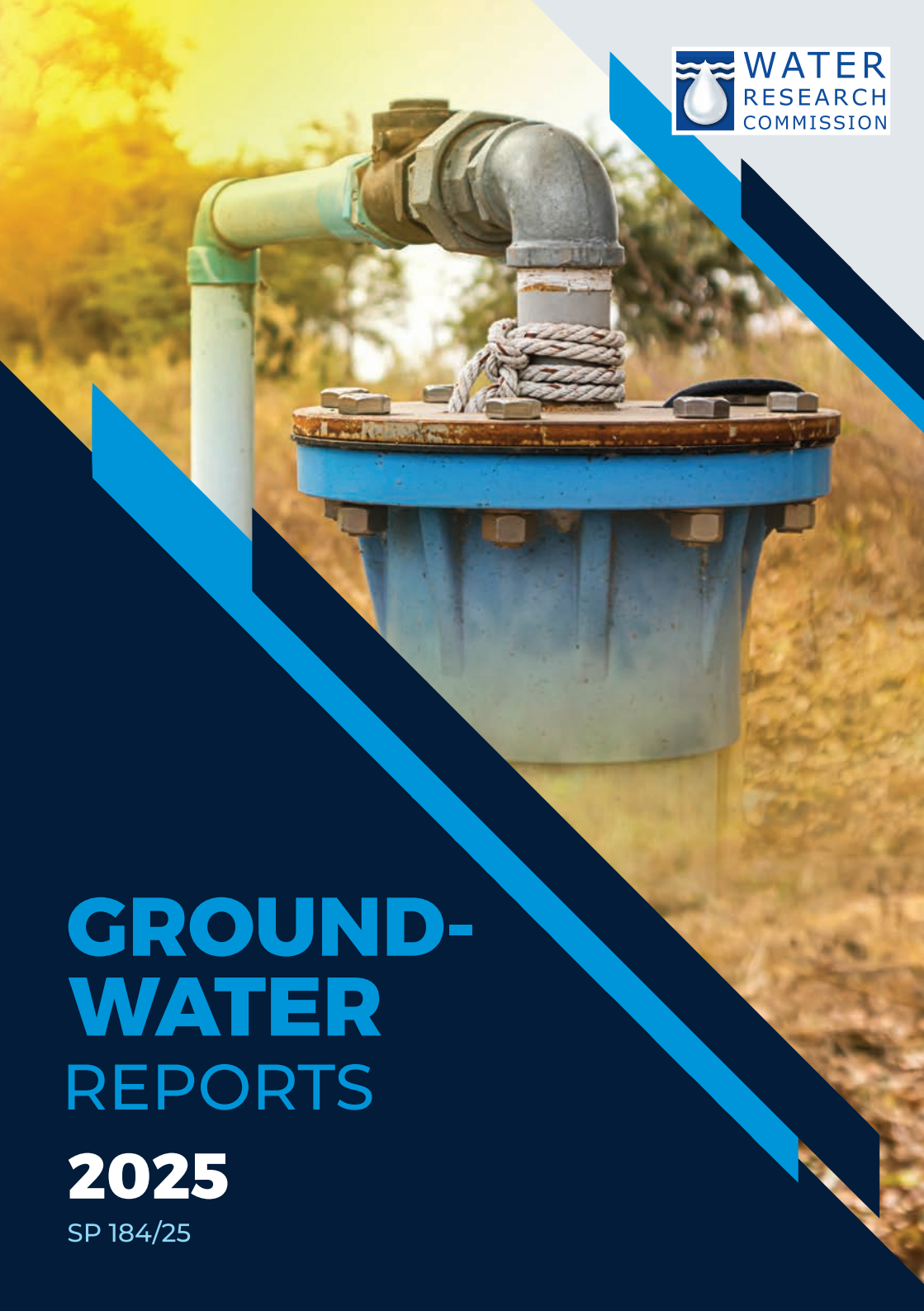

WATER RESEARCH COMMISSION

GROUND-WATER REPORTS

2025

SP 184/25

Obtainable from:

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SP 184/25

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INTRODUCTION

The Water Research Commission (WRC) was established in terms of the Water Research Act (Act No 34 of 1971), following a period of serious water shortage. It was deemed to be of national importance to generate new knowledge and to promote the country's water research purposefully, owing to the view held that water would be one of South Africa's most limiting factors in the twenty-first century.

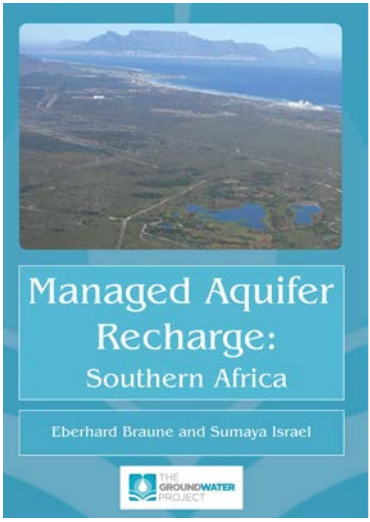
Now in its fifth decade of serving South Africa, the WRC is working with its government and non-government partners to contribute new water knowledge and solutions to South African, African and global water challenges by developing and harnessing the water research and development capability in the country.

The primary functions of the WRC are to fund and steer the water research agenda in South Africa, and to effectively disseminate and communicate research findings. Administrative activities are carried out to ensure compliance with regulatory requirements and to provide an enabling environment for research management. In recent years the WRC has been increasingly called upon to not only develop new knowledge in the water and sanitation science and technology domain, but also to support and further develop human capacity and skill as well as lead technology, product and industry development.

The Research, Development and Innovation (RDI) branch offers new knowledge in water and sanitation through research and development projects. The knowledge generated results in new or refined technologies and innovations which the WRC provides to the water sector to address specific needs and challenges. The branch is actively involved in human and institutional capacity development using research and development projects, research products and services.

