherwise arid environment.

Groundwater resources should be preserved and protected as an underground treasure, as a strategic reserve for drinking water supply in prolonged periods of drought and for future generations. It must not be spoiled by over-exploitation now, just because the water "is there", and care should be taken not to contaminate them with pollutants.

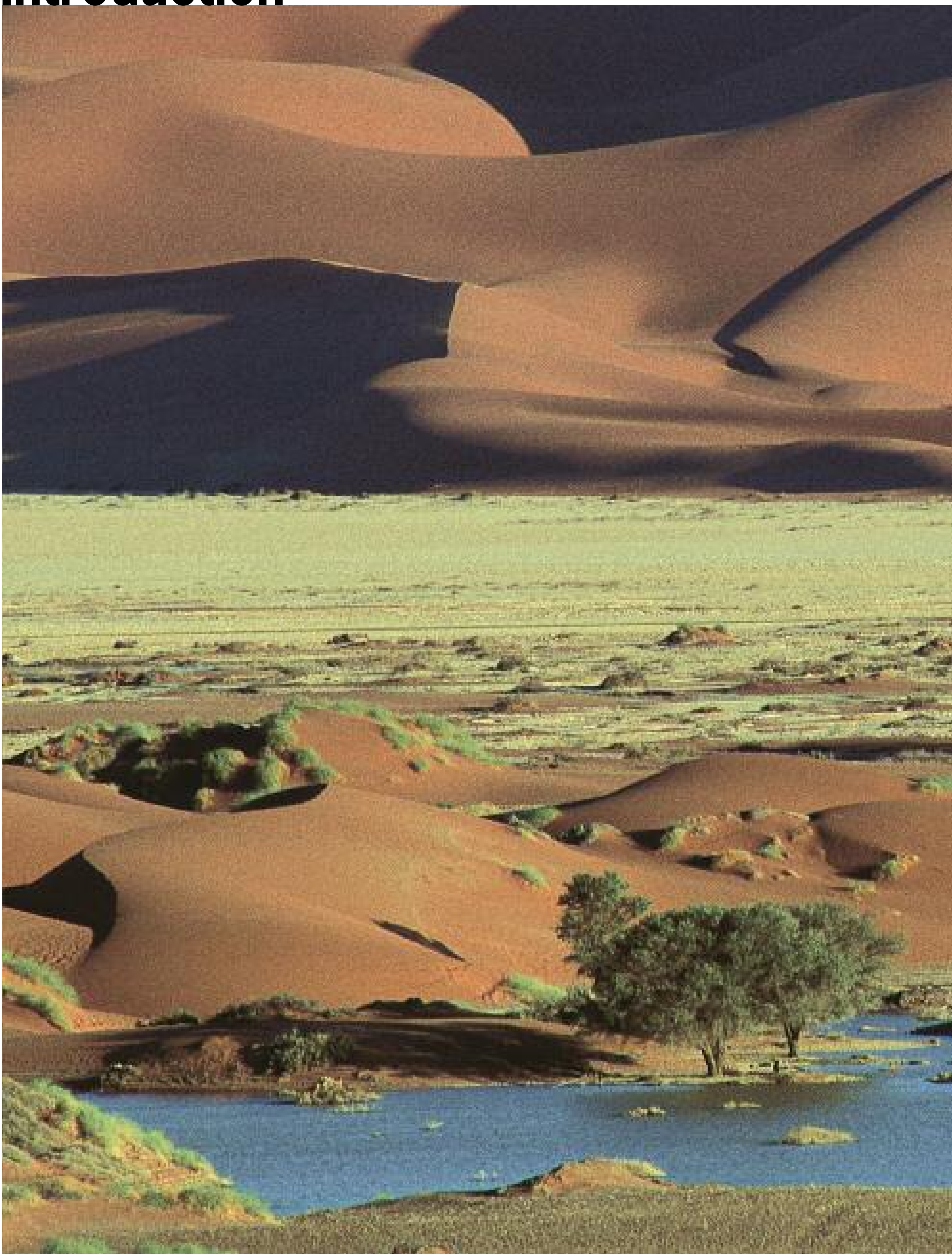
The Hydrogeological Map and this Book summarise the information on groundwater in Namibia, and pinpoint where groundwater is sparse or abundant. This information, judiciously used, can provide the backbone for the equitable distribution, sound development and long-term sustainable management of Namibia's groundwater resources, and the protection of groundwater resources from degradation in quantity and quality. As such, these results of the Hydrogeological Map of Namibia Project are a milestone in groundwater-related work in Namibia and a cornerstone for a sustainable, environmentally-sound water development strategy for Namibia.

