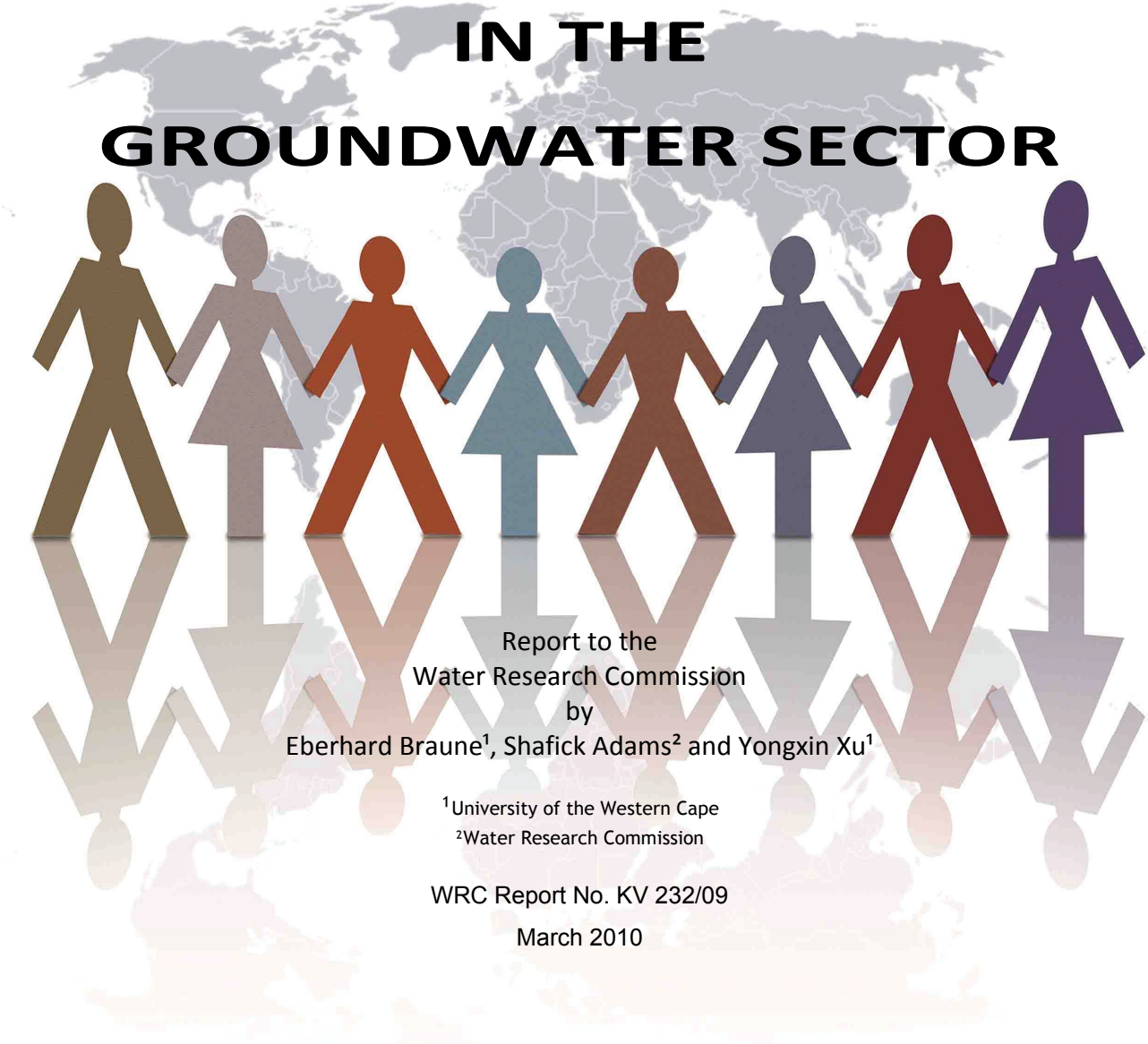
ASSESSING THE IMPACT OF RESEARCH FUNDED BY THE WATER RESEARCH COMMISSION ON CAPACITY BUILDING IN THE GROUNDWATER SECTOR



Report to the
Water Research Commission
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Executive Summary

Water plays a central role in the South African economy, society, environment and health. Sustainable development of the country's water resources already faces major challenges, which will be further exacerbated in future, including through increased demands, services backlogs, ecosystems' assimilative capacities, and climate change. The biggest challenge area that must be addressed up front and as part of all other challenge areas is human and institutional capacity building.

