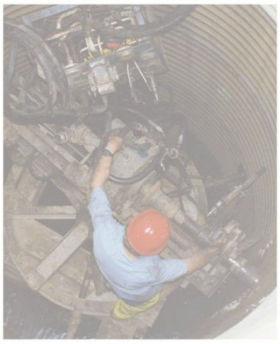
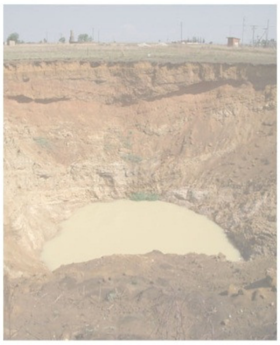




National Groundwater Strategy

Draft 4 - April 2016





water & sanitation

Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

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List of Abbreviations

A

ADE	Aquifer Dependent Ecosystem
AFD	Agence Française de Développement
AGWNet	African Groundwater Network
AGSA	Auditor-General of South Africa
AMCOW	African Ministers Council on Water
AMD	Acid Mine Drainage
AquiMon	Software for Groundwater Management

B

Burdon Network	Professional network linked to the International Association of Hydrogeologists working on groundwater in the developing world

C

CAPNet	Capacity Building Network
CGS	Council For Geoscience
CMA	Catchment Management Agency
CMS	Catchment Management Strategy
COGTA	Department of Cooperative Governance and Traditional Affairs
CPD	Continued Professional Development

D

DANIDA	Danish International Development Agency
DBSA	Development Bank of Southern Africa
DEA	Department of Environmental Affairs
DFID	United Kingdom Department for International Development
DMC	Disaster Management Centre
DMR	Department of Mineral Resources
DWA	Department of Water Affairs
DWAF	Department of Water Affairs and Forestry

E

EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
EU	European Union

F

FETWater	Partnerships and networks for promoting groundwater in SADC

G

GDAS	Hydrogeological Data Access System
GEF	Global Environmental Facility
GEOSS	Mapping and groundwater consultancy in South
GSSA	Geological Society of South Africa
GW	Groundwater
GWDSA	Groundwater Division of the Geological Society of South Africa
GWLS	Global Water License Services
GH	Geohydrology (synonymous with hydrogeology)
GMI	Groundwater Management Institute
GRA	Groundwater Resource Assessment
GRIP	Groundwater Resources Information Project
GS	Groundwater Strategy

I

IAH	International Association of Hydrogeologists
ICRAF	World Agroforestry Centre
IDC	International Development Co-operation
IDP	Integrated Development Plan
IGARF II	Impact of groundwater abstractions on river flows: Phase 2
IMESA	Institute of Municipal Engineers of Southern Africa
ISARM	Internationally Shared Aquifer Resources Management
ISP	Internal Strategic Perspective
IWRM	Integrated Water Resource Management

K

KZN	KwaZulu-Natal

M

MAR	Mean Annual Runoff
MDG	Millennium Development Goals
MPRDA	Minerals and Petroleum Resources Development Act

N

NEMA	National Environmental Management Act
NGA	National Groundwater Archive
NGOs	Non-Governmental Organisations
NGDB	National Groundwater Database, hosted at DWS
NORAD	Norwegian Agency for Development Cooperation
NRF	National Research Foundation
NWA	National Water Act (Act 36 of 1998)
NWRS	National Water Resource Strategy

O

ODA	Overseas Development
O&M	Operation and Maintenance
ORASECOM	Orange-Senqu River Commission

P

PGDP	Provincial Growth and Development Plan
PSDP	Provincial Spatial Development Plan
PSP	Provincial Spatial Plan

R

RO	Regional Offices
RSA	Republic of South Africa

S

SA	South Africa
SACNSP	South African Council for Natural Scientific Professions
SADC	Southern African Development Community
SALGA	South African Local Government Association
SGWCA	Subterranean Government Water Control Area
SusIT	Sustainability Indexing Tool
SW	Surface water
SW-GW	Surface water – groundwater

T

TBA	Transboundary aquifers
TCTA	Trans-Caledon Tunnel Authority

U

UGEP	Utilisable Groundwater Exploitation Potential
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational Scientific and Cultural Organisation
URV	Unit Reference Value

W

WARMS	Water Use Authorisation Registration Management System
WaterNet	Partnerships and networks for promoting groundwater in SADC
WC/DM	Water conservation / demand management
WFGD	Water for Growth and Development
WISA	Water Institute of Southern Africa
WMA	Water Management Areas
WRC	Water Research Commission
WRM	Water Resource Management
WRP	Water Resource Planning
WRSM2000	Water Resources Simulation Model 2000
WSA	Water Service Authority
WSDP	Water Services Development Plan
WSP	Water Service
WTE	Water Trading Entity (Provider)
WUA	Water User Associations
WULA	Water Use License Application

Symbols

Cl	Chloride
kℓ	Kilo Litre
kWh/m^3	Kilowatt hours per cubic metre
ℓ/s	Litres Per Second
m^3/a	Cubic Meters Per Annum
m^3/hr	Cubic Meters Per Hour
m^3	Cubic Meters
mg/ℓ	Milligrams per litre
million ℓ/day	Million Litres Per Day
ML/day	Mega litres per day

Executive Summary

Since democratisation of the country in 1994, groundwater's role in South Africa has undergone a major change from an undervalued resource with a 'private water legal status' to a source of domestic water and general livelihood to more than 50% of communities in thousands of villages and small towns country-wide as part of the national drive to meet basic water needs.

In 2010 the Department responded to this change with an internal Groundwater Strategy, and already took the decision to work towards a national strategy together with the wider sectors. The national strategy is required to:

- Let the full role/potential of groundwater towards water security in SA unfold.
- Establish a framework within which stakeholders at all levels can become an essential part of good groundwater governance in SA.
- Initiate a long-term process of rolling out sustainable groundwater utilization within WRM.

This document represents the draft strategy which will be widely consulted during 2016 among stakeholders in the water sector and related sectors to become the National Groundwater Strategy.

Together with stakeholders, we want to create the sustainable development vision for the resource and roll it out in a number of strategy themes and strategic actions in which every stakeholder will recognize the overall needs as well as his own objectives and his own areas of influence.

It is important to note that IWRM remains the overall vision and the groundwater strategy will be an integral part and sub-strategy of the next National Water Resource Strategy. Groundwater resources management has already benefited greatly since 1994 from being developed within an IWRM framework across the full spectrum of policy, regulations, institutional development, protection, planning and information management. The roll-out of the NGS will have to continue within this overall framework.

The world-wide, as well as South African, experience has been that management of the open access, local resource, groundwater, is complex and the evolution of appropriate groundwater management systems is a long-term process. It is intended to start the strategy roll-out with an agreed overall governance framework as tool to achieve stakeholder understanding and role clarification in the immediate development of the NGS and in the longer-term process of improving overall groundwater governance and specific management systems.

The Groundwater Strategy recognises the need for a paradigm shift for it to progress on a path towards local level participative management within the overall IWRM framework. The way forward has been captured in a groundwater governance framework for action (see below). Its concept is based on the Global Groundwater Governance Framework completed recently (UNESCO et al., 2015), while its detail has been informed by local context, both by hydrological and by overall governance context, and by macro-economic objectives.

NGS Groundwater Governance Framework

National Level (enabling environment)
Enabling legislation and strategy (is in place) 1. Stakeholder-driven development 2. National Groundwater Leadership
National / Provincial (Basin) Level
3. Responsive groundwater regulatory framework 4. Groundwater resource protection 5. Sustainable groundwater resource utilization 6. Appropriate institutional development 7. Redirecting finances 8. Groundwater resource planning and development 9. Groundwater information management 10. Regional and international partnerships 11. Water sector skills and capacity
Local (District / Aquifer) Level
12. Local level action

As core of the NGS, the twelve strategy themes have each been developed in terms of Background, Challenges, Principles, Objectives and Strategic Actions.

The way forward will have to be tackled strategically together with stakeholders, with a strong national groundwater champion role coming from the Department of Water and Sanitation and the science leadership role from the Water Research Commission. Jointly these two should harness stakeholder capacity in the both government and private sectors in order to facilitate local action and build capacity in new local level groundwater management institutions through sector implementation.

1. Introduction

1.1. Purpose and Scope of this Strategy

Local and world-wide experience has shown that the development of effective approaches for the management of precious underground water resources will require a long term process through which viable national, regional and local institutional systems can evolve.

A national strategy is required:

- To let the full role/potential of groundwater towards water security in SA unfold.
- To establish a framework within which stakeholders at all levels can become an essential part of good groundwater governance in SA.
- To initiate a long-term process of rolling out sustainable groundwater utilization within IWRM.

This is in line with the direction of the DWA Functional Management Committee 2/2011 to establish a national strategy by:

- Initiating a public-participation process to solicit comments on the strategy; and Clarifying and drafting roles and responsibilities of the wider sectors in relation to groundwater management, water security, future exploration, transboundary aquifers, etc.

It is hoped that this document will be moulded during the coming year by stakeholders from all development sectors to become their framework for joint action towards sustainable, shared utilization of the precious groundwater resource.

1.1. Where are we now?

The first initiative to develop a National Groundwater Strategy (NGS) was undertaken during the early 2000s, in order to help take groundwater from a neglected private water status to that of a significant resource managed as part of Integrated Water Resource Management (IWRM) and to provide groundwater input into the first edition of the National Water Resource Strategy (NWRS1). This strategy did provide inputs to the NWRS1, but was not considered inclusive enough during its development. Hence the need for a more fully representative NGS was identified.

Following a detailed consultative process, a Framework for National Groundwater Strategy (DWAF, 2007a) was developed, serving as foundation upon which a comprehensive strategy was finally produced in 2010. The Groundwater Strategy was designed to be implemented as part of the Department's Strategic Plan 2010/11 - 2012/13, with six Priority Areas identified to allow for effective management of the nation's water resources in alignment with agreed government priorities.

The above Strategy was widely quoted in the second edition of the National Water Resources Strategy, in which a clear undertaking was made that the DWS will ***"implement the National Ground Water Strategy, thereby promoting the use of groundwater on a larger scale. The focus is on supplying water mainly for household use in remote rural areas, where levels of water services are often unacceptable, as well as in other situations where groundwater can contribute to the reliability of supply for domestic and other uses".***

This strategy was still seen as a departmental strategy and, in line with the mandate from the Departmental Management, it will now enter a public consultation process towards achieving buy-in and becoming the National Groundwater Strategy.

1.2. Process to develop the National Groundwater Strategy

The approach in the coming year will be to achieve essential stakeholder input and buy-in for a continuously expanding framework of 'good' groundwater governance in which the stakeholders will become the beneficiaries and the drivers of an optimally used and well governed resource. This will be done firstly by a process of ***consultation with individual sector stakeholders***, like mining, agriculture, local government and catchment management agencies, to share best understanding of good governance and learn about their expectations, concerns, and potential contributions to improved groundwater governance. A second way of consultation will be with a spectrum of stakeholders at a regional level (in each province) to learn together how a system of joint development and management of groundwater resources could evolve, taking into account the water resources, socio-economics and the IWRM institutional development of the region.

Another critical consultation will be within the Department of Water and Sanitation itself. How can the widely accepted groundwater governance approach of 'national facilitation of local actions' be rolled out over time within the South African IWRM framework? What national enabling environment of assessment, planning and regulation would be required to move forward and sustain good groundwater governance?

At the same time the role and linkages of related institutions and sectors towards good groundwater governance will be explored. There is the groundwater private sector with a wealth of capacity, experience and information covering every aspect of resource development and management. There are the science councils that have had unique roles and experience with regard to groundwater's sustainable utilization.

A particular challenge for the strategy will be to maximize the role of the Water Research Commission, which has invested for 40 years already into groundwater knowledge creation and into the building of capacity in the whole water sector for the sustainable utilization and management of groundwater resources.

Groundwater practitioners, who are active in all the above institutions, are called upon to be actively involved throughout the institution-building process to share their vast experience and focus the process.

Most importantly, development of a national strategy offers new opportunities for linking users of shared groundwater resources into local institutions with a common purpose of sharing and maintaining the benefits of these resources.

A national consultation also presents an opportunity to even more strongly focus the strategy on emerging national challenges for groundwater, namely sustainable water services to thousands of communities, of finding completely new groundwater sources in areas where surface sources have reached their limits, and of protecting vulnerable groundwater resources from region-wide impacts like shale gas development.

Together, it is intended to create the sustainable development vision for the resource and roll it out in a number of strategy themes and strategic actions in which every stakeholder will recognize the overall needs as well as his own objectives and his own areas of influence.

2. Need for a National Groundwater Strategy

South Africa is approaching increasing water scarcity. According to the National Water Resource Strategy 2 (2013), development of groundwater resources will be crucial for sustaining water security. Surface water, the traditional source for bulk supply, is becoming limited and even unavailable in many catchments and infrastructure and the costs of construction and maintenance is prohibitive.

Already groundwater's role in South Africa has undergone a major change during the water sector transformation post-1994, from an undervalued resource and a 'private water legal status' to a source of domestic water and general livelihood to more than 60% of communities in thousands of villages and small towns country-wide as part of the national drive to meet basic water needs.

These changes present a major challenge for the resource which occurs mainly in hard rock aquifers in which yields are limited and a water sector which had treated it largely as an emergency water supply by drilling boreholes during drought emergencies. Its sustainable utilization by many different role players at thousands of locations will require a very unique approach.

There are serious warning signals that groundwater use is presently on an unsustainable path. Water services to communities, a national priority, are under threat. Many municipal schemes from groundwater have failed or are close to failing. Municipal managers have expressed themselves against the use of groundwater and virtually no management of the resource takes place at local level. Just based on national monitoring networks, it is clear that Karst aquifers and coastal aquifers, the major aquifers the country has, are under pressure in many locations through over- abstraction, declining water levels and water quality degradation. Even hard-rock aquifers in Limpopo show local declining trends in groundwater levels as a result of over-abstraction. Equally concerning is the wide-spread trend of increasing nitrate levels (parts of Limpopo, Northwest and Free State Provinces), most probably as result of human activity. Water quality impacts by mining on groundwater must be present, but cannot be readily detected from the present national scale monitoring.

From the beginning it was recognized that the National Water Act, 1998 was a framework act, which had to be underpinned with regulations to make it functional. This was particularly important for groundwater, which had not received regulatory attention in the past. Therefore a number of early initiatives were undertaken to address groundwater resources development and management strategically:

1997: Towards a regulatory framework for the development and management of groundwater in South Africa
2000: Policy and Strategy for Groundwater Quality Management in SA
2001: DWAF DANIDA Groundwater Strategy (and its piloting in two WMAs)
2004: NORAD-assisted programme: Groundwater toolkit for water services (and its piloting in two DMs)

None of these early, excellent strategies found implementation, because they were largely carried out in isolation, and because the groundwater function of the national Department of Water Affairs had been considerably weakened at a time when implementation was to begin (see **Box A**).

Full integration of groundwater into water resources management took time and cannot be seen as complete yet. The first National Water Resource Strategy (NWRS, 2004) did not see groundwater as a separate resource, requiring special focus and, where necessary, separate strategic plans. The national groundwater mapping programme (GRAI and GRAII) finally produced groundwater information on par with surface water information and allowed for the first time the inclusion of groundwater into Water Resources 2005 (now updated to WR 2012) and into national water resources panning.

As part of the national Department's restructuring in 2003 to prepare for its IWRM role and devolved management, specialist groundwater staff were integrated into various water management functions like Planning and Water Quality Management, and the Directorate Geohydrology was disbanded. Groundwater has benefited greatly from being rolled out as part of national planning, resource allocation and resource protection and its national visibility has increased significantly.

However, the disappearance of the Directorate Geohydrology resulted in a loss of critical mass and a rapid loss in overall groundwater capacity in the Department. This loss is of particular concern at a time when a National Groundwater Champion is needed to help new groundwater capacity in CMAs and in local government. It is clear that local government, which has the devolved water services responsibility, is presently unable to meet its objectives, including the achievement of the MDGs with respect to water and sanitation delivery, because of a complete lack of capacity for the sustainable utilisation and management of local groundwater resources. Lack of a national groundwater champion also prevents a proper synchronization of research and national development objectives and prevents the academic sector to fully play its science leadership role.

Box A: Groundwater Governance: Key deficiencies identified in global diagnostics

Groundwater management challenges are not unique to South Africa. Below are the findings of a global groundwater diagnostic, in which South Africa participated (Groundwater Governance, 2015).
The highest level challenges are very similar throughout the world.

- Inadequate Leadership from Government Agencies
- Limited awareness of Long-Term Groundwater Risks
- No Measurement of Groundwater Resource Status
- Non-Performing Legal Systems on Groundwater
- Insufficient Stakeholder Engagement in Groundwater Management
- Limited Integration of Groundwater in Related National Policies.

Groundwater Governance (2015)

The way forward

In the light of these general challenges, there has been a recognition, world-wide, that, with increasing level of groundwater development, there has to be an incremental institutional path, moving from technical development of the resource to groundwater management and ultimately to groundwater governance as part of IWRM. This is the path South Africa will also have to follow. <u>South Africa has the major benefit of a functioning legal and institutional framework for the water sector in which groundwater has already evolved considerably.</u> The Groundwater Strategy published in 2010 and the present moves towards a national framework strategy signify this development.

3. National Strategic Imperatives

3.1 Guidance from the NWRS2

The National Groundwater Strategy is an integral part of the National Water Resource Strategy of 2013 (NWRS2), which responds to South Africa's vision for 2030, as articulated in the National Development Plan (NDP) and to National Government Outcomes outlined in National Government's Programme of Action for 2010-2014. These priorities are key drivers for change and, as such, are the national strategic imperatives that shape the NWRS2 and the NGS.

Water has a critical role to play in the socio-economic development of South Africa. In its Vision 2030 within the National Development Plan (NDP) Government articulates the national development goal of eradicating poverty and sharply reducing inequality by 2030. To achieve this, Government has defined a New Growth Path (NGP), one of inclusive growth and development, with a focus on diversification and wide participation by South African citizens within a vibrant and growing economy. As water plays a central role in all sectors, including agriculture, energy, mining, industry, tourism, urban growth and rural development, the allocation, development and protection of water is an essential prerequisite for inclusive economic growth, poverty reduction and the significant reduction of inequality in South Africa.

High-level direction from the NWRS2 indicates the objectives of developing national water resources towards achieving SAs development priorities, namely:

- to support development and the elimination of poverty and inequality;
- to contribute to the economy and job creation; and
- to ensure water is protected, used, developed, conserved, managed and controlled sustainably and equitably.

Protection of water resources is necessary *for securing ecosystem services* for economic development and growth and protection of human and animal health. Protection of water resources encompasses management of quality and quantity of both surface water and groundwater and protection of the habitats.

Other relevant high-level direction includes:

- **Addressing past imbalances (access to water services, access to water resources, access to benefits from water resource use) will be a continued focus;**
- **Groundwater's role will be increasing; South Africa is experiencing water-stress and surface water resources are already limited in many catchments;**
- **Climate change will be an increasingly important driver of water availability and of water requirements;**
- **Groundwater must therefore be seen, throughout the country, as a high-priority conjunctive-use source option or, in the more arid regions, as a sole water source;**
- **Groundwater, compared to available surface water resources, still has significant potential for development.**

3.1.1. Future water needs and associated impacts

The most important consideration of the NWRS2 is that water is scarce and it requires careful management to enable provision of basic water services and equitable allocation, while meeting the needs of inclusive economic growth without threatening the integrity of aquatic ecosystems. Based on Reconciliation Strategies, surface water availability and its remaining development potential will not be sufficient to support the growing economy and associated needs in full. Surface water development potential only exists in a few water management areas, while serious challenges remain in the majority of water management areas. Also, surface water infrastructure development and the costs of construction and maintenance are prohibitive. Therefore, to meet growing needs, South Africa has to prioritise water use and consider other potential sources, including water re-use, desalination and groundwater utilisation, towards a mix of options available to supply the growing water requirements for equitable allocation for development and economic growth. To see groundwater also as a bulk water supply option will in many instances require a mind-set change.

As basis for the groundwater development and management as part of IWRM, the water needs of all the economic sectors as identified in the NWRS2 need to be considered (see below).

Table 1: Water needs of economic sectors in South Africa (NWRS2)

Agriculture sector
About 8.5 million people are directly or indirectly dependent on agriculture for employment and income. The sector contributes about 3% to the GDP and 7% to formal employment. The agricultural sector is made up of commercial farmers and subsistence farmers and about 1.3 million ha are irrigated. The New Growth Path (NGP) has set a target of 300 000 households in smallholder schemes by 2020 and 145 000 jobs to be created in agro-processing by 2020. Irrigated agriculture is the largest single user of water in South Africa (60%) and it has a huge potential socio-economic impact in rural communities. Water availability is the major limiting factor in the growth of this sector and poor water quality has a negative impact on agricultural exports and associated foreign income. The Irrigation Strategy for South Africa has set a target of an increase of more than 50% of irrigated land in South Africa. For future scenarios, the DWA assumes that the volume of water allocated for agriculture will remain the same.
Forestry sector
Development opportunities for forestry are confined to high rainfall zones, such as in the Eastern Cape. For the sector to grow, more forestry areas are needed, and growth can also be enhanced by downstream processing activities, such as sawmills, pulping and paper production. Downstream activities, however, may use considerable volumes of water and pollute water resources. Forestation will reduce streamflow and protect biodiversity, especially in KwaZulu-Natal, the Eastern Cape and, to a lesser extent, in Mpumalanga and Limpopo Provinces.
Mining sector
The country is renowned for an abundance of mineral resources, accounting for a significant proportion of both world production and reserves, and South African mining companies dominate many sectors in the global industry. Mining and quarrying contributed 4.9% to gross domestic product (GDP) in 2013. While mining's contribution to GDP has declined over the past few decades, this may be offset by an increase in the downstream or beneficiated minerals industry, which the government has targeted as a growth sector. The NGP has set a potential employment target of 140 000 new jobs by 2020 for the mining sector. Mining and related activities require significant quantities of water and impact on the environment through associated potential pollution. The mining sector is also faced with legacy issues of past pollution, for example, acid mine drainage. The development of new mines in water-scarce areas requires planning to make arrangements for the transfer of water and development of new sources, and appropriate attention to waste processing and remediation. There are thousands of mine workings that are abandoned or derelict in South Africa. At the same time, new mining operations are underway, particularly for coal and platinum. Some of these new mines are in water-scarce areas (for example, in the Lephalale and Steelpoort Valley areas) and these activities will put more pressure on the available water resource. Both abandoned and new mines also pose a water pollution threat.

Energy sector

Although only using 2% of the available water sources, this sector contributes about 15% to the GDP of South Africa and creates jobs for 250 000 people. The sector generates about 95% of South Africa's electricity and also exports it to countries in Africa. Power generation remains a water use of strategic importance.

Energy production capacity is expected to increase as the Department of Energy is planning significant investment in new power generation capacity. Current plans include building dry-cooled coal-fired power stations that will be more water efficient. However, these power stations are located in water-scarce areas, and would strain available water resources. The return to service of older power stations, which are wet-cooled, has further burdened available water resources. The NDP proposes the use of renewable energy sources to mitigate carbon emissions. Renewable energy, such as solar energy, may also need cooling water.

Manufacturing sector

South Africa has developed an established, diversified manufacturing base that has shown its resilience and potential to compete in the global economy. The manufacturing sector contributed 15.2% to the GDP and 13.3% to jobs in 2013. The NGP has set a target of 350 000 new jobs for this sector by 2020. Water is required in the manufacturing processes and it is used for cooling.

Tourism sector

Tourism is a vital contributor to the South Africa economy. In 2013 the sector contributed directly and indirectly 7% to the GDP and 9% to sustained employment of the country. This sector is earmarked for high economic growth, which is expected to generate a significant number of new jobs. The NGP has set a target of 275 000 new jobs by 2020. Drinking water quality that matches international standards and reliable water supply and sanitation services are critical to the success of this sector. Many tourism sites require on-going attention to aquatic ecosystems.

Water services sector

Local government, through a network of district and local municipalities, provides drinking water and sanitation services to residential, commercial, and industrial sectors of the economy. As such, it is a major user of water (27% of total water use in South Africa).

Climate change

Scenarios currently indicate that the net effect of climate change for South Africa will be a reduction of water availability, although impacts will be unevenly distributed, with the eastern coastal areas of the country probably becoming wetter. In the interior and the western parts of the country, climate change is likely to lead to more intense and prolonged periods of droughts. In general, climate change will probably lead to weather events that are more intense and variable, such as sudden high volumes of rainfall, leading to flooding.

3.2 Guidance from the National Development Plan

While taking its direction from the NWRS2, some areas are highlighted here where the unique characteristics and functioning of groundwater can be seen to have a unique response to the National Development Plan (NDP). In **Table 2** the different strategy themes of the NGS are mapped against Outcomes outlined in the National Government's Programme of Action for 2014-2019.

Table 2: Importance of various National Groundwater Strategy themes in terms of Outcomes outlined in the National Government's Programme of Action for 2014-2019.

No.	Priority Outcomes		NGS Links to Outcomes	NGS Theme*
1	Education	Quality basic education	*	11
2	Health	A long and healthy life for all South Africans	***	4,3, 5
3	Safety	All people in South Africa are and feel safe	-	
4	Economy	Decent employment through inclusive growth	**	1, 5, 7, 8
5	Skills	A skilled and capable workforce to support an inclusive growth path	**	11, 9, 6
6	Infrastructure	An efficient, competitive and responsive economic infrastructure network	***	5, 7, 8
7	Rural Development	Vibrant, equitable, sustainable rural communities contributing towards food security for all	****	1, 5, 7, 8, 12
8	Human Settlements	Sustainable human settlements and improved quality of household life	***	5, 4. 3, 7, 8
9	Local Government	Responsive, accountable, effective and efficient local government	**	3, 6, 11
10	Environment	Protect and enhance our environmental assets and natural resources	*****	Most
11	International	Create a better South Africa and contribute to a better Africa and a better world	***	10, 5, 9, 11
12	Public Service	An efficient, effective and development-oriented public service	**	2, 3, 6, 8, 9
13	Social Protection	A comprehensive, responsive and sustainable social protection system	-	
14	Nation Building	A diverse, socially cohesive society with a common national identity	**	1, 6, 12

* developed in Chapter 7

Box B: Goal 6: Water and Sanitation in the Sustainable Development Goals (SDGs)*

- By 2030, achieve universal and equitable access to safe and affordable drinking water for all
- By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations
- By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally
- By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity
- By 2030, implement integrated water resources management at all levels, including through transboundary cooperation as appropriate
- By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes
- Support and strengthen the participation of local communities in improving water and sanitation management.

United Nations (2015)

*2015 UN-Water Annual International Zaragoza Conference. Water and Sustainable Development: From Vision to Action. 15-17 January 2015

Issues that stand out are the (potential) contributions of improved groundwater governance to human health, rural development, human settlements, water infrastructure development, enhanced environmental assets and a contribution to development on the continent. A more detailed analysis is presented in **Appendix 1**.

Aspects for consideration in the National Government strategy include:

- Enabling agricultural development for food security as well as job security through groundwater's untapped role in smallholder irrigation;
- Systematic planning and implementation for groundwater to play its critical role in drought emergencies; and
- Fully visualizing and developing the role of women in local groundwater resource development and management.
- Shale gas development and groundwater resource protections.

It is important to note that the NDP was written with a surface water focus. The Groundwater Strategy will have to inform and guide the agricultural sector about the realistic potential of groundwater for their development objectives.

3.2.1 Sustainable Development Goal 6: Clean Water and Sanitation

In 2015 the United Nations General Assembly adopted the 2030 Agenda for Sustainable Development (see **Box B**) in which universal access to clean water and sanitation became one of 17 Global Goals in the international sustainable development agenda. Achieving this goal will, on the one hand, require a major investment in adequate infrastructure and, on the other, the protection and restoration of water-related ecosystems such as forests, mountains, wetlands and rivers in order to mitigate water scarcity. More international cooperation is also needed to encourage water efficiency and support treatment technologies in developing countries. An integrated approach is crucial for progress across the multiple goals.

The overarching areas of concern highlighted in these goals include [universal] access to drinking water and sanitation; sustainability of water resources; disaster risk management;

climate resilience, adaptation and mitigation; management and governance; rights and equity; economic benefits of allocation; monitoring of water resources and SDG targets; and cross-cutting issues, such as the water-food-energy nexus. Groundwater is not explicitly included or its role taken into consideration. An integrating proposal that had initially been made for inclusion was (IGRAC, 2015):

"sustainable development, management and use of surface and groundwater resources, respecting ecosystems requirements."

UNESCO's International Groundwater Assessment Centre (IGRAC) is committed to still help craft SDG targets, which take into account the role of groundwater in sustainable development and to mobilize the network of global groundwater professionals as required to meet the SDG targets and satisfy the post-2015 development agenda. Its recommendations are shown below as an important direction for the National Groundwater Strategy.

Table 3: Examples: Incorporating Groundwater into Global SDGs for 2030 on Water and Sanitation (IGRAC, 2015))

Target Areas	Examples of Groundwater Goals
Target Area 1: Access to Drinking Water, Sanitation and Hygiene	Enhance the role of groundwater in sustainably providing water, sanitation and hygiene Ensure that wells are built and maintained to provide long-term and safe access to groundwater resources
Target Area 2: Improved Water Quality and Waste Management	80% of drinking water wells should be protected from contamination Reduce by 25% the volume of contaminated groundwater
Target Area 3: Sustainable Use and Development of Water Resources	Decrease by 30% the number of aquifers which are overexploited and/or severely contaminated Increase by 30% the number of aquifers monitored for changes in quality and quantity Utilize non-renewable groundwater in a socially acceptable manner
Target Area 4: Disaster Risk Management	Enhance drought and flood preparedness by both including groundwater monitoring in early warning systems and groundwater wells in emergency water supply schemes Utilize storage and buffering capacity of groundwater to increase resilience to natural disasters
Target Area 5: Water Governance, Rights, Equity, Peace & Security	Include groundwater in integrated water resource management and planning, especially when implementing conjunctive use schemes Equitably and transparently distribute rights to groundwater, taking into account traditional use

4. Groundwater resources availability and utilisation

4.1 Groundwater occurrence

Water not only covers three quarters of the Earth's surface: it is also present almost everywhere below ground surface, down to considerable depth and in continuous motion. It represents an invisible component of the hydrosphere and of the water cycle. This groundwater represents by far the biggest portion of all liquid (not frozen) freshwater on earth – about 96% (see figure below). In comparison, the global volume of freshwater in lakes is less than 1% of the total fresh groundwater volume (see **Figure 1**).

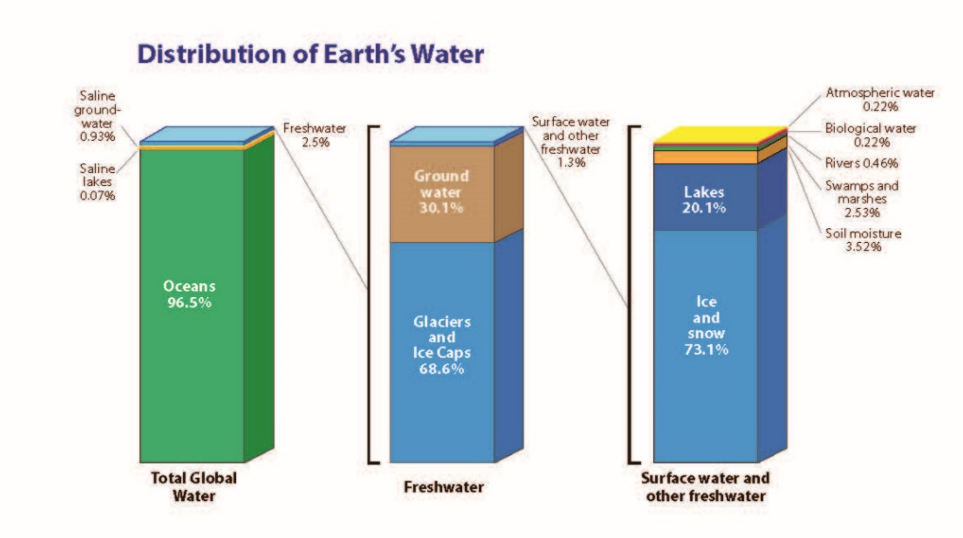


Figure 1: The groundwater portion of the earth's freshwater

4.2 Groundwater occurrence in South Africa

South Africa's aquifer systems have received their water-bearing properties, in particular the permeability, through the region's historical geological and hydrological development and as a result of the physical and chemical composition of the different rock types. **Figure 2** illustrates the main types of permeability found in different rock types. Permeability is termed primary if it is formed as the rock is formed (intergranular) and secondary if it is formed in the rock formation itself (fissures and caverns, fractures, joints and faults).