Artificial recharge

(This section covers publications from both the WRC and DWS and publications in the public domain)



MANAGED AQUIFER RECHARGE: SOUTHERN AFRICA

The depletion of aquifers has become so excessive that the water from their depletion runs off into the oceans to contribute 25% of recent sea level rise. Excessive runoff is enhanced by the cutting of forests and the deterioration of soil health. The only option for reversing this trajectory towards disaster is to reduce the amount of freshwater that escapes to the oceans. For this, the most readily implementable approach is to use engineering to increase the amount of rainfall that recharges groundwater reservoirs so that less escapes to the oceans. This is now widely known as 'managed aquifer recharge' (MAR) or 'artificial recharge" (AR). This book is authored by two South African groundwater scientists. South Africa has the most experience with MAR because there are dozens of substantial MAR applications in diverse hydrologic and geologic conditions ranging from unconsolidated aquifers in semi-arid climates to fractured rocks in desert climates. South Africa is a leader in MAR as a result of more than 50 years of research and practice supported by farsighted government funding.

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IMPLEMENTATION GUIDELINE FOR MANAGED AQUIFER RECHARGE (MAR) IN COMBINATION WITH BLUE-GREEN INFRASTRUCTURE (BGI) AT LOCAL SETTLEMENT LEVEL

WRC report no. TT 950/24

Existing water resource management practices in many South African cities are not resilient to climate change impacts. This has necessitated the consideration of more adaptive urban water supply, sanitation and stormwater management systems that focus on diverse sources for water supply, improved water quality, flood protection, amenity and biodiversity. These include blue-green infrastructure (BGI) which can help to address some of the deficits of conventional urban water services provision. This project contributes to the need to build the evidence base for urban place-specific resilience-building initiatives, and the widening of state-of-the-art knowledge, by providing ethnographic and policy-focused research, and developing implementation guidelines based on a City of Cape Town (CoCT) demonstrative case study on managed aquifer recharge (MAR) in combination with BGI for stormwater recharge at local settlement level.

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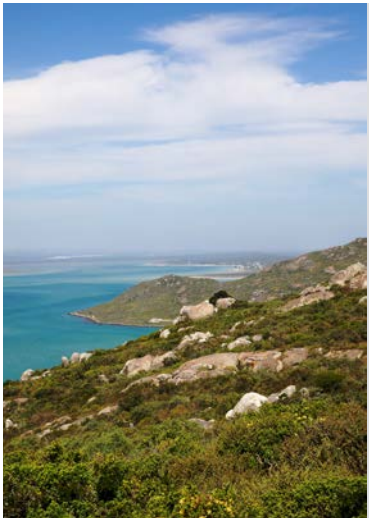

TOWARDS SUSTAINABLE EXPLOITATION OF GROUNDWATER RESOURCES ALONG THE WEST COAST OF SOUTH AFRICA

WRC report no. 2744/1/21

The West Coast area has been the subject of periodic hydrogeological studies since the 1960s, resulting in the identification of the so-called "Lower Berg River Super-Unit" and the sub-division into four smaller aquifers, namely Langebaan Road, Elandsfontein, Grootwater and Adamboerskraal. In the late 1990s, a wellfield was developed in the Langebaan Road aquifer (LRA), with 4 production boreholes. The most recent research entailed a pre-feasibility hydraulic response study to evaluate and assess the practical implementation of MARS in the LRA and wellfield. This MARS pilot study produced significant and valuable insight that substantially advanced the understanding of the behaviour and response of the confined aquifer resulting from MARS. The study also raised pertinent questions and identified significant knowledge gaps and recommendations, such as identifying a suitable area for MARS, conducting MARS feasibility tests in a phased manner, and monitoring. The overarching aim of this project was therefore to investigate the sustainable exploitation of groundwater resources on the West Coast of South Africa.

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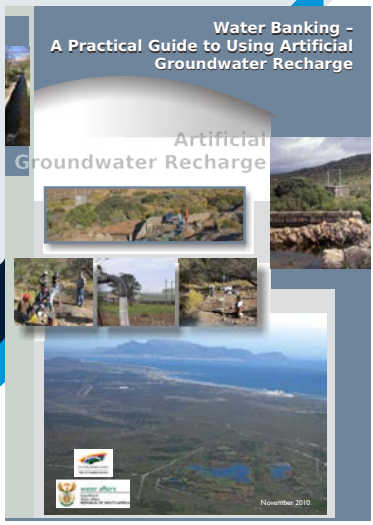

WATER BANKING - A PRACTICAL GUIDE TO USING ARTIFICIAL GROUNDWATER RECHARGE

In the years proceeding this guide there had been many significant and exciting developments in the field of artificial recharge. Water banking is the process of storing surplus water to help maintain sufficient water for our needs, to be drawn on when demand requires. Artificial recharge can be defined as the process whereby surface water is transferred underground to be stored in an aquifer. The most common methods used involve injecting water into boreholes or transferring water into spreading basins where it infiltrates the subsurface. Underground water storage is an efficient way to store water because it is not vulnerable to evaporation losses and it is relatively safe from contamination. The department published its artificial recharge strategy in June 2007 and in November of that year began implementing it. Potential artificial recharge areas had been identified for the whole country and a detailed artificial recharge assessment had been conducted in one Water Management Area (WMA) – the Olifants-Doorn WMA.

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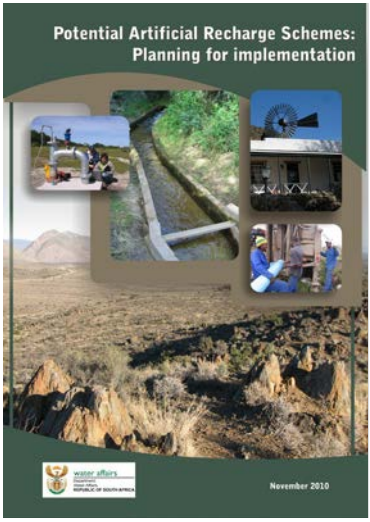

POTENTIAL ARTIFICIAL RECHARGE SCHEMES: PLANNING FOR IMPLEMENTATION

This report focuses on two of the DWS supported artificial recharge assessments undertaken during the rollout of the artificial recharge strategy, namely those at Prince Albert and Plettenberg Bay. It also summarises the other studies undertaken during the rollout project, namely those at Sedgefield, Hermanus and in the Vermaaks River Valley near Oudtshoorn, as well as the recent borehole injection tests carried out on the Langebaan Road Aquifer. Brief summaries have been included on other areas where artificial recharge has been proposed, like the Sand Dams of the Limpopo and Mpumalanga Provinces, the Lephalale artificial recharge assessment, and the Kenhardt and Kathu proposals. The aim of the report is to provide examples of various levels of investigation into artificial recharge.