During the droughts of the sixties, the SA government, at the time, identified the need to establish a water research facility which could assist in more informed decision-making. The added challenge was that this institution should be sustained and resourced by the water users themselves to ensure that it remained relevant and responsive to current and future challenges faced by the sector. Since its inception, now almost 40 years ago, the WRC has been striving to fulfill its mandate of serving the water sector, including:

- Promoting co-ordination, co-operation and communication in the area of water research and development
- Stabilising water research needs and priorities
- Stimulating and funding water research according to priority
- Promoting effective transfer of information and technology
- Enhancing knowledge and capacity-building within the water sector.

Capacity building is thus a key component of the WRCs mandate.

The WRC periodically invests in anecdotal and quantitative research in order to assess the impact it has created in different arenas in the water sector and to benchmark itself internationally. The objective of this study is to focus on research regarding groundwater resources, which are becoming increasingly important in South Africa.

Groundwater has always been the Cinderella of water resources in South Africa. While it now has a strategic importance as main source of community water supply throughout the country, this role is not yet properly understood and reflected in policies and strategies and appropriate capacity at the right levels. This situation can only be changed through ongoing awareness and capacity building with regard to groundwater resources within an IWRM and 'Water for Growth and Development' framework.

Like with other resources, the management of the groundwater resource will not be possible without adequate human capital development through education and training as well as research and development. The study hence highlights an important aspect of long term investment in building sufficient human capital to face both current and future challenges faced by this sector.

In line with a growing international understanding, this assessment of the impact on water sector capacity has focused on both more effective people and more effective institutions, which together would be better able to provide products and services on a sustainable basis.
The general template used throughout the assessment addressed research inputs and their impacts on knowledge creation, human resources development, knowledge transfer and impact on water resources management.

The assessment found that WRC investment into groundwater research in South Africa has been strategic and ongoing for 35 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.

The research priorities over many years were of a resource characterization and groundwater technology nature. Since 2000 a greater resource management focus within an IWRM framework was added. This progression in research focus reflects the progression of groundwater attention nationally, before and after the National Water Act, 1998.

The Water Research Commission was instrumental in developing the strong research and teaching centers in groundwater hydrology in South Africa (e.g. Institute for Groundwater Studies at the University of the Free State and the groundwater programme within the Earth Science Department at the University of the Western Cape). The WRC also supported several other universities (Fort Hare, Venda, Pretoria, KwaZulu-Natal and Witwatersrand), science councils, NGOs and consulting firms.

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.

The groundwater research undertaken in South Africa could generally be classified as applied research and little of the research outcomes could be viewed as cutting edge research. A weakness in this regard was the relatively limited publishing in the international literature. Also missing have been longer-term research partnerships with leading international researchers.

Significant knowledge transfer has taken place through the freely available WRC reports. Particularly valuable in this regard has been the synthesis of knowledge for key Africa groundwater issues, published in book form by leading international science publishers.

The highest impact on improving groundwater resource development, utilization and management was obtained when there had been a planned synchronization of research and national development objectives. Such a coordinated approach has proved to be very challenging, because of the continuing poor institutionalization of the groundwater resource management function in government.

While growing in strategic importance, groundwater has, for a variety of reasons, experienced a serious decline in capacity for its sustainable utilization and management, particularly in the government sector (national and local) as well as in the academic sector. Given this situation, it is imperative that the WRC's investment into groundwater research and capacity building is continuing and is made even more effective and efficient than it has been to date.

Considerable weaknesses are apparent in the capacity building process in South Africa. These appear to be amenable to positive change if there was a much greater and strategic cooperation in the water sector. Opportunities to move in this direction present itself at this point in time with all the major players, both nationally and on the continent. Given its mandate, resources and excellent track record, the WRC should play a critical facilitation role to bring the key players with their respective roles and resources together for the common objective of growing the capacity for the sustainable utilization of groundwater resources in South Africa and beyond.