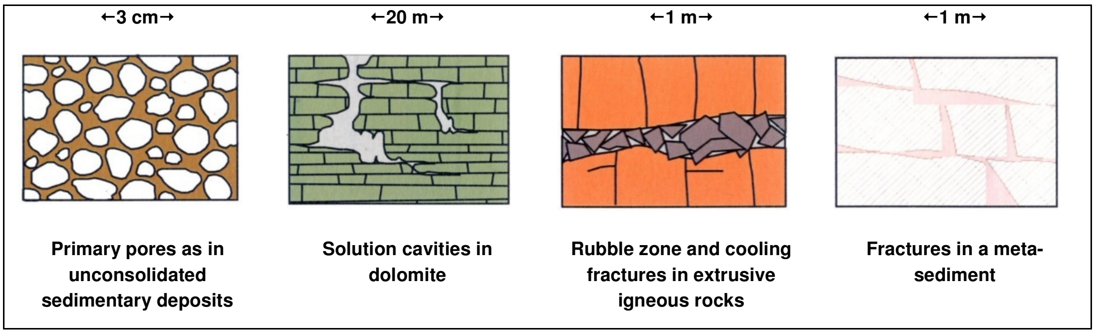


Figure 2: Different aquifer permeability types (Colvin, 2000)

The simplified geology map in **Figure 3** enables a national-scale view of the main aquifer types in South Africa based on the aquifer properties of the main lithology (rock type) of the different rock strata.

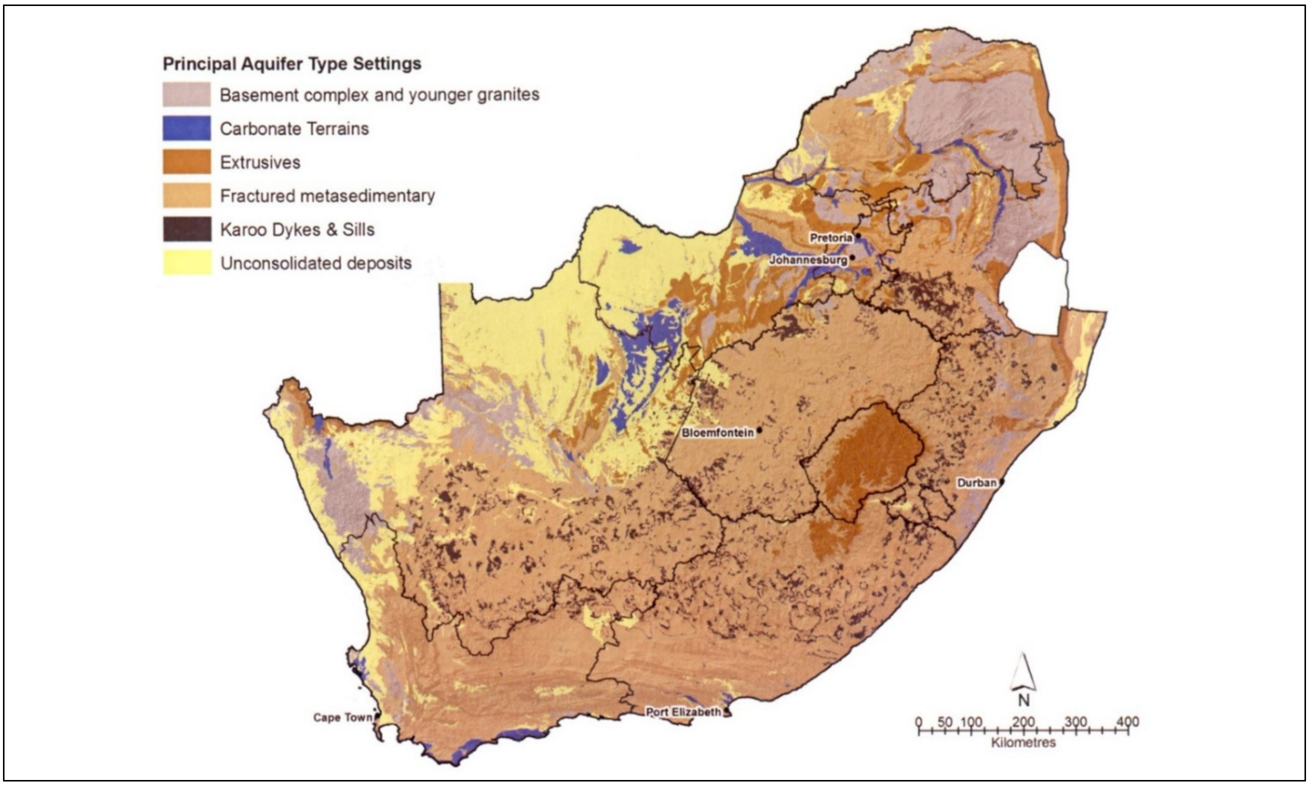


Figure 3: Main aquifer types in South Africa

More than 90% of South Africa is underlain by hard-rock, or secondary, aquifers controlled by secondary faulting and jointing. Primary (sandy) aquifers generally are restricted to the coast, alluvial valley deposits and the Kalahari.

A very pragmatic aquifer classification was already developed in 1995 to support the regulatory system developed by the then Department of Water Affairs and Forestry – see (Parsons, 1995).

Table 4: Aquifer Systems in South Africa (after Parsons, 1995)

AQUIFER SYSTEM CLASSIFICATION	COVERAGE OF COUNTRY (%)	GENERAL LOCATION
MAJOR AQUIFERS	**18**	Primary aquifer systems along the coast; Dolomitic systems in parts of Gauteng, Mpumalanga, the Northern Cape and North West Province; Rocks of the Table Mountain Group bordering the Cape coast; Parts of the Karoo Supergroup; Cities and towns receiving water from major aquifer systems are Pretoria, Mmabatho, Atlantis, St. Francis Bay and Beaufort West.
MINOR AQUIFERS	**67**	Minor aquifers occur widely across South Africa with variable borehole yield and water quality. They supply many smaller settlements, e.g. Nylstroom, Williston, Carnarvon and Richmond.
POOR AQUIFERS	**15**	Poor aquifers occur mainly in the dry northern and western parts of the country. The generally low borehole yields of poorer quality are, however, still of critical importance to small rural communities.

A map showing the spatial distribution of major, minor and poor aquifers is shown in **Figure 4.** The map also shows locations where groundwater sources are used, either as sole source or in combination with surface water sources.

A critical characteristic in terms of groundwater's exploitation is the depth that has to be drilled to encounter groundwater. This is expressed as the depth to the first water strike and the country-wide situation is shown in the map**, Figure 5**. This depth ranges between 30 – 60 m for large parts of the country, to over 120 m, in particular under the deep sand cover in the Kalahari.

The thickness of the water-saturated formation determines the storage of an aquifer. This is particularly important in times of drought. However, the sustainable utilization of an aquifer is dependent on its natural replenishment or recharge, just as in the case of river flow. The management task is to ensure that utilisation stays within the limits imposed by rainfall and recharge. Groundwater differs from rivers in that the response to rainfall is not "flashy", but reflects over a period of months or even years. The response to droughts is also much slower, with groundwater therefore a far more buffered resource than surface water. Surface characteristics and geology can result in 'preferential recharge areas' and it is important to know and understand these. A project supported by the WRC is presently underway to map these areas, so that they can be better protected (Nel et al., 2013; Nel et al., 2015).

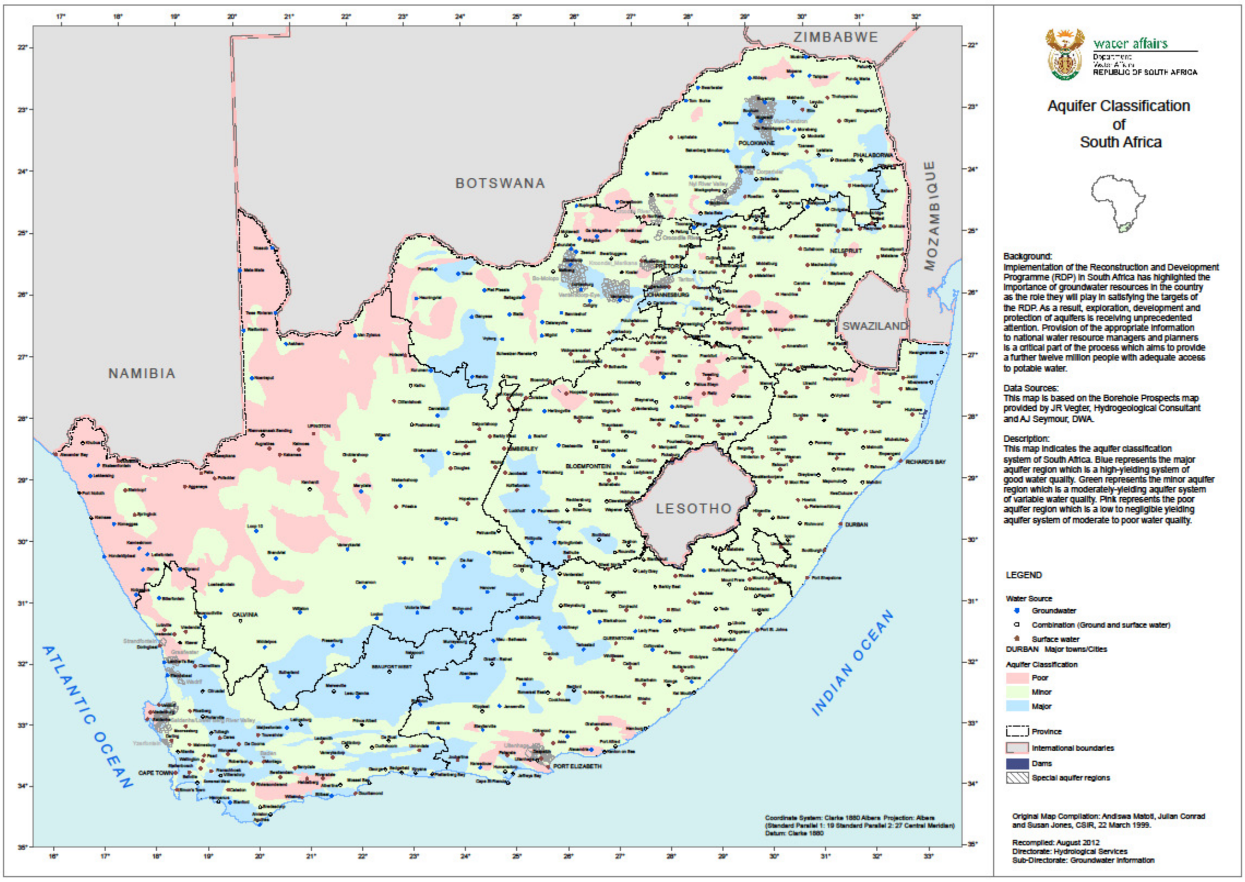


Figure 4: Aquifer classification in South Africa

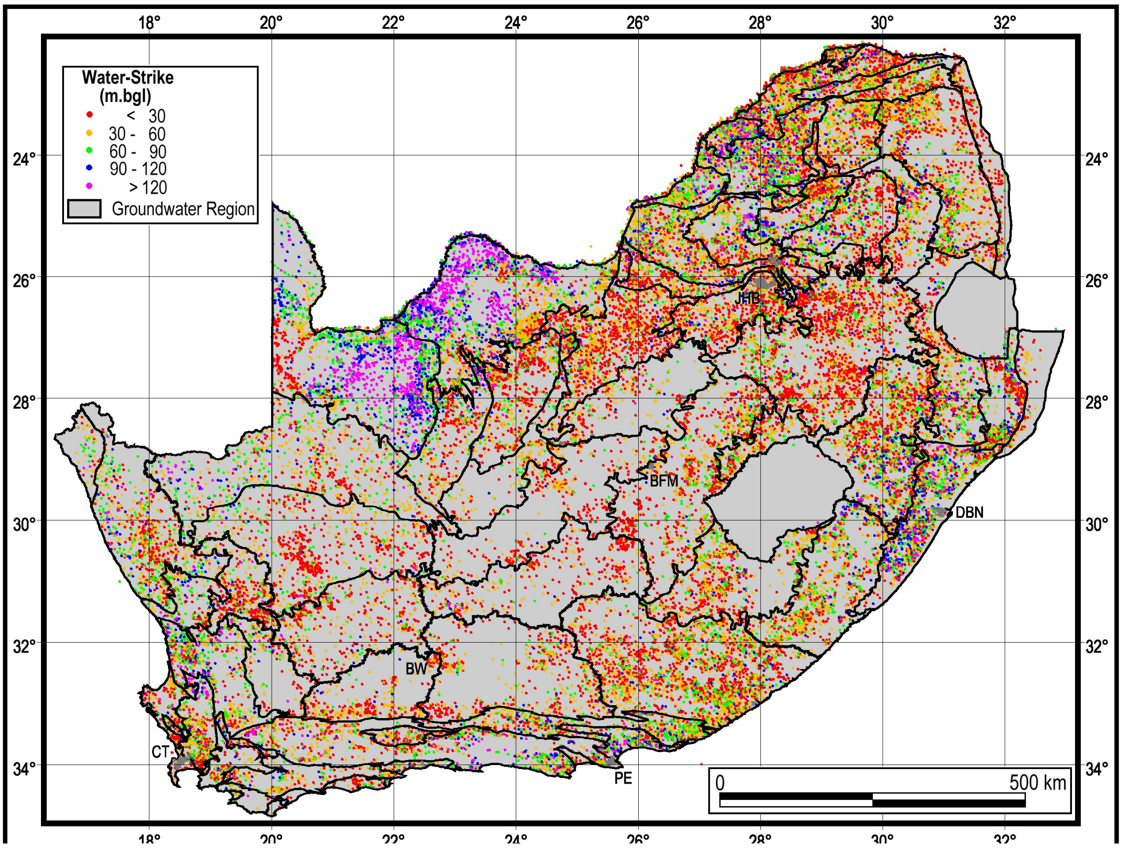


Figure 5: Depth to Water Strike in South Africa

4.3 Groundwater – environment linkages

An aquifer – literally a 'water carrier' – is both a reservoir and a transport channel. Groundwater flow in an aquifer is governed by the aquifer's intrinsic characteristics (shape, size, permeability etc.) but also by its recharge, largely produced by infiltration of precipitation. Most of the groundwater flow eventually ends up in springs and streams. In coastal areas there may be a significant outflow into the sea. Groundwater recharge and groundwater discharge are thus the links between groundwater and the other components of the water cycle. This is illustrated in the water cycle diagram (**Figure 6**) below (Colvin et al., 2007).

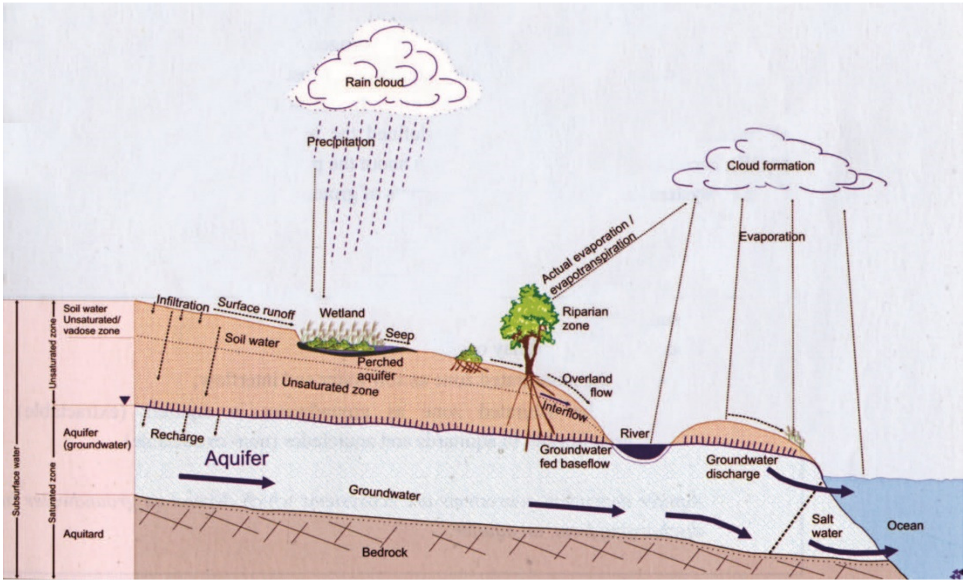


Figure 6: Subsurface and surface flows of water in the environment (Colvin, et al., 2007)

Wherever groundwater flows or discharges to the surface, Aquifer-Dependent Ecosystems (ADEs) can occur. Their identification is often difficult, but a type-setting and identification study has been undertaken to guide groundwater management and allocation (Colvin et al., 2007). Examples of known South African Aquifer-Dependent Ecosystems include:

- in-aquifer ecosystems in the dolomites (North West Province);
- springs and seeps in the TMG sandstone (Western Cape);
- terrestrial keystone species such as Acacia erioloba in the Kalahari;
- lakes and punctuated estuaries on the shallow sand aquifers of the east and south coast;
- riparian zones in the seasonal alluvial systems of the Limpopo;
- seeps on the Karoo dolerite sills.

A first overview of the types of ADEs which are known and thought to occur in South Africa was provided by Colvin et al. (2007). **Figure 7** from their report shows vegetation groups with a high, medium and low probability of being linked to aquifers.

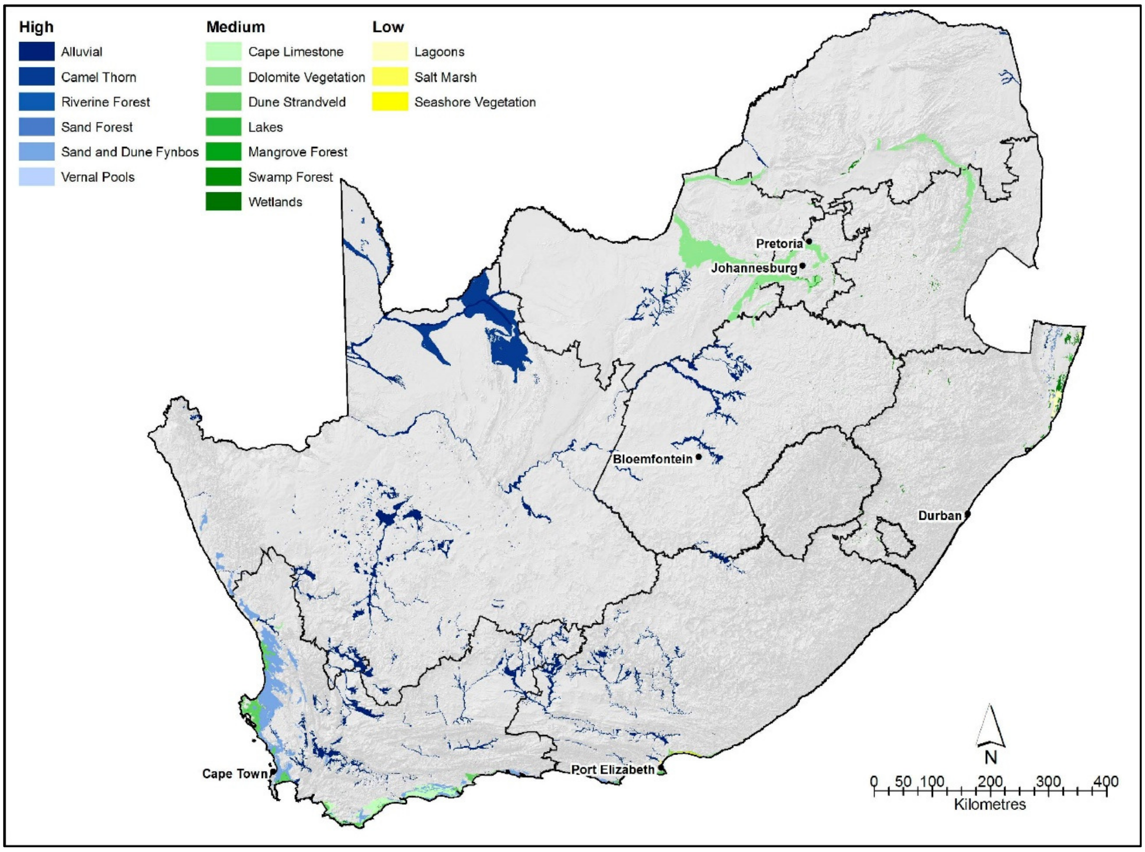


Figure 7: Groups of vegetation types with a high, medium and low probability of being aquifer dependent, (Colvin, et al., 2007)

An important groundwater – ecosystem linkage is the dry-weather flow in a stream or river, called base flow, resulting largely from groundwater seeping into riverbanks or the riverbed. The map below (**Figure 8**) provides a country-wide indication of the amount of baseflow in our rivers. It illustrates the typical semi-arid to arid climate situation in large parts of the country in which groundwater tables are too deep to contribute to river baseflow. However, groundwater is still discharged from the system by means of evaporation and evapotranspiration.

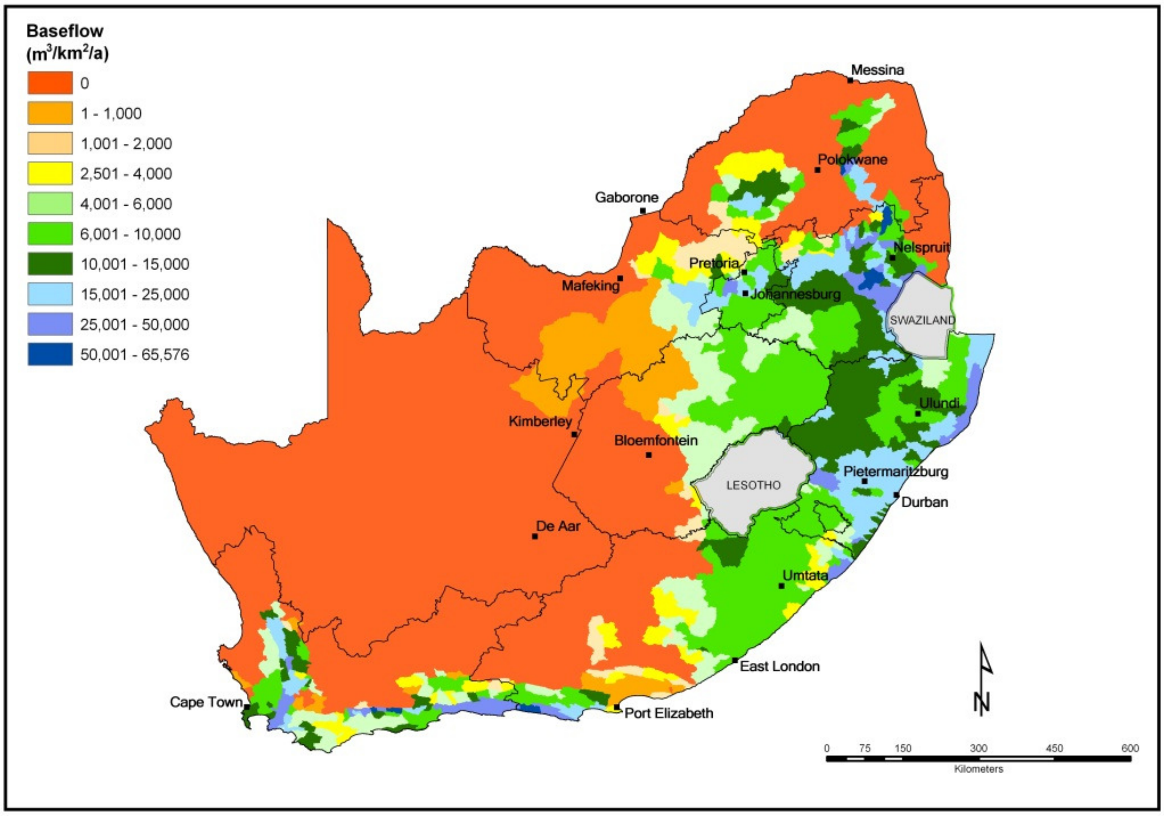


Figure 8: Groundwater contribution to baseflow

4.4 Groundwater resource potential

The systematic country-wide quantification of our groundwater resources as we have it today, followed out of a national groundwater mapping programme of the Department of Water Affairs and Forestry, launched in 1992, jointly with the Water Research Commission. Its first output, largely based on the life-long work of J.R. Vegter, was a series of national maps and an explanatory document published by the Water Research Commission (Vegter, 1995). In parallel, over the period 1995-2003, the Department published a set of 21 hydrogeological maps covering the country at a scale of 1:500 000, with accompanying explanatory booklets.

Because of the immediate demand for this type of information by the Department's water resources planners, a further phase of national assessment and quantification of groundwater resources at quaternary catchment level followed (2003-2005), aided by a consortium of consultants and culminating in the Groundwater Resource Assessment Phase 2. Importantly, the fourth iteration of the Surface Water Resources of South Africa (2004-2007) for the first time included groundwater, drawing largely on the database and outputs from the GRA 2 project.

Some key findings from the above studies, also summarised in the Department's Groundwater Strategy (DWAF, 2010), are shown below. The total volume of available, renewable groundwater in South Africa (the Utilisable Groundwater Exploitation Potential – see **Figure 9**) is 7 500 million m³/a, allowing for factors such as physical constraints on extraction, potability, and a maximum allowable drawdown. Current use is between 3 000 and 4 000 million m³/a. There is thus the potential to considerably increase groundwater supplies in South Africa. In contrast, the assured yield of South Africa's surface water resources is approximately

12 000 million m³/a, but more than 80% of this is already allocated. As the National Water Act had indicated in 1998, groundwater is indeed a "significant resource".

It must be remembered that this groundwater is not evenly distributed, but spread variably, often thinly, over the whole country. This can be an advantage in providing water for small-scale local use, but to utilise it for bulk water supply to larger centres of demand, may require a large number of boreholes and connecting pipelines. This may not always be economic, and operation may be a major consideration.

The quality of South African groundwater is generally of a potable standard (the shades of blue in **Figure 10**). Salinity of water can be measured as electrical conductivity, expressed in units of mS/m. The target water quality is between 0 and 70 mS/m and above 150 mS/m water will have a marked salty taste. Highest salinities occur in the very arid regions and in some coastal regions. Depending on the geological formation, individual quality constituents can sometimes exceed the drinking water limit, for example flourides in parts of the North West Province.

Pollution of groundwater can be a serious problem, because the impacts of activities on the land surface are poorly understood and contamination of the underground source can go undetected for a long time.

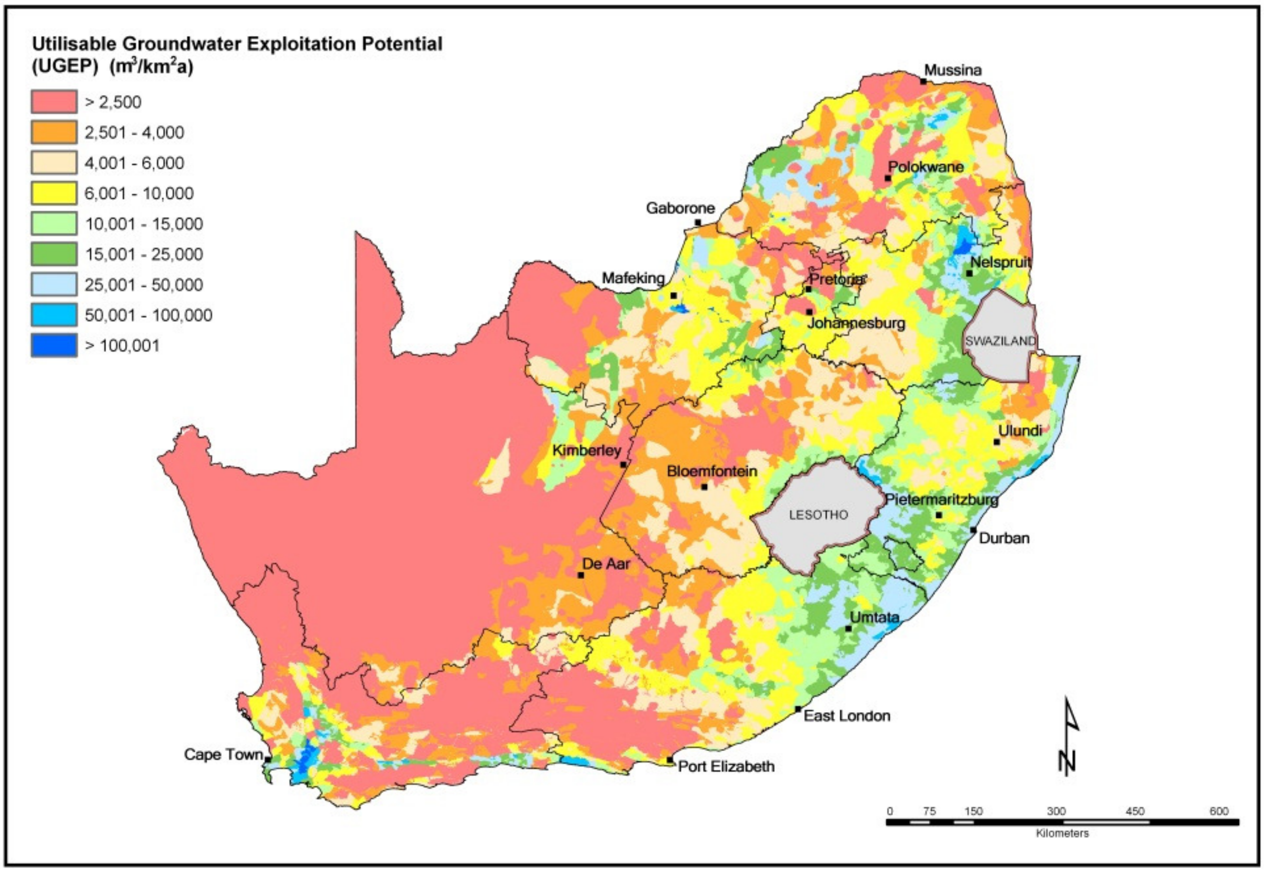


Figure 9: Utilisable Groundwater Exploitation Potential

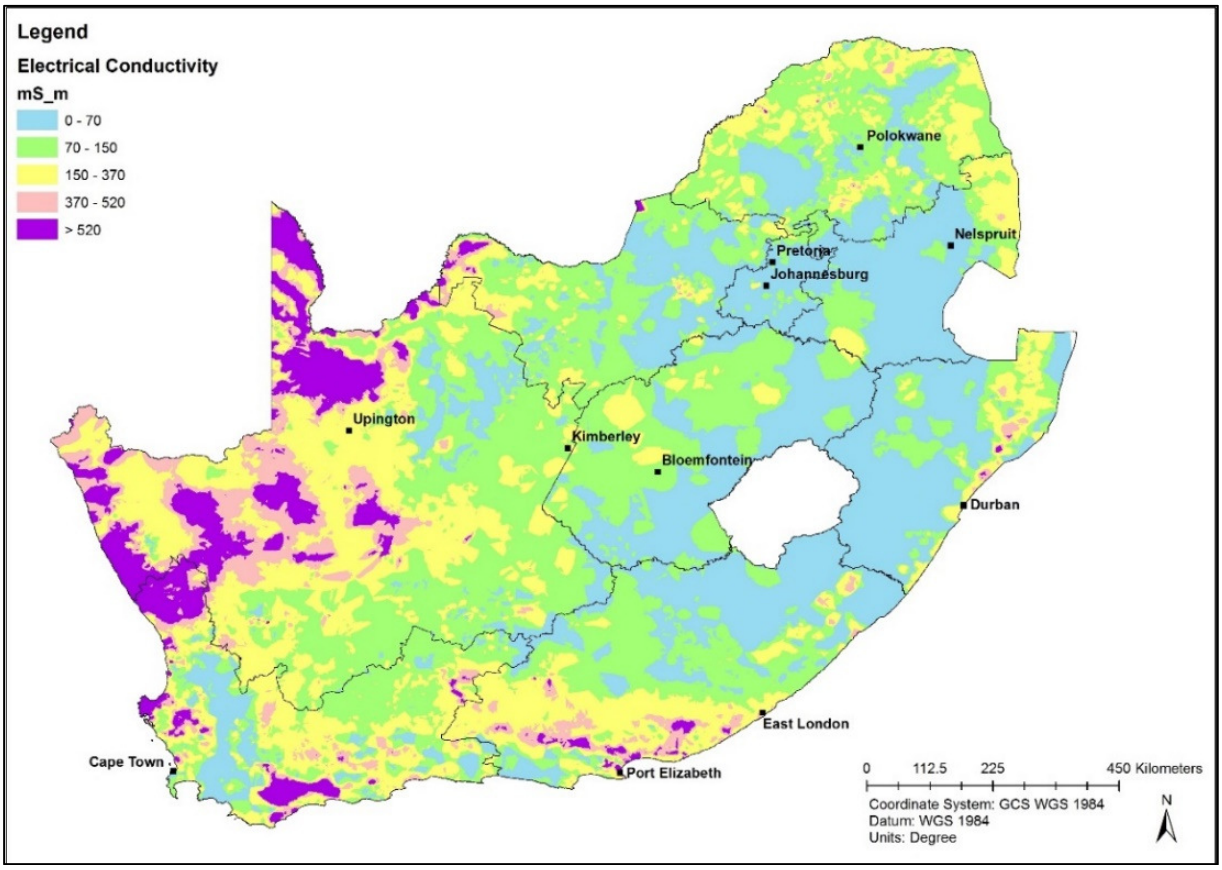


Figure 10: The potability of South African groundwater (after Murray et al., 2012)

4.5 Groundwater development

The exploitable groundwater resources of an area cannot be assessed properly without taking into account the practicalities of getting access to the groundwater and withdrawing it. Both are highly dependent on characteristics of the aquifer (depth, permeability etc.). The most economical are obviously the situations where no external energy source is required to lift the water to the surface, for example springs or flowing (artesian) boreholes. Pumping leads to energy requirements and thus higher production running and maintenance costs.