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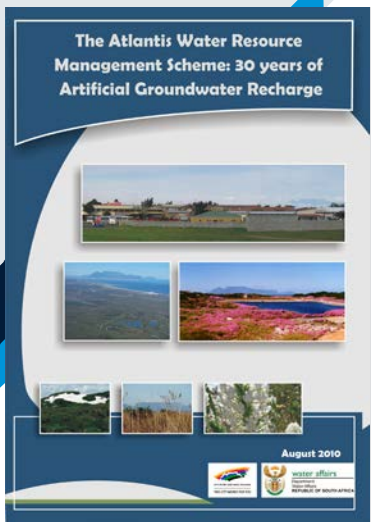

THE ATLANTIS WATER RESOURCE MANAGEMENT SCHEME: 30 YEARS OF ARTIFICIAL GROUNDWATER RECHARGE

The town of Atlantis is located 50 km north of the centre of the City of Cape Town on the dry west coast. It forms part of the metropolitan area of Cape Town. Atlantis provides an example of wise water use. Treated wastewater and stormwater is diverted to large basins where it infiltrates into a sandy aquifer from where it is abstracted and reused for municipal supplies. Polokwane in the Northern Province and Windhoek in Namibia practice similar forms of water conservation and storage, and a number of other towns throughout South Africa are in the process of investigating or implementing such schemes.

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POTENTIAL ARTIFICIAL RECHARGE AREAS IN SOUTH AFRICA

The Artificial Recharge Strategy identified two key areas in the planning sphere that needed attention, one, to incorporate artificial recharge in key planning documents such as the National Water Resource Strategy and, two, to identify areas where artificial recharge could help solve the water resource problems. This report deals with the second item, and aims to provide those involved with water resource and supply planning with ideas on how artificial recharge could help solve a water supply problem. It also gives examples of how artificial recharge can be used to reverse the environmental effects of historical large-scale groundwater abstraction. This report's main aim is to feed planners with ideas and concepts on how subsurface storage can be used as an alternative way to solve particular water resource problems.

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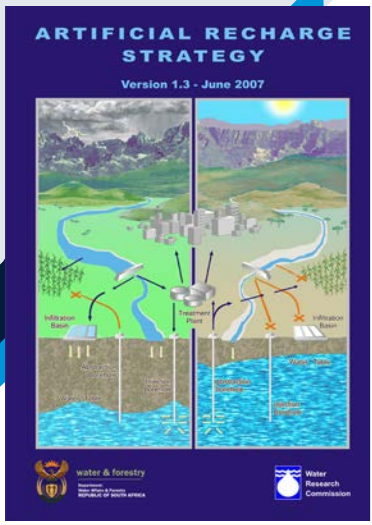

ARTIFICIAL RECHARGE STRATEGY VERSION 1.3

Artificial recharge (AR) is the process whereby surface water is transferred underground to be stored in an aquifer. The most common methods used involve injecting water into boreholes and transferring water into spreading basins where it infiltrates the subsurface. The development of South Africa's artificial recharge strategy was a process that involved many people and organisations. The (then) Department of Water Affairs & Forestry provided the vision and leadership; the WRC supported this and has supported research into artificial recharge for many years; and the CSIR and Groundwater Africa were key roleplayers in promoting, supporting and undertaking research in artificial recharge.

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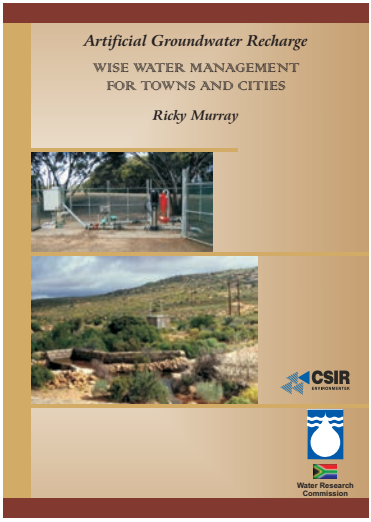

ARTIFICIAL GROUNDWATER RECHARGE: WISE WATER MANAGEMENT FOR TOWNS AND CITIES

WRC report No: TT 219/03

This booklet is written for those who are involved in water planning, management and supply from large-scale city supplies to small-scale town and village supplies. It describes artificial groundwater recharge – a method of managing water wisely by optimising sub-surface storage. Artificial recharge is the process of transferring water into an aquifer. The source of the transferred water is usually surface water. Treated wastewater and urban storm runoff are becoming popular sources of artificial recharge water. Water managers are increasingly seeing the advantages of integrating surface and groundwater in their desire to conserve water and use it opti¬mally. It also makes sense from an economic and environmental perspective to use available sub-surface storage. The booklet covers the key issues that affect the success of artificial recharge schemes, including the recharge water source, quality and reli¬ability; water quality issues; aquifer hydraulics and groundwater recovery; economics; and scheme management. In addition, five case studies are pro¬vided from southern Africa, including Windhoek, the Namaqualand, Atlantis, Polokwane and the Namib Desert.

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OTHER REPORTS

PILOT ARTIFICIAL RECHARGE SCHEMES: TESTING SUSTAINABLE WATER RESOURCES DEVELOPMENT IN FRACTURED AQUIFERS

The project aimed to test the artificial recharge concept in South African secondary aquifers; demonstrate the potential for artificial recharge in secondary aquifers to hydrogeologists and water resource planners; and to train local water resource managers in the operation and maintenance of the pilot artificial recharge schemes.