G CHRISTELIS, W STRUCKMEIER


Cronje Loftie-Eaton

**Water is life – but it can be dangerous and destructive**

# Introduction



# Water in Namibia and rationale for a Hydrogeological Map Project

Claudia du Plessis

**In arid areas, where rainfall is limited and surface runoff is only available during the rainy season, man has learnt through experience that there is water underground that can be used during the dry season. Thus, groundwater has played an important role in the development of Namibia.**

Groundwater resources have been recognised and used for drinking purposes since humans settled in Namibia. The preferential areas of settlement were near springs or fountains from which groundwater naturally seeped into ponds or even formed the beginning of small perennial watercourses. Hauchabfontein, Sesfontein and Kowarib are well known examples. Even the capital city, Windhoek, owes its origin to the availability of safe groundwater from flowing springs. Later, springs and ponds were deepened by hand to reach more water. Wells were also dug into the dry watercourses where no springs existed, but where the groundwater was shallow. Today, groundwater resources lying hundreds of metres below the surface, are tapped by deeply drilled boreholes.

When Namibia became a Protectorate of the German Empire in 1884, momentum was given to the development of agriculture, mining and infrastructure such as railways, roads and water supplies. As the population grew, permanent towns and farms were established and it soon became apparent that more reliable, assured water supplies were required to support future economic activities in Namibia.


**Old drilling machine for groundwater boreholes**

In October 1896, Dr Rehbock was commissioned by the German Government to investigate the occurrence, availability and utilisation of the water resources in the country. In 1897, he distributed the first rain gauges to farmers to better understand the hydrology of the country by obtaining information about rainfall and runoff. The advice in the report to his Government gave more direction to water resource development in Namibia.

In 1903, the first drilling machine arrived in the country and by 1906 there were two drilling units, one for the south and one for the north. They operated under the control and supervision of a geologist, Dr Lotz, who conducted the search for groundwater in an organised manner. This improved technology and expertise brought into the country, made it possible to drill boreholes for groundwater at greater depths and in water bearing geological formations that had previously been inaccessible. In 1906, Dr Range, a hydrogeological expert, was sent to Namibia to assist with the groundwater development programme and he takes credit for recognising the artesian conditions of the Stampriet basin. By 1913, a geographer, Prof Jaeger, used the available information on surface runoff and groundwater to compile the first water register for the country.

After the First World War, a new Administration for the Territory of South West Africa was established and an Irrigation Department with a Boring Division, directed by a drilling engineer, was created. The duty of this Department was to find groundwater sources suitable for stock farming and irrigation. The activities of the Boring Division, as well as the work of many geologists, hydrogeologists, water diviners and private drilling contractors since then, made it possible to extend the availability of groundwater sources to many places in the country where there had previously been no water available for stock drinking and human consumption. This increased availability of groundwater secured the development of stock farming on the grasslands in the more remote areas of Namibia, and the development of stronger boreholes made it possible to sustain the larger towns and settlements, as well as other important economic activities such as mining, industry and small-scale irrigated agriculture.