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1. Introduction

1.1 Background

Water plays a central role in the South African economy, society, environment and health. Sustainable development of the country's water resources already faces major challenges, which will be further exacerbated in future, including through increased demands, services backlogs, ecosystems' assimilative capacities, and climate change. To respond to these challenges, new legal and institutional measures have been invoked since 1994, in particular national planning, the Ecological and Basic Human Needs Reserve, transboundary water management, Catchment Management Agencies and local participation by users.

During the droughts of the sixties, the SA government, at the time, identified the need to establish a water research facility which could assist in more informed decision-making. The added challenge was that this institution should be sustained and resourced by the water users themselves to ensure that it remained relevant and responsive to current and future challenges faced by the sector.

Since its inception, now almost 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
- Stabilising water research needs and priorities
- Stimulating and funding water research according to priority
- Promoting effective transfer of information and technology
- Enhancing knowledge and capacity-building within the water sector.

Capacity building is thus a key component of the WRCs mandate.

The WRC sets targets periodically to ensure that its operations and overhead costs do not overtake the core business of investing on its mandate. The organisation, served by 55 employees, invests more than 75% of its annual income in research and capacity building. This national entity has acquired excellent status nationally and internationally in leading water research and in making a marked difference in the South African water sector.

In its attempt to create evidence regarding the above, the WRC periodically invests in anecdotal and quantitative research to assess the impact it has created in different arenas in the water sector, in particular the impact on knowledge creation, human resources development, knowledge transfer and impact on water resources management.

The objective of this study is to focus on research regarding groundwater resources, which are becoming increasingly important in South Africa.

Groundwater has always been the Cinderella of water resources in South Africa. While it now has a strategic importance as main source of community water supply throughout the country, this role is not yet properly understood and reflected in policies and strategies and appropriate capacity at the right levels. There is even concern that local government, which has the devolved water services responsibility, is 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 utilization and management of local groundwater resources. This situation can only be changed through ongoing awareness and capacity building with regard to groundwater resources within an IWRM and 'Water for Growth and Development' framework.

Like with other resources, the management of the groundwater resource will not be possible without adequate human capital development through education and training as well as research and development. The study hence highlights an important aspect of long term investment in building sufficient human capital to face current or future challenges faced by this sector.

The Water Research Commission was instrumental in developing the strong research and teaching centers in groundwater hydrology in South Africa (e.g. Institute for Groundwater Studies at the University of the Free State and the groundwater programme within the Earth Science Department at the University of the Western Cape). The WRC also supported several other universities, scientific councils, NGOs and consulting firms. The funding and research projects enabled these institutions to grow and develop significantly. However, the country now finds itself with a skills shortage within the academic and government sectors.

Building capacity for an essential sector in our economy should be addressed in a strategic way. This requirement could not have been put more strongly than by AMCOW in its recommendations from the African Ministers for Water meeting in 2003 in Addis Ababa:

"To reach the African Water Vision of sustainable water management and to meet the MDG's in the water sector in Africa, the biggest challenge area that must be addressed up front and as part of all other challenge areas is human and institutional capacity building. Because of past neglect, political will and a strategic approach are essential".

1.2 Objective of study

Study goal:

To utilize the WRC as a major vehicle for capacity building in the groundwater resources management field in South Africa, with a resulting impact on the whole African continent.

Study objective:

To quantify the impact of WRC groundwater research on the capacity development within the water sector in South Africa, and identify the causes of the skills shortages within the academic and public sectors;

To develop way forward proposals for the achievement of the above goal within the framework of IWRM in South Africa and together with key national, regional and international structures and processes.

1.3 Report structure

The point of departure for the report is the objectives and functioning of the Water Research Commission within the broader water resources management environment in South Africa. From a clarification of the concept of (water resources) capacity building, the report moves to the situation with regard to groundwater resources capacity and capacity building in South Africa and the WRC's declared role in this regard.

From a summary of the inputs of the WRC in groundwater research over the last 30 years, the impact of this investment is assessed. With this as foundation, an analysis of the strengths, weaknesses, opportunities and threats with regard groundwater resource management capacity-building in South Africa is made, with key focus on the WRC.

The report is concluded with a vision for groundwater resources capacity building and recommendations for strategies and actions for the WRC towards this vision. The recommendations are supported through comparison to international best practice.