There are many different cost items involved in the drilling of a borehole. Below an example from sub-Saharan Africa of drilling a 50m deep borehole at an average cost of US$ 129 per meter, i.e. nearly R 2000 per meter drilled (Danert et al., 2014). With this type of cost, the importance of professionalism in all aspects of the work, in particular the siting, drilling and equipping of the borehole, cannot be stressed enough.

Table 5: Example of Borehole Cost Breakdown (Danert, 2014)

Item	Unit	Quantity*	Rate ($)	Amount ($)
Siting	Lump sum	1	400	400
Mobilisation & demobilisation	Lump sum	1	1 538	1 538

Drilling	m	50	40.1	2 005
Casing & Completion	m	50	21.2	1 060
Well development & pumping test	Lump sum	1	478	478
Platform casting & pump Installation	Lump sum	1	935	935
Water quality testing & disinfection	Lump sum	1	50	50
Total cost				6 466
Average cost ($/m)				$ 129.3/m

* 110 mm diameter u PVC lined borehole; 50 m deep; drilled by drilling rig costing $ 170 000, depreciating over 10 000 hours.

In a breakdown of costs and resource valuation, the wellfield operation costs make up a very important element of overall costs. At present, capital costs still tend to be considered in far more detail than the recurrent costs. Groundwater sources in South Africa today are often attended only when they fail, and indications are that this is a much more costly approach than providing for ongoing management sustainable operation and maintenance.

4.6 Groundwater utilization

Groundwater contributes 15 % of all the water resources been used in South Africa**. Figure 11** below provides a breakdown of groundwater use for different economic sectors and **Figure 12** indicates how this is further broken down into different Water Management Areas. Large volumes of groundwater are used for irrigation in the drier, more sparsely populated west of the country. Such a volumetric aggregate is however not always a good reflection of the importance of groundwater for a specific sector.

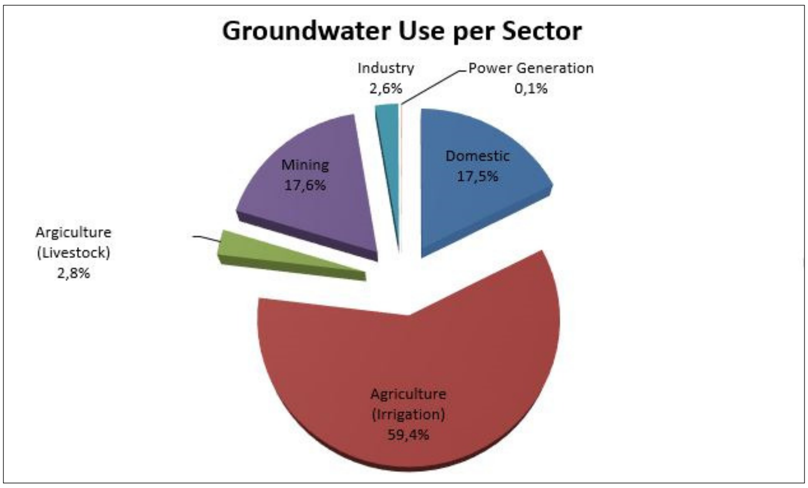


Figure 11: Breakdown of groundwater use for different economic sectors

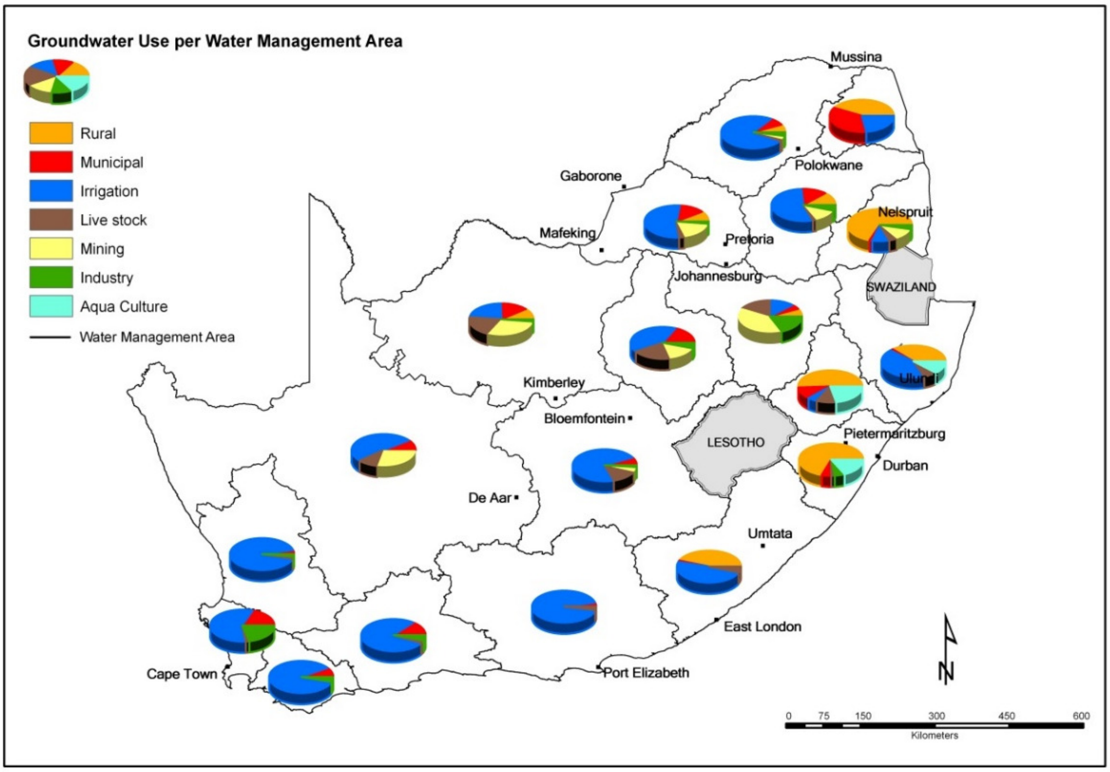


Figure 12: Groundwater use in the different Water Management Areas

The Reconstruction and Development Programme (RDP) and subsequent plans and strategies have enabled major progress in supplying our citizens with an improved water supply since 1994. According to the 2010 Millennium Development Goal (MDG) Report (UNDP, 2010) in 1996 only 61% of the national population was using an improved drinking water source. In 2013 that figure stands at 95% (DWA, 2013), meaning that South African has easily achieved its MDG obligation in relation to water. This achievement would not have been possible without groundwater becoming an important source. In 5 of the 9 provinces more than 50% of settlements now have a groundwater supply, Limpopo leading with 84% followed by North West and Northern Cape Provinces, both with more than 65% of communities supplied from groundwater. In terms of volumes, it represents a very small portion of the overall water supplied, but in terms of the national objective of development and the elimination of poverty and inequality, it represents major progress.

Groundwater is becoming increasingly important for urban water supply. 22% of towns use groundwater as sole source and another 34% in combination with surface water. Water sources of domestic water supply (urban & rural) are shown in **Figure 13**.

A major advance towards improved development and management of the country's groundwater resources has been that groundwater use has been registered for the first time in terms of the provisions in the National Water Act, 1998. **Table 6** below presents a summary from the Departmental WARMS database of the groundwater use per economic sector for each of the 9 Water Management Areas.

A critical next step is the verification of this registered groundwater use. It will require the participation of groundwater stakeholders and could thus lay the foundation of improved groundwater governance and eventually protection.

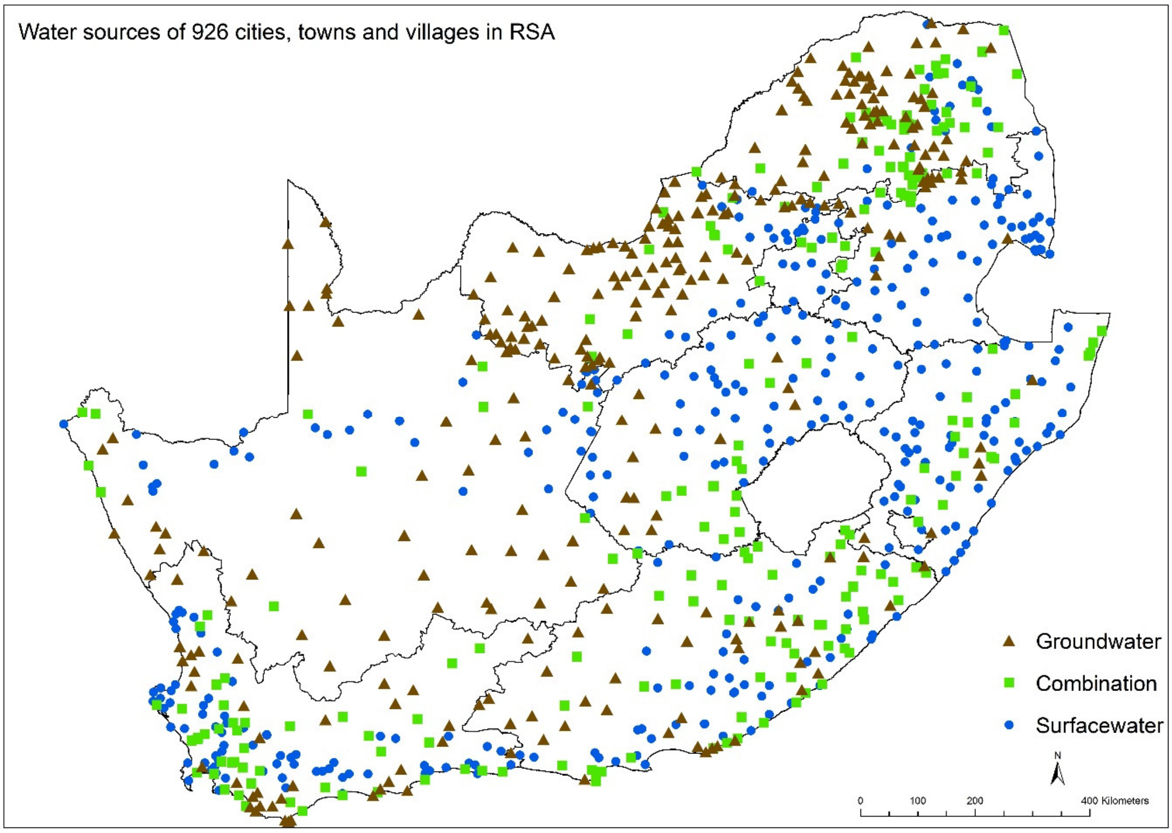


Figure 13: Water sources of domestic water supply (urban & rural)

Table 6: Sectoral groundwater use according to WMA (million m3/annum) (WARMS, DWS

WMA	Domestic	Agriculture	Mining	Industry	Power Generation	Total	Groundwater use as % of total use
LIMPOPO	258.01	510.02	37.39	17.61	0.00	823.03	30%
OLIFANTS	36.08	171.38	344.23	6.06	0.64	558.38	21%
INKOMATI-USUTHU	18.47	17.40	3.96	1.65	0.04	41.52	2%
PONGOLA-UMZIMKULU	7.47	8.32	0.04	2.66	0.01	18.51	1%
VAAL	57.36	366.80	125.15	22.05	0.00	571.35	21%
ORANGE	12.45	133.13	2.61	3.02	0.09	151.30	6%
MZIMVUBU-TSITSIKAMMA	51.48	83.40	0.26	1.71	0.28	137.13	5%
BREEDE-GOURITZ	19.32	192.30	0.05	6.16	0.00	217.83	8%
BERG-OLIFANTS	4.46	183.74	0.66	15.18	0.04	204.07	7%
TOTAL	465.10	1666.49	514.34	76.10	1.09	2723.13	

2016)

5.5. Objectives and principles

5.1 The objectives of the NWRS2

VISION The water sector vision for the National Water Resources Strategy 2, as aligned with the vision of South Africa 2030, is: Sustainable, equitable and secure water for a better life and environment for all.
GOAL Towards achieving this vision, the overall goal is: Water is efficiently and effectively managed for sustainable growth and development.
OBJECTIVES **1**: Water supports development and the elimination of poverty and inequality. 2: Water contributes to the economy and job creation. 3: Water is protected, used, developed, conserved, managed and controlled sustainably and equitably.

5.2 The objectives of the NGS*

VISION Our Precious Shared Groundwater Resource Sustaining Life, Environment and Development throughout South Africa.
MISSION To ensure sustainable, accessible and cost-effective groundwater supplies for human survival and socio-economic development, while maintaining the environmental services that groundwater is supporting, in an integrated development approach.
OBJECTIVES 1: To achieve improved rural water supplies for basic and livelihoods needs from groundwater and other local sources. 2: To achieve sustainable small town / village supplies from groundwater, practicing integrated water resource management at local scale. 3: To improve water security for urban development from groundwater through a range of conjunctive-use options, integrated with waste water management. 4: To expand irrigated agriculture, especially for small-scale and supplementary irrigation from groundwater, with focus on sustainability and appropriateness and cost-effectiveness of technology. 5: To develop new groundwater sources in increasingly complex locations, including brackish water, for industrial / mining supply in situations of increasing water scarcity. 6: To achieve appropriate groundwater resource governance and sustainable resource utilization at all levels through national / regional facilitation (resource assessment and planning, setting of norms, regulation, user empowerment, institutional development) of local participative actions (joint use, management and protection of common resources). * to be refined with stakeholders

5.3 Principles to inform the NGS

A number of principles guide how governance of groundwater translates into practice. The principles below have emerged from the global groundwater diagnostic already referred to (Groundwater Governance, 2015) and have been combined with groundwater and development principles experienced in South Africa.

Unique Development Role

Groundwater is a key resource for poverty reduction and for the economic development of rural and peri-urban areas, because of its ubiquitous occurrence and its protected/buffered nature.
Using this role, the country could be broadening its current focus on human rights to water beyond access to drinking water and sanitation provision to providing integrated services to enhance livelihoods of especially the poor.

Conjunctive use

Groundwater should not be managed in isolation, but conjunctively as appropriate with other water sources to improve water security and assure ecosystem health. Natural storage of groundwater systems is their most valuable asset. This allows maximizing the productive capacity across a flow system (surface and / or groundwater) through conjunctive use by taking 'the right water, from the right place, at the right time'.
This gives groundwater a critical role in adaptation to climate change. It also allows for step-wise and adaptive development of resources.

Protection of a vulnerable system

Land-use exerts a major influence on groundwater in terms of contamination from a wide range of activities and through impacting groundwater recharge processes. The potential negative impacts are enhanced by ignorance and by the unseen nature of groundwater.
Groundwater recharge zones are thus in urgent need of protection from pollution and degradation and for this groundwater management needs to be harmonised with land management.

Co-governance of subsurface space

Effective groundwater governance requires co-governance of subsurface space – a concept, which is still in its infancy, but needs to be developed. In South Africa this principle will be well understood because of the risks presented to whole regions through shale gas development presently under consideration.

Unique management requirements

Groundwater's life-sustaining role and vulnerable character requires holistic approaches to resource management and protection – in particular integrated water and sanitation delivery.
Institutions and approaches need to be attuned to local conditions (wide-spread distribution and physical complexities as well as social acceptance as private resource). Generally these conditions:

- limit direct government interventions and needs focus on preventative management approaches;
- bring out the importance of involving local communities (most familiar and most directly affected) in the management of groundwater resources;
- may require novel approaches of valuing, planning, and implementing widely distributed systems;
- make it clear that investing in education of stakeholders will always be critical and will ultimately lead to a society-driven sustainable development.

This management approach must be led, nurtured and supported by a national government 'groundwater champion'.

Integrated Water Resource Management

Despite some unique characteristics and development requirements and challenges, groundwater is an integral part of the hydrological cycle. Principle 2 of the fundamental principles underpinning the National Water Act, 1998 declares groundwater fully subject to national control and part of IWRM, which is the vision of the Act.

> ***'All water, wherever it occurs in the water cycle, is a resource common to all, the use of which shall be subject to national control. All water shall have a consistent status in law, irrespective of where it occurs.'***

Integration must take place at three effective levels, integration within the hydrological cycle (the physical processes), integration across land and water, across catchments and aquifers (spatial integration), and integration across the overall social and economic fabric from national to local level.

Importantly, there needs to be coordination with the macro-policies of other sectors – such as agriculture, energy, health, urban and industrial development and the environment. In many cases policy action in these sectors holds the key to groundwater resource sustainability.

Groundwater in South Africa has benefited greatly from being developed within an IWRM framework across the full spectrum of policy, regulations, institutional development, protection, planning and information management. The roll-out of the NGS will have to continue within this overall framework.

6. Groundwater Governance

6.1 The concept of governance

The water community has increasingly emphasized that the global water crisis is centrally a crisis of governance. The first key message from the final report of the 2012 Marseille World Water Forum expresses this clearly - The 'water crisis' the world community faces today is largely a governance crisis. Securing water for all, especially for vulnerable populations, is often not only a question of the water resources situation (water availability, quality, supply, needs) and financing, but equally a matter of good governance.

Governance has recently been defined by the UNDP as:

> ***'the exercise of political, economic and administrative authority in the management of a nation's affairs at all levels — and thus comprises the mechanisms, processes and institutions through which the citizens of the nation articulate their interests, mediate their differences and fulfill their legal rights and obligations."***

Governance is a broader notion than government, is dynamic in nature and enmeshed in the social, economic, biophysical and political landscape in which it occurs. Key principles that underpin good governance include participation, transparency, equity, accountability, coherency, responsiveness and being integrative.

6.2 Groundwater governance

Appropriate governance is particularly important for groundwater, a very complex common pool (open access) resource. Because of its ubiquitous nature and relative ease of local access, there are widely distributed and generally dispersed abstraction points and many stakeholders, who are involved in its development, use, as well as misuse. Also, changing land-use patterns through agricultural intensification, urbanization and deforestation have wide-ranging impacts on resource recharge and quality. Determining who is implicated and who should be involved in conserving and protecting aquifers to maintain a set of groundwater uses is a key challenge for groundwater governance. Principles for the governance of 'common pool resources' were first defined by Ostrom (see **Box C**). The above considerations complicate the traditional national approaches to resource regulation and require a very high degree of participative management. These also require novel approaches to the systematic planning, financing and implementation of hundreds and even thousands of small, locally-dispersed groundwater schemes (Braune et al., 2008 and Burke and Moench, 2000).

Box C: Ostrom Principles to Counteract the 'Tragedy of the Commons'

In 1968 Grant Harding first coined the expression 'tragedy of the commons' in respect of 'common pool resources – defined as 'natural resources that are difficult to divide up or to fence in, for which what one resource user does can effect what is available to other users'. For almost 40 years subsequently Elinor Ostrom (Nobel Laureate for Economics 2009) has been leading research and analysis to understand how institutions for the regulation of many types of 'common pool resource' can be developed, sustained and modified, how and why they are (or are not) effective, and how best to transfer such knowledge (Ostrom, 1990).

In relation to the governance of groundwater, a very important common pool resource, application of the Ostrom Principles would suggest that the following general approach is required:

- Clearly-defined boundaries for the purpose of resource evaluation and allocation
- Congruence between resource allocation and the prevailing local conditions and constraints
- Formal recognition by government of the rights of the community to organise resource use
- Collective arrangements for the participation of stakeholders in decision-making
- Layers of nested stakeholder groups to cope with larger resource systems
- Effective monitoring by persons who are part of, or accountable to, stakeholders
- Graduated sanctions on resource users who do not respect the communal rules
- Conflict-resolution mechanisms which are readily accessible and of low cost

This outline structure is the approach that has been advocated for promoting sustainable groundwater resource management by the GW•MATE initiative of the World Bank in their excellent briefing Notes Series on groundwater resources governance (Foster and Kemper, 2002-2009).

It is important not to lose sight of major emerging issues and technologies that will have implications for groundwater governance. The disposal of nuclear waste is one extreme example, as is the use of hydro-fracturing to mobilise shale gas. Others will include the storage of carbon dioxide, the continuing threat of acid mine drainage and the deeper encroachment of the built environment. These will continue to pose new governance challenges.

With the focus on local stakeholder involvement, a number of major issues will have to be addressed from the beginning of the roll-out of this strategy to encourage stakeholders to be more willing to contribute to the management efforts, in particular (Burke and Moench, 2000):

- Proper valuation of groundwater: stakeholders respond to economic factors
- Scientific understanding and reliable supporting data: without understanding, people are often unwilling to act
- Education and social ethics: broad-based education is often central to building social support for proper management methodologies.

These need to work in concert with legal and regulatory frameworks that both enable local populations to develop management approaches suited to regional conditions, and provide avenues for higher level interventions to address the actions of large individual consumers or polluters.

The management approach advocated under these unique circumstances has been coined as 'top-down facilitation of local actions' (Foster, 2006) and is illustrated in **Figure 14**.

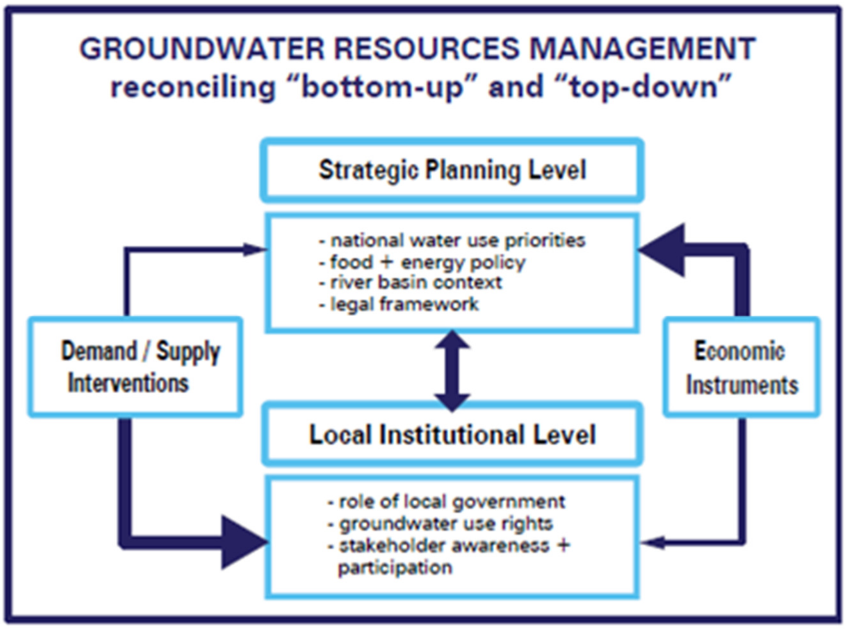


Figure 14: Groundwater Resource Governance (Forster, 2006)

6.3 Governance provision for implementation of groundwater management

The importance of governance to take place at all the appropriate levels, i.e. policy, national support and local action level, is illustrated in the useful groundwater-specific analytical framework (see **Box D**), coming out of Groundwater Governance - A Global Framework for Action (2011-2014) (Wijnen et al., 2012).

Box D: Strategic Framework for Groundwater Governance

"Governance is the operation of rules, instruments and organisations that can align stakeholder behaviour and actual outcomes with policy objectives."

Enabling Environment / Policy level

Processes by which a nation establishes its objectives for groundwater, integrates those policies with water, land and environmental policies, and aligns and harmonises them with other related policies affecting groundwater.

Strategic / National level

Institutions and instruments designed by a nation to align stakeholder behavior and actual outcomes with policy objectives. These include planning, regulation, economic instruments, institutional development and information management.

Local level

Organisations and institutions that control actual outcomes on the ground and respond (in varying degrees) to the rules and incentives from strategic level governance. This level includes the individual groundwater users, local collective management institutions and relevant public agencies.

Wijnen et al. (2012)

In a case study on groundwater governance in South Africa that formed part of a World Bank project, Pietersen (2012) concluded: ***''Strengthening and implementing groundwater governance measures should preferably follow a 'parallel track and adaptive approach' within the existing legal and institutional framework. Such an approach would strengthen the***

said frameworks without disruption, taking cognizance of the capacity and willingness to implement."

In this regard, Knüppe (2011), in a systematic and participative analysis of groundwater governance in South Africa, concluded further that **the South African groundwater management regime still lacked the capacity for adaptive management**, i.e. moving from conventional bureaucracies to adaptive structures that could increasingly take into account the complex system linkages between hydrogeological, political, socio-economic and environmental domains. She suggested a number of supporting approaches, such as tools for cooperation, participation and information networks, to facilitate the implementation of adaptive water management approaches and hence to achieve institutional change in the political arena of groundwater management.

While it is crucial to encourage whatever management actions are currently feasible, the long-term process of developing flexible, integrated management systems should not be delayed. A strategic framework is seen as an essential precursor and progressive instrument for effective groundwater management (Burke and Moench, 2000). In practice, this should result in a groundwater management plan that will identify actions necessary to contribute to an effective water resources management framework of policies, legislation, financing structures, capable institutions with clearly defined roles, stakeholder participation and a set of management instruments.

A Water Research Commission project has been completed in South Africa (Riemann et al., 2011) to establish a pragmatic framework for the elaboration and implementation of such local action level groundwater governance. This management framework for aquifer protection and aquifer utilization is illustrated in **Appendix 2** together with their respective responsibility matrix.

It is intended to use this framework (and further refined products) as tool to achieve stakeholder understanding and role clarification in the immediate development of the NGS and in the longer-term process of improving groundwater management systems.

7. Strategy

7.1 From Policy Framework to Action

The importance of a groundwater policy framework and appropriate principles as a way of integrating regional and national groundwater policy and leading to action on the ground can be illustrated in the framework development for New South Wales in Australia.

Box E: New South Wales (Australia) State Groundwater Policy

There had been rapid development of groundwater since the early 1980s, initially for rural towns, industry and mining and more recently for high-value agriculture. Besides water allocation, land-use planning, urban planning and environmental protection were seen as critical to the sustainable development of the resource. In 1997, the government of New South Wales released its State Groundwater Policy Framework, which was supported by three subsidiary policies on: (i) groundwater quality protection (ii) groundwater quantity management and (iii) groundwater-dependent ecosystems. Its guiding principles were a mix of principles, like those underpinning South Africa's National Water Act and unique groundwater principles as elaborated in the chapter Objectives and Principles of this Strategy.
Implementation was guided by risk assessment, so that increased focus and levels of management would be applied to more stressed aquifers on a priority basis. The management tools introduced through the framework document included:

- Groundwater management plans (ultimately ~ 20 were developed in high/over-exploited situations);
- A Water Sharing Plan based on combined surface and groundwater assessment;
- Groundwater Management Committees;
- Supporting guidelines for local government and industry;
- Creation of aquifer resources and vulnerability maps;
- An education strategy;
- Legislative mechanisms for groundwater management;
- Licensing tools and conditions for users that better reflect resource protection objectives;
- Economic instruments applicable to groundwater management.

Giordano and Villholth (2007)

7.2 NGS Groundwater Governance Framework

To address the groundwater vision and objectives and the present inadequate groundwater management situation in South Africa outlined above, a groundwater governance framework for action has been developed. Its concept is based on the Global Groundwater Governance Framework completed recently (UNESCO et al., 2015), while its detail has been informed by local context, both hydrological and by the overall governance context. Governance will have to happen at three essential levels, namely a national enabling level a national strategic level and a local level.

NGS Groundwater Governance Framework

National Level (enabling environment)
Enabling legislation and strategy (is in place) 1. Stakeholder-driven development 2. National Groundwater Leadership
National / Provincial (Basin) Level
3. Responsive groundwater regulatory framework 4. Groundwater resource protection 5. Sustainable groundwater resource utilization 6. Appropriate institutional development 7. Redirecting finances 8. Groundwater resource planning and development 9. Groundwater information management 10. Regional and international partnerships 11. Water sector skills and capacity
Local (District / Aquifer) Level
12. Local level action

Besides the existing enabling legislation and strategy, the other critical enablers of national groundwater leadership and stakeholder-driven development need to be established without delay. The essential local actions need to be facilitated by a wide range of actions at the national / CMA level. A critical role of national groundwater leadership will be to maintain the vertical integration between the different governance levels and to build strong functional linkages to other sectors that are using and / or impacting groundwater. Twelve strategy themes have been identified and have each been developed in terms of Objectives, Principles, Situation Assessment, Current challenges, and Strategic Actions. These are:

7.3 NGS Strategy Themes

1	**Stakeholder-driven development and implementation** Continuously improve stakeholder understanding and collectively agree on and work within an expanding framework of local level participative management and 'good groundwater governance.'
2	**National Groundwater Leadership** Develop and maintain the national groundwater champion that must hold the overall groundwater governance framework together and facilitate and support its roll-out, smooth functioning and growth.
3	**Responsive groundwater regulatory framework** Anchor the shared understanding of groundwater governance in appropriate policy and regulations that will enhance sustainable and efficient use of groundwater resources.
4	**Groundwater resource protection** Develop and maintain approaches for pro-active protection of groundwater resources and aquifer-dependent ecosystems to secure a sustainable supply of water for human survival and socio-economic development, while maintaining essential groundwater environmental services.
5	**Sustainable groundwater resource utilization** Translate practical understanding of groundwater resources into appropriate guidance material to fully capacitate those responsible at all levels for sustainable groundwater resource utilization, covering planning, development, management and protection.