WRC Report No: 967/1/02

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ARTIFICIAL RECHARGE – A TECHNOLOGY FOR SUSTAINABLE WATER RESOURCES DEVELOPMENT

By the mid-1990s artificial recharge had gained acceptance worldwide as an effective method of conserving water for future use, for improving water quality, for averting saline water intrusion, among other water uses. The aim of artificial recharge for water supply purposes is to rapidly replenish aquifers with water that would otherwise be lost through evaporation and streamflows. The aim of this project was to assess the feasibility of using artificial recharge technologies in South Africa for community water supplies.

WRC report no. 842/1/98

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MODELLING GROUNDWATER CONTAMINATION IN THE ATLANTIS AQUIFER

The main aim of this study was to gain information on the mechanisms responsible for the pollution of groundwater. Among others, the project involved the development, application and refinement of a model which can be applied to contaminated aquifers, with the Atlantis aquifer being the subject of study.

WRC report no. 175/1/90

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PRELIMINARY INVESTIGATION OF MODELLING OF THE ATLANTIS AQUIFER

The main purpose of this study was the development of a preliminary mathematical-physical model, describing groundwater flow in the Atlantis aquifer.

WRC report no. 113/1/87

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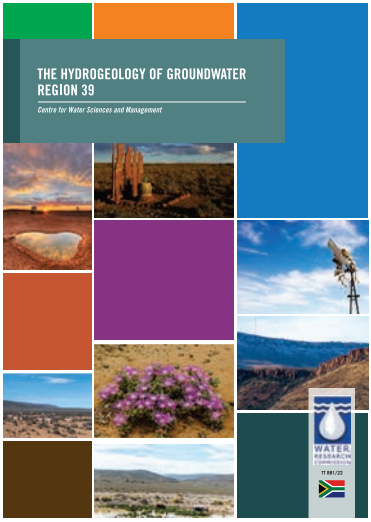
Exploration, characterisation & development



THE HYDROGEOLOGY OF GROUNDWATER REGION 39

WRC report no. TT 881/22

Vegter Region 39 is located in the central Karoo. Groundwater resources within the study area is an important source of water for many towns, farmers and domestic users. However, this resource plays a key role in sustaining many of the ecosystems (e.g. those found at springs and wetlands) within the area. In order to obtain a better understanding the groundwater resources within Region 39, current available groundwater information was statistically analysed according to Vegter's methodology. The geostatistical analyses for the study as a whole are discussed and also the individual analysis of the different geological units as identified in the 1:1 000 000 simplified geological map of the area. Vegter's methodology is followed as closely as possible. The proposed delineation method, based on the work of Vegter (2001) provides a methodology in which aquifers can be delineated. This allows the groundwater specialists to conduct studies/research on aquifer boundaries which deviates from the current approach of using surface water boundaries to delineate study areas. This approach can for example be applied in Groundwater Resource Directed studies.

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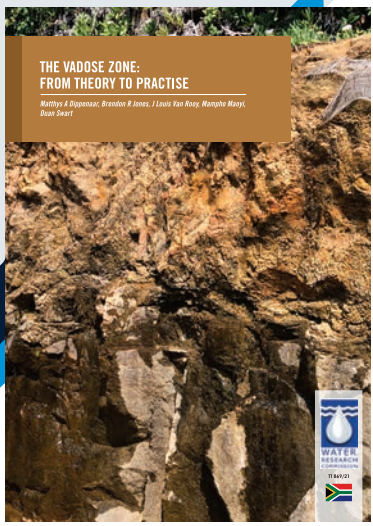

THE VADOSE ZONE: FROM THEORY TO PRACTICE

WRC report no. TT 869/21

This book is the product of a series of projects focused on the role of the vadose zone in the hydrological and geotechnical behaviour of materials, as well as those exacerbated by anthropogenic change. A number of projects built up to this, working progressively through theory of the vadose zone, interstitial systems, fractured systems, karstic systems, and contaminant transport and flow changes in cemeteries as a case study. These contributions culminated in this project, requiring these systems to be overlain into a complex vadose zone system subjected to anthropogenic change. This report links knowledge on the behaviour of primary, secondary and tertiary and anthropogenically altered vadose zone systems at highly variable moisture contents. The report supplies improved understanding with respect to especially fractured systems, while incorporating this with advances in karst systems, applications to cemeteries, and other new developments.

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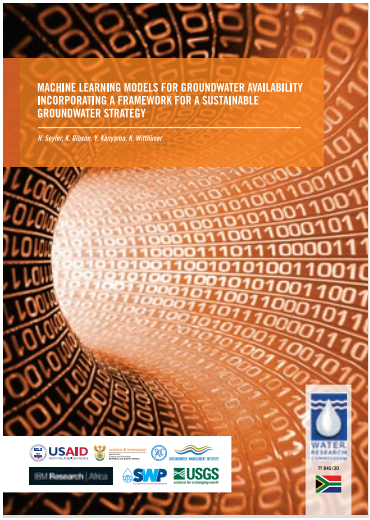

MACHINE LEARNING MODELS FOR GROUNDWATER AVAILABILITY – INCORPORATING A FRAMEWORK FOR A SUSTAINABLE GROUNDWATER STRATEGY

WRC report no. TT 845/20

This project (1 of 4 projects) developed a strategy for sustainable groundwater use which is an approach for achieving best practice groundwater management. The strategy is essentially a list of actions necessary for achieving sustainable groundwater use and is applicable to any aquifer or group of aquifers (a groundwater basin). It is recommended that the approach be implemented particularly in heavily used aquifers, in aquifers with sensitive receptors, and the approach would support improved groundwater management in transboundary aquifers.