2. What is capacity building?

The concept of capacity building was recognized as a priority item at Mar del Plata (Biswas, 1978), even though during this United Nations Water Conference in 1977, the term capacity building did not exist. The emphasis at Mar del Plata was on human resources development in terms of education, training, and research (Recommendation F), and institutional strengthening (Recommendation D), all of which are now considered as integral components of the capacity building process.

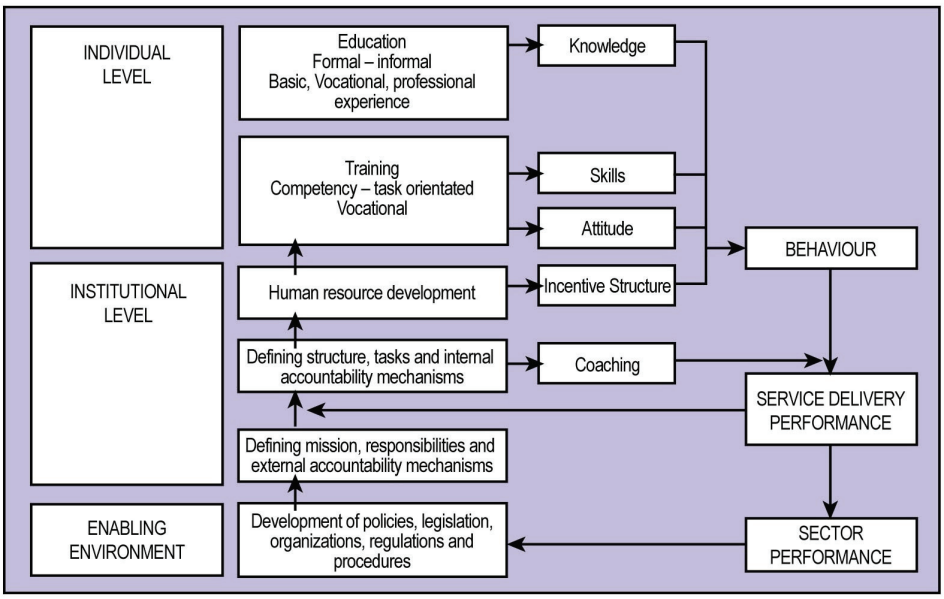
The Symposium on capacity building for the water sector, convened by UNDP and the International Institute for Hydraulic and Environmental Engineering, in Delft in 1991, defined capacity building as (UNDP, 1991):

- the creation of an enabling environment with appropriate policy and legal frameworks;
- institutional development, including community participation (of women in particular);
- human resources development and strengthening of managerial systems.

Participants recognized that capacity building is a long-term, continuing process, in which all stakeholders participate (ministries, local authorities, non-governmental organizations and water user groups, professional associations, academics and others).

This definition has been further refined over the years into a structure and process adopted in the World Water Development Report (UNESCO, 2006), as illustrated in **figure 1** and the explanation following.

Figure 1: Capacity development: Levels, activities, outputs and goals



This definition shows three levels of capacity development (UNESCO, 2006):

INDIVIDUAL

Enables individuals to embark on a continuous process of learning – building on existing knowledge and skills, and extending these as opportunities appear.

INSTITUTIONAL

Involves building on existing capacities, encouraging existing institutions to grow.

SOCIETAL

This involves capacities in society as a whole, or a process of transformation to assist development. An example is creating the kinds of opportunities, whether in the private or public sector, that enables people to use and expand their capacities to the fullest. Without this, skills rapidly erode, or become obsolete.