6	**Appropriate institutional development** Develop, facilitate, capacitate and support appropriate institutions that will allow effective local-level participative management of groundwater resources.
7	**Redirecting Finances** Redirect incentive policies and public expenditures impacting groundwater by and within different sectors to achieve a combined, much stronger focus on sustainable and efficient groundwater management.
8	**Groundwater resource planning and development** Achieve integrated groundwater resource planning at national, regional and local levels that will fully and sustainably establish the unique potential of groundwater for socio-economic development.
9	**Information management** Grow and maintain the groundwater resource knowledge base, focusing on the resource itself, its socio-economic role and its appropriate management. Develop and maintain effective and efficient information and information systems, as a shared national objective and an integral part of water management strategies, in support of groundwater development and management at all levels.
10	**Regional and international partnerships** Actively participate in and grow appropriate regional and international partnerships towards groundwater resource understanding and optimal utilization, including transboundary resource management.
11	**Water sector skills and capacity** Develop and maintain skills and capacity for the sustainable development and management of groundwater resources at all management levels and with participation of all stakeholders as part of a long-term, ongoing process.
12	**Local Action** Manage and maintain actions on all strategy fronts in a concerted effort from government at different levels, from municipalities and utilities, the private sector, civil society , educational institutes, media and professional associations to achieve the essential local level actions for sustainably managing shared groundwater resources.

Theme 1: Stakeholder-driven development and implementation

Objectives

Continuously improve stakeholder understanding and collectively agree on and work within an expanding framework of local level participative management and 'good' groundwater governance.'

Principles

Social dimensions are as important as technical dimensions in the development of approaches to address emerging groundwater challenges.

Effective user participation based on education and constructive dialogue is therefore an essential input for resolving complex issues relating to groundwater. Without this, important and urgent management requirements often cannot be implemented in practice.

Situation Assessment

Provision in policy and strategy

The National Water Act, 1998 provided for a fundamental reform of the law relating to water resources in South Africa. The scarce resource belonging to all people, government's role as national trustee, the ultimate aim of water resource management and the institutional development to enable participation are all covered in the Preamble of the Act (below).

> **PREAMBLE -** National Water Act, 1998
> Recognising that water is a scarce and unevenly distributed national resource which occurs in many different forms which are all part of a unitary, interdependent cycle;
> Recognising that while water is a natural resource that belongs to all people, the discriminatory laws and practices of the past have prevented equal access to water, and use of water resources;
> Acknowledging the National Government's overall responsibility for and authority over the nation's water;
> Recognising that the ultimate aim of water resource management is to achieve the sustainable use of water for the benefit of all users;
> Recognising that the protection of the quality of water resources is necessary to ensure sustainability of the nation's water resources in the interests of all water users; and
> Recognising the need for the integrated management of all aspects of water resources and, where appropriate, the delegation of management functions to a regional or catchment level so as to enable everyone to participate.

The National Water Resource Strategy 2 spells out the required institutional development in terms of:

- Regional water utilities (for regional bulk services – water and wastewater)
- Catchment management agencies (nine CMAs to undertake water resource management)
- Catchment management forums (for effective participation)
- Water user associations (WUAs) (co-operative associations of individual water users – can have delegated management powers).

Experience for groundwater to date

A generally recognized factor that must drive sustainable groundwater utilization is participation of local water users and other stakeholders. Despite the good intent of the National Water Act, 1998, this critical requirement is still virtually completely missing for groundwater resources. There are no Water User Associations for groundwater and very few local monitoring committees are functional. Some of the reasons for this situation are:

- Establishment of CMAs has been very slow and is still not complete;
- A structured process is still required for identifying functions that CMAs can delegate to WUAs with capacity;
- WUAs have largely come about through the process of transformation of the former Irrigation Boards and these had very little interest in groundwater.
- Groundwater's previous "private water" nature still plays a major role in its lagging far behind the institutional development for surface water resources.
- There is no sustained DWS support available to establish and empower Water User Associations and monitoring committees for groundwater.
- Verification of groundwater use, a prerequisite for local participative management, is laborious and has not received priority and funding.

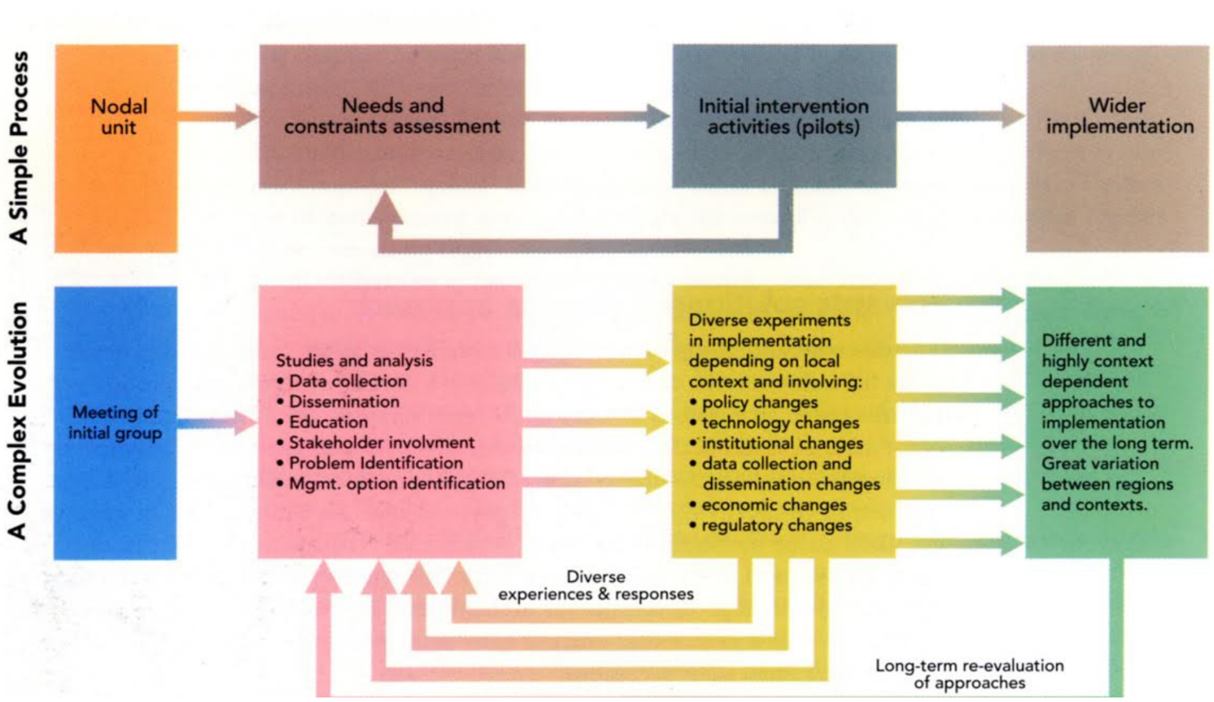


Figure 15: A process to guide complex and diverse local level implementation

Process to guide local level implementation

The world-wide experience is that the evolution of groundwater management systems is a long-term process. A phased approach and a management framework that can articulate the local level complexity, but has a common multi-dimensional approach, addressing both the social and technical dimensions, is essential to the management of the resource.

The approach starts with the commitment at policy level to review policy and ensure stakeholder participation (including establishment of mechanisms necessary for that to occur), followed by the establishment of a core group composed of stakeholders, experts, government representatives and concerned individuals. This group is essential in order to guide and move a long-term process forward. It then proceeds through analysis of needs and constraints to experimentation and, finally, to widespread implementation. **Figure 15** attempts to illustrate this process (Burke and Moench, 2000).The strategic analysis that follows, designed to produce a baseline assessment of needs, constraints and opportunities, must include an institutional analysis, covering aspects such as (Burke and Moench, 2000):

- What are the roles and functions of current institutions and their suitability/capacity for addressing different aspects of emerging problems?
- Do existing institutions have the capacity to address management needs, including the involvement of critical stakeholders?
- If not, how might they be restructured or what capacities need to be developed for them to address those needs.

In a follow-on phase of the long-term process, the focus would be to transform the initial conceptual strategic framework into a practical and implementable management and policy strategy. Key products of this third phase would include the legislative and policy frameworks necessary to specify the way management organisations can be formed at the scale needed and the array of powers they might utilize. Such reforms would only be possible following a significant period of dialogue and debate.

A fourth and final phase in the long term process would take the experience gained to scale, moving from demonstration projects to widespread implementation. For this to occur, mechanisms must be in place to enable natural resource management across communities, economic sectors, and political or administrative jurisdictions.

Current challenges

Key challenges in terms of groundwater stakeholder involvement experienced in South Africa in recent years include:

- Despite the good intent of the National Water Act, 1998, stakeholder involvement, a critical requirement for groundwater management, is still virtually completely missing for groundwater resources.
- The distributed, invisible and common pool nature of groundwater resources makes management of a shared resource very difficult.
- The national will to overcome these problems and establish participative management for groundwater has so far been lacking.
- Different users do not speak to each other – no Aquifer forums or CMA forums exist; no Government forum with local users (LM/DWS/CMA and user is in place)

Strategic Actions

DWS commitment

DWS needs to make a firm commitment to policy innovation with stakeholder participation and to encourage formation of a stakeholder core group with sufficient interest and concern to guide and carry out the groundwater institutional development process. Consultation and communication regarding improved groundwater governance can be started through workshops at national/regional level.

Institutional development

The long-term process of strategic analysis of the groundwater management situation in South Africa, the institutional development that needs to take place and the wider implementation of improved groundwater resource management should be facilitated and supported nationally. Existing stakeholder forums need to be involved and civil society needs to be brought into the process to become a champion and watchdog. Provision should be made for stakeholder involvement in groundwater management, starting with the initiation of community forums and community-based organizations. Structured processes, events and tools should be developed to facilitate participation by targeted persons and organisations/forums.

Groundwater awareness-raising

The long-term process of institutional development must be supported by a major ongoing awareness campaign at all levels regarding the need for improved groundwater management to achieve the desired understanding, participation and support for long-term transformation. This requires that science and applied technology serve to enhance education and outreach programs in order to broaden stakeholder understanding. The information sharing should also include other government departments. The Academic sector could give support to the other sectors like Agriculture, Local Government, etc. through capacity-building and skills- training programmes.

Groundwater Trust

It is strongly suggested to establish a South African Groundwater Trust through involvement of the groundwater sector / industry as a whole to develop and lead a multilevel awareness and education campaign, both inside and outside the public sectors. The widely-distributed hydrogeological fraternity should be used as extended arm of the Trust. Randwater and the DWS's Learning Academy could play a role in the functioning of the Trust. Examples of such cooperation towards groundwater outreach are the Groundwater Trust in the United States and the South Australian Groundwater Forum. The Groundwater Division of the Geological Society of South Africa could play a lead role in this regard.

Theme 2: National Groundwater Leadership

Objectives

Develop and maintain the national groundwater champion that must hold the overall groundwater governance framework together and facilitate and support its roll-out, smooth functioning and growth.

Principles

The widely accepted management (governance) approach for groundwater is 'national facilitation of local actions.' This brings out the critical importance of national leadership to create the enabling environment of groundwater policy and regulation, the appropriate institutions, capacity-development and ongoing support.

Situation assessment

Government has to play the central role of 'guardian' for natural resources such as groundwater. Besides the strategic-level resource management functions listed below, a critical long-term role will be that of mobilizing stakeholder participation and of building the capacity of the lower and middle levels of management.

The key oversight functions which need to be performed regarding the groundwater field include:

- Setting and maintain groundwater management norms and standards
- Resource evaluation and strategic planning
- Groundwater information management
- Ensuring groundwater awareness raising and stakeholder involvement
- Ensuring resource quality protection and impact mitigation
- Ensuring abstraction and use regulation
- Ensuring groundwater sustainable utilization
- Ensuring groundwater monitoring
- Ensuring hydrogeological exploration for groundwater development
- Vertical and horizontal policy integration / harmonization

At an early stage, it will be important for the institution responsible for groundwater resources to analyze potential impediments to the management process (inadequate groundwater management boundaries, weak regulatory enforcement, lack of social consensus, poor inter-institutional coordination) and define ways of confronting them.

In the light of the present lack of depth in skills and leadership in hydrogeology at national level, there has been a wide-spread call in recent years, inside and outside the Department, for a well-capacitated groundwater champion in DWS – a groundwater governance unit, which can guide and direct the required oversight. DWS has now taken the decision, that a groundwater unit will be created to oversee integrated local management (Mochotlhi, 2014).

To see such a unit in perspective, this theme should be read together with all the other strategy themes.

Challenges

Key challenges experienced in terms of creating a national groundwater champion in recent years include:

- At present, the country lacks the depth in skills and leadership in hydrogeology to drive the understanding and acceptance of groundwater from national down to local management level. Steps must be taken to strengthen geohydrological skills and build technical training capacity at institutions across the country (Water for Growth and Development Strategy, DWAF, 2008a).
- There is still limited understanding at DWS decision-making level on the long-term role and unique and critical governance requirements of groundwater resources.
- Lack of leaders in various sectors to champion groundwater use and protection in their sector.

Strategic actions

Groundwater governance unit

There is a great urgency with the establishment of such a unit in DWS. This is because nothing can happen in terms of NGS implementation without this leadership entity. At this stage not even a groundwater forum still meets in DWS to achieve some form of coordination.

A task description for such a unit needs to be developed as soon as possible in the light of the requirements for an enabling environment and strategic-level management as well as support of the unfolding institutional development and specifically for local-level groundwater resource management. The unit will not be about doing everything, but being the entry and coordination point. The unit must be a place where all the actions are linked which are presently often happening uncoordinated – e.g. planning; financing; guidelines; monitoring. Focus should not only on developing an appropriate structure, but on all the necessary coordination processes.

For greatest efficiency and effectiveness, one could foresee a 'governance center' which, in formally agreed ways, could draw on the resources of other institutions to fulfil the evolving, wide range of its responsibilities.

Needs and Constraints Assessment

An essential early action for this unit will be the strategic analysis highlighted under Theme 1, together with stakeholders, to analyse potential impediments to the management process (e.g. inadequate groundwater management boundaries, weak regulatory enforcement, lack of social consensus, poor inter-institutional coordination, lack of adequate information) and define ways of confronting them.

Theme 3: Responsive groundwater regulatory framework

Objectives

Anchor the shared understanding of groundwater governance in appropriate policy and regulations that will enhance sustainable and efficient use of groundwater resources.

Principles

Policy and legislation are key enablers of the intended groundwater governance approach of "national facilitation of local actions." While continuing to operate within an overall IWRM framework, for effectiveness and efficiency in implementation, regulation that takes into account the unique characteristics of groundwater that have a bearing on its sustainable development and management (ubiquitous occurrence, many users, open access and invisible nature, complex physical characteristics, availability of natural storage), needs to be developed and rolled out within this framework. All approaches need a focus on impact prevention and on user education and support.

Situation assessment

Policy shift

With the promulgation of the National Water Act, groundwater lost its previous status of private water (rights to groundwater were held by the owner of the overlying property, who could essentially abstract groundwater with little or no control) and became recognised as a common asset, whose custodianship is vested in the state and which is subject to all the stipulations of the Act. The Act states that water is an indivisible national resource (rivers, streams, dams, and groundwater) for which national government is the custodian. It contains rules about the way the water resource is protected, used, developed, conserved, managed and controlled in an integrated manner. The Act is premised on balancing the three legs of social benefit, economic efficiency and environmental sustainability.

Furthermore, the National Environmental Management Act (Act of 1998) and the Minerals and Petroleum Resources Development Act (Act of 2002) lay out new obligations for the mining and other industries in terms of the monitoring and remediation of pollution of water resources.

In terms of the National Water Act, 1998 groundwater is fully subject to national control and part of IWRM, which is the vision of the Act. 'All water, wherever it occurs in the water cycle, is a resource common to all, the use of which shall be subject to national control. All water shall have a consistent status in law, irrespective of where it occurs.' Groundwater in South Africa has benefited greatly from being developed within an IWRM framework across the full spectrum of policy, regulations, institutional development, protection, planning and information management. The roll-out of the NGS will have to continue within this overall framework.

Important for the management of local groundwater resources are the subsidiarity approaches. The 1997 Water Policy White Paper (DWAF, 1997) stipulates that responsibility for the "development, apportionment and management of available water resources" should be delegated to a "catchment or regional level in such a manner as to enable interested parties to participate." The present generalised lack of technical and managerial expertise in the country led to the decision in 2012 to reduce the number of Catchment Management Agencies to nine from the original proposal of 19 CMAs. Up to now only two CMAs have been gazetted and regional level water management is still carried out by the offices of the national department.

Based on a framework of developmental water management adopted in the National Water Resource Management Strategy and on experience of the last fifteen years, a decision has recently been taken to bring the National Water Act and the Water Services Act into one, seamless piece of legislation governing the entire water value chain (DWA, 2013). One consequence of this will be a multiple water use approach, which incorporates all water uses in an area, to be followed in planning and implementation of water schemes.

Despite the raised policy profile for groundwater in South Africa, the second National Water Resources Strategy (DWA, 2013), twenty years later, recognizes that 'groundwater is an important, currently under-valued and under-used resource'. Some findings related to proper valuation of the resource made in a SADC evaluation, hold for South Africa too (Braune et al., 2008):

- Growing awareness at decision-making levels about the importance of groundwater is not adequately reflected in policies and practices.
- Investment in groundwater, relative to its potential to address national objectives, is limited and this is still offset by pollution and ineffective maintenance.

Since then the Water Research Commission has put the spotlight on the important valuation issue (Pearce et al., 2013). It is clear that aquifers are natural assets. They form part of the ecological infrastructure of a country. And the values of these assets theoretically appear on a country's natural resources balance sheet.

Groundwater use authorisation

The most important mechanism to bring groundwater fully operating within the National Water Act. 1998 framework is the mechanism of water use authorisation. In general, a water use must be licensed, unless it is listed as a Schedule 1 use in the Act, is an existing registered lawful use or is permissible under a general authorisation. The authorisation hierarchy obtained through these different instruments is shown in the figure below. General Authorisations are used to alleviate the burden of issuing licences for common, but low-impact water uses. The first General Authorisation accepted a ceiling of 50% of 'Groundwater Harvest Potential' for different regions as basis and was consolidated into 4 zones for section 21(a) water use. In 2004 the GA's were revised to 5 zones (see **Table 6**). A new revision is expected in 2016.

Table 6. General Authorisation for S 21 (a) Groundwater use (2004) in terms of the National Water Act, 1998

Zone	General Authorisation (m^3/ha/annum)
1 (arid regions)	Only Schedule 1 use
2	< 45
3	< 75
4	< 150
5	< 400

Areas that were already groundwater-stressed, were excluded from the general authorisation. The first groundwater-use registration drive was completed in 2000, providing the first overall assessment of groundwater use. For groundwater, the registration requirement had been set for uses of 10 m³/day and more. This was to form the basis for water resource planning, prioritisation of licensing, adjusting of general authorisations, where necessary and for implementation of a water-use charge system. The first general authorisation of 1999 has been reviewed in 2004 and a further review is ready for implementation, probably during 2016.

Determination of the Reserve (the Ecological and Basic Human Needs Reserve) as defined in the NWA, 1998, is part of every groundwater licence application. A general concern in the water sector is that the issuing of groundwater abstraction licences takes prohibitively long and this is one of the reasons why groundwater users in the mining and agriculture sector shy away from groundwater use. The delay is partly due to a lack of appropriate groundwater-specific methodologies for the Reserve determination as well as the lack of groundwater specialist capacity in the regulatory arm of the DWS.

The achieving of compliance with licence conditions has become a major new priority for the DWS and its Regional Offices. Monitoring information must be checked and must be uploaded to the relevant national databases for archiving. Guidance must be given with regard to improved management and monitoring. Licences must be regularly reviewed based on compliance information, and where necessary, compliance must be enforced.

Compliance in terms of sustainable groundwater use by municipalities is at this stage still poor. This is a serious concern, because domestic water supply to communities represents the most strategically important use of groundwater in South Africa.

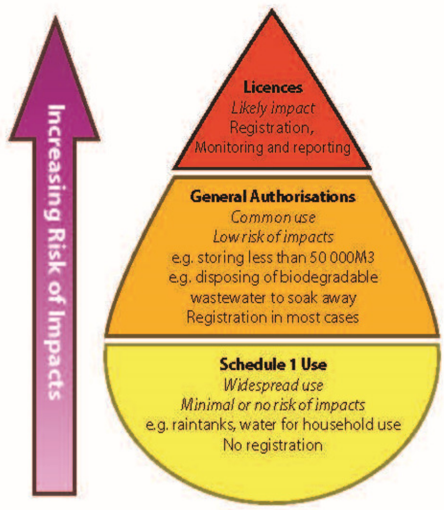


Figure 16: Water use authorisation hierarchy

Currently, the Department owns and manages water resource infrastructure itself, with an asset value of approximately R100 billion. Regulatory oversight in the form of standards setting, monitoring of performance, setting of prices, etc. of the groundwater component of this infrastructure requires serious improvement.

Registration of drilling contractors

An estimated 80 000 to 100 000 water boreholes are being drilled annually. In terms of the need for a preventative management approach for this widely distributed resource, there is an urgent need to regulate the drilling industry in order to maintain a high standard of work. The drilling industry in South Africa through the Borehole Water Association of Southern Africa (BWA) embarked on a process of self-regulation. Since its inception in 1980, the BWA has been committed to establishing minimum standards of practice for the industry (www.bwa.co.za). Its initial effort resulted in the publishing of general guidelines or a code of practice for its members - 'A Minimum Code of Practice for Borehole Construction and Pump Installation'. Since 1996 this was followed by a project to develop a comprehensive 9-part set of groundwater industry standards (drilling, pump installation, rehabilitation of boreholes etc.) through the South African Bureau of Standards (SABS) (e.g. SABS, 2003).

The Department of Water and Sanitation recently embarked on a project to investigate the mechanisms for successful registration of drilling contractors as well as possible training and controlling mechanisms. A particular objective is to get the data from the thousands of boreholes drilled annually on a national database for the benefit of the country as a whole. This had already been proposed at the time of writing the National Water Act, 1998, but it was then felt that registration of water use was a major task and immediate priority, whereas the more detailed aspect of borehole registration should follow later. This must now be seen as a very high priority.

Regulations specifically for groundwater

A separate chapter on groundwater was initially foreseen for the Act, but this was not pursued to maintain the focus on integrated water resource management in the intended framework legislation. The work was published by the Water Research Commission (Lazerus, 1997) and needs to be revived in support of urgently required groundwater regulation. Some of the gaps / challenges identified in that assessment are shown in the following section on 'Challenges'.

Groundwater protection, including pollution control and groundwater quality protection will be discussed under the theme 'Groundwater Resource Protection'.

Challenges

Key challenges in terms of groundwater policy and legislation experienced in recent years include:

- The absence of a national groundwater management policy which lays down norms and standards to guide regional and local groundwater management practices;
- The lack of implementation of the 'Policy and Strategy for Groundwater Quality Management in SA, 2000;
- Insufficient co-operation between different government departments involved in land-use management and activities which impact upon groundwater resources;
- The absence of clear and effective regulation of subterranean government water control areas;
- The absence of strategies to involve the private sector and communities in the regulation and management of groundwater resources;
- The lack of professionalism in parts of the groundwater industry;
- The absence of an effective conflict-resolution mechanism to resolve disputes between competing users concerning over-abstraction or interception of groundwater resources;
- The lack of effective monitoring, compliance and control systems regulating groundwater abstraction.
- The backlog in issuing groundwater abstraction licenses, resulting in groundwater use taking place without proper regulation.
- The challenge of dealing with illegal water use while only 20% of groundwater use has been verified at this stage, a process which must be seen as a major task ahead and for which only limited capacity exists within the regulator.
- The lack of uploading groundwater-use monitoring information on the relevant data base as required in term of the licenses.
- The slow process of achieving compliance with water-use licence conditions as a result of limited capacity in Regional Offices to carry our compliance monitoring.
- The poor compliance by municipalities in terms of sustainable groundwater use for domestic

water supply to communities. Regulatory oversight in the form of standards setting, monitoring of performance, setting of prices, etc. of the groundwater component of this infrastructure requires urgent high-level attention.

Strategic actions

Valuation of groundwater resources

Focused development work on groundwater resource and source valuation and assessments should continue until it has become standard practice in groundwater resource planning and implementation at all levels, for example in exploration drilling, characterisation of aquifer potential and pre-feasibility and feasibility studies.

Groundwater norms and standards

As a basis for integrated and cooperative management of groundwater resources, a clear and widely-understood national groundwater policy which lays down norms and standards to guide regional and local groundwater management practices should be developed and systematically implemented. As next step these could become regulated Best Practice.

Policy coordination

In terms of the important principle of integrated land, water and environment management, policy coordination should be initiated at national level with the respective institutions to ultimately work through to all levels to align and harmonise such policies towards more sustainable groundwater utilisation.

This policy coordination should work down to specific regulation, where necessary, in particular appropriate municipal by-laws to ensure protection and efficient management and use of local groundwater resources. Self-regulation by a specific sector must be seen as an ideal in participative management.

Groundwater use authorization

The overall processes of Schedule 1, General Authorisation, Licensing and Compulsory Licensing need to be reviewed in terms of implementation experience and groundwater development priorities to achieve administrative efficiency and effectiveness and user cooperation.

Groundwater use verification

Verification of groundwater use registration as well as licence compliance monitoring should start without delay. This information is at this stage seriously missing in planning and licensing. In the implementation, priority should be given to the most stressed and most vulnerable groundwater resource areas.

Subterranean government water control areas

While the subterranean government water control areas are used extensively as part of the classification and licensing process, water-use rights in these areas in terms of the previous Act need to be urgently clarified and appropriate regulations provided for use in these areas, fully synchronized with the general water-use regulation outside these areas.

Aquifer management

Aquifer management, including drawing up water-sharing agreements, using conceptual and numerical models, monitoring, regular assessment and adaptive management needs to be implemented by aquifer management committees in identified priority aquifers, based on appropriate guidelines and regulations.

Regulated groundwater use

Specific regulations should be prepared for all sectors using and impacting groundwater. Groundwater use for domestic water supply should receive priority in this regard so that national water security objectives can be met. This would include appropriate national guidelines, half-yearly assessments by a professional geohydrologist, following the monitoring and management direction provided, and full participation in aquifer management committees, where these have been established. Early warning systems and borehole, wellfield and aquifer operating rules need to be developed.

Regulation of the groundwater industry

As part of the preventative management principle in the case of groundwater, appropriate regulation of the groundwater industry, in particular drillers and pump installers, is now urgently required. This is to be undertaken jointly by the regulator and the industry to find the appropriate mix of voluntary regulation by the industry and agreed national regulation. The submission of acquired borehole data into a national data base is one of the key objectives of the regulation.

Theme 4: Groundwater Resource Protection

Objectives

Develop and maintain approaches for pro-active protection of groundwater resources and aquifer-dependent ecosystems to secure a sustainable supply of water for human survival and socio-economic development, while maintaining essential groundwater environmental services.

Principles

In South Africa's situation of widespread and highly localised groundwater occurrence and use, it will be physically and economically impossible to protect all groundwater resources to the same degree. For effective and focused intervention, a differentiated protection approach is necessary, based on the vulnerability – and regional, as well as local importance - of aquifers.

The special nature of groundwater must be recognised in implementing policy. Impacts on groundwater are often long term and irreversible. The precautionary principle must therefore be strictly applied when making decisions about groundwater resources.

Situation Assessment

Water resource protection

Resource degradation through pollution of underlying groundwater is wide-spread in Africa in both urban and rural areas (Xu and Usher, 2007). This is because of its invisible nature - it takes a long time to notice that it has become polluted and, unlike surface water, it has limited ability to purify itself. In South Africa our knowledge of groundwater pollution is only incidental, because monitoring information is only available at a national / regional level, whereas pollution impacts are often very localized and compliance monitoring is not yet functional. A major concern, picked up through the national monitoring, is increasing nitrate levels in boreholes in parts of Limpopo, Northwest and Free State.

The NWA provides for the protection of water resources through three main measures, namely:

- Classification of water resources;
- Determination of the Reserve and
- Setting the Resource Quality Objectives (RQOs) for the selected class.

The Water Resource Classification System (WRCS) was formally established in September 2010 whereby water resources are categorised according to specific Classes that represent a management vision of a particular catchment. Before classification of water resources was systematically introduced in various catchments, the key Resource Directed Measures process was the Reserve determination in support of water use licensing. A Reserve determination, covering both Basic Human Needs and the Ecological Reserve, must be undertaken when a license application for water allocation is processed. Determination of the Reserve for aquatic ecosystems entails investigation of the relationship of major interactive components of the hydrologic cycle, namely groundwater and surface water bodies, including rivers, lakes and estuaries. Depending upon the current stress of the water resource in question, the Reserve determination required may be a rapid or intermediate estimate, or a comprehensive evaluation.

Experience with RDM implementation has made it clear that the unique characteristics and role of groundwater resources in the South African water resources environment have not yet been properly addressed. Groundwater resources are seen as a contributor to surface water systems and all the protection focus is on these and not on the groundwater resource itself. As a result, despite almost country-wide implementation, RDM has to date given very little practical protection for groundwater resources and its various uses. The Basic Human Needs Reserve, which could play a critical role to secure groundwater quality for domestic water supply, has not yet been used in this way.

Groundwater quality protection

Protection of the quality of groundwater resources is an essential part to meeting the Sustainable Development Goals. A comprehensive groundwater quality protection strategy of the Department (DWAF, 2000) had been virtually forgotten in the GRDM methodology development. It stated then: "As the country's people start depending more and more on groundwater, so the need grows to provide for the security of its supply. Protection of groundwater has, therefore, now become a national priority."

This strategy foresaw three main functional groupings, namely Source-directed strategies, Resource-directed strategies and Remediation strategies and a fourth group, Integrated strategies, to integrate and support the work of the other three as shown in **Figure 17**(DWAF, 2000).

The (pollution) source-directed strategies are equally important for groundwater resource protection as the Department's RDM measures (the Resource-directed strategies). Other departments and other legislation, such as the National Environmental Management Act, 1998 (NEMA), are crucial instruments for preventing or minimizing various forms of high impact on groundwater sources. Classification of groundwater resources, which could provide an important signal to the Department and other authorities to implement source-directed control measures, has, however, not yet been properly undertaken as a result of the RDM focus on surface water systems (as highlighted above).

Protecting sources of drinking water

The highest protection requirement in terms of the groundwater quality protection policy is the protection of community water supplies by preventative means. This measure is standard practice for the protection of groundwater resources in many parts of the world. It includes minimum requirements regarding borehole construction, land-use controls around the abstraction points (see **Figure 18**) and where necessary, site-specific protection of the aquifer (recharge zones) itself.