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Also available as part of this series are the following reports:

- Imagining solutions for extracting further value from existing datasets on surface and groundwater resources in Southern Africa (**WRC report no. TT 842/20**). Click here to download the report
- Localising transboundary data sets in Southern Africa: A case study approach (**WRC report no. TT 843/20**). Click here to download the report
- Data analytics and transboundary water collaboration. Theme 1: Consolidation of data and application of Big Data tools to enhance national and transboundary data sets in Southern Africa that support decision-making for security of water resources (**WRC report no. TT 844/20**). Click here to download the report

THE KARST VADOSE ZONE: INFLUENCE ON RECHARGE, VULNERABILITY AND SURFACE STABILITY

WRC report no. TT 779/19

The project emanated from a series of projects related to vadose zone hydrology applied to engineering geology and hydrogeology. Karst systems are intrinsically complex. Surface instability in the form of sinkholes and subsidences affects infrastructure, and groundwater is vulnerable in areas where karst features promote quicker and more direct connection to the land surface. The project informed regarding the properties dictating the hydraulic behaviour of the possible strata making up the hydrostratigraphical model of Southern African dolomite karst systems.

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OTHER REPORTS

THE RELATIONSHIP BETWEEN HEUWELTJIES AND SALINE GROUNDWATER ALONG THE WEST COAST OF SOUTH AFRICA

Large parts of the coastal zone of the Western and Northern Cape of South Africa are affected by variably saline groundwater, traditionally attributed to the effects of evaporation and evapotranspiration that exceed the mean annual precipitation (MAP). However, the larger coastal zone of southern Africa (including Namibia) has similar MAP profiles and associated high evaporation rates and yet does not suffer from the same level of salinization. Heuweltjies are palaeo-termite mounds (5 to 20 m in diameter with 0.5 m elevation) that form a distinct landscape across much of the west coast region of South Africa. This study examined the relationship between heuweltjies and saline groundwater on the west coast of South Africa in both the Western Cape and the Northern Cape to see if there is a potential causal relationship.

WRC report no. 2825/1/22

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TOWARDS SUSTAINABLE EXPLOITATION OF GROUNDWATER RESOURCES ALONG THE WEST COAST OF SOUTH AFRICA

The West Coast area has been the subject of periodic hydrogeological studies since the 1960s, resulting in the identification of the so-called 'Lower Berg River Super-Unit' and the sub-division into four smaller aquifers, namely Langebaan Road, Elandsfontein, Grootwater and Adamboerskraal. In the late 1990s, a wellfield was developed in the Langebaan Road aquifer (LRA), with 4 production boreholes. The most recent research entailed a pre-feasibility hydraulic response study to evaluate and assess the practical implementation of Managed Aquifer Recharge and Storage in the LRA and wellfield. The overarching aim of this project was therefore to investigate the sustainable exploitation of groundwater resources on the West Coast of South Africa.

WRC report no. 2744/1/21

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IMPACTS OF TRACE METALS FROM GEOTHERMAL SPRINGS TO THEIR SURROUNDING SOIL AND VEGETATION WITHIN SOUTPANSBERG

Geothermal springs are natural geological phenomena that occur throughout the world. South Africa is endowed with several springs of this nature. Thirty-one percent of all geothermal springs in the country are found in Limpopo province. The springs are classified according to the residing mountain: Soutpansberg, Waterberg and Drakensberg. This study focused on the geothermal springs within the Soutpansberg region; that is, Mphephu, Siloam, Sagole and Tshipise. The study was aimed at assessing the impacts of trace metals from geothermal springs to their surrounding soil and vegetation in the Soutpansberg region. This study also assessed the potential human health risks associated with trace metals from geothermal springs and surrounding soils in the study areas.

WRC report no. 2739/1/20

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URBAN GROUNDWATER DEVELOPMENT AND MANAGEMENT

Groundwater use by urban areas urgently needs to shift from lack of active management of groundwater and indirect use (of groundwater's assimilative capacity) with negative implications, to active management leading to the potential for bulk water supply from urban groundwater resources. In cases where urban groundwater will not be used for bulk supply for whatever reason, active management of the urban groundwater is still required to protect the resource for other uses (ecological services, garden irrigation, food gardens). Contributing to this shift is the core motivation for this project; which aimed to: understand the status quo of urban groundwater development and management in South Africa; compare these to best practice for urban groundwater management; and develop position papers and a tactical plan to address the gaps.

WRC report no. 2741/1/19

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GEO-STATISTICAL ANALYSIS AND SUB-DELINEATION OF ALL VEGTER REGIONS

The Vegter methodology is used to perform geostatistical analysis on the Vegter regions. This methodology has been well documented by Vegter himself. It is however a tedious process to obtain all the relevant data, process the data and calculate the required statistics. In the light of the aforementioned a software tool was developed to automatically perform the analysis.

WRC report no. 2745/1/19

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GROUNDWATER SAMPLING MANUAL

There is no best single method that will suit all sampling objectives/needs or is applicable at all sites or times. Thus, as new methods, techniques and equipment are developed, there is need to continuously update the groundwater sampling manual (GSM) in line with the state-of-the-art to provide best practice guideline. In some other instances, new groundwater sampling needs might arise and such will also require updating of the existing sampling guides. This guide presents an update version of the 2nd edition of the WRC's Groundwater Sampling Manual (Weaver, Cave, and Siep 2002)

WRC report No. TT 733/17

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HYDROGEOLOGY OF GROUNDWATER REGION 10: THE KARST BELT

Groundwater Region 10 stretches from approximately Delmas and Springs, east and southeast of Johannesburg respectively, to the Botswana border north of Mafeking, an east-west distance of just over 300 km. It has a roughly triangular shape extending from the Delmas/Springs area in the east to a maximum width of almost 100 km in the west where it abuts against granitic basement rocks and a short section of the Botswana/South Africa border.