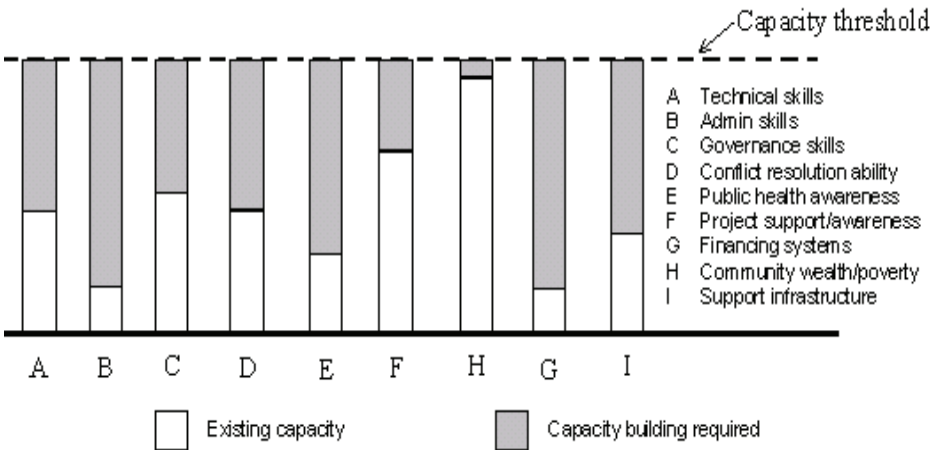
The issue of capacity is critical and the scale of need is enormous, but appreciation of the problem is low. The link between needs and supply is weak. There is a lack of realistic funding. There is need for support for change. Training institutions are isolated - communications are poor.

Development of teaching materials is inefficient. Alternative ways of capacity building are not adequately recognized (Wikipedia).

One of the key challenges has been to measure capacity and find appropriate indicators for capacity building (Cap-Net). Abrams(1996) made the conclusion that capacity building and sustainability are closely related. Without adequate, appropriate capacity at different levels of government and at local level, services will not be sustainable.

The factors which determine whether a development will be sustainable or not (the sustainability indicators), provide the pointers to the areas where capacity needs to be established and maintained (Abrams, 1996). This can be illustrated in **figure 2** below, showing capacity thresholds essential for agreed service level options and technology choices in different component fields of water services provision, the present levels of capacity in these fields and thus the respective skills gaps that must be addressed to achieve a sustainable service (Abrams, 1996).

Figure 2: Identification of capacity gaps in relation to capacity thresholds (Abrams, 1996)



This important link to sustainability is best captured in the most recent UNDP definition of capacity building (UNDP, 1996):

"Capacity building" is defined as the sum of efforts to nurture, enhance, and utilize the skills and capabilities of people at all levels - local, national, regional, and international - so that they can better progress towards sustainable development. At the basic conceptual level, building capacity involves empowering people and organizations to solve their problems rather than attempting to fix those problems directly. When capacity building is successful, the result is more effective people and institutions better able to provide products and services on a sustainable basis".

In any strategy for building groundwater resources management capacity in South Africa it will be important to address all the different levels of capacity and not only the individual one, and to have ways to measure capacity and monitor progress in its development.

3. Groundwater management capacity in South Africa

3.1 Role of groundwater in South Africa

Groundwater has always been the Cinderella of water resources in South Africa. This has not changed significantly from the time under the previous Water Act, 1956, when it was legally classified as 'private water'. While it is now recognised as a significant resource in the National Water Act, 1998, it is still neglected in its management, and its value has been understated.

Increased and sustained investment, economic growth and poverty reduction in South Africa requires that all potential water resources are appropriately utilised. If groundwater is to be beneficially utilised as a significant resource it will require greater upfront investments in infrastructure, institutions and capacity in order to achieve water security.

While many of the 19 Water Management Areas will already have reached the limits of their available water resources once the ecological reserve is fully implemented, only 20 to 30% of available groundwater resources are currently used. Local groundwater resources are particularly important for water supply to thousands of rural communities for whom a bulk water supply solution would be unaffordable and impractical. Groundwater should be the major source to meet the remaining water services backlogs and will also be able, to a large extent; to address local productive water needs to help ensure sustainable livelihoods. Today groundwater supplies more than 60% of the communities with water, going up to 90% in some provinces. This has been achieved as part of a country-wide water services drive under the Reconstruction and Development Programme since 1994.