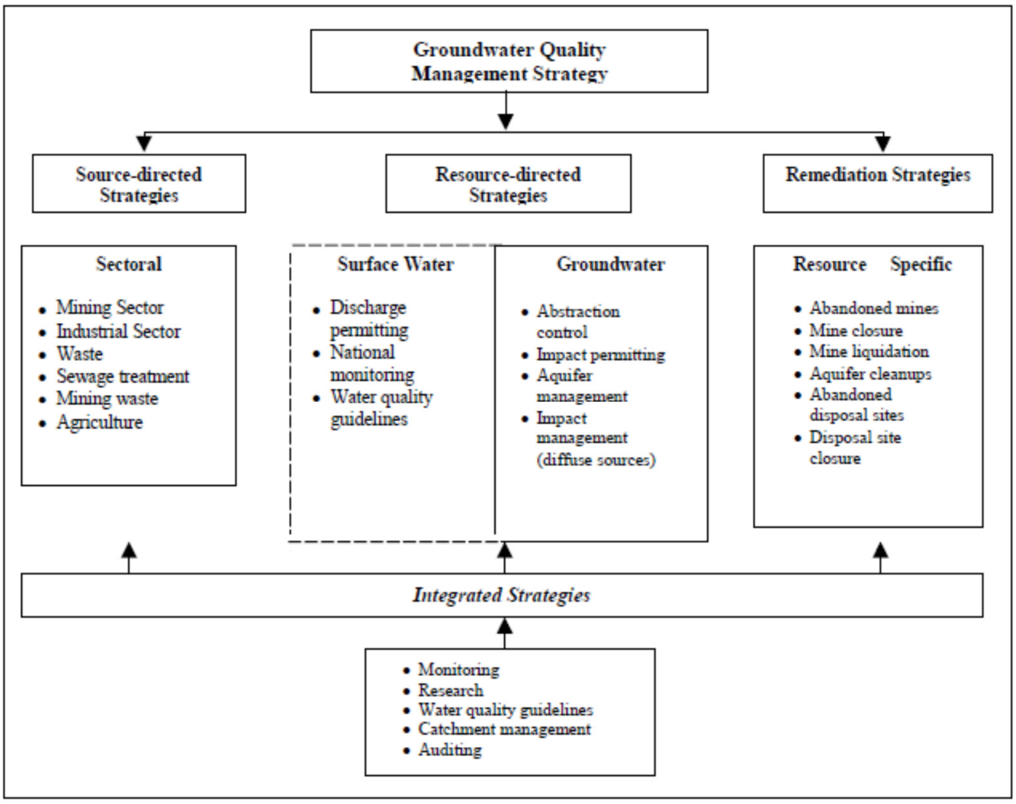


Figure 17: Relationship between the three main groundwater quality management strategies and the functional groups around each (DWAF, 2000)

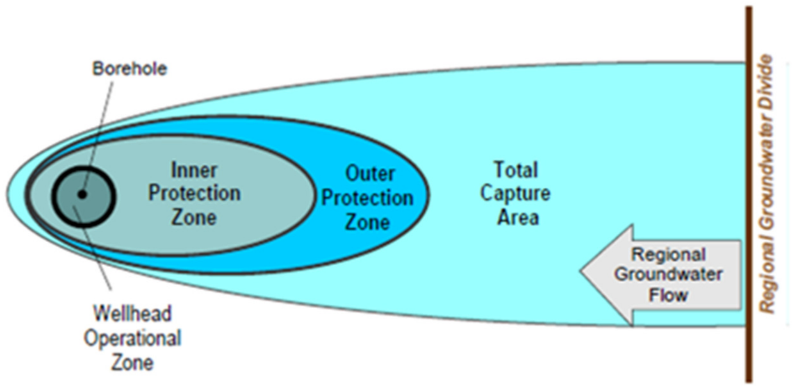


Figure 18: Common protection areas delineated around drinking water supplies

It is critical that local-level communities and government become convinced of the merits of this approach, because zoning of land for different purposes is a function of local government.

The Department in 2007 initiated a project in this regard with the UWC, namely „Feasibility Study towards the Policy Development on Aquifer Protection Zoning", but this was not followed through. A new opportunity to link-in groundwater protection zoning is the WRC project „Strategic Water Source Areas".

Challenges

Key challenges for groundwater resource protection experienced in recent years include:

- Knowledge about groundwater pollution is very limited, because national monitoring will only rarely pick it up, whereas compliance monitoring has not yet properly kicked in;
- This is a concern, because incidences of groundwater pollution need to be addressed as soon as they are detected. It is far cheaper and easier to prevent pollution or address it in the early stages, than to attempt to "clean up" an aquifer afterwards.
- Groundwater use is not yet adequately verified and thus resource management and protection cannot be focused appropriately;
- RDM measures have to date not focused on the unique protection needs of groundwater resources and have achieved no practical groundwater resource protection despite considerable investment;
- Protection of groundwater supplies for domestic use, initially the highest protection priority, has been completely neglected to date. This can present a threat to the achievement of the Sustainable Development Goal on Water and Sanitation;
- The wide-spread serious threat of acid mine drainage is still tackled piece-meal and urgently needs a comprehensive and cooperative approach with regard to groundwater issues at abandoned and derelict mines;
- Emerging problems like nitrate pollution, largely as a result of poor sanitation, need to be properly assessed and addressed before they become a wide-spread threat to water security.
- Groundwater has not yet been systematically addressed with appropriate guidelines and regulations in the cooperative approach, so important for integrated land and water management.

Strategic Actions

Policy and Strategy for Groundwater Quality Management

The comprehensive strategy, already developed in 2000 with wide participation and signed off by the Minister, needs to be fully implemented. If necessary, it should be aligned with the more recent RDM framework. This should take place and be incorporated as a sub-strategy of the NGS.

Groundwater pollution assessment

Undertake a national assessment of the present impact of pollution on groundwater resources, taking into account the main pollution pressures, the different aquifer classes and their vulnerability to pollution. This is essential because national monitoring has not provided a proper baseline.

Public awareness

Make public awareness and understanding of groundwater issues as well as existing and emerging pressures and impacts a key instrument in the precautionary approach to groundwater protection. Develop a strategy in this regard as part of the stakeholder consultation process.

Groundwater use verification

Immediate attention should be given to the verification of groundwater use country-wide as the only basis for systematic groundwater resource management and protection. This should be achieved in a 3-year programmatic approach, using aquifer importance, vulnerability and stress condition as criteria for prioritization.

Groundwater-use authorisation

Use groundwater licenses, including general authorisations, much more to achieve resource protection objectives. Licence conditions must provide, inter alia, for the collection of groundwater quality monitoring information and uploading of this information to the national databases.

Resource-directed measures

RDM methodology as it relates to groundwater must be urgently reviewed to address the unique hydrogeological characteristics and vulnerability of groundwater systems, unique groundwater-dependent ecosystems as well as the role that these groundwater systems play in the country's development. The methodology must include technical support requirements in terms of appropriate exploration geophysics and drilling, pumping tests and distributed numerical models.

An appropriate groundwater resource classification approach should be urgently developed, as an integral part of the RDM Classification System. As for surface water resources, the resource class of a groundwater resource (aquifer or other resource unit) should determine the planning and implementation of more detailed protection measures through appropriate Resource Quality Objectives.

Because RDM methodology is very information-intensive, such methodology revision will have to inform a groundwater resource information strategy, including a revision of GRA2, with emphasis on resource exploration, assessment, monitoring and information storage and sharing.

Protection of groundwater sources for domestic supply

Groundwater sources for domestic use should receive the highest protection priority with measures such as minimum requirements regarding borehole construction, wellhead protection zoning and, where necessary, site-specific protection of the aquifer (recharge zones) itself. Certain aquifers/areas need to be classified as no-go areas. This is becoming critical in the light of possible hydraulic fracturing for shale gas exploration.

Regulation and prohibition of land-based activities

Develop a suite of regulations for land-based activities which may affect the quantity and quality of groundwater (section 13 of the National Water Act), i.e. the location and nature of development in relation to its impact on groundwater quality; develop a suite of guidelines and best practices to underpin these regulations.

Work towards a national policy of integrated (ground)water and sanitation development as a precautionary way to protect the investment that is being made in groundwater infrastructure and in the health benefits of uncontaminated groundwater sources. Consider replacing the Groundwater Protocol, which has not had a practical protection impact, with on-site sanitation Best Practice requirements.

A comprehensive water policy framework needs to be developed within the Department to deal with (ground)water issues at abandoned and derelict mines. The mine closure strategies currently being developed elsewhere in government should be developed in close cooperation with the Department and groundwater specialists. Appropriate Departmental guidelines should be prepared to underpin these external regulations.

Cross-sector collaboration

Establish formal cross-sector collaboration to enhance sustainable utilization of the resource. This is extremely important for widely occurring and hidden groundwater resources.

Theme 5: Sustainable groundwater resource utilization

Objectives

Translate practical understanding of groundwater resources into appropriate guidance material to fully capacitate those responsible at all levels for sustainable groundwater resource utilization, covering planning, development, management and protection.

Principles

Groundwater is facing increasing development pressures. In this situation it is becoming critical that its unique characteristics need to become widely understood and properly considered in development, management and protection of the resource in order to achieve sustainable resource utilization.

Situation assessment

Groundwater has unique characteristics and has unique development, management and operation and maintenance requirements, which all need groundwater specialist attention if is to be utilized sustainably. With increasing devolution of groundwater resource management to lower levels, in particular to CMAs and WUAs, this requirement will have to be addressed through appropriate regulation, clear guidance and ongoing education and training initiatives and awareness raising. Unique aspects of sustainable utilization that need to be addressed in this way include:

- Groundwater source development
- Groundwater source protection (more fully addressed under Theme 4)
- Conjunctive use of groundwater and other water sources
- Artificial recharge of groundwater sources
- Operation and maintenance of groundwater sources

Abstraction works

The process of establishing a water supply borehole represents a significant investment in both financial terms and in faith. The financial terms relate to the cost of construction of the facility and, if successful, its subsequent proving and equipping. The faith aspect relates to the anticipation that the borehole will be successful, an intangible factor that depends not only on the competence of the person(s) responsible for marking the site of the borehole, but also on the competence of the contractors (drilling and pumping) who will be responsible for seeing the process through to its conclusion. In both instances, competence can be measured by the knowledge, experience and integrity of the parties involved (Hobbs, 2010).

Poor borehole development practice can result in large cost overruns, much increased operation and maintenance cost and complete failure of the abstraction facility. All this can lead to giving groundwater itself a bad name, a situation that we continue to have in South Africa. Application of a compendium of 'best practice' directions is probably the most practical indicator of good management, given the complex management environment of widely-distributed groundwater and close to a hundred thousand boreholes drilled every year.

The main national standards in this regard are the Department's (Hobbs and Marais, 1997) and those of the South Africa Bureau of Standards (SANS, 2003). Self-regulation is striven for by the Borehole Water Association of Southern Africa (BWA). It was formed in 1980 with the strategy to:

- Promote awareness via education of the consumer of the responsible use of the resource and its future management;
- At all times guaranteeing the protection of groundwater by demanding the application of minimum standards of practice from its members.

This is an area for ongoing improvement, because changes to borehole designs, procurement and contract management practices, well clustering for economies of scale, siting and supervision practices as well as support to and professionalization of the private sector can all serve to bring drilling costs down, and improve construction quality and success rate.

Knowledge of groundwater development standards for different aquifer environments must be seen as a part of groundwater resource assessment and planning, because the exploitable groundwater resources cannot be assessed properly without taking into account the practicalities and costs of getting access to groundwater and withdrawing it.

Vulnerable aquifers

Groundwater resources are commonly vulnerable to pollution, which may degrade their quality. Unlike flowing surface water, groundwater has low resilience to pollution, which increases its vulnerability to pollution and makes the effects of pollution persistent. Groundwater in shallow water table aquifers and in karst aquifers is the most vulnerable to all pollution processes, no matter whether these are local and ongoing, accidental or diffuse over large areas. Caves or natural sinkholes often become uncontrolled waste dumps.

In principle, deep, confined aquifers are protected against pollution generated at the surface. However, they can be penetrated by boreholes that bring waters of different layers and qualities into contact. They can also not be expected to be protected against the effects of anything stored or injected underground.

Groundwater resources are also sensitive to how and at what rate they are abstracted. Significant declines in the water table can lose the hydraulic connection with surface water bodies, can lead to significantly higher pumping costs and may also cause compaction of aquifer material and irreversible degradation of the hydraulic characteristics. In addition it may cause environmental impacts, eg the drying up of wetlands. Coastal aquifers are particularly vulnerable as even minor disturbances of the dynamic equilibrium can result in seawater intrusion.

Evaluating the fragility and vulnerability of groundwater systems, in whatever circumstances, is an integral part of assessing the exploitable groundwater resources (Margat and van der Gun, 2013). Resource development, management and protection have to be undertaken accordingly.

Sustainable Yield

Sustainability refers to renewable natural resources; therefore, sustainability implies renewability. In nature, surface water and groundwater are related. Surface water can become groundwater through infiltration, while groundwater can become surface water through exfiltration. Therefore, surface water and groundwater are inextricably connected; renewability of one cannot be considered or evaluated without regard to the other.

Sophocleous (2000) and others (Seward et al., 2006) pointed out that the traditional concept of safe yield ignores the fact that, over the long term, natural recharge is balanced by discharge from the aquifers by evapotranspiration and/or exfiltration into streams, springs, and seeps. Consequently, if pumping equals recharge, eventually streams, marshes, and springs may dry up. Additionally, continued pumping in excess of recharge may eventually deplete the aquifer.

Sustainable yield, a concept that is replacing safe yield, does not depend on the size, depth, or hydrogeologic characteristics of the aquifer. It assumes that all groundwater pumping comes from capture (Sophocleous, 2000); the greater the intensity of pumping, the greater the capture. Capture comes from decreases in natural discharge and increases in recharge. Natural discharge supports riparian, wetland, and other groundwater-dependent ecosystems, as well as the baseflow of streams and rivers. Sustainable yield depends on the amount of capture, and whether this amount is socially acceptable as a reasonable compromise between little or no use, on one extreme, and sequestration of all natural discharge, on the other extreme.

A holistic approach to groundwater sustainability considers the hydrological, ecological, socioeconomic, technological, cultural, institutional and legal aspects of groundwater utilization, seeking to establish a reasonable compromise between conflicting interests. In South Africa, the National Water Act, 1998 and its requirement that the Ecological Reserve and the Basic Human Needs Reserve must first be addressed before groundwater can be allocated for use, gives direction for dealing with this compromise.

Artificial recharge is obviously an appropriate approach in situations where a lot of the natural recharge has already been captured by abstraction and natural discharge has been depleted, in particular in for situations where this discharge plays a critical role, e.g. preventing seawater ingress in coastal aquifers.

With increasing importance and vulnerability of the combined surface water / groundwater system, it becomes increasingly important to develop a comprehensive conceptual water budget, understand the boundaries and rate of replenishment of the system, monitor water use and water ecosystem parameters like groundwater levels, spring flow and wetland conditions and work with stakeholders to understand trade-offs and develop consensus. Numerical models of such aquifer systems are essential support tools to achieve the agreed sustainable situation.

Using the groundwater buffer

Both groundwater professionals and water resource planners are stressing the importance of not going for either a groundwater or a surface water solution, but seeking conjunctive use solutions. This has to do with both water security and with resource sustainability. "Conjunctive use of surface and groundwater consists of harmoniously combining the use of both sources of water in order to minimize the undesirable physical, environmental and economic effects of each separate solution and to optimize the efficient use of the total water resource."

Groundwater resources development can in most aquifers go beyond intercepting part or all of the natural flux provided by aquifer recharge. It may also include a deliberate use of the groundwater buffer provided by the aquifers.

The groundwater storage reserves may buffer not only between wet and dry seasons but also between wet and dry years, and compensate for the lack of surface water during dry periods, like surface water reservoirs do. Groundwater buffers thus have an important role in drought-proofing communities. They will also prove to be invaluable in mitigating predicted water-scarcity problems relating to climate change.

Such an active and carefully planned utilization of the reserves should not be confused with over-abstraction, as long as temporary depletion of reserves is followed by periods of recovery and a long-term hydrodynamic equilibrium is pursued. Importantly, depletion of aquifer storage can enhance aquifer recharge. There are estimates that more intensive use of the groundwater buffer could raise the global groundwater flux by about 40% (Margat and van der Gun, 2013).

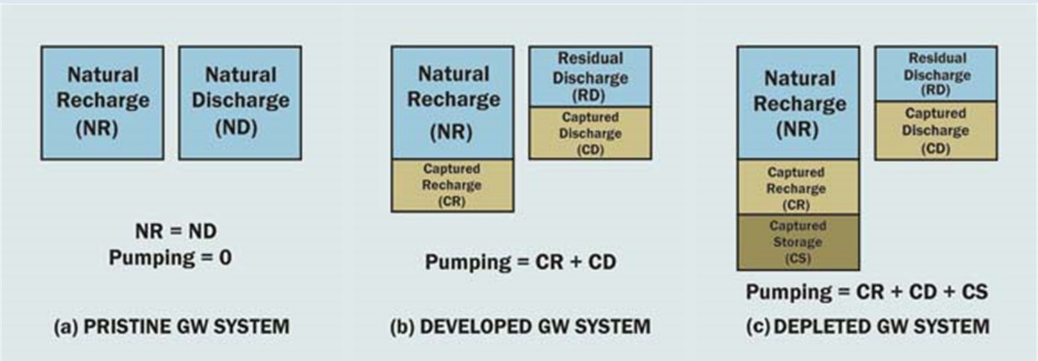
Box F : Recharge and discharge in groundwater systems

Three groundwater scenarios are possible (as illustrated in the figure) (Ponce, 2007):
(a). A pristine groundwater system, in equilibrium or steady state, in the absence of pumping;
(b). A developed groundwater system, in equilibrium or steady state, with moderate pumping at a fixed depth; and
(c). A depleted groundwater system, in non-equilibrium or unsteady state, with heavy pumping at an ever increasing depth.
In the pristine groundwater system, [average] natural recharge is equal to [average] natural discharge, net recharge is zero, and pumping is zero.

In the developed groundwater system, net recharge is equal to the sum of captured recharge plus captured discharge. Net recharge varies with the intensity of pumping; the greater the intensity of pumping, the greater the net recharge. Captured recharge is the increase in recharge induced by pumping. Likewise, captured discharge is the decrease in discharge induced by pumping. Then, residual discharge is equal to natural recharge minus captured discharge.

In the depleted groundwater system, in addition to captured recharge and captured discharge, there is also captured storage. Net recharge is equal to captured recharge plus captured discharge. Pumping in the depleted groundwater system is equal to net recharge plus captured storage.

The greater the level of development, the greater the amounts of captured recharge and captured discharge, and, in the case of a depleted system, captured storage. The greater the captured discharge, the smaller the residual discharge. Since all aquifer discharge feeds surface water and evapotranspiration, it follows that intensive groundwater development can substantially affect local, subregional, or regional groundwater-fed surface water bodies and groundwater-dependent ecosystems.



Because of the available buffer, groundwater lends itself to an adaptive management approach. A new resource development does not need perfect information to start with and management objectives, e.g. the borehole or wellfield yield can be adjusted as improved information becomes available through monitoring or when other conditions change.

Resource augmentation - Artificial recharge

Artificial recharge is a related practice, making more intensive use of the buffer capacity of aquifers by augmenting the resources. Often it is based on diverting surface water peak flows, thus providing a smoother flow regime and loosing less water to evaporation. 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.

Internationally, artificial recharge is becoming an increasingly recognised form of water storage and conservation. The different approaches of managing the water buffer to achieve water security have featured strongly at recent World Water Forums. In South Africa, this technology is still very much under-utilised, with only one major and a few minor established artificial recharge scheme (See **Box G**).

However, the Department has made a major effort to promote the technology by way of a government strategy (DWAF, 2007b) and by extensive documentation to guide its country-wide implementation. Purposes for artificial recharge, also called Managed Aquifer Recharge, as included in the Departmental planning options, are:

- Store and conserve water in the subsurface for later use;
- Prevent seawater intruding into coastal aquifers by creating hydraulic barriers at the coastline;
- Use aquifer media for water treatment, like a large-scale sand filter;
- Maintain the Reserve, whereby surplus water (fresh or waste) would feed areas where the Reserve is considered to be under threat due to large-scale abstraction.

Box G: Atlantis Artificial Recharge Scheme

The town of Atlantis is situated about 50km north of Cape Town, in the Western Cape Province, and has a population of over 100 000 people. It has no major surface water sources, and annual rainfall is only about 450mm. Atlantis abstracts water supply from boreholes at two wellfields to the west and south-west of the town, supplying 30-40% of the town's water. Groundwater consumption in 2004 was 2.8 million m^3.

Artificial recharge of the aquifer, first begun in the early 1980s, is carried out to improve water security during droughts, re-use wastewater and storm run-off, and help to prevent the intrusion of seawater into the aquifer. Treated waste water and storm run-off is diverted to two large recharge basins about 500m up-gradient of one of the wellfields, which are used to infiltrate the good quality water back into the aquifer for later abstraction.

Poorer quality waste water (some of it from the town's industrial area) is infiltrated down-gradient of the wellfields, between the town and the sea, where it is disposed of conveniently and responsibly and also helps to ensure saline water is kept out of the aquifer. Together with some imports of good quality surface water from the Cape Town municipal supply, Atlantis is able to meet its water supply needs using combined groundwater abstraction and artificial recharge. Management by the municipality includes dealing with technical issues such as clogging, pH adjustment and water softening – good management procedures are in place and the system operates reliably (DWA, 2010).

DWS's artificial recharge website provides access to all the documents and tools listed:

National Resources for Artificial Recharge

- Artificial Recharge Strategy (2007)
- Potential Artificial Recharge Areas in South Africa (2009)
- A check-list for implementing successful artificial recharge projects (2009)
- Lecture notes on artificial recharge (2009)
- Artificial Groundwater Recharge: Recent initiatives in Southern Africa (2010)
- The Atlantis Water Resource Management Scheme: 30 years of Artificial Groundwater Recharge (2010)
- Artificial Recharge Strategy, Version 2 (2010)
- Potential Artificial Recharge Schemes: Planning for Implementation (2010)
- Planning and Authorising Artificial Recharge Schemes (2010)

www.artificialrecharge.co.za

Operation and Maintenance

Overall, groundwater is perceived by many (if not most) municipal role-players and communities as an unreliable and difficult source to manage, and they have a marked preference for surface water sources – ideally with bulk potable water supplied by a water board.

Failure of groundwater supply schemes is often blamed on the resource (i.e. the aquifer or the groundwater) rather than on the infrastructure (borehole, pump, pipes, valves etc.) used to abstract the groundwater. It is common to hear that "the borehole dried up", or "the groundwater ran out". This is partly because groundwater is out of sight – it seems mysterious to the layperson in comparison with surface water. In fact, failure of groundwater supply schemes is almost always either due to failure of infrastructure (e.g. a blocked borehole screen) or unsuitable pumping regimes (e.g. pumping at very high rates for short periods of time) that are related to a lack of monitoring.

A vital element of groundwater management therefore is day-to-day operation and maintenance (O&M), including the maintenance of infrastructure (cleaning and de-scaling pipes, replacing worn out components, cleaning of boreholes, checking the operation of switchgear, etc.) as well as the monitoring of groundwater levels, groundwater quality, demand, etc.

Since groundwater is a "distributed resource", meaning it is generally found locally, the basic skills and personnel for proper operation and maintenance of groundwater systems ideally need to be distributed widely rather than only available at certain key points or large towns. This presents a challenge that is different to O&M of surface water systems, which can often be centralised to a greater degree.

The challenge is one of lack of understanding and of capacity. At the decision-making level, the operation and maintenance budgets come under pressure from other budgetary demands throughout the financial year, and planning O&M under such circumstances is difficult. On the ground, there is a lack of skilled technicians and other O&M specialists, particularly in small towns and remote areas where many groundwater schemes are found.

There is, however, very high agreement that carrying out O&M on groundwater sources results in lower costs and higher reliability overall.

Box H: Benefits of Operation and Maintenance

A recent cost-benefit study of groundwater supplies for rural areas in developing countries found that:
- Almost 40 times more benefit, than cost, is provided with a properly constructed, operated and maintained well system.
- A 3 to 5 fold increase in net value is realized with the implementation of an operation and maintenance (O&M) program.
- Neglecting O&M results in much more substantial loss of overall value than most people realise. As Taljaard (2008:42) states, "Basic first-line maintenance is an absolute necessity for sustainable operation of any borehole and plant and should be conducted conscientiously."

At present capital costs tend to be considered in far more detail than recurrent costs. Groundwater sources in South Africa today are attended to only when they fail, and indications are that this is a more costly approach than providing for on-going O&M.

Cobbing, et al. (2013 Del. 3.)

Challenges

Key challenges in terms of sustainable groundwater resource utilization experienced in recent years include:

- There is still a widespread lack of understanding about the unique characteristics of groundwater that have a bearing on its appropriate utilization, management and protection;
- The lack of understanding is reflected in a lack of appropriate regulation of groundwater resources nearly 20 years after groundwater had been recognized as a significant resource in the National Water Act, 1998.
- No special management/protection has been given to the country's most vulnerable aquifers, the dolomitic aquifer systems and the coastal aquifers. Serious degradation of these important resources has taken place.
- Many excellent guidelines for appropriate management and protection of South Africa's groundwater resources have been produced through projects of the Water Research Commission and by the Department Affairs itself. Very few of these have ever found practical application.

Strategic Actions

Sustainable utilisation objectives and plans

The overall objective of guidance implementation needs to be translated into a series of specific, prioritised objectives and implementation plans together with the relevant stakeholders, e.g. guidance for resource development, resource planning, source operation and maintenance and resource / source protection.

Sector and institutional (WSDPs and CMS) groundwater plans need to be developed. **Protection is discussed separately under Theme 4**.

Good hydrogeological practice

Good hydrogeological practice is essential in the complex, integrated resource and socio-economic environment in which sustainable utilization is taking place. This must include always obtaining a proper system understanding, adequately monitoring and modelling system behaviour and adapting groundwater utilization and aquifer management accordingly, jointly with informed stakeholders.

Review / development of guidelines

Focused guidelines need to be developed and adapted for the above objectives to become part of a series of official, widely available and regularly reviewed guideline documents. Existing documents to form the basis of this action, include:

Selected existing guidelines

- Minimum Standards and Guidelines for Groundwater Resource Development for the Community Water Supply and Sanitation Programme (DWAF, 1997).
- Policy and Strategy for Groundwater Quality Management in South Africa (DWAF, 2000).
- A Protocol to Manage the Potential of Groundwater Contamination from On-site Sanitation (DWAF, 2003).
- NORAD Toolkit for Water Services (DWAF, 2004).
- Artificial Recharge Strategy (DWAF, 2007).
- A Guideline for the Assessment, Planning and Management of Groundwater Resources in South Africa (DWA, 2008).
- Groundwater Management Framework (WRC – Riemann et al., 2011).

Training programmes in support of guideline implementation

Guidelines should be introduced with relevant training programmes for the specific stakeholder groupings.

Inter-departmental cooperation

Inter-departmental cooperation should be strengthened through formal agreements and focused guidelines, in particular:

Drilling programmes implemented by:

- Department of Education,
- Department of Health
- Department of Agriculture, Forestry and Fisheries

Integrated authorization system to improve the regulation of environmental management, water resource management and related activities / land-uses such as mining:

- Department, the Department of Environmental Affairs
- Department of Mineral Resources

Ongoing auditing and awareness-raising

The Blue Drop Assessment, updated to allow for the proposed groundwater assessment, should be implemented as soon as possible, as part of an overall strategy to improve local groundwater management. Setting of standards and guidelines must go hand in hand with regular auditing of the implementation of these.

National capacity for groundwater governance

Direction of the support for sustainable groundwater resource utilization must become one of the key responsibilities of the groundwater governance structure to be established within the Department of Water and Sanitation. The skills required cover the whole spectrum of groundwater resource planning, development, management and protection. This is addressed further under Theme 2.

Local Hydrogeologist

Because of the urgency in this regard, the Groundwater Division had an initiative of groundwater consultancies "adopting a municipality" and providing a free service to get the municipal groundwater management in order.

This was successful in parts, but to make groundwater management sustainable, District and Local municipalities' will have to appoint/contract/share a hydrogeologist to manage their aquifers, if necessary in terms of appropriate regulation.

Theme 6: Appropriate Institutional Development

Objectives

Develop, facilitate, capacitate and support appropriate institutions that will allow effective local-level participative management of groundwater resources.

Principles

Given the situation of a widely-distributed resource affected by a plethora of local users and polluters, the required management (governance) approach has been coined as 'national facilitation of local actions.' This brings out the importance of the stakeholder-driven local-level management for groundwater and the appropriate local institutions to achieve this.

Situation assessment

Water resources institutional development

In South Africa, the subsidiarity principle provided the umbrella opportunity for the management of local groundwater resources. The 1997 Water Policy White Paper (DWAF, 1997) stipulates that responsibility for the "development, apportionment and management of available water resources" should be delegated to a "catchment or regional level in such a manner as to enable interested parties to participate."

A major purpose of the Act is to achieve the establishment of suitable institutions for appropriate and participative management of water resources. This is particularly important for highly localized groundwater resources which cannot be physically managed centrally. The Act provides for three levels of management, namely national government, nineteen catchment management agencies (now consolidated into nine) at the regional management level and water user associations acting cooperatively at the local level.

All three levels hold specific opportunities and responsibilities for improved groundwater management. Water user associations can practice conjunctive use of water resources and practice artificial recharge of aquifers, put catchment conservation into practice on their land and reverse over-exploitation and degradation of water resources. They can also create an opportunity for community development through the sharing of skills and resources. The catchment management level which has devolved management responsibilities is crucial for addressing groundwater development, management and use in a planned and integrated way in the public interest. It will also have to provide the essential support for local-level management, which has been completely lacking in South Africa for groundwater management.

Water services institutional development

In line with the interim Constitution, the White Paper confirmed that the long-term goal was to have democratic local government take responsibility for both providing and sustaining water services. This happened when local government came in place after the elections of 2000. The Strategic Framework for Water Services established in 2003, mapped out a vision for how the water sector as a whole will work in providing water services. The then DWAF was to continue to set the policy frameworks and oversee and regulate the activities of all water service institutions.

A key responsibility was to systematically develop the capacity of local government, jointly with relevant role players in national government, SETAs and professional associations. The recent joining of the water and sanitation functions in national government and the strong focus on regional implementation and support should greatly help in this regard. The highest level of this joining is to bring the National Water Act and the Water Services Act into one, seamless piece of legislation governing the entire water value chain.

Water services from groundwater

From 2000, with the advent of wall-to-wall municipal government and the introduction of local government in the former 'homelands' for the first time, responsibility for managing thousands of groundwater schemes was transferred from the Department and community-management structures to new municipal administrations. In essence there was a decentralization of management responsibility from the Department 'down' to local government, and centralization of operational responsibility 'up' from community-management structures to local government, without ensuring that the local government structures have the ability to perform the necessary functions.

Since then there have been many reports of scheme failure, starting with the much publicized Dinokana disaster in 2004 (sudden groundwater supply failure from an excellent dolomitic aquifer after a complete lack of groundwater level monitoring) and Delmas in 2005 (disbanding a local groundwater supply, following inadequate sanitation and a typhoid outbreak through polluted groundwater, for a much more expensive piped surface water scheme). There are no overall figures of performance of groundwater schemes, because of a complete lack of scheme monitoring and reporting to DWS Regional Offices or CMAs. The majority of smaller groundwater supply schemes are not covered by the Blue Drop reporting system. The available evidence suggests that the reasons for failure have less to do with hydrogeology and aquifer yields than with the lack of implementing operational requirements of sound groundwater management. It exposes a widespread lack in appropriate institutional capacity and necessary skills levels of water services providers.

A complimentary concern is the widespread wariness of groundwater as a source of municipal water in South Africa. Despite the raised profile at a national planning level, experience on the ground indicates that many municipalities only turn to groundwater as a very last resort in case of drought emergency.

Local collective management institutions

Some form of regulation and organisation of local groundwater users is generally seen as essential for the sustainable development of the resource. Working cooperatively is new for groundwater users for whom the resource had been their 'private water' before the new water legislation was promulgated. The Act now provides for local-level organization through the institution of a Water User Association (WUA). WUAs are defined in the NWA as water management institutions whose members voluntarily agree to undertake water related activities for their mutual benefit. Principal functions of an Association are concerned with management of the water resource or infrastructure. Typical examples (surface water related) in this category are preventing water wastage or unlawful use, regulating flow of the watercourse, protection of the water resource and monitoring flow quantity and quality. The Minister of Water and Sanitation must establish a WUA, once he or she is satisfied that it is in the public interest and that wide public consultation has taken place.

Despite the good intent of the National Water Act, 1998, the establishment of local collective management institutions is still virtually completely missing for groundwater resources. There are no Water User Associations for groundwater and very few local monitoring committees are functional. Besides the challenges of a complex and poorly understood resource, its previous „private water" nature still plays a major role in this lagging far behind the institutional development for surface water resources management and monitoring.