Whenever there is a scarcity of water, it is mainly due to low rainfall. The distribution of rainfall across the Southern African subcontinent is the lowest along the south-western Atlantic coast, an area largely covered by the territory of Namibia (refer to the "Rainfall and Watershed" inset map on the Hydrogeological Map). In addition to the general paucity of precipitation, rainfall events are extremely unreliable, variable and unevenly distributed in space and time over the landscape. Furthermore, the prevailing high temperature in the rainy season and huge evaporation losses make Namibia not only the driest country in southern Africa, but most probably in the whole of the Southern Hemisphere.

In order to utilise surface runoff, dams have been built to capture and store water from the floods during the rainy season. However, the assured sustainable safe yield of such dams is dependent on unreliable and unfavourable hydroclimatic conditions. The availability of surface water resources can therefore not be guaranteed, even with creation of the most appropriate facilities. The construction of storage reservoirs or dams is also limited by the topography of the landscape and there are large areas in Namibia where the terrain is too flat to build viable dams to harness surface runoff.

It may be reasoned that in areas where surface water use is limited, one rather expensive option is to import the water required over long distances from other surface or groundwater sources, however, the use of local groundwater sources is still the most appropriate and cost-effective way to provide water in most of these areas.

Wilhelm Struckmeier

**Omatako Dam, a dam site vulnerable to high evaporation**

The weather systems, rainfall, surface runoff and open water bodies are the visible components of the water cycle. However, the surface water that infiltrates into the ground fills up the voids and pore spaces of the rock formations making up the crust of the earth, and this accumulation of water in the aquifers below the surface is not only invisible, but an integral part of the hydrological cycle. The availability of water resources in Namibia is reflected in the table below.

Like surface water sources, groundwater can also be regenerated and replenished by rainwater filtering into the ground. The magnitude and sustainable yield of the groundwater sources are therefore determined by the size and extent of the aquifers, the conditions that facilitate the rate of recharge to the aquifers and the potential of the hydroclimate to produce rainfall and runoff.

**Water availability**

| Source | Volume ($Mm^3/a$) | Remark |
|---|---|---|
| Groundwater | 300 | Estimated long-term sustainable safe yield |
| Ephemeral Surface Water | 200 | Full development at 95 % assurance of supply |
| Perennial Surface Water | 150 | Presently installed abstraction capacity |
| Unconventional | 10 | Reclamation, re-use, recycling |
| Available Resources | 660 | |

However, there are also fossil groundwaters that have accumulated tens of thousands of years ago in water-bearing aquifers when the climate in the southern African region was much wetter and a large lake covered areas in northern Namibia and southern Angola where the Cuvelai Basin is located today.

In order to find groundwater, more than 100 000 boreholes have been drilled, and of these a large number have either come up dry or dried up over time. It is estimated that there are more than 50 000 production boreholes in use in the country. Groundwater is pumped from these installations for domestic, livestock and wildlife consumption, as well as for mining, industrial operations and irrigation.

The only assured water supply from surface water is lim-


Orange River at the Noordoewer Bridge

ited to the perennial rivers on the northern and southern and borders of Namibia, but this water must also be shared with the countries neighbouring Namibia. The country is thus highly dependent on groundwater because the surface water sources in the interior of Namibia are unreliable. The dependence on groundwater is accentuated during prolonged periods of drought, when surface water sources tend to dry up.

The advantage of using groundwater sources in Namibia is that it is possible to supply water to isolated communities, and for economic activities like mining, industry and agriculture over nearly 80 % of the country. Without groundwater, development in many of these cases would have been impossible due to the need to import prohibitively expensive water over long distances via canals or pipelines. About 45 % of the water supplied to towns, villages and farms in Namibia comes from boreholes or springs. It is also interesting to note that 45 % of the water used in agriculture comes from groundwater sources. The table below shows the use of the water resources in Namibia by each major consumer group.