Strategic importance of groundwater resources in South Africa

Available yield of surface water resource	10 200 Mm^3
Available yield of groundwater resources	10 400 Mm^3
Present groundwater use	2 000 Mm^3
Groundwater use for strategic rural domestic use	300 Mm^3

DWAF (2004)

Groundwater is the sole source for many towns in the drier parts of the country and an important supporting source for our larger cities. For example, the City of Tshwane obtains a significant portion of its water supply from boreholes and springs, which is blended with surface water within the bulk distribution system. More than 60% of Capricorn District Municipality water is derived from groundwater resources. The City of Cape Town is considering developing future water supplies from the Cape Flats and Table Mountain Group Aquifer systems. Local groundwater sources are also seen as a crucial bridging supply in the informal areas, where water services cannot keep pace with rapid urbanisation. The mining sector relies heavily on groundwater sources, particularly in the drier parts. The total groundwater use figure is dominated by commercial agriculture, but this takes place only in a few areas with favorable groundwater conditions. The use of predominantly hard-rock groundwater systems for small scale farming in Africa is widely advocated, but its feasibility, including the water quality issue, has remained largely untested.

Groundwater has important environmental functions. Many ecosystem services have a direct linkage with groundwater storage, recharge and discharge. However, the interdependencies between ecosystem services and groundwater are not yet recognised and valued in decision making and in the management of water resources and river basins.

It is estimated that groundwater is presently utilized at about 20% of its full potential. A major resource development and sustainable utilization task therefore still lies ahead in South Africa. The typical key functions that will have to be performed over the long term include (World Bank, 2006):

- Hydrogeological exploration for resource development;
- Groundwater resource assessment and strategic planning;
- Groundwater abstraction and use regulation;
- Groundwater resource and source protection;
- Groundwater supply operation, monitoring and impact mitigation;
- Groundwater monitoring and information management.

While increasing local management of the highly localized resource will be essential, there is international agreement that the essential task of mobilising stakeholders and establishing and sustaining aquifer management organisations requires a national champion (World Bank, 2006). This is presently lacking in South Africa.

3.2 Capacity needs and gaps for groundwater resource management

Because of past neglect, as well a present lack of strategic attention to groundwater in South Africa, serious capacity gaps have developed at this stage, mainly in national government, local government and in the academic sector. In a questionnaire action to the groundwater sector, 'lack of capacity and institutional development' was seen as the greatest challenge for the sector (Adams, 2007).

NATIONAL GOVERNMENT

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 (Act No. 36 of 1998). Because of the significance and weight of this submission, key passages are quoted verbatim below (Ground Water Division, 2008):

"Unfortunately, the implementation of the National Water Act has proved to be problematic as it is highly dependent on sufficient skilled and experienced staff – both in the public and private sector. An inability to implement the National Water Act prevents groundwater from being used productively and sustainably to promote economic growth and social upliftment; or creates unnecessary burdens on those who attempt to do so. Some specific issues that relate directly to provisions within the National Water Act include:

- The absence of quantified guidance in terms of setting volumes associated with reasonable domestic use, market gardening, etc. in order that decisions are less subjective.

- The failure to register and verify existing groundwater use across most parts of the country.
- The general authorisations for groundwater, including why some of the most productive aquifers in South Africa have a 0 m^3/ha/a general authorization (e.g. Atlantis Aquifer, Cape Flats Aquifer, Langebaan Road Aquifer, etc.), thus requiring any potential groundwater user to go through a licensing process.
- The inability of DWAF to issue groundwater use licenses; alternatively why such applications are so onerous and take months and years to issue, rather than weeks.
- Why groundwater abstraction is subject to both a water use license (Department of Water Affairs and Forestry) and environmental authorisation (Department of Environment Affairs and Tourism); and why a single streamlined licensing process has not been implemented."

It is crucial that a grouping similar to the old Directorate of Geohydrology be established to develop and strengthen DWAF's expertise and experience in the field of groundwater, with it's earlier inability to integrate with other groups and structures within DWAF being an area that has to be addressed. This grouping – to be functional at both Head Office and in the Regions – should have the following key focus areas:

- Rural water supply: In addition to using groundwater to ease the plight of millions of South Africans in general – and women in particular – who suffer because of inadequate access to potable water; this focus area could be used to develop the practical skills to recent graduates through a 2 year internship programme.
- Extension services: DWAF has a responsibility to provide extension services to Catchment Management Agencies, District Municipalities and Local Authorities and other users or polluters of groundwater.
- Licensing and control: The development and implementation of a streamlined and effective groundwater licensing procedure would be the responsibility of this subgroup.
- Data management and monitoring: Proper groundwater management is highly dependent on access to data. This function currently managed by DWAF needs to be expanded to capture and exchange data with consultancies, universities and other groups.
- Staff development: By ensuring the ongoing development of groundwater skills within DWAF, the country will be ensured of sufficient skills and experience to manage the country's groundwater supplies."