Challenges

Key challenges in terms of groundwater institutional development experienced in recent years include:

- The weakness in the groundwater function in national government is of particular concern at a time when new groundwater capacity has to be built in CMAs, local government, and local management institutions. Without a groundwater champion and a critical capacity in national government the country will not be able to move forward meaningfully towards good groundwater governance.
- The devolution of water resource management to lower levels, as foreseen by the National Water Act, 1998, and seen as critical for good groundwater governance, is taking much longer than expected.
- Participation of local water users and other stakeholders in the management of local groundwater resources has not yet taken place and groundwater is lagging far behind surface water resources in terms of institutional development. Despite the good intent of the National Water Act, 1998, this critical requirement is still virtually completely missing for groundwater resources.
- Lack of capacity in municipalities where groundwater has, in many instances, become the sole source of domestic water supply, is regarded by many as the most important factor holding back sustainable development and management of groundwater resources in South Africa. This has resulted in a widespread wariness of groundwater as a reliable and sustainable source of municipal water in South Africa and is starting to give groundwater as a resource a bad name.
- The biggest challenge for water management in South Africa will be the bridging period of the next ten to twenty years in which transformation from a highly centralized situation to new functional and highly participative institutions at different levels will have to take place.

Strategic Actions

A strategic governance framework

Systematically develop a strategic framework with key stakeholders as an essential precursor and progressive instrument for effective groundwater governance. Ensure that it becomes a formal part of the National Water Resource Strategy and catchment management strategies, as the accepted way to integrated water resources management implementation. As basis for capacity development and support, an analysis is required of the relevant vocational and professional inputs needed into groundwater management, and the relationship between these in terms of planning/oversight/analysis/direction/operation rules.

Capacitating municipalities

The general trend for decentralization and the establishment of new institutions to achieve sustainable water and sanitation services at local level needs to be supported with systematic capacity development in parallel. Local government should be brought on board as a major local player in sustainable groundwater resource development, utilization and protection, both as immediate focus and as part of a multi-stakeholder mobilization. Capacity building needs to be targeted at municipalities in cooperation with the whole sector, in particular the Department of Cooperative Governance and Traditional Affairs (CoGTA), the Local Government SETA, the South African Local Government Association (SALGA) and the Institute of Municipal Engineers of Southern Africa (IMESA).

Approaches in this regard could include awareness raising, guidelines and training and targeted support, with a special focus on potentially underutilized local government capacity.

Compliance with existing government requirements

Water Boards (Utilities) are subjected to annual reporting in terms of applicable legislation. However, their reports only cover the number of surface water schemes they manage, including the volumes abstracted, but nothing on groundwater schemes. This indicates a lack of monitoring of groundwater use (abstraction and water levels) by these institutions. This gap should be closed by compelling these institutions to report on both surface and groundwater including the quality of groundwater supplied, in terms of the requirements set Water Services Act.

As part the Public Finances Management Act (PFMA), an Asset Register must be kept by municipalities and be updated annually. Boreholes and borehole equipment are not listed and this should be addressed by municipalities, whether through instruction by the Auditor General or other (Blue Drop, etc.).

Communication and awareness-raising

A champion needs to be found within each sector, for example in municipalities, who is respected and understands/speaks the local government language and sees to groundwater management issues and solutions within the municipal environment. It is crucial to collect and tell the success stories of community water supply schemes supplied from groundwater to counter the growing perceptions that groundwater is an unreliable and not a sustainable source.

Guidelines

Practical guidelines on all aspects of groundwater scheme operation and maintenance and institutional arrangements in this regard need to be developed urgently, to be used by all sectors.

Local participative management institutions

Systematically develop, capacitate and support local management institutions, in particular monitoring committees to collect data and source management solutions, aquifer management committees and water user associations. These should increase the influence of stakeholders, and create platforms for information sharing, consensus-building and joint resource enhancement and protection.

District and Local municipalities utilising the same aquifer / compartment or sharing it with other users, must become part the above-mentioned local management institutions or help with their establishment where these do not yet exist.

National sector support for local management

Through improved sector understanding, identify and strengthen within-sector support structures and processes which could facilitate local-level management by that sector, e.g. training in land-care matters provided to farmers by the Department of Agriculture, could include groundwater resource management and sustainability issues.

Widely-occurring local-level needs, e.g. improved understanding required by farmers of water-use allocation processes, could be fed back to the Department of Water Affairs and Sanitation.

National groundwater champion

Urgently create a fully capacitated national groundwater champion to fulfil the critical national facilitation responsibility. This groundwater capacity at national level is required in all aspects of groundwater governance, from strategic planning and assessment to developing the necessary regulations and guidelines and supporting local institutional development. There is capacity and willingness in the private and academic sectors, which needs to be harnessed in win-win partnerships. This is unpacked further under Strategy Theme 2.

Theme 7: Redirecting Finances

Objectives

Redirect incentive policies and public expenditures impacting groundwater by and within different sectors to achieve a combined, much stronger focus on sustainable and efficient groundwater management.

Situation assessment

Groundwater-related expenditure is taking place in different branches of DWS, for example in support of water resources planning and of water services implementation. Related expenditure will also take place in other sectors like health, agriculture, mining and local government. Very little coordination between these potentially-related activities is taking place at present.

The groundwater function in DWS has shrunk since restructuring of the Department in 2003 and the loss of the Directorate Geohydrology. No further resource assessment has been taking place since then and important functions like groundwater monitoring are seriously under-resourced.

Lack of finance could become a serious bottleneck to the implementation of the groundwater governance framework, particularly because of groundwater's 'private water', neglected, and under-valued status.

The actions below are a first attempt to remedy the situation at a strategic level. International experience in this regard was included, obtained from the Global Groundwater Governance Framework completed recently (UNESCO et al., 2015).

Strategic Actions

Align groundwater finance

Align all public groundwater finance with the new priorities. Aligning happens inside and outside the Department, e.g. All Towns national planning and its follow-through in Regions (Water Services) and implementation by municipalities. Alignment is important between different sectors, e.g. there should be no provision of farming subsidies in groundwater-stressed areas and there should be a significant charge for using high volumes of groundwater to counter over-use. Other subsidies, in particular for fuel and electricity should be strongly discouraged in such situations.

In appropriate settings provide economic incentives to encourage groundwater conservation, in particular artificial recharge of aquifers.

Address financing as a high priority in the hierarchy of groundwater decision-making and action.

Encourage private investment

The systems of regulations and incentives should encourage private investment in sustainable groundwater management. In this regard, develop investment portfolios in sustainable and productive groundwater management. In addition, ensure that investments in other sectors (such as roads, aquaculture and leisure) can be tailored to have groundwater benefits like promoting recharge. Alternative approaches are necessary to leverage parallel investments by groundwater users and by the beneficiaries of other functions of aquifer systems. Many investment programs that serve the sustainable use of groundwater are likely to contribute to other livelihood and ecosystem functions, and this multi-functionality should make the programmes more attractive to investors.

Invest in governance

Funding of groundwater governance must be in line with its strategic importance. The basic groundwater management functions should not be compromised: there needs to be investment in the actors, institutions, policies and knowledge. Legal instruments and regulatory provisions must be matched by the means required for their implementation.

Improved groundwater management and O&M will be a huge cost saving. Planning and allocating money for groundwater O&M is money well-spent.

Improve efficiency of charging for groundwater use

Groundwater use should be charged as incentive to conserve and protect the resource. This, in turn, means that there must be adequate measurement of use. Because of the many abstraction points, efficiency in measurement and charging is required. For example, where water is metered at hydrants, breakthroughs in information and communication technology make charging for water more feasible and more efficient. Mobile money – held on smartphones – for instance can be used to pay for water use and ensure full payment of charges.

Ideally, groundwater use charges should be used for its sustainable development and management. Alternatively, with all charges going to a catchment fund, groundwater's management needs and backlog need to be recognized. Importantly, tariffs should not be uniform, but should be set according to the (groundwater) management needs of a catchment.

Theme 8: Groundwater resource planning and development

Objectives

Achieve integrated groundwater resource planning at national, regional and local levels that will fully and sustainably establish the unique potential of groundwater for socio-economic development.

Principles

Groundwater is an integral part of the hydrological cycle. Groundwater in South Africa has benefited greatly from being developed within an IWRM framework across the full spectrum of policy, regulations, institutional development, protection, planning and information management. The roll-out of the NGS will have to continue within this overall framework.

Integration must take place at three effective levels, integration within the hydrological cycle (the physical processes), integration across land and water, across river basins (catchments) and aquifers (spatial integration), and integration across the overall social and economic fabric from national to local level.

Situation assessment

Groundwater in the planning function

The vision of the National Water Act, 1998 is Integrated Water Resources Management. All water resource management at national, catchment and local levels should be based on the principles of IWRM. Groundwater resource management should not operate in isolation, but should be part of the drive towards integrated water resources management. In this way scarce resources can be shared and major synergies can be achieved.

It was therefore crucial that, with the major restructuring of the Department in 2003, groundwater was integrated into the various water resource management functions, in particular the water resource planning function. Groundwater is now fully part of the planning basket, with groundwater specialists in the planning team. This has had tremendous benefits for groundwater resource development and management:

- At the national level it led to development of a Departmental Groundwater Strategy and the extensive inclusion of groundwater into the second edition of the National Water Resources Strategy.
- Groundwater became part of the nationwide programme to develop water reconciliation strategies for WMA's, metro's, towns, villages and clusters of villages across the country, starting in 2008. These studies provided the groundwater potential for each municipality at a local scale and identified possible target aquifers in the vicinity of the towns, where this appears to be feasible (e.g. DWA, 2011);
- Groundwater staff had the opportunity to comment on major municipal projects to be undertaken with government grant funding, e.g. the Municipal Infrastructure Grant (MIG);
- Departmental guidelines could be prepared, addressing various aspects of sustainable development and management of groundwater resources (e.g. DWAF, 2008b and Murray and Ravenscroft, 2010).

Greater use of groundwater sources does indeed hold enormous promise for accelerating sustainable access to improved water service and augmenting supply in many parts of the country. The lead times for developing groundwater resources are far shorter than are typically found in big surface water development projects, which allows for delivery of the benefits far sooner. There is also scope for substantial cost savings in developing local decentralized groundwater-based schemes, instead of big regional surface water schemes with major pipelines conveying water from distant impoundments.

Planning at different levels

While planning has been well established at the national level, there are as yet no catchment management plans (strategies) as foreseen in the National Water Act, 1998. Until such time as the CMAs are operational, water management at WMA level is guided by a series of documents developed by the Department between 2002 and 2004 called Internal Strategic Perspectives (ISPs). The essential element of stakeholder consultation is still missing.

At the municipal level, each municipality designated as Water Services Authority, must develop a Water Services Development Plan (WSDP) as part of the Integrated Development Plan (IDP) process that concentrates on increasing access to water services, and must also take into account water supply sustainability. This level still suffers from a serious lack of technical capacity. There are examples of municipalities' general planning documents containing little on groundwater, despite having a major aquifer system in their area, despite having a profitable local industry relying on these resources and despite serious degradation of the resource through over-abstraction and acid mine drainage.

The role of the national groundwater function as auditor, enabler and capacitor of the new levels of groundwater planning and implementation will thus be critical in coming years.

Challenges with groundwater for municipal supply

Despite this raised profile on paper, experience on the ground indicates that many municipalities only turn to groundwater as a last resort or in emergencies. Groundwater is perceived as an unreliable and difficult source to manage. According to the Department, 'more than 70% of WSAs do not want localised solutions and prefer regional schemes.' Financing via the Regional Bulk Infrastructure Grant (RBIG) gives municipalities large financing in their own control, often resulting in a complete neglect of local groundwater sources. In some cases very expensive options such as desalination are implemented as short or medium term solutions, without groundwater being given early, serious consideration (e.g. at Sedgefield).

In general, municipal water supply from groundwater remains a major problem. World-wide it is accepted that drinking water supply to communities requires the highest standards of planning, implementation, operation and maintenance. Local government in South Africa, at this stage, does not have the groundwater technical capacity to undertake this function responsibly. Policy, regulation and comprehensive support is required for a more sustainable way forward.

Challenges

Key challenges for groundwater resources planning and development experienced in recent years include:

- Whilst national water resource planners are well aware of the potential of groundwater, many planners and managers at regional and local level do not incorporate groundwater into their water development plans, or else treat it as a last resort, to be used only in emergencies.
- Groundwater management links to groundwater-dependent sectors like agriculture, rural development, health and environment are not well established in policy or in practice. Decision makers in the fields of climate change preparedness, rural poverty alleviation, and related fields do not always have adequate information about the ways in which groundwater can assist them, and spatial planning documents rarely consider groundwater, even where groundwater is a potential major factor in continued economic development.
- Investment in groundwater, relative to its potential to address national objectives, is limited and groundwater is unlikely to attract high profile champions in the construction industry, because developments are generally modest when compared to surface water impoundments and long-distance pipelines.
- Planning and financing processes and accompanying study and exploration investment, addressing groundwater (often in the form of many, widely distributed, relatively small, individual sources) systematically through all phases, are not in place. In particular, a lack of macro planning for groundwater prevails.
- Local and vulnerable groundwater resources need a much more participative approach to development, operation and protection. This is still completely missing.
- Despite groundwater's crucial role in drought preparedness and emergency response, particularly in rural areas, groundwater as part of drought risk management has not yet been mainstreamed into on-going planning and development processes.
- Lack of adequate monitoring and assessment of groundwater resources is resulting in poor attention to groundwater planning at all levels. This is particularly serious for drought risk management.
- Within municipalities, groundwater is widely perceived as unreliable and a difficult source to manage. The real problem is that local government in South Africa, at this stage, does not have the groundwater technical capacity to undertake this function responsibly.

Strategic Actions

Groundwater priority

The groundwater development priority must be worked through into Treasury instructions and other instruments of planning and financing, ie catchment management strategies and WSDPs and IDPs.

Macro planning

The country should ultimately be covered with groundwater plans at catchment and priority aquifer level. Planning should not only address water resource reconciliation issues, but also the regulatory support and the human and institutional capacity requirements for a sustainable utilisation of local water resources. At this stage such macro planning does not really exist. The focus is water resource planning. That there is appropriate capacity to manage is implied and not a planning outcome; this needs norms and standards coming from elsewhere.

Catchment management strategies

The national and catchment management strategies should become major vehicles for integration. Each catchment management agency (CMA) should include a groundwater management plan as part of the catchment management framework and to have sufficient groundwater specialists available to oversee sustainable development, monitoring and management of groundwater resources.

Groundwater planning guidelines

Establish guidelines for the groundwater content of emerging Catchment Management Strategies (CMS), and other water resource management guideline documents.

Best Practice Guidelines

Develop and implement "Best Practice Guidelines" for the mining sector as well as for the municipal, agriculture, energy and forestry sectors to ensure the protection of groundwater resources. Where necessary, these need to be regulated, eg. Water Services regulations for WSDPs.

Drought risk management

The critical role of groundwater in drought risk management needs to be mainstreamed into ongoing planning and development processes. There needs to be a move away from crisis management to ongoing implementation of drought-proofing measures. This could entail the development of regional and sub-regional information on areas expected to be most affected by drought, with plans for monitoring and targeting drought-proofing measures during and ahead of droughts (e.g. rehabilitation of groundwater supply infrastructure and well deepening).

Stakeholder involvement in planning

The importance of aquifer and basin plans is that stakeholders can be systematically introduced to the groundwater resources in their area and involved in the drawing up and regularly reviewing such plans. This process must be formally established through the NGS.

Groundwater information

Appropriate information is often the bottleneck in planning – especially the lack of monitoring by municipalities. There needs to be regional reporting on the implementation of the All Towns plans and the business processes followed – municipalities very often follow their own limited understanding.

Groundwater information needs to be developed for planning at various levels of a scope and level of detail comparable to other options in water resource assessments. This should include information on groundwater infrastructure and cost requirements.

Groundwater development

Conduct groundwater resource assessment and development programmes (including the rehabilitation of existing water supply boreholes) for towns threatened by surface water shortages as water needs increase.

Implement groundwater development programmes for domestic and productive water use to support national imperatives such as the Comprehensive Rural Development Programme, the Water Allocation Reform process, addressing the Millennium Development Goals, etc.

Develop groundwater in a conjunctive manner with other local resources (such as surface resources, reuse, desalination and rain water harvesting).

Theme 9: Groundwater Information Management

Objectives

Grow and maintain the groundwater resource knowledge base, focusing on the resource itself, its socio-economic role and its appropriate management.

Develop and maintain effective and efficient information and information systems, as a shared national objective and an integral part of water management strategies, in support of groundwater development and management at all levels.

Principles

'No sustainable development of a scarce natural resource is possible without understanding the resource and managing it wisely according to this growing understanding' (Minister of Water Affairs, Ronnie Kasrils, 2003). Such understanding must include the resource and its environmental connections, the users and their needs and the appropriate management and expansion interventions. Proper understanding is particularly important for groundwater, because of its hidden and neglected nature.

To transform water management in South Africa from a highly centralized to a strongly devolved and participative approach, information management will become a strategic requirement. This is particularly important for groundwater governance – 'national facilitation of local actions'. A rapidly increasing number of stakeholders will have to provide groundwater data and will need information support. Sharing information improves efficiency, stimulates development and reduces the probability of making wrong decisions.

A groundwater information system must lead and maintain this whole process, created and sustained by vision and commitment and anchored in legislation. Some critical success factors will be:

- A dynamic system (continuously updated and adapted)
- Participative and client-driven development
- Appropriate technology to achieve participation and effectiveness
- Central direction, coordination and maintenance
- Openness to all.

Situation assessment

Role of information management

The regular collection, analysis and dissemination of data and information are fundamental for any programme of groundwater management that wants to influence policy, decision makers and public opinion. Lack of information and lack of access to information are the two issues widely identified by experts and stakeholders as constraining the development of effective strategies and policies for managing groundwater. This is while international experience shows a move towards even more data-intensive groundwater assessment methodologies. Increasing data density and availability in South Africa should be a core part of future groundwater resource assessments. Ultimately models and information must become the basic tools groups of stakeholders of shared aquifer resources use to reach agreement on management options.

Groundwater information management in South Africa

A first national assessment of available groundwater resources was initiated in 1995 through the publication of Groundwater Resources of South Africa, consisting of a report and accompanying set of groundwater maps published by the WRC (Vegter, 1995). The maps were based on a statistical analysis of data from approximately 70 000 boreholes held mainly by the Department of Water Affairs and Forestry. The seven national scale maps on two A0 sheets were a first attempt at a visual representation of South Africa's groundwater resources, including:

- Borehole prospects
- Saturated interstices
- Depth of groundwater level
- Mean annual groundwater recharge
- Groundwater component of river flow
- Groundwater quality
- Hydrochemical types.

The regional mapping was undertaken by the Department of Water Affairs and Forestry, leading to the publication of a series of 21 hydrogeological maps by 2003. Importantly, the follow-on assessment phase, Groundwater Resources Assessment (GRA2), completed in 2005, led, for the first time, to the inclusion of a groundwater component in the Water Resources of South Africa study (WR2005).

Ongoing monitoring is essential to be aware of the state of a system and its response to external impacts and management interventions. Monitoring takes place at a national (unimpacted) level, a regional (unimpacted and impacted) level and a local (aquifer) level in support of management at these different levels. Besides establishing national monitoring programmes, the National Water Act, 1998 also requires the Minister to establish mechanisms to coordinate the monitoring at the different levels.

While monitoring of our rivers and dams has started around a hundred years ago, only a few groundwater level records are longer than 40 years. The map of national groundwater level monitoring stations still shows large blank areas and investment into groundwater monitoring is about 15% of that for the surface water network (DWAF, 2004), whereas it is no less important.

The foundation for all groundwater resource assessment and mapping was the development of the National Groundwater Database (NGDB) in 2004. It contains about 250 000 borehole records at present and is foundational to any national and regional assessments as described above. In preparatory work for the Groundwater Strategy, concern was expressed about the decline of borehole data capture (Witthueser et al., 2009). A further concern, already recognised with the writing of the National Water Act, 1998, was that information from private drilling (approximately 100 000 boreholes are drilled in South Africa per year) is not ending up on the National Groundwater Database. It is likely that a process to centralize “private” data would be a very cost effective and rapid way of expanding national groundwater data archives. In 2009/10 there was a change-over to the National Groundwater Archive (NGA). The NGA has become a lot more user-friendly and accessible to users in recent years. Importantly, users can now upload and control their own data.

The Water Use Authorisation Registration Management System or WARMS, records volumes of groundwater used. This is based mainly on registered volumes, which have a high level of uncertainty, because a systematic verification process has not started yet. Groundwater-use data has only been collected with the licensing process since 1998. Before this there had been no need for groundwater users to supply the Department with groundwater use, level and quality information except in the Subterranean Government Water Control Areas (SGWCAs).

A lack of reliable groundwater data makes it difficult to make accurate assessments of the availability (i.e. quantity and quality) and abstraction (i.e. rates, quantities and drawdown levels) of groundwater. This, in turn, leads to poor management and an inability to foresee resource degradation through drought and pollution. Lack of data on the status of water supply infrastructure (i.e. borehole construction, pumps, etc.) is a major constraint on investment in operation and maintenance activities. All the above illustrate a lack of ‘ownership’ for the underground resource.

The Groundwater Resource Information Project (GRIP) is a Departmental project to improve data and information holdings by accessing unpublished or “private” data and reports as well as “new” groundwater data collected by visiting boreholes in the field – particularly in priority areas. To date, GRIP has been most fully implemented in the Limpopo Province, where it began in 2002 - more than 2 500 villages have been visited, 15 500 borehole sites have been verified, and results from 1 500 additional pumping tests have been added to the provincial database. The extra data has led to a higher borehole drilling success rate in the province, saving a considerable amount of money. The GRIP projects in the Eastern Cape and KwaZulu-Natal lack budget and are not as advanced as in Limpopo.

Related hydrological and environmental datasets (e.g. rainfall volume, chloride concentrations in rainfall, spring-flow measurements, etc.) are also key to the better understanding of our groundwater resources. However, these are not always designed with groundwater in mind, and are not aligned with groundwater management strategies.

Data on groundwater in South Africa exists in various different databases held by a variety of organizations and individuals. Many of these databases are inaccessible (e.g. those held by private companies) or are difficult to access (e.g. groundwater data held at a provincial level). Combining databases would make groundwater planning easier and cheaper. The process should start by integrating those databases that are already publicly available (in theory), and later address the problem of “private” groundwater data.

All geohydrological investigations that the Department has undertaken up to 2003, when the Directorate Geohydrology was disbanded, are available in hard copy as GH reports. Many of these are now electronically available through an initiative to scan these reports. This can be seen as equally important to the archiving and making available on the Internet of the unpublished reports ('grey literature') of the British Geological Survey throughout Africa.

Characteristics of groundwater systems

Groundwater resources management has to deal with balancing the exploitation of a complex resource (in terms of quantity, quality and surface water interactions) with the increasing needs of water and land users (which can pose a threat to resource availability and quality).

All aquifers have two fundamental characteristics: a capacity for groundwater storage and a capacity for groundwater flow. Different geological formations vary widely in the degree to which they exhibit these properties and their spatial extent can vary with geological structure from a few to many thousands of square kilometres.

The flow boundaries of groundwater (in space and depth) are generally more difficult to define than for surface water systems and may vary with time. The difference is further accentuated because groundwater forms the 'invisible part' of the hydrological cycle.

The recharge rates of aquifers are a fundamental consideration in the sustainability of groundwater resource development. Furthermore, understanding aquifer recharge mechanisms and their linkages with land-use is essential for integrated water resources management. The quantification of natural recharge, however, is subject to significant methodological difficulties, data deficiencies and resultant uncertainties because of wide spatial and temporal variability of rainfall and runoff events and widespread lateral variation in soil profiles and hydrogeological conditions. Nevertheless, for most practical purposes it is sufficient to make approximate estimates, and refine these subsequently through monitoring and analysis of aquifer response to abstraction over the medium term.

Aquifers are experiencing an increasing threat of pollution from urbanization, industrial development, agricultural activities and mining enterprises. Varying degrees of vulnerability to these impacts can be distinguished according to the depth of the water table, soil permeability and conditions at the land surface.

With progressive development, it becomes more and more important to understand the functioning of the groundwater system and its interaction with both the aquatic and terrestrial environment. However, not only the scientific factors, but also institutional and social acceptance are crucial in addressing sustainability.

Knowledge of South Africa's groundwater systems

According to Vegter (2001) the use of groundwater in South Africa has grown from about 700 to an estimated 3500 million m³/annum between 1950 and 1999 respectively. He described the increasing activity of groundwater investigation and research during this period of increasing groundwater use in a number of eras (**Table 7**)

Groundwater Research & Development

The first WRC groundwater-related research project, initiated in 1974, dealt with the recharging of storm water into the Cape Flats aquifer. The initial research focus was on resource characterisation and groundwater technology. The investment from the WRC in these study fields over the years has undoubtedly led to a greater understanding of South Africa's complex aquifer systems, and finding ways to effectively manage them.

Since 2000 a greater resource management focus within an integrated water resource management framework was added to the WRC research portfolio. This progression of research focus reflects the progression of groundwater attention nationally, before and after the promulgation of the National Water Act in 1998.

Funding for groundwater projects has varied between 6% and 16% of the Commission's annual research spending. In 2012, more than R5-m was invested in groundwater projects, with another R2.8-million in 2013. The current areas of focus include groundwater-surface water interactions and improving understanding of South Africa's vast fractured rock aquifers in terms of hydraulic behaviour and chemical characteristics. Another focus is around building, understanding and developing the necessary tools for groundwater management at the local (i.e. municipal) level (Adams, 2013).

able 7: Eras of groundwater investigation and research activities according to Vegter (2001)

1888-1935	**Pre-geophysics era**	Locating borehole sites based on surface indications; the first regional and national assessments of the water-bearing properties of the more important geological formations (based on data from some 10 000 boreholes drilled by the Department of Irrigation and its predecessors)
1936-1955	**Era of geophysical borehole siting**	The Geological Survey supported the drilling activities of the Department of Irrigation and also other central (eg Railways) provincial and local authorities with borehole siting, using geophysical methods. This reduced the development costs of groundwater supplies and improved the understanding of different groundwater systems.
1956-1976	**Quest for quantification era**	There was a growing recognition of the need for not only siting boreholes scientifically, but for a quantitative assessment of different groundwater supplies. Such assessment became a prerequisite where subsidies were granted to local authorities for groundwater exploitation for urban supplies (in terms of the Water Act, 1956). Where local authorities were reluctant to use groundwater resources, the Department of Water Affairs and Forestry (DWAF), supported by the Geological Survey undertook the exploration and resource assessment. Only in a few instances were the above government team able to observe the performance of these groundwater supply schemes over time to improve the evaluation of groundwater resources. A lot of experience, data and information was gained on the dolomitic groundwater resources during the intensive investigations of dewatering, subsidence and sinkhole formation on the Far West Rand. Unfortunately this intensive data collection was not maintained
1977-1997	**Era of expanding activity**	Systematic exploration of the dolomitic formations of the Southern Transvaal as an emergency water supply for the PWV area. A large number of regional investigations of Karoo, coastal and stream-aquifer systems were concluded. In 1995 the first comprehensive estimates of groundwater availability at a national scale were published. These and later regional maps mainly relied on data held by DWAF in its databases – much of which was gathered over decades of government-sponsored drilling programmes
1998-	Integrated management era	By 2003 the DWAF had made available a set of twenty three “general” hydrogeological maps at a scale of 1:500 000 which together cover the entire country (Groundwater Resources Assessment phase 1 - GRA1). This was followed by the GRA2 phase, concentrating on the quantification of the resource, water quality characterization, the quantification of recharge and groundwater/surface water interaction, the classification of aquifers, and the quantification of groundwater use for the above mapped areas. This phase was largely undertaken by consultants

Emerging capacity needs

The above regional resource estimates will in most cases not be adequate in new local groundwater investigations (aimed at establishing a reliable water supply for a town, or tackling a groundwater pollution plume, or improving environmental flows, for example). All of these situations call for a high degree of confidence in the outcomes of the work – usually much higher than can be obtained by using regional estimates based on limited local data only. More sophisticated methods for groundwater resource management, in particular numerical modelling of a shared aquifer system, also require a high degree of certainty in the description of the system in space and time.

A major effort will be required in the regular assessment of the sustainability of present abstractions countrywide in terms of quantity, quality and environmental contribution.

To date South Africa has largely developed shallow, unconfined groundwater resources. However, increasing water scarcity and greater reliance on groundwater resources, for example in the Limpopo province, will require a systematic exploration effort to locate possible deeper systems. This will require a groundwater development capacity greater than the country had in the era of expanding activity to enable locating, characterizing and evaluating resources at a depth.

Closure of a large number of coal mines and the prospect of region-wide mining of shale gas pose new threats for South Africa's vulnerable groundwater resources at an even larger scale than for the re-watering of dolomitic groundwater systems and the consequent acid mine drainage related to region-wide gold mine closure. Good groundwater systems understanding will have to feed into the much improved mining planning and authorization processes and mitigation measures will need to be in

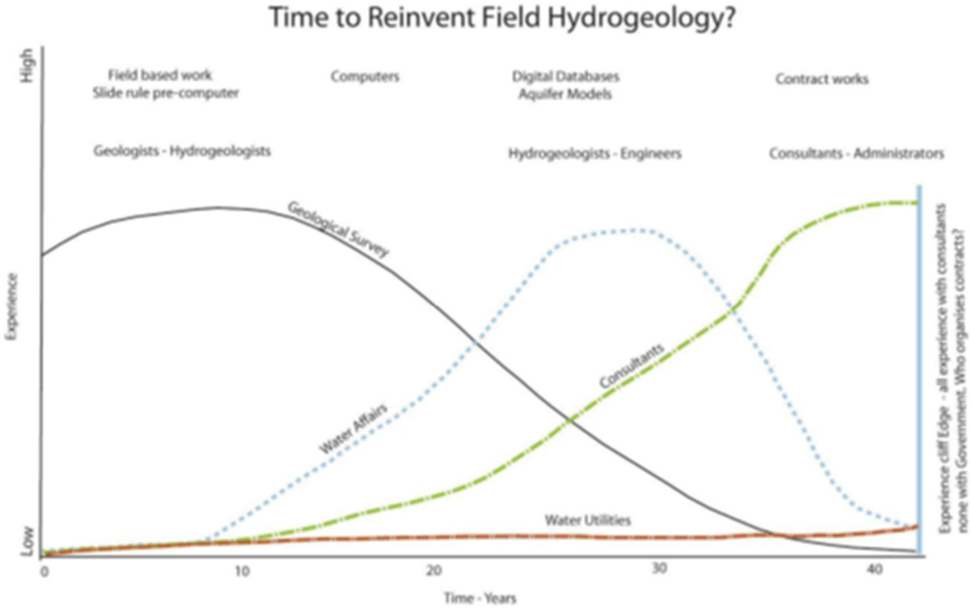


Figure 19: How the distribution of hydrogeological experience has changed during the last 40 years. (Davies et al., 2015)

place before hydraulic fracturing for shale gas development proceeds in South Africa.

The capacity gap for groundwater resource assessment that has developed in South Africa (and in many other countries) has been well illustrated by Davies et al. (2015). Their figure of how hydrogeological experience has changed over the last 40 years (see Error! Reference source not found.) closely matches the eras of groundwater investigation in South Africa (**Table 7.**)

The key conclusion of Davies et al. (2015) based on experience in many different also needs serious consideration in this strategy. "We need to return to basics and not rely on digital models founded on inadequate data of uncertain pedigree, and get out into the field to carry on the trade of sensible, pragmatic hydrogeology that provides sustainable outcomes for the benefit of the people."