Thus it is obvious that Namibia could not survive without using its precious groundwater resources. However, although groundwater had been sought and used for more than a century, the occurrence, magnitude and potential of groundwater resources are still not fully known. This is particularly true in remote areas where the demand for water is small and little groundwater investigation had been done. Even in areas of intensive groundwater abstraction, the knowledge about the water balance or recharge versus abstraction, is often insufficient due to the short period of monitoring of these aquifers (in many cases less than 50 years). This makes it difficult to predict the long-term assured, sustainable, safe yield of an aquifer. Each major aquifer is operated according to an aquifer management plan. The behaviour of the aquifer is closely monitored, and an appropriate management strategy adopted to ensure the sustainable utilisation of the aquifer.

**Use of water resources per consumer group in 2000**

| Consumer Group | Demand ($Mm^3$) | Source of Supply * | | | | | |
|---|---|---|---|---|---|---|---|
| | | Perennial Rivers | | Ephemeral Rivers | | Groundwater | |
| | | ($Mm^3$) | (%) | ($Mm^3$) | (%) | ($Mm^3$) | (%) |
| Domestic** | 73 | 18 | 25 | 20 | 27 | 35 | 48 |
| Stock | 77 | 14 | 18 | 3 | 4 | 60 | 78 |
| Mining | 14 | 8 | 57 | 1 | 7 | 5 | 36 |
| Irrigation | 136 | 60 | 44 | 41 | 30 | 35 | 26 |
| **Total** | **300** | **100** | **33** | **65** | **22** | **135** | **45** |

* The unconventional water sources are included in the ephemeral and groundwater sources

** Industrial and tourism use is included in domestic use because it is only about 4 % of the total water consumption in Namibia

It is also clear that Namibia has a "hidden treasure" of groundwaters, and these resources have to be identified and mapped for the whole country to provide a comprehensive basis for the utilisation of groundwater in development planning. All natural resources and how they function must be well known and fully understood, and this knowledge taken into account in any national development strategy if planners want to make optimum use of the assets provided by nature. Equitable and sustainable development, as spelled out in the Constitution of Namibia, includes the proper and wise use of all natural resources including groundwater, to supply the water needed without harming the environment.

Information about the occurrence of groundwater and the magnitude of groundwater resources have been gathered in Namibia for more than a century, but all this knowledge had never been collated and presented in a way that the general public and scholars can access, appreciate and understand.

The Hydrogeological Map of Namibia at scale 1:1 000 000, provides an overview of the groundwater situation in the whole country. It shows the aerial extent of the rock bodies containing groundwater and their potential. Moreover, it depicts the hydrodynamic features such as the groundwa-

Wilhelm Struckmeier

**Drilling is required to know more about groundwater resources**

ter flow direction, depth to groundwater, artesian areas, and major groundwater quality restrictions. Information on installations for the abstraction of water (water supply schemes, irrigation schemes), as well as the distribution and transfer of water (canals and pipelines) are portrayed, too. The Map integrates all this complex and interdependent information in an easily readable form.

There are many important reasons why a Hydrogeological Map for Namibia and this explanatory book "Groundwater in Namibia" were prepared. The Map and this book will greatly improve the knowledge and understanding of the groundwater situation in Namibia. It will create an awareness of a natural resource that is vulnerable, but vital for water supply in the country. The Map will also serve as a guide to national development strategies aimed at the sound and sustainable development of the Nation's natural resources. However, a Hydrogeological Map is never complete and the inset map on the "density of boreholes" clearly shows that there is a lack of information in certain areas. This will certainly encourage further investigations into those groundwater resources that are not yet well known. The same applies to the inset map on the "Vulnerability of the groundwater resources" in Namibia. More studies in this field are also vital as there is no hope of recovery if an aquifer in an arid area is polluted. The work that has been done on the Map and this book provides information, creates awareness, gives guidelines for development, and illustrates some of the major challenges that face water resource managers now and in future.

P HEYNS, W STRUCKMEIER

**FURTHER READING**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