WRC report no. TT 553/14

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Groundwater management

GUIDANCE DOCUMENT ON PROTECTION ZONES (DELINEATION AND PROTECTION): DEVELOPMENT OF METHODOLOGICAL APPROACH AND IMPLEMENTATION PLAN

WRC report no. TT 902/22

Groundwater is a vital source of freshwater and its role in meeting water demands will only become more pivotal under future climate and population growth scenarios. Already, in southern Africa, the South African Development Community (SADC) heavily relies on groundwater, with an estimated 70% of the SADC's population utilising this resource for basic water needs. Currently, there are no implemented legislative guidelines on establishing groundwater protection zones in South Africa. This guidance document aims to describe how knowledge-based and precautionary management approaches may be used to protect groundwater resources from existing pollution sources, and from future threats (quality and quantity) through delineation and establishment of a groundwater protection scheme. This guideline deals only with aspects of pollution prevention rather than remediation or prevention of recharge reduction or over abstraction, which constitutes a fundamental, but separate component of aquifer protection. The groundwater protection scheme is applicable to groundwater resource supply schemes of all scales and uses where groundwater quality needs to be preserved. More specifically, this guideline outlines a methodological approach to implementing a groundwater protection scheme for pollution prevention, including delineation of groundwater protection zones, vulnerability mapping, and identifying potentially contaminating activities within protection zones.

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GUIDANCE DOCUMENT ON GROUNDWATER SCHEME DEVELOPMENT

WRC report no. TT 903/22

The Strategic Water Sector Cooperation between Denmark and South Africa is long-term bilateral cooperation contributing to the South African water sector by sharing practical experience and providing expert input into the South African municipal sphere gaps. The cooperation support intends to add long-term value to optimise groundwater utilisation. This project aims to facilitate the development of guidelines for groundwater schemes at the municipal level. Typical groundwater schemes in South Africa comprise boreholes equipped with pumps or motorised wellfields operated by water agencies or local authorities. In some settings, the boreholes may form part of the water treatment and reticulation system. This project aimed to facilitate the development of guidelines for groundwater schemes at the municipal level. The objectives were, among others, to construct the resource development lifecycle for groundwater scheme development at the municipal level; customise a groundwater mapping methodology based on the Denmark approach; assess conjunctive use of surface water and groundwater and its role in water security in installing groundwater schemes; include groundwater monitoring network design incorporating quality and quantity in the guidelines for proactive mitigation of issues; and develop a framework approach for the final design, which includes aspects of wellfield/borehole development, bulk infrastructure, management plan, costing and training.

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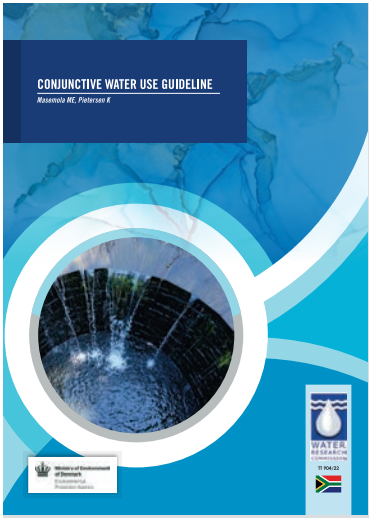

CONJUNCTIVE WATER USE GUIDELINE

WRC report no. TT 904/22

This guideline forms part of a series of guidelines developed as part of the Danish and South African Strategic Water Sector Cooperation. It is recognised that groundwater can play a significant role in decreasing the pressure placed on water supply due to unplanned fast urban growth outpacing economic, social and institutional interventions. Water planners are forced to explore developing and maintaining a combination of water supply sources to ensure water security and reduce the impacts of extreme climatic conditions such as drought. Groundwater can be developed conjunctively with surface and other measures, such as reducing non-revenue water to support the growing demand for clean water in South Africa. A solid knowledge base provides the foundation for conjunctive water use. This guidance document adds to the knowledge by promoting the emergence of groundwater as a significant contributor towards water security and resilience. Municipalities can benefit from the guideline as a resource to guide decisions rooted in providing net social benefits through coordinated institutional involvement and well-informed processes for selecting options for conjunctive water use.

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GUIDANCE DOCUMENT ON GROUNDWATER DATA COLLECTION

WRC report no. TT 905/22

Groundwater resources support many urban and rural communities within South Africa. To protect and ensure the sustainability of this resource, groundwater management approaches rely on effective data collection, collation, quality control, storage and management. The guidance document provides individuals from all spheres, including government, consultancies, universities and communities, as well as stakeholders and citizen scientists, with the necessary tools to undertake accurate monitoring, where data is collected using the correct field procedures, captured consistently, quality controlled and stored appropriately for further interpretation and analysis. The guidance document presents a set of standard procedures for all aspects of groundwater data collection, with an emphasis on groundwater monitoring (groundwater level, groundwater quality and groundwater abstraction) and groundwater development (well drilling and test-pumping).

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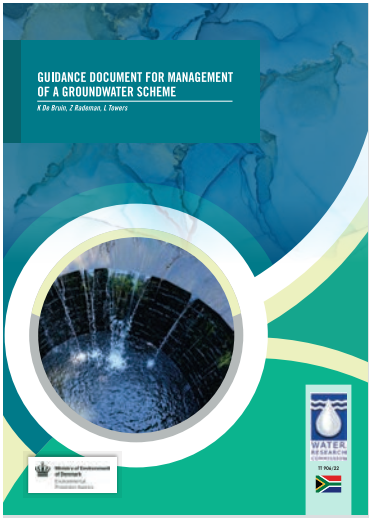

GUIDANCE DOCUMENT FOR MANAGEMENT OF A GROUNDWATER SCHEME

WRC report no. TT 906/22

This guideline aims to promote groundwater management principles applicable to common types of groundwater schemes and associated users. It incorporates outcomes of the Strategic Water Sector Cooperation (SSC) between Denmark and South Africa. The SSC is a long-term cooperation that has contributed Denmark's well proven practical knowledge of legal frameworks, practices, and technologies to the sustainable use, protection and management of groundwater resources in South Africa. The guidance document aims to offer an outline of best practice for monitoring, operation, and maintenance (O&M) of various groundwater schemes in the context of South Africa's governance and legislative structures, international principles of Integrated Water Resource Management (IWRM), and the hierarchy of stakeholders involved in a groundwater scheme. This document includes a generalised blueprint for establishing a monitoring network and programme, informed by monitoring objectives, that may be applied to groundwater schemes of various types and scales. Monitoring objectives are integrated with O&M requirements to outline tools, procedures and best practice methodologies toward scheme optimisation, longevity and environmental sustainability. Finally, the management structures for groundwater schemes in the South African legislative hierarchy are shown, and principles of groundwater conflicts are briefly discussed. Any reader of the Guidance Document can effectively fulfil their role as a stakeholder in managing a groundwater scheme of any type or scale, at any location in South Africa.