Challenges

Key challenges for groundwater information management experienced in recent years include:

- There has been a continued undervaluation of groundwater resources at national, regional and local levels even under the National Water Act, 1998.
- The last systematic exploration of whole groundwater systems as part of national water resource planning has taken place some 20 years ago. No alternative arrangements for this type of regional exploration has been made so far since the DWAFs Directorate of Geohydrology, which had come about from a merger with the Groundwater Division of the Geological Survey, was disbanded. WRC-projects on their own cannot fill this gap.
- The almost complete loss of groundwater technical capacity in national government is a major concern in the light of groundwater's increasing importance, but also increasing development and management challenges.
- Past regional and national assessments of groundwater resources have been largely based on data resulting from state drilling operations. Drilling services of DWS have, however, ceased for a number of years already and drilling by other state departments (i.e. Department of Health, Department of Agriculture and Provincial Departments of Education) takes place without the type of professional supervision that would ensure data quality.

Box I: The value of Information

As freshwater resources are declining in quantity and deteriorating in quality, water resource management is of greater importance than ever before. Decision-making in water resource management is a difficult task that requires sound and reliable information about the water resource in terms of physical, hydrological and demographic characteristics. In the case of groundwater, its invisible nature adds uncertainties that complicate the decision-making process and add to the information challenge.
Information has become an issue in all fields of development and the value of information has become a much-studied scientific concept. Value of information or VOI is defined as:
"VOI is the amount a decision maker would be willing to pay for information prior to making a decision."
Studies in many different sectors have shown:

- Good Information Reduces Costs
- Information Saves Time
- Information Improves Decision Making
- Information Yields Customer Satisfaction

As more investments in high-tech information technology like satellite remote-sensing are contemplated, indications are that the expected impact of investing in these is positive, but that outcomes strongly depend on the accuracy of the information system and the range of informational benefits perceived. However, more data do not necessarily mean more information and not necessarily better decision-making.
In the case of wide-spread groundwater systems, Vivier and van der Walt (2011) suggest that data-gathering programmes should be planned to be iterative to allow for assessment of information sufficiency as decisions are beginning to be made. They also suggest that groundwater specialists should be trained in basic decision-making principles and processes.
With new institutions and devolved management of shared groundwater resources, accessible and appropriate information becomes extremely important to aid good interaction of local institutions and shared decision-making. Staged devolution, capacity-building and national support are critical ingredients for this type of management arrangement.

(Crase and Ghandi, 2009).

- There has been limited national investment into groundwater monitoring compared to surface water. No national targets have been set for monitoring, resulting in a very uneven monitoring effort by different DWS Regions.
- Despite the long-standing national need of making available data from the many private consultants and private sector drillers to a national data base and sharing these in the national interest, very little has happened to date.
- Inaccessibility of data and fragmentation of databases is a serious problem.
- Groundwater use information is still inadequate for management, because very little verification has been undertaken.
- Monitoring has not yet become the basis of improved aquifer management.
- Local municipalities, agriculture and the mining sector are not monitoring their groundwater use / impact / levels/ quality.
- There has been virtually no evaluation of supply sustainability of the many municipal supply schemes from groundwater that have been developed in the last twenty years and even before. This could be a major source of information for any national/regional groundwater resource assessment. This is also concerning because the lack of technical capacity of municipalities is well known.

A few thoughts on the value of information in decision-making are provided in **Box I**.

Strategic actions

Appropriate groundwater knowledge base

Address the overall required groundwater knowledge base strategically as part of developing a groundwater Research & Development plan. Consider the available national groundwater knowledge capacity and propose cooperative ways of addressing the overall needs. Include stakeholders in such an assessment to achieve greater understanding and a greater drive towards cooperation and buy-in. Also consider the role of international cooperation in such a strategic approach to growing the groundwater resource knowledge base.

National Groundwater Champion

This most critical requirement is further addressed under strategy Theme 2.

Groundwater data and information

Address the vital issue of groundwater data and information management strategically, as foundation for improved management and cooperation of stakeholders. Focal points include:

- An assessment of information needs, sources of existing data and information and major gaps.

- The setting of standards for groundwater data collection and management, with emphasis on appropriateness and value for money.
- Achievement of a major increase in data accessibility.
- A data culture is required throughout the participating sectors, because of the challenges with groundwater information.

While this must be the responsibility of a National Groundwater Champion, a specialized facility like the Computing Centre for Water Information could be considered for this purpose.

Groundwater monitoring strategy

Develop a comprehensive groundwater monitoring strategy (quantity, quality, use, supporting measurements like rainfall, isotopes and chlorides), based on proper valuation of the resource, its various roles and its functioning in the different sectors and at different governance levels, with provision for monitoring guidance and auditing. Monitoring is needed for different purposes which must be clearly specified and addressed, e.g. water use authorization, resource protection and planning. The strategy needs to address the lack of systematic groundwater resources and abstraction monitoring in large parts of the country and to achieve a more integrated monitoring system with that of surface water.

Undertake this development as a WRC project with full stakeholder involvement. Link with the important DWS project presently underway to review and plan all monitoring together with key partners like the WRC and the South African Environmental Observation Network (SAEON).

Groundwater use information

Verify water use from groundwater within a reasonable time frame, prioritizing major and stressed aquifers, and implement programmes to enforce compliance with respect to water use license conditions. Implement stricter regulations regarding uploading of information to the NGA and non-compliance with respect to water use license conditions.

Centralized "private" data

Develop a process to centralize "private" data (held e.g. by private consultants and drillers) as a cost-effective and rapid way of expanding the national groundwater data archives. Develop regulations in this regard in consultation with the groundwater industry.

Many reports are produced for municipalities but the information never ends up on the NGA. Much clearer regulation is required to ensure that information produced with government money ends up on the NGA for general use.

Related data from other institutions

Engage and support relevant authorities to improve hydrological and environmental monitoring programmes necessary for groundwater management, such as the rainfall monitoring systems maintained by the South African Weather Service, the Department of Agriculture and the integrated information system to record and report on the status of active and abandoned mines maintained by the Department of Mineral Resources.

Harmonisation of data bases / information systems

Improve aspects of accessibility and exchange of data, standardization of data capturing formats for various purposes, reporting of data and information, etc.

Include provisions / clauses in all DWA contracts specifying that all data collected as part of the project be submitted to the Department, in a standard Departmental format linked to, for example, the NGA.

Integrated information service

Provide an integrated groundwater information service at municipal and aquifer management level.

Work towards a GIS supported information service with purpose-made maps and other information products based on the best available info on the data bank.

Improve the compatibility (and/or integration) of existing groundwater databases / information systems maintained by different institutions (including water quality databases and municipal groundwater asset registers).

Achieve a streamlined flow of information and appropriate processes/systems to manage it, through analysing the expected flow of data and information from and to different stakeholders and levels in the water management hierarchy.

Knowledge sharing

Make groundwater knowledge management an on-going contribution from the groundwater science sector to the long-term process of developing increasing stakeholder involvement towards good groundwater governance. This would include ever wider sharing, archiving and effective communication of information and knowledge products. The WRC should remain the lead organization in this regard.

Publicity of groundwater information

A vast amount of groundwater information is available and needs to be appropriately captured and publicized for universal use.

The brochures accompanying the 21 general hydrogeological maps of the country are particularly useful in this regard. The outstanding ten brochures need to be printed without delay.

Foster widespread promotion and use of the information system amongst the hydrogeological community, so that hydrogeological data and information exchange can be more readily achieved.

Groundwater use and infrastructure information

Stop the wastage of groundwater infrastructure. Find ways of extending and financing the GRIP programme in all DWS regions to gather information on existing groundwater infrastructure, to enable its inclusion in water supply schemes where relevant.

Monitoring as part of aquifer management

Establish aquifer monitoring and modelling as an integral part of aquifer management by all sectors. Achieve this through the responsible CMAs and the licensing process. Implement this as part of an information management process for all catchments, facilitated by the national groundwater champion.

National State of Water Resources Reporting

Information systems should be geared for regular, integrated and streamlined national and regional state of water resources reporting. Such reports should address key questions such as (example of the Australian Water Resources 2005 – a Baseline of Water Resources):

- What was the size of our total water resource?
- How much of our water resource was used by the economy and the environment?
- How was this water used?
- Was our consumptive use sustainable?
- What was the correlation between consumptive use and the health of our rivers and wetlands?
- Where are our stressed rivers and catchments?
- What are the implications of surface water and groundwater interactions on consumptive or environmental use of water?

This should be discussed in terms of set Resource Classes and Resource Quality Objectives and indicate remedial measures where necessary.

This would provide the highest level indication of the state of groundwater resources and of groundwater governance.

Use of the Blue Drop and WSDP systems could provide an indication (bird's eye view) of the state of management of groundwater by municipalities.

These bi-annual assessments are not enough to pick up trends, i.e. dropping borehole levels and deterioration of bore water quality and the regular monitoring and reporting in terms of aquifer management.

Regional perspective

Share information, knowledge and experience across and far beyond national boundaries to achieve benefits from understanding global and regional patterns and processes and recognize potentials, problems and trends related to groundwater. This will also contribute to standardization of methods and observational practices. It should be seen as part of the knowledge-sharing action, but also links strongly to national government's international obligations.

Theme 10: Regional And International Partnership

Objectives

Actively participate in and grow appropriate regional and international partnerships towards groundwater resource understanding and optimal utilization, including transboundary resource management.

Principles

Sharing knowledge and experience across boundaries has the potential to accelerate our learning processes significantly. It improves efficiency, stimulates development and reduces the probability of making wrong decisions.

Situation assessment

Sharing knowledge

Groundwater has been the Cinderella of water resources in many parts across the globe. A lot has been learned from each other's failures and breakthroughs, technical, social and managerial. Besides area-specific information, e.g. about the dolomitic groundwater systems in China or Zambia, there are various international institutions and programmes of crucial importance for enhancing and disseminating knowledge on groundwater around the world. South Africa has benefitted tremendously from its groundwater international cooperation, in particular taking it from its 'private water' role to that of a significant player in Integrated Water Resource Management. Equally, South Africa has a lot to give in terms of Africa-relevant and well-documented groundwater research.

Our neighbours and transboundary institutions

Formal regional cooperation in the SADC Water Sector was established in 2000 through a protocol, the Revised Protocol on Shared Watercourses in the Southern Africa Development Community. Of its 15 major river basins which are shared by two or more nations, 11 have by now some form of institutional framework for shared management, e.g. ORASECOM and LIMCOM.

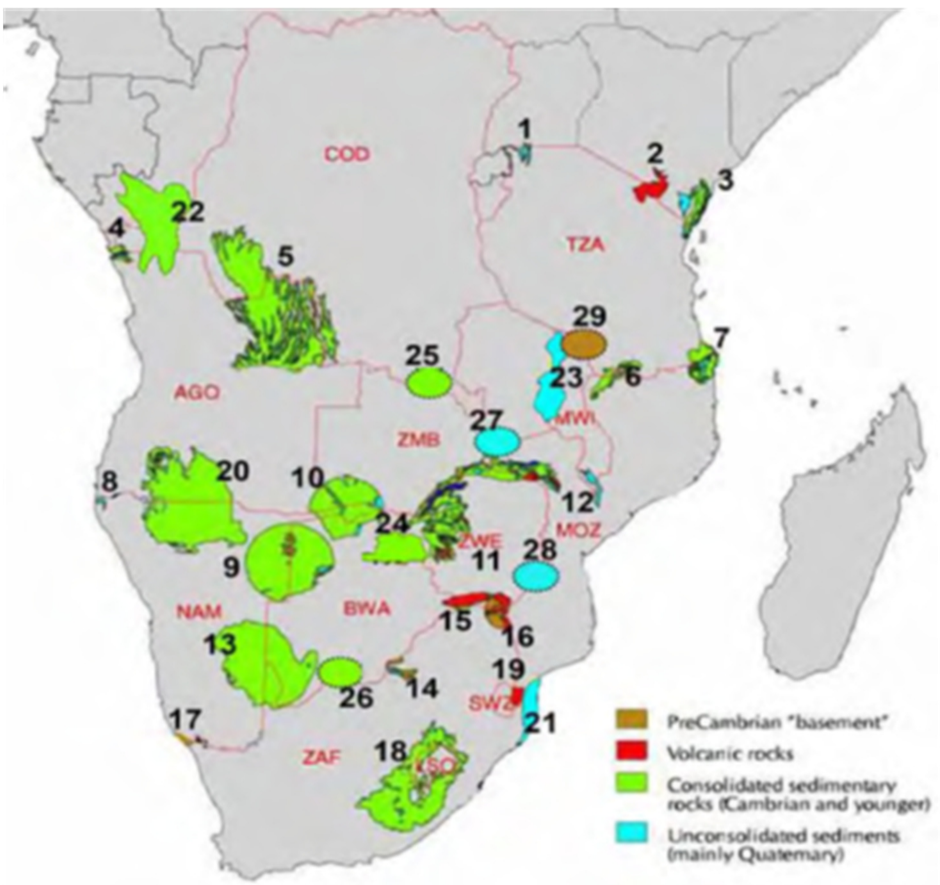


Figure 20: Transboundary aquifers of Southern Africa (Vasak, 2008 with modifications) (Braune and Xu, 2011)

The Water Sector of the SADC has developed a 'Groundwater Management Programme for the SADC Region'. The Programme is part of the Regional Strategic Action Plan for Integrated Water Resources Development and Management, undertaken with the support of many cooperating partners. The Programme, far from being a substitute to the responsibilities of individual member States, is rather, a support and incentive mechanism to increase the efficiency of national programmes with due consideration of transboundary issues. As part of this programme a SADC Groundwater Institute has been established and the University of the Free State was contracted to host the regional facility.

Through the UNESCO-ISARM programme transboundary aquifers were identified in the region in support of the SADC Groundwater Management Programme. The Southern Africa Hydrogeological Map and Atlas project further expanded on this work (SADC, 2010). A recent position paper in this regard by UNESCO indicates 29 such aquifer systems shared by two or more neighbours in the SADC region (Figure 20) (Braune and Xu, 2011).

The continent

A major opportunity has arisen to take continent-wide action through a resolution by the African Ministers Council on Water (AMCOW) taken in 2007 at its 6th Ordinary Session in Brazzaville, namely that AMCOW would become the custodian of a continent-wide strategic groundwater initiative. Its vision is expressed in a roadmap for an African Groundwater Commission which is to function under the umbrella of AMCOW to facilitate and direct regional, national, and international action on a number of fronts (AMCOW, 2008).

Global partners

UNESCO's International Hydrological Programme (IHP) has a strong and on-going groundwater component. African countries are, however, not yet organized in the same way as, for example, Latin America, to receive the full benefit of participating in the IHP programmes. The most visible and continent-wide programme is the UNESCO-IHP ISARM initiative (Internationally Shared Aquifer Resources Management) initiative. It is presently in a stage of identifying transboundary aquifer systems (TBAs) in Africa which will be followed by monitoring of these systems in a globally supported Global Environmental Facility (GEF) programme as well as by selected case studies of joint Trans-Boundary Aquifer (TBA) management.

UNESCOs groundwater work is facilitating through the establishment of chairs and centres, in particular the UNESCO Chair in Groundwater at the University of the Western Cape and the recently established UNESCO Category II Groundwater Centre in Kenya. The excellent IHP groundwater publications cover virtually every aspect of groundwater and development and are available free of charge.

The Global Environmental Facility (GEF) was created to support the sustainable development and management of large common-property environmental systems. Their approach to key stakeholder involvement, to co-funding and of a systematic diagnostic analysis of the threatened environmental system, followed by a strategic action plan to address the issues, often has a high sub-regional impact. To date the region has had support for the SADC Groundwater and Drought Programme and for the Illumeden Transboundary Aquifer Programme.

Significant contributions are also made by several other actors, among others the UN Food and Agriculture Organization (FAO), the International Atomic Energy Agency (IAEA), the World Meteorological Organization (WMO), the International Water Management Institute (IWMI) and the World Bank. The Bank has played a significant groundwater advocacy and support role, to a large extent enabled by its GW-MATE programme (Groundwater Management Advisory Team) of producing practical summary publications by international experts of every aspect of groundwater resources management and of case studies around the world.

Professional Associations

The International Association of Hydrogeologists (IAH) is a world-wide professional association and has individual membership throughout Africa and many African countries have a formal national committee of the IAH. The IAH is a formal partner in the UNESCO IHP groundwater programme.

Networks

Networks, supported by international funding, play a crucial role in capacity building in the region. WaterNet is a regional network of university departments and research and training institutes specialising in water. The network aims to build regional institutional and human capacity in Integrated Water Resources Management (IWRM) through training, education, research and outreach by harnessing the complementary strengths of member institutions in the region and elsewhere. It arranges many short courses, produces region-relevant publications and runs an annual water conference. WaterNet has recently become integrated into the institutional structure of the SADC Water Sector.

Cap-Net UNDP is an international network for capacity development in sustainable water management. It is made up of a partnership of autonomous international, regional and national institutions and networks committed to capacity development in the water sector. The recently established Africa Groundwater Network (AGW-Net), in collaboration with CAP-Net and others, has produced excellent groundwater training material and runs regular courses. It was established to increase awareness of the potential and value of groundwater across the continent and to contribute to capacity building in the groundwater sector in Africa.

Academic institutions

Most national universities have a Department of Geology with a groundwater component. The challenge is that these institutions and their groundwater part usually have very limited staff and capacity. A number of these institutions play a sub-region / region-wide role, e.g. the UNESCO Chair in Groundwater at the University of the Western Cape and the SADC Groundwater Institute, hosted at the University of the Free State in South Africa.

A promising development is the establishment of NEPAD Centres of Excellence to allow Higher Education and Research institutions in a region to cooperate across national and discipline boundaries and focus their science on the development of the region. This is the result of the emphasis which Africa's Science and Technology Consolidate Plan of Action (CPA) had put in 2003 on developing an African system of or network for scientific research and technological innovation to address challenges of securing and sustaining water. This became one of the main flagship programmes of the New Partnership for Africa's Development (NEPAD). The first of these in the water field, the NEPAD Water Centre of Excellence, has by now eight countries as members and is already undertaking a major project for the African Union. A Western Africa Centres of Excellence is presently becoming operational. This presents a major opportunity for groundwater cooperation across country and institutional boundaries.

An excellent way of strengthening the capacity of local institutions is that of twinning with well-established international groundwater role players. Groundwater management in Uganda, for example, has benefitted tremendously from a long-standing cooperation with the University College of London.

National policy

In terms of the NWRS2, the DWS is committed to engage with international partners bilaterally and through multilateral forums. Through international engagements the South African water sector shares valuable lessons and learns from international best practices to improve service delivery and aspects of the whole water value chain.

South Africa is a signatory to the Revised Protocol on Shared Water Courses in the SADC; it thus has an obligation to fulfil its commitments through cooperation with its neighbours in the management of international waters in the interest of regional economic integration, peace and security. South Africa shares four major rivers systems with six neighbouring countries.

Water Research Commission

Since its inception, more than 40 years ago, the WRC has been striving to fulfil its mandate of serving the water sector, including promoting co-ordination, co-operation and communication in the area of water research and development. In this period South Africa has become a world leader in water and sanitation technology and its groundwater capacity is on par with the best in the world. The WRC recognizes South Africa to be part of the global village, a village of shared natural phenomena like global warming and the present El Nĩno cycle, shared human conditions of increasing poverty and inequality, as well as the international responses in terms of policy and innovation. The WRC already has collaboration agreements with a number of leading international water research institutions. Regional and global cooperation is part of its Roadmap (WRC, 2015) and a revision of the Water Research Act, 1971 is presently underway, which will, inter alia, address ways to facilitate international collaboration. .

Challenges

Before 1994, South Africa had been in international isolation, because of Apartheid. The water sector has not yet fully responded to the opportunities offered by international collaboration.

Strategic Actions

SADC and Africa

South Africa should become an active and leading player in the SADC Groundwater Programme and become a champion of the African Groundwater Commission in the roll-out of AMCOW's Africa Groundwater Initiative. Important vehicles for cooperation should be the UNESCO Chair in

Groundwater at the University of the Western Cape and the NEPAD Southern Africa Water Center of Excellence.

The Department should use the opportunity of bilateral talks to put groundwater on the agendas.

Basin Commissions

Groundwater is forming an integral part of the tansboundary basins' resources. Basin Commissions like ORASECOM and LIMCOM should take groundwater fully on board and need to develop a groundwater management plan for each of these basins.

UNESCO International Hydrological Programme

South Africa should become an active participant in UNESCOs International Hydrological Programme. Because this is an inter-governmental programme, national leadership from DWS is required. Once South Africa's role in this programme is established, it could play an important lead role for groundwater in Africa.

International Association of Hydrogeologists (IAH)

Ways should be urgently sought for widespread membership of South African groundwater professionals in the IAH. Because of the substantial costs involved, a deal should be sought by the Groundwater Division, on the one hand with the main employers of these professionals in South Africa and on the other with the IAH.

Groundwater Division

The Groundwater Division of the Geological Society should become a sector leader to help take many of the coordination efforts into the groundwater sector.

Theme 11: Water Sector Skills And Capacity

Objectives

Develop and maintain skills and capacity for the sustainable development and management of groundwater resources at **all** management levels and with participation of all stakeholders as part of a long-term, ongoing process.

Principles

Capacity building is a long-term, continuing process, in which all stakeholders should participate (ministries, local authorities, non-governmental organizations and water user groups, professional associations, academics, private consulting firms and others).

It is important that all levels of capacity development must be addressed, the individual, the institutional and societal levels. When all these work together we will see a well-performing groundwater sector.

It is important to have ways to measure capacity and monitor progress in its development.

Situation assessment

Unfolding of groundwater capacity

The capacity available for groundwater development and management in South Africa at national level can be described in the same eras used to describe different periods of groundwater investigation and research under theme 9.

Present capacity situation

Overall, the country has an excellent capacity in the groundwater resources field, on par with the best in

able 8: Capacity available during eras of groundwater investigation and research activities according to Vegter (2001)

1888-1935	Pre-geophysics era	State drilling service with geologist support
1936-1955	Era of geophysical borehole siting	Developments as a result of recommendations of the Interdepartmental Committee of Enquiry re Groundwater Supplies, 1953: Establishment of a new Division of Hydrological Research in the Department of Irrigation; Strengthening of the Geological Survey personnel.
1956-1976	Quest for quantification era	Developments as a result of Expert Committee of Enquiry into the Groundwater Situation in the RSA, 1973: DWAFs Chief Directorate of Scientific Services evolved from Division of Hydrological Research, comprising three Divisions (later Directorates) – Hydrology, Geohydrology and Hydrological Research. Underground Water and Geophysics Branch of the Geological Survey. Very few private hydrogeologists as professional service providers.
1977-1997	Era of expanding activity	From the 1970s onward there has been a growth of (hydro)-geological and engineering consulting firms operating in the groundwater field. The Council for Scientific and Industrial Research (CSIR), the Atomic Energy Board (AEB), and several universities (Orange Free State, Witwatersrand, Western Cape) also entered the field. In 1977 the Groundwater Division of the Geological Survey transferred to DWAF and merged with the Division of Geohydrology. Part of the overall contribution of these two organisations up to the end of this era is contained in about 3000 internal Geohydrology reports. The Institute for Ground Water Studies (IGS) and the UNESCO Chair in Groundwater were established at the University of the Orange Free State and the University of the Western Cape respectively. More private hydrogeology companies were established.
1998-	Integrated management era (in terms of NWA, 1998)	In 2003, as part of a major DWAF restructuring, the Directorate of Geohydrology was disbanded and staff integrated into various water resource management functions, eg hydrological information, planning, pollution control, resource directed measures as well as DWAF Regional Offices. In 2008, serious capacity shortcomings in the national Department of Water Affairs (DWA) were pointed out in a submission by the groundwater sector, represented by the Groundwater Division of the Geological Society to the Parliamentary Portfolio Committee on Water Affairs and Forestry during their Review of the National Water Act: "An inability to implement the National Water Act, as a result of a lack of sufficient skilled and experienced staff, prevents groundwater from being used productively and sustainably to promote economic growth and social upliftment." (Groundwater Division, 2008)

the world. Many new groundwater consulting companies were established throughout South Africa during the past twenty years. There is a strong hydrogeologist and groundwater technical corps, well-coordinated and represented by the Ground Water Division of the Geological Society and the Borehole Water Association of Southern Africa. Appropriate academic institutions were established and wide-ranging research has been undertaken for 40 years and more. The Council for Geosciences, the Department of Water and Sanitation, the Water Research Commission and the CSIR have all been major role players at different points in time.

Various Memorandums of Understanding have been signed between government and parastatals to share the load and capacitate each other in various fields of expertise.

Water Research Commission

The WRC operates in terms of the Water Research Act (Act 34 of 1971) and its mandate is to support water research and development as well as the building of a sustainable water research capacity in South Africa. The WRC serves as the country's water-centered knowledge 'hub', leading the creation, dissemination and application of water-centered knowledge, focusing on water resource management, water-linked ecosystems, water use and waste management and water utilisation in agriculture. Its mandate includes enhancing knowledge and capacity-building within the water sector. Through cross-cutting Impact Areas, a strong integration of research activities is achieved towards national development objectives.

The WRC investment into groundwater research in South Africa has been strategic and ongoing for 40 years now. This investment has, in all probability, been the most significant contribution to the building of capacity for the sustainable utilization and management of groundwater resources in South Africa. It has included:

- Capacitating the water sector with knowledge and tools for improved groundwater resource management;
- Increasing the number of students involved in water research as a source of human capital for the water sector as a whole;
- Encouraging the achievement of post-graduate qualifications as part of groundwater research;
- Placing particular emphasis on the support of historically disadvantaged students and researchers;
- Helping to develop strong research and teaching centers in groundwater hydrology in South Africa and continue to support academic institutions through groundwater research projects and science networking;
- Helping to create research infrastructure in specialized fields such as isotope hydrology.
- Widely publicizing research findings through attractive research reports and publications like Water Wheel and Water SA and creating easy access through the WRC Knowledge Hub.

Academic sector

Already in 1973, the then Minister of Water Affairs and Forestry started negotiation with the University of the Free State concerning an Institute for Groundwater Studies (IGS). It was to be established at the same time as the Water Research Commission to train potential researchers which could contribute to the working of the WRC.

Almost 20 years later, with the reopening of the global science world to South Africa, a UNESCO Chair in Groundwater was created at the University of the Western Cape to serve the southern African region with developing groundwater expertise.

Approximately 600 students graduated in the last 10 years from these two institutions alone, 127 with a Masters or PhD. Approximately 70 % of these postgraduate qualifications would have been achieved through a WRC project.

The WRC also supports several other universities (Fort Hare, Venda, Pretoria, Zululand, KwaZulu-Natal, North West and Witwatersrand), science councils, NGOs and consulting firms in developing groundwater expertise.

Through the academic institutions that have developed and that had the benefit of this research investment, a significant human resources development impact has been achieved nationally, in the southern African region and on the continent as a whole. Very importantly, experience from the groundwater industry is increasingly being made available on a voluntary basis for education and training at academic institutions. Young graduates are thus the key carriers of the country's groundwater capacity.

Council for Geoscience

The Council for Geoscience (CGS) is one of the National Science Councils of South Africa and is the legal successor of the Geological Survey of South Africa, which was formed in 1912. The organization has a Water Geoscience Unit which provides professional consulting and contract research in the broad field of hydrogeology, groundwater resource management, rural water supply, environmental management, groundwater characterisation, and groundwater contamination management.

Overall, the Council is in a unique position through its huge geological knowledge base and expertise and the established branch offices of the organization to support the increasingly decentralised water management and be a partner in specialized groundwater research. Its research focus is determined by its statutory-funded projects that bear national importance, as well as collaborative research projects and research funded by various institutions, including the Water Research Commission.

CSIR

The Council for Scientific and Industrial Research (CSIR) has been active in groundwater research and development since the mid-1950s, a decade after its establishment in 1945. The period since 1994 is characterised by a shift from a mainly scientific and technological research and development focus targeting regional groundwater resources, to the application of scientific research with a focus on practical implementation in the service of society and the environment. A more recent shift is that from a groundwater-centric staff complement to one which offers expertise across a broader spectrum of water resources science. Disciplines now include surface water hydrology, vadose zone hydrology, agro-hydrology and environmental hydrology/hydrogeology driven by the paradigm of Integrated Water Resource Management (IWRM).

The many different technical competencies and excellent laboratory infrastructure within the organization has allowed it to undertake significant multidisciplinary work in this field.

Institutional capacity challenges

The capacity challenge in South Africa at this point in time lies at the institutional level. Lack of appropriate capacity in critical stakeholders, in particular in municipalities where groundwater has, in many instances, become the sole source of domestic water supply, is regarded by many as the most important factor holding back sustainable development and management of groundwater resources in South Africa. The key issue is a complete lack of capacity for the sustainable utilisation and management of local groundwater resources.

Serious capacity shortcomings in the national Department of Water Affairs & Forestry were pointed out to the Parliamentary Portfolio Committee on Water Affairs and Forestry in 2008. Even though a Departmental Groundwater Strategy was prepared in 2010, with considerable input from the private sector, very few of the recommendations have been rolled out so far, because the Department does not have the capacity and leadership / organization to act on them. The weakness in the groundwater function in national government is of particular concern at a time when new groundwater capacity has to be built in soon to be established CMAs and in local government.

The Department is able to contract out a considerable proportion of technical groundwater work to the private sector. However, this role still demands a thorough understanding of the issues and experience as well as technical competence, which is increasingly lost. This lack in capacity at national level also prevents a proper synchronization of research and national development objectives and prevents the academic sector to fully play its science leadership role.

Human capacity decline

There has been a decline in the number of “person-years” of experience in hydrogeology in the state sector. Experienced professionals are leaving public institutions to work in the private sector and in foreign countries due partly to the inability of these institutions to attract and retain such staff.

Retired personnel are often not replaced. In addition, the number of vacant posts in the Department for hydrogeologists is around 47% and 53% for geotechnicians and this is compounded by its inability to attract staff. More than 50% of the current groundwater personnel have fewer than 5 years’ experience and do not have experienced mentors to guide them.

Historically the Department was the “conveyer belt” for delivering groundwater professionals in South Africa. However, key groundwater planning, development and management functions are being completely eroded within the Department.

Experienced hydrogeologists are also necessary for mentoring younger professionals – without this function it takes longer for new recruits to gain the skills they need, and deprives them of job satisfaction. In the worst case, a vicious circle of high staff turnover and dwindling institutional memory will occur.

Partnerships

The new water resource management hierarchy and new and more integrated approaches to water resources management will require a strategic approach to research and development, technology transfer and capacity building. The networking of education and training providers and users, as well as researchers, as recommended by the UNESCO/WMO mission to South Africa in 1998 in their FET-Water proposal, will need urgent and widely coordinated implementation. This is fully in line with the national objective of cooperative governance, but will need a national champion to implement it.

International Cooperation

International cooperation has greatly benefited the South African groundwater sector, in particular during the challenging period of making groundwater a part of IWRM. This has included a UNESCO/WMO Mission in 1998 to assess Education and Training needs of the water resources management services in South Africa, a DANCED-assisted cooperative project intended to support the implementation of programs towards achieving IWRM (2001-2004), and a NORAD-assisted programme for the sustainable development of groundwater sources under the Community Water Supply and Sanitation Programme (2000-2004).

South Africa's groundwater research and development capacity also plays a major regional role in southern Africa and wider. At this stage there are only about three other institutions in the SADC outside South Africa, which have groundwater research and development (R&D) and teaching capacity. Not surprising then that the Institute of Groundwater Studies at the University of the Free State was requested to host the newly inaugurated SADC Groundwater Management Institute.

Challenges

Some of the reasons for the capacity gaps are unique to groundwater, but others are an outflow of the general gap in science and engineering capacity in South Africa at this point in time. Some key challenges for groundwater capacity development experienced in recent years are listed below. (Braune and Adams, 2009).