LOCAL GOVERNMENT

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 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. No local government has its own groundwater expertise and 74 out of 231 local authorities did not even employ technical experts (MacKay and Koster, 2005).

ACADEMIC SECTOR

South Africa's groundwater academic sector is not yet institutionally well established and is presently seriously hampered by staff losses in key positions, which will take years to rebuild.

PRIVATE SECTOR

The private sector has been experiencing a groundwater boom since the late nineties through the widespread development of groundwater infrastructure for community water supply and through the attention to environmental impact management in the mining industry and parastatals.

3.3 Reasons for serious capacity gaps in groundwater field

Any attempt to raise capacity for groundwater management in South Africa does not only have to understand the capacity gaps that exist, but the reason for their existence. It was not possible to make a special study of these for this assessment, so they can just provide the authors' best understanding of the situation. Some of the reasons highlighted below 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.

- 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 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 (MacKay and Koster, 2005). We are seriously missing the public sector as a major player in capacity building;
- 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;
- There is a widespread lack of understanding that capacity-building is more than just training (MacKay and Koster, 2005); While the engineering sector as a whole is starting to address capacity-building strategically, this has not yet happened in the water sector, despite several attempts since 2000;
- 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. MacKay and Koster (2005) warn that all players need to rapidly move forward together with innovative solutions for capacity building in the water sector, before international groups mobilize our skills for initiatives outside of South Africa.

4. National initiatives towards water sector capacity building

4.1 Strategic level initiatives

While the capacity problem is acute in the groundwater field, it is clear that it a major issue for the water sector as a whole, covering both water resources management and water services provision. What has been lacking since the sweeping water reforms of the 1990s, is a strategic approach to support these ambitious policies and acts with appropriate capacity to implement them. While there have been at least two internationally supported initiatives in this regard, DWA and the sector as a whole have always lacked a champion to take the good thinking and general agreement forward. Capacity building has not yet been established as a function requiring ongoing strategic, and practical, and not just Human Resources (HR) administrative attention. For continuity and context for the groundwater thinking, two previous national initiatives are highlighted here.

UNESCO/WMO MISSION TO ASSESS E&T NEEDS OF THE WATER RESOURCES MANAGEMENT SERVICES IN SOUTH AFRICA (DWAF/UNESCO/WMO, 1998)

The Mission was in response to South Africa's re-entering the UN family, the strategic importance of water in the reconstruction and development of the country and the potential to spread an investment made in South Africa in terms of water resources E&T into the SADC region. The mission and objectives, as formulated in 1998, are provided in Appendix 8.

At a concluding national workshop of this important partnership initiative it was decided that the WRC should drive the main strategy proposed by the mission, namely the Framework for Education and Training in Water (FET-Water). The strategy of 'collaboration, sharing and networking' was seen as highly appropriate for the South African water sector at the time. The WRC foresaw substantial opportunities for synergy with its growing research networks. Importantly there was political commitment to fund FET-Water by the then Minister of Water Affairs and Forestry.

FET-Water has been slow to take off, largely because the Department of Water Affairs and Forestry tried to implement it itself, its budget was limited and because the concept of networking was fairly new to South Africa. Handing over the administration of FET-Water to the WRC for its phase II, started in 2008, has been a step in the right direction.

Overall, however, it can be stated that FET-Water is presently still operating at a fraction of its original intent.

CAPACITY BUILDING STRATEGY FOR THE SOUTH AFRICAN WATER SECTOR (DWAF, 2001)

During 1999, a consultative process commenced with a specific objective of developing a sectoral capacity building strategy that will be informed by the objectives of the new water legislation. This process culminated in 2000 in a Water Sector International Stakeholder Workshop on Capacity Building. The sectoral strategy for capacity building was to become a key component of the National Water Resources Strategy which was under development at that time. A Task Team that was set up to develop the strategy formulated a very ambitious objective:

" In 15 years time, all roleplayers in the water sector in South