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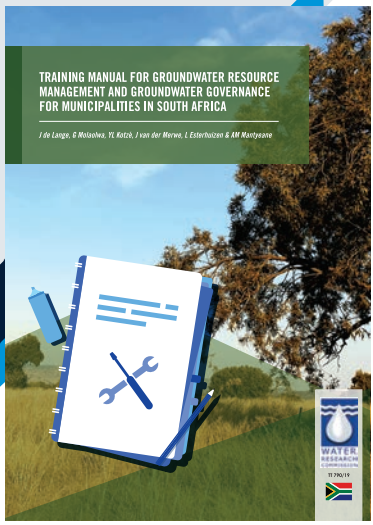

TRAINING MANUAL FOR GROUNDWATER RESOURCE MANAGEMENT AND GROUNDWATER GOVERNANCE FOR MUNICIPALITIES IN SOUTH AFRICA

WRC report no. TT 790/19

Groundwater is a vital concept worldwide and many nations and various people and many industrial premises depend on it for their water supply. Accelerated development over the past few decades has resulted in great social and economic benefits, by providing low-cost, drought-reliable and (mainly) high-quality water supplies for both the urban and rural population and for irrigation of (potentially high value) crops.
In South Africa's most water supplies in small towns originate from groundwater sources. These are geographically widespread and almost two-thirds of South Africa's population depend on them for their domestic water needs This manual is aimed at aiding groundwater management at municipal level.

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OTHER REPORTS

ASSESSING WATER USER IMPACTS ON ECO-HYDROLOGY USING STABLE ISOTOPES

Water quality monitoring has been used for decades in South Africa to trace sources of environmental stress on aquatic ecosystems, but this remains a relatively imprecise process when trying to identify the primary source of stress. This is due to many key traces such as, the primary nutrients used in photosynthesis (nitrates and phosphates), originating from both natural and anthropogenic sources. Stable isotopes of nitrogen and carbon have been used to understand the structure and function of aquatic food webs, and in recent decades have also been used in various parts of the world to trace intensification of human land cover change, particularly in agricultural and urban landscapes. Stable isotopes of sulfur have more recently been used to trace the effects of both urbanisation and mining on river ecosystems. There is space for innovation in the South African context to explore how all three of these stable isotopes, when used in conjunction with more traditional chemical tracers of water quality such as nutrients and heavy metals, might provide a new set of tools with which to distinguish between contrasting anthropogenic sources of eco-hydrological stress

WRC report no. 3079/1/23

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GOVERNING GROUNDWATER IN CITY REGIONS: WATER METABOLISM AND ACTOR NETWORKS IN THE CASES OF CAPE TOWN AND NELSON MANDELA BAY

Exploiting groundwater during crises, as an urgent and reactive measure, gives rise to poorly coordinated regulation of increasing users and usage, and fragmented management of aquifers. This undermines the sustainability with which groundwater resources are used and managed, putting both aquifers and those reliant on groundwater at risk of over-depletion and pollution. This study focused on the metropolitan municipalities of Cape Town and Nelson Mandela Bay (NMB) as 'learning laboratories' to co-produce a more comprehensive

understanding of each urban water system. The focus was on how groundwater links with other urban water flows, what actors influence these water flows, and how things may change under various climate change and land use scenarios.

WRC report no. 3066/1/23

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ASSESSING WATER USER IMPACTS ON ECO-HYDROLOGY USING STABLE ISOTOPES

Water quality monitoring has been used for decades in South Africa to trace sources of environmental stress on aquatic ecosystems, but this remains a relatively imprecise process when trying to identify the primary source of stress. Stable isotopes of sulfur have more recently been used to trace the effects of both urbanisation and mining on river ecosystems. There is space for innovation in the South African context to explore how all three of these stable isotopes, when used in conjunction with more traditional chemical tracers of water quality such as nutrients and heavy metals, might provide a new set of tools with which to distinguish between contrasting anthropogenic sources of eco-hydrological stress.

WRC report no. 3079/1/23

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PROTOTYPE DEVELOPMENT OF A REAL-TIME MONITORING SYSTEM FOR GROUNDWATER LEVEL AND QUALITY USING THE GEOGRAPHIC OF THINGS

Groundwater level and quality monitoring are essential for the sustenance of water resources, especially in an arid and/or semi-arid country like South Africa. The objective of this project was to develop a system for acquiring, transferring, analysing and displaying real-time information to manage groundwater level and quality resources from a geographically distributed network of wells. This project entailed the development of a portable, low-cost, real-time, Geography of Things (GoT) sensor prototype system for monitoring groundwater level and quality.

WRC report no. 3032/1/22

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MOBILE APP FOR HYDROCENSUS AND GROUNDWATER MONITORING

A mobile application was developed to capture borehole information. Essentially the application will serve as a continuous hydrocensus tool collecting borehole information over time. The application is aimed at both the groundwater professional, but also aims to engage the general public to partake in data collection, generally known as citizen science.

WRC report no. 2827/1/22

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CISMOL – MONITORING GROUNDWATER IN THE HOUT CATCHMENT

Groundwater is an increasingly important source of water supply to agriculture, households, and industry. Groundwater is generally well protected against pollution, can be exploited anywhere depending on the local conditions, and has a year-round availability. Among others, this project aimed to train citizens on the use of appropriate technology to obtain relevant data on groundwater and rainfall; improve the understanding of hydrogeological processes and groundwater-related socioeconomic and agricultural issues in typical geological settings and farming communities in RSA, exemplified by the Hout/Sand River catchment in the Limpopo Province; and define and promote sustainable groundwater management options in the Hout/Sand Catchment based on integrated hydrological modelling, resource indicator tools, and stakeholder engagement (citizen science).