- Poor standard of maths and science university entrants, largely a legacy of an inferior education system for the majority of the population over many years and an inability of the school system to catch up over the last 25 years;
- The global scarcity of science & technology manpower, the much greater mobility of professionals and a resulting global competition for the limited pool of available skills;
- The great difficulty in retaining skilled, experienced specialists and technical managers in the public sector. Most of the professional capacity in South Africa is located outside the public sector and will remain so;
- Seriously missing is the public sector as a major player in capacity building and mentoring;
- Mentoring of new entries becomes a problem in this situation. Universities, on the other hand are unable to provide practical education and training without real life problems, access to technical infrastructure and funding support for mobility.
- While the public sector work is still done by means of outsourcing, the private sector has not yet taken on a role in national capacity building;
- The complete lack of capacity within municipalities for the sustainable utilisation and management of local groundwater resources is regarded by many as the most important factor holding back sustainable development and management of groundwater resources in South Africa;
- The specific lack of groundwater capacity is strongly related to the continued undervaluing of the resource at decision-making level, and thus in a lack of systematic investment in its sustainable utilization;
- The very vulnerable capacity situation in the groundwater academic sector is as a result of a lack of role-player cooperation in groundwater capacity building. This needs to be urgently addressed together with innovative solutions, before international groups mobilize more of our skills for initiatives outside of South Africa.

Strategic Actions

Capacity gap analysis

A capacity gap analysis needs to be undertaken within the emerging groundwater governance framework and linked to the groundwater research planning of the WRC and to existing capacity building initiatives in different sectors. The key players in groundwater capacity building need to be identified and engaged in a common way forward. This could be a recurring initiative which will over time link to catchment management strategies and aquifer management plans.

DWS lead role

The Department of Water and Sanitation should take the lead role in groundwater capacity building as part of a national water sector capacity building strategy linked to the National Water Resources Strategy and with systematic support that facilitates capacity development in areas identified in the strategy. The Department's PSP contracts present an opportunity for the leveraging of such capacity development, but it needs high-level support in-house.

WRC leveraging role

The WRC should continue its critical capacity-building role for groundwater resources development and management. As the key role player, it should help build a coherent knowledge infrastructure among government and private sector research and educational institutions in South Africa.

Utilizing of synergies should also extend to regional and international initiatives like AMCOWs, the Africa Groundwater Commission and UNESCOs International Hydrological Programme.

As part of this strategy it will be essential to continue to build networks of people and technology across institutional borders to share information and experiences and improve its usefulness and accessibility.

FET-Water

The main recommendation of UNESCO/WMO Mission to Assess E&T Needs of the Water Resources Management Services in South Africa (DWAF /UNESCO/WMO, 1998) was to establish a Framework for Education and Training in Water (FET-Water). This is a framework programme for effective 'collaboration, sharing and networking' for the provision of education, training and capacity building in the water sector. This approach was seen as highly appropriate for the South African water sector at the time. The Water Research Commission has been implementing the most recent phases of FET-Water.

With the strong emphasis to achieve cooperative projects between stakeholders and on the strategic leveraging of resources and harmonising complimentary relationships for support, in particular WRC/DWS/NRF/Private Sector, the FET-Water approach needs to be further developed for capacity development in the groundwater governance field.

Academic institutions

Universities are a key player in groundwater capacity development. They need to take the lead to bring further resources and key partners on board and into the center of national capacity development (e.g. UNESCO and other UN Agencies in the case of the University of the Western Cape).

There is a need for experts who are trained to look beyond aquifers systems, and understand the way and means to govern the entire subsurface space and balance various social and economic objectives. However, Instead of education being holistic, the classical emphasis on single disciplines prevails. It is essential that educational organisations and professional associations intensify the efforts to build capacity in groundwater governance and to come up with new courses and curricula to groom new cohorts of 'broader' professionals.

Academic institutions can play a major role, offering 'refresher' short courses to 'older' hydrogeologists with focus on the latest research findings and technology developments.

Private sector role

The private sector needs to play a much larger role in education and training (as is happening in the mining sector) as well as in the mentoring of students through practical work experience and support of post-graduate studies. Its human and technology resources should be available for mentoring and practical experience-gaining on a voluntary basis.

The Groundwater Division of South Africa could play a stronger role in mobilizing the groundwater sector as nurturer of the groundwater human resources.

SA Groundwater Center of Excellence

SA needs its own Groundwater Center of Excellence (could be a virtual center) to provide leadership for and coordination of the diverse groundwater research and education capacity in the country. A dedicated industry-supported groundwater chair or center could facilitate such cooperation.

Technical Education & Training

Groundwater technical capacity-building has been neglected and needs serious attention. There should be a rethink on the role of universities and technical universities to cater for different capacity gaps in various parts of the water sector.

Professional registration

There should be a groundwater sector-wide strategy for registration of hydrogeologists and a system of required Continued Professional Development, with key support players in the DWS Learning Academy and the Groundwater Division of South Africa. The DWS Learning Academy will therefore have to be strengthened with groundwater expertise.

Long-term relationship: government / academic institutions

Groundwater academic institutions have largely been created by government in the interest of national development. Their relationship with government for this purpose should be anchored in agreements of sustainable cooperation, including focused Education & Training programmes, technical support from the academic institutions, annual bursary provision and cooperative research opportunities offered by government.

Public/private sector partnerships

As professional service providers the private sector groundwater professionals have a critical opportunity to provide for capacity-building of municipal staff and the transition of management functions from national to local institutions. National government (DWS) should use this opportunity to facilitate innovation and reward/fund excellence.

Stakeholder involvement

The increasing and systematic involvement of all stakeholders, from the central government to the communities, from the public and private sector alike, is seen as the critical factor in a long-term, sustained process to strengthen institutions, develop human resources and create the supporting policy and legal environment.

International cooperation

South African water research should become more Africa-orientated. Participating in regional, continental and international initiatives provides real opportunities for dealing with the capacity gap in South Africa. The thrust should be anchored in the regional cooperation objectives of both the national Department of Water and Sanitation and the WRC.

Capacity building indicators

Adequate capacity-building indicators need to be found for the groundwater sector and need to be continuously monitored.

Theme 12: Local Action

Objectives

Manage and maintain actions on all strategy fronts in a concerted effort from government at different levels, from municipalities and utilities, the private sector, civil society , educational institutes, media and professional associations to achieve the essential local level actions for sustainably managing shared groundwater resources.

Principles

The unique, widely distributed groundwater resource, with its open access to a large number of users and a wide range of impacts, requires local level management of the shared groundwater resources within an appropriate enabling and supporting environment.

Situation Assessment

Very little groundwater local action has happened in South Africa to date. Key reasons for this are the slow establishment of catchment management agencies, the lack of national regulation in this regard and lack of sustained support for the establishment and capacitating of appropriate local management institutions. Coordinated action on a number of national fronts will be required in order to achieve systematic implementation of sustainable local level groundwater management. Functioning local institutions will be the ultimate test for good groundwater governance in South Africa.

Because of the lack of local experience at this level, the experience gained in the Global Groundwater Governance initiative has been consulted widely for possible strategic actions at this level (UNESCO et al., 2015).

Strategic Actions

Aquifer management

Aquifer management needs to be introduced on a priority basis, starting with the most vulnerable and most stressed systems as well as systems for domestic water supply. Users of a shared aquifer resource have to implement aquifer management, including detailed planning, implementation of regulations, demand / supply-side measures, resource / source protection, and groundwater use / resource monitoring. This may require geohydrological professional support in terms of resource assessment and specialized aquifer monitoring and modelling.

Action by municipalities

Local government is responsible for a sustained water service provision, including from local groundwater resources. As such municipalities are responsible for the operation and maintenance of groundwater infrastructure and the conservation and protection of their groundwater sources. It is essential that they fully participate in the management of shared aquifer resources.

As groundwater is quintessentially a local resource, much of the effort to apply the governance framework and ensure management in line with policy goals rests with local government bodies and decentralized agencies in close cooperation with local stakeholders.

Local governments are uniquely positioned to foster integration between land management and groundwater management and protection. As such they should support integration of land use planning and groundwater management – to protect recharge zones but also to develop healthy and productive landscapes by managing groundwater recharge at scale.

Increasingly, other uses of the sub-surface space risk interfering with aquifers, and municipalities need to monitor and manage this. They are well positioned to help achieve an integrated management of the sub-surface zone.

Action from private sector players

The private sector is a main user, not least the myriad private owners of agricultural wells, and hence has an obligation to behave responsibly. Almost everywhere, agriculture is the primary user of groundwater, and this is in the hands of both private small farmers and large agricultural corporations.

Small farmers have to be brought into the governance framework through participatory institutional approaches. This is challenging, in particular they fell outside any regulatory or monitoring under the previous water legislation. As stakeholders they will now have to work in partnership with government and with each other to develop and operationalize institutional measures for self-regulation and local collective management.

Larger agricultural ventures can be formal partners of government in good practice sustainable management. Sustainable use of groundwater and control of pollution can be part of an agreed long-term business model, requiring the business to invest in the protection and efficient and sustainable use of the groundwater collective asset. One possibility would be to include sustainable, non-polluting groundwater use in the current thrust towards certification and labelling of sustainable practices.

Industries are major users and can be called on to conserve groundwater and protect quality. There is a trend in some industries to reuse process water and hence save on costs and pollution loads and to contribute to groundwater resource conservation. There is an important function of government agencies here to regulate and allocate water to high yielding clean industries.

Mining companies, including the oil and gas sector, compose a special stakeholder group in groundwater governance. As mining companies share the same subsurface space as groundwater users, they are called upon to share data and be responsible users in terms of pollution, safety and geological disturbance and, as far as possible, to take a long-term lifecycle view of their operations, for example by leaving mining sites in as good a condition as they found them.

Action from utilities

There is usually scope for utilities – water suppliers, irrigation service providers, energy companies – to work within groundwater management plans on conservation and resource protection. Action is required from local utilities to secure their groundwater sources and to control leakage and discharge of untreated waste-water. Energy utilities are encouraged to liaise closely with groundwater managers, for example to achieve water conservation goals through energy pricing.

Action by media and civil society

Media – both traditional and new - could provide more in-depth coverage, making the case for the need to govern and manage groundwater. This coverage could create broad and factual understanding and highlight current risks and future potential, in order to create broad awareness and better understanding. Wider public discussion could trigger citizen initiatives, increase political support and strengthen the motivation of those directly involved to act on the issues. The current highly networked world and the ability to report fast and visually provides the opportunity to both 'name and shame' offenders as well 'raise and praise' change-makers and champions.

Civil society is also called upon to contribute to wider awareness of groundwater challenges and opportunities and of the need for more effective governance. Awareness activities should cast the net wide, so that many champions are encouraged. Beyond this, civil society could undertake initiatives to contribute to better groundwater governance – linking stakeholders, promoting new approaches and developing local visions. Civil society can also act as a watchdog on inappropriate policies and report on gross violations of water use, pollution and the destruction of groundwater-dependent ecosystems.

8. Key deliverables

A first estimate of key deliverables for the first 5 years after publication of the NGS strategy has been provided in **Table 9** below. The 10-year implementation target towards which the whole strategy process is working, is a substantial establishment (40%) of local groundwater management institutions. This will mean that other critical deliverables, such as an agreed governance framework in year 2, are achieved on time.

The deliverables and financial implications will be refined during the coming year of stakeholder consultation.

Table 9: Critical Deliverables for National Groundwater Strategy

Yr	Deliverable	Implementation (Year 1-10)	Financial Implication*	Responsibility
1	Stakeholder Communication in place		Once-off	DWS, WRC
1	Critical Assessments undertaken (Themes 4,9, 11)		Once-off	DWS, WRC
2	Strategic Governance Framework agreed		Once-off	DWS, Sector
2	National Champion functional		Annual	DWS
3	Groundwater regulations drafted		Once-off	DWS
3	Groundwater Trust established		Annual	GW Sector
3	Municipal GW Management framework		Once-off	DWS, DLG
4	Groundwater regulations published		Once-off	DWS
4	Revised Groundwater RDM in place		Once-off	WRC, DWS
4	Guidelines & training pgms for Municipalities.		Once-off	DWS, WRC
5	15% GW Management Institutions in place		Once-off	DWS, CMAs
5	National Information System functional		Annual	DWS, WRC
5	5 groundwater protection zonings in place		Once-off	DWS, Munps.
5	Shared GW COE of Excellence functional		Annual	
7 8 9				
10	40% GW Management Institutions in place		Once-off	DWS, CMAs

**Cost estimates will be included in time*

A detailed action plan must be developed together with key stakeholders. **A prototype has already been developed by the Department of Water and Sanitation, listing current actions, future actions and responsibilities under the different strategy themes.**

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Appendix 1: NGS Considerations related to National Planning Commission's Vision 2030

Outcomes	Objectives	NGS Considerations
ECONOMY AND EMPLOYMENT **(Outcome 6)**	An additional 11 million jobs; Increase the benefit to the country of our mineral resources by increasing water Infrastructure …	This needs to be read together with objectives 'Environmental Sustainability and Resilience' and 'Inclusive Rural Economy'. Groundwater was able to provide a basic domestic water supply to about 60% of communities throughout the country in some 15 000 villages. Although largely limited in yield, this resource could also play an important role in creating productive livelihoods for the poor in smallholder irrigation. Its natural storage can provide the resilience to bridge seasonal and even over-year shortages in water for irrigation. The WAR programme is expected to provide financial support to resource poor farmers.
ECONOMIC INFRASTRUCTURE **(Outcome 6)**	Incorporate a greater share of gas in the energy mix, using shale gas	This would represent by far the most widespread intervention and potential impact South Africa has experienced into the underground domain in which fresh groundwater resources occur. Based on the experience of other mining initiatives and their lasting environmental impacts, in particular, coal and gold, groundwater resource protection should be pro-actively developed and be central in any shale gas mining planning and implementation.
	A comprehensive management strategy including an investment programme for water resource development, bulk water supply and wastewater management for major centres by 2012, with reviews every five years;	Making 30-40% groundwater contribution possible in the supply diversification is one of the big tickets for groundwater development. This represents a development scale that groundwater resources in South Africa have never functioned at. An agreed groundwater planning and development framework needs to be developed as a matter of urgency, which illustrates, in a comparative way with surface water resources, the development steps, effort/cost and time frames required for groundwater resources.
ENVIRONMENTAL SUSTAINABILITY AND RESILIENCE	A set of indicators for natural resources, accompanied by publication of annual reports on the health of identified resources to inform policy.	Because of its largely local role and unseen nature, a wide range of impacts from human impacts on and beneath the land surface go undetected for long periods of time. Addressing the quality challenge (mining, sanitation, salinity) is one of the big issues of groundwater development.

(Outcome 10)		Groundwater requires a pro-active, preventative approach to resource protection. Implementation of the DWS 'Policy and Strategy for Groundwater Quality Management' of 2000 needs implementation without delay.
	Improved disaster preparedness for extreme climate events	Poor communities are particularly vulnerable to droughts and similar water-related disasters which destroy their assets and incomes. Groundwater, used conjunctively with other water resources, has a major role in providing drought resilience. To date, the response to droughts continues to be emergency drilling programmes. As a way of disaster preparedness, we should combine development and maintenance of water for productive use and water for basic domestic services for economies of scale and community interest in the infrastructure. Such investment would also enhance the resilience of people and the economy to climate change.
	Increased investment in new agricultural technologies, research and the development of adaptation strategies for the protection of rural livelihoods (support services for small-scale and rural farmers) and expansion of commercial agriculture.	See 'Economy and Employment' Achieving sustainability through optimal utilization of groundwater storage and recharge is another big challenge of groundwater development.
INCLUSIVE RURAL ECONOMY **(Outcome 7)**	Rural economies will be activated through improved infrastructure and service delivery, a review of land tenure, service to small and micro farmers (especially women);	See 'Economy and Employment'
	The transformation of the economy should involve the active participation and empowerment of women.	Women have carried the traditional burden of domestic water supply and use in the household. They are often also the primary users of water for productive activities such as agriculture. In an increased use of groundwater for productive purposes, women need to play an important role in line with advancing women's equality and building on their experience.
SOUTH AFRICA IN THE REGION AND THE WORLD	Strengthening regional cooperation in food and energy markets and water	Groundwater's unique characteristics and development role present challenges of both neglect and resource degradation throughout the continent and globally. Given South Africa's past neglect of groundwater on the one hand, and the potential for major advances with implementation of the NGS and the excellent R&D support available in South Africa on the other, it is imperative that regional and global cooperation is sought (eg the SADC Water Division, AMCOW's Africa Groundwater Commission, the UNESCO International Hydrological Programme (IHP) and the International Association of Hydrogeological Science (IAH)).

HEALTH CARE FOR ALL **(Outcome 2)**	Prevent and control epidemic burdens	Due to the slow development of sanitation and the non-functioning of many water supplies, there is still a serious threat of water-borne diseases in rural areas in South Africa. Groundwater which is generally seen as safe drinking water is particularly at risk because of undetected pollution. Particularly strict standards are required where groundwater serves as domestic water supply.
BUILDING A CAPABLE AND DEVELOPMENTAL STATE **(Outcome 9)**	Relations between national, provincial and local government are improved through a more proactive approach to managing the intergovernmental system.	Good governance for the very vulnerable, common pool, very widely distributed resource, groundwater, is particularly challenging. In South Africa the achievement of the MDGs is threatened, because of a failure in groundwater governance. It is generally recognized that the internationally accepted governance approach for groundwater of 'national facilitation of local actions' requires a strong national groundwater champion. The re-establish such a champion within DWS lies at the heart of the whole NGS.
	Develop regional utilities to deliver some local government services on an agency basis where local or district municipalities lack capacity.	The lack of capacity for providing water services from groundwater sources is particularly challenging for groundwater, because of the unseen and widely distributed nature of the resource. New regional institutions should immediately take groundwater resources on board and develop the necessary capacity to undertake this challenge.

Appendix 2: Groundwater Governance at Local Level (Riemann et al., 2011)

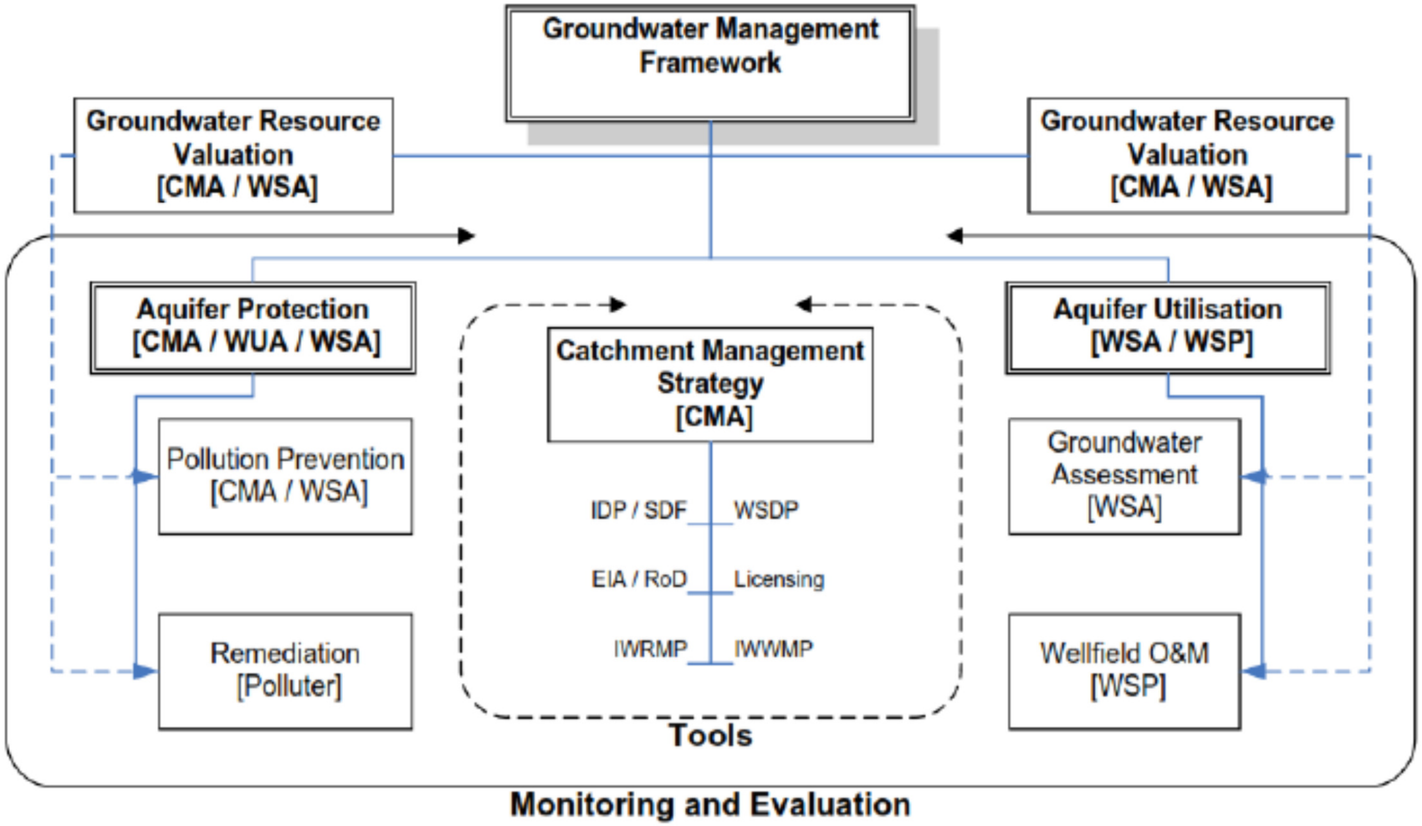

Figure 2 *Structure of Groundwater Management Framework with categories 'Aquifer Protection' and 'Aquifer Utilisation', their subcategories, overarching functions of 'Monitoring and Evaluation' and 'Groundwater Resource Valuation' and main available tools*

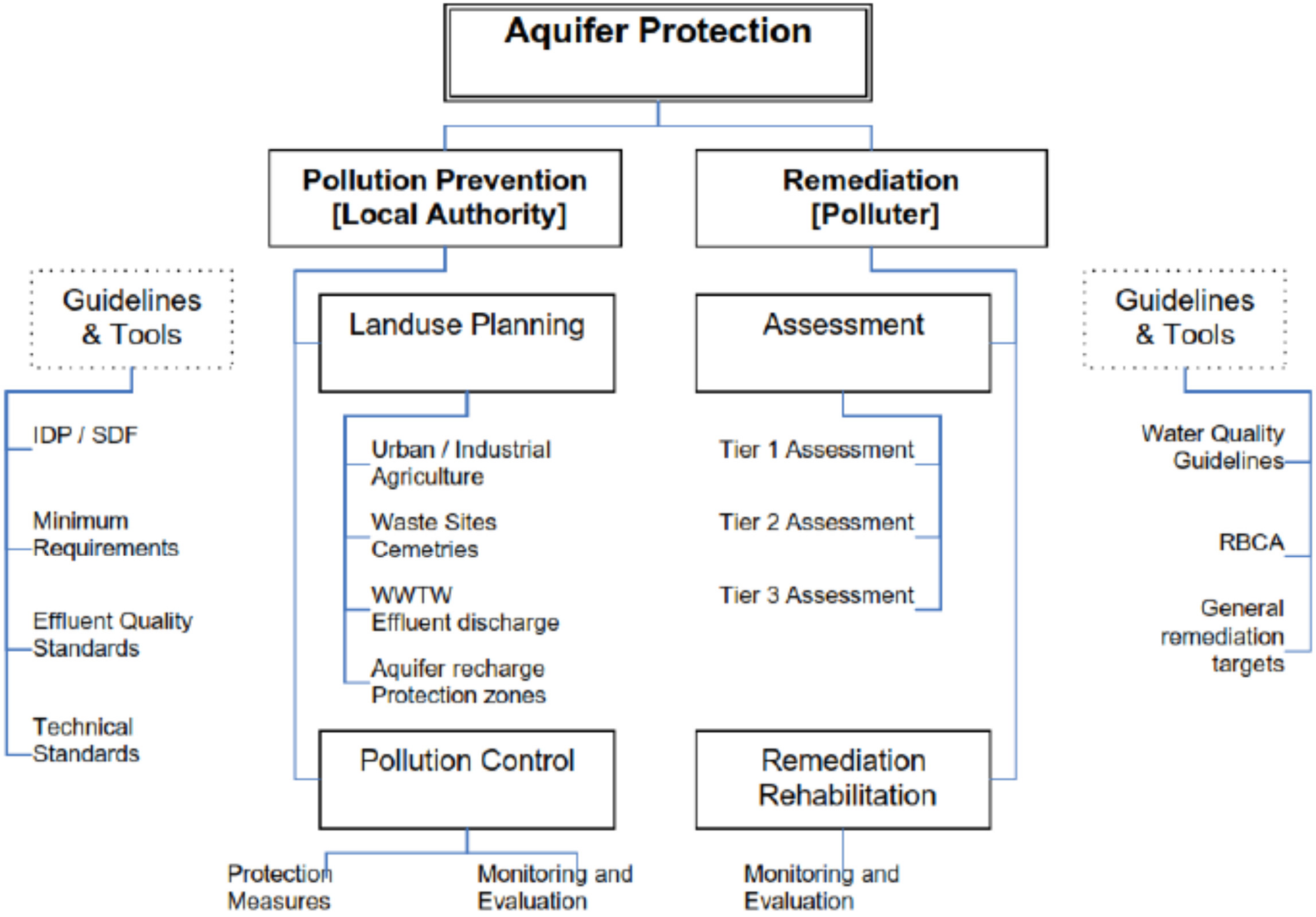

Figure 3
Aquifer protection category with subcategories 'Pollution Prevention' and 'Remediation', aspects and details per subcategory and available guidelines and tools

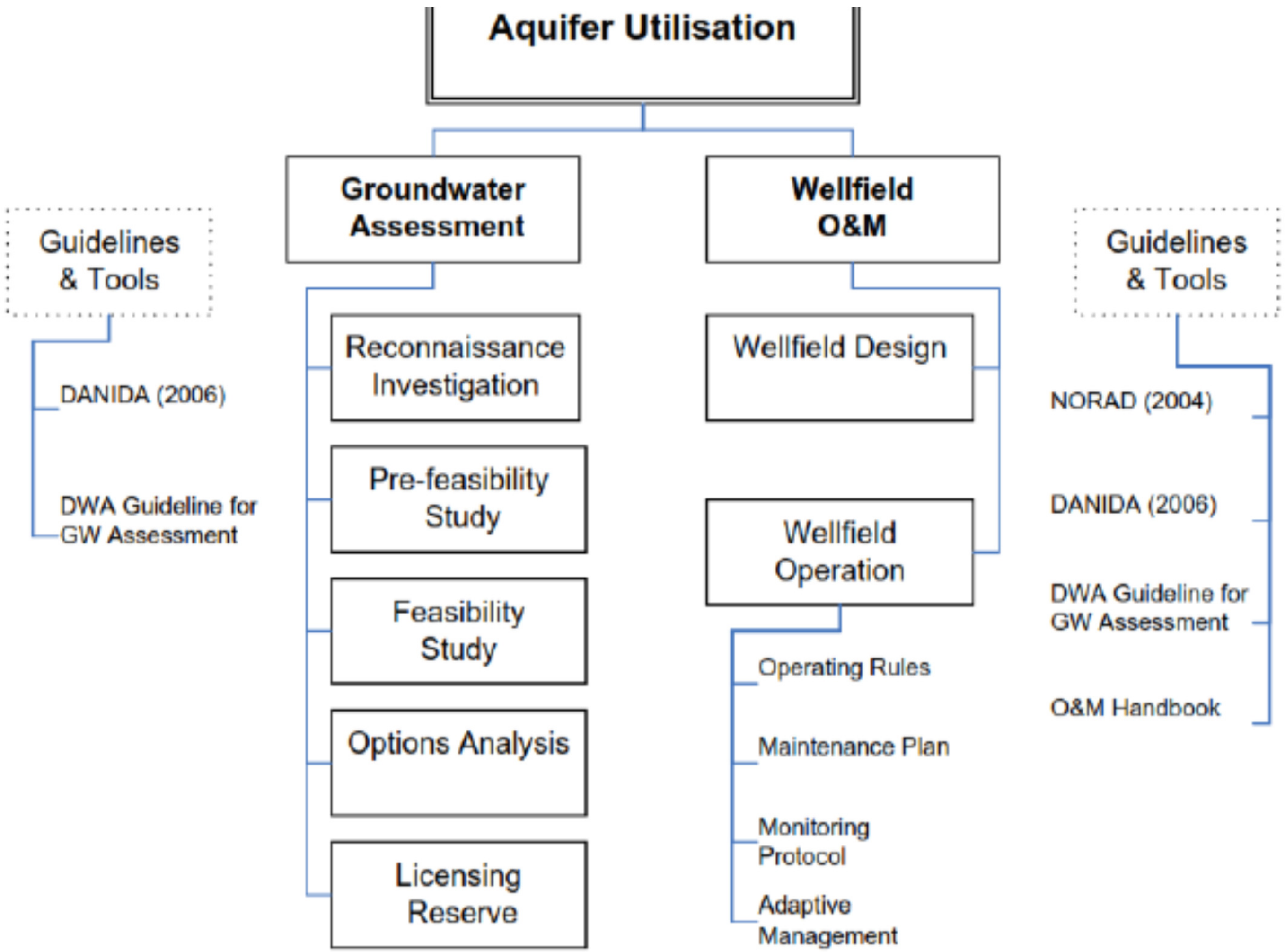

Figure 4
Aquifer utilisation category with subcategories 'Groundwater Assessment' and 'Well-field O&M', aspects and details per subcategory and available guidelines and tools

Responsibility Matrix for aspects of Aquifer Protection

	WSA					WSP / Water Board					DWS/CMA			WUA			DEA			
Aquifer Protection (SDM)	Labour	Operator	Supervisor	WR Manager	Head Development	Labour	Operator	Supervisor	Manager	Head Development	Technician	WR manager	Head Development	Technician	WR manager	Head Development	Case Officer	Manager	Head Development	Polluter
Landuse																				
Catchment Management Strategy				C								R	A		C	I				
Development/ update of IDP/ SDF				R	A							I			C	I				
Landuse Planning				R	A							R			C	I		I	I	
Waste management									R	A		I			C	I		I	I	
Waste water management				I					R	A		I			C	I		I	I	
Effluent quality management				I		S	R	A	I			I						I	I	
Remediation																				
Groundwater remediation				I								C						I	I	R/A
Monitoring																				
Groundwater monitoring	S	R	A	I								I		S	I	I				
Regional GW monitoring				I							R	I	A	S	I	I				
GWQ monitoring (pollution)				I	S	R	A	I				I		S	I	I		I	I	R
Ecological Monitoring											R	I	A	S	I	I		I	I	

Responsibility Matrix for aspects of Aquifer Utilisation

	WSA					WSP / Water Board					DWS/CMA			WUA			DEA		
Groundwater development (RDM)	Labour	Operator	Supervisor	WR Manager	Head Development	Labour	Operator	Supervisor	Manager	Head Development	Technician	WR manager	Head Development	Technician	WR manager	Head Development	Case Officer	Manager	Head Development
Groundwater Assessment																			
Reconnaissance Study				R	A				I	I		C			I	I			
Pre-feasibility Study				R	A				I	I		C			I	I			
Feasibility Study				R	A				I	I		C			I	I			
Options Analysis				R	A				I	I		C			I	I			
Licensing Application				R	A				C	I		C			C	I			
Reserve Determination				C	I				C	I	S	R	A		C	I			
EIA/ RoD				C	I				C	I		C			C		R	C	A
Licensing				C	I				C	I		R	A		C	I		C	
Wellfield O&M																			
Wellfield planning & design				I					R	A		I						I	
Wellfield development				I				S	R	A		I						I	
Wellfield operations and maintenance				I		S	R	C	A		S	I		S				I	
Monitoring																			
Groundwater baseline monitoring	S	R	C	I	A						S	I		S	I			I	
Groundwater compliance monitoring				I		S	R	C	I	A		I			I			I	