WRC report no. 3017/1/22

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TRAINING MANUAL FOR GROUNDWATER RESOURCE MANAGEMENT AND GROUNDWATER GOVERNANCE FOR MUNICIPALITIES IN SOUTH AFRICA

This project produced a training manual on groundwater resource management and groundwater governance for municipalities in South Africa. It concludes that the training manual can be used for capacitating municipal officials, technicians, managers, and decision-makers, as well as communities where villages and towns are partially or solely reliant on groundwater resources.

WRC report no. 2447/1/19

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GROUNDWATER USE BY ALIEN INVASIVE PLANTS: ASSESSING THE IMPACT OF PROSOPIS SPP INVASIONS ON WATER SUPPLY TO GROUNDWATER DEPENDENT COMMUNITIES

The deep-rooted desert adapted shrub or tree, Prosopis spp, is a major invader species in the arid and semi-arid parts of the country. Near the turn of the 19th century, six Prosopis species from Central America were introduced to Namibia and the arid parts of South Africa for fodder, fuel and shade. This study seeks to quantify the impact of Prosopis invasions on supply to groundwater dependent communities.

WRC report no. 2256/1/18

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A REVIEW OF THE IMPLEMENTATION OF GROUNDWATER PROTECTION MEASURES, IN PARTICULAR RESOURCE DIRECTED MEASURES, IN SOUTH AFRICA IN THE CONTEXT OF CHINAFRICA WATER FORUM DIALOGUES

This review of groundwater protection measures in South Africa focuses on the actual implementation of groundwater protection, in particular the Resource Directed Measures legislated in the National Water Resources Act, 1998 as the key protection measure for all significant water resources.

WRC report KV 364/18

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THE CAPTURE PRINCIPAL APPROACH TO SUSTAINABLE GROUNDWATER USE

Many current tools to support groundwater management broadly apply water balance type calculations for aquifer yield assessments in which groundwater availability is directly related to some portion of pre-abstraction recharge. These assessments are often completed at quaternary catchment scale, and aquifers (or catchments) with high use compared to recharge are generally identified as 'stressed' or 'over-used'. The approach can limit groundwater development based on a perceived stress. Impeding implementation of the capture approach to sustainability is the fact that the approach is intertwined with adaptive management. Management must proceed on less than ideal information, and decisions adjusted as groundwater use continues. This is awkward to regulate. The ultimate purpose of the project was to promote the capture principle approach to sustainable groundwater use. The project proposed the development of a tool – a 'decision framework' – that could facilitate the translation of theoretical hydrogeological principles for sustainable groundwater use based on the capture principle approach into practice.

WRC report No. 2311/1/17

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Pollution & the environment

GROUNDWATER RESOURCE DIRECTED MEASURES (2012 EDITION)

WRC report No. TT 506/12

To be able to implement the National Water Act (NWA), the Minister of Water and Sanitation needs to ensure that the tools and expertise required to implement the Act are available. This manual addresses the methods and procedures needed to implement Resource Directed Measures (RDM). To distinguish between RDM in general and RDM related to groundwater, the term Groundwater Resource Directed Measures (GRDM) will be used when the focus is only on groundwater. However it is important to note that the NWA clearly includes groundwater in a unitary hydrological cycle and in the definition of a water resource, but the characteristics of groundwater sometimes require it to be considered or managed differently to other water resources. In essence, this manual is about the techniques to ensure that groundwater resources will be used in a sustainable way as prescribed by the NWA. This forms the cornerstone of the long-term sustainable use of the resource – the other two components being equity and efficiency.

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OTHER REPORTS

SMART MONITORING AND EARLY WARNING SYSTEM OF SINKHOLE WITH FIBRE OPTIC SENSORS AND INSAR

Sinkholes are alarming and dangerous events, they have a worldwide occurrence, and are imposing a potential risk to infrastructure, urban communities and the widely developed built environment. However, although they represent a natural risk that may hit catastrophically without clearly detectible precursors, they are often overlooked by the public and local authorities. Therefore, sinkhole monitoring and associated early warnings constitute an important research topic, with high associated, impact. In this project we developed a combined two scale approach for the monitoring of sinkhole development. Satellite Synthetic aperture Interferometry earth observation methods were used to monitor and assess susceptible to sinkhole hazard urban areas in Centurion.

WRC report no. 2937/1/22

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ENVIRONMENTAL RISK ASSESSMENT, MONITORING AND MANAGEMENT OF CEMETERIES

Investigation for cemetery sites require the detection of a wide range of different contaminant groups, at typically very low to concentrations (if present), (iii) natural and geological impacts on the proposed developments; and with important human and ecosystem health effects, if undetected. The project detailed in this report developed as part of a long-term series of projects on vadose zone hydrology. The project investigated certain identified research questions pertaining to cemeteries.

WRC report no. 2449/1/18

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GEOPHYSICAL DELINEATION AND MONITORING OF AMD IN THE CRADLE OF HUMANKIND

The main aim of the project was to assess the applicability of the time-lapse two-dimensional electrical resistance tomography (ERT) survey method to monitor changes in local aquifer contamination levels (sulphate content).

WRC report no. 2440/1/18

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DEVELOPMENT OF AN INTERACTIVE VULNERABILITY MAP AND MONITORING FRAMEWORK TO ASSESS THE POTENTIAL ENVIRONMENTAL IMPACT OF UNCONVENTIONAL OIL AND GAS EXTRACTION BY MEANS OF HYDRAULIC FRACTURING

This WRC study was proposed in light of the applications that were made by various companies for exploration permits for the extraction of shale gas and coalbed methane. The study focused specifically on understanding the unconventional oil and gas extraction process, identifying possible impacts associated with unconventional oil and gas extraction and hydraulic fracturing, as well as identifying vulnerable areas that need protection in terms of unconventional gas extraction.

WRC report No. 2149/1/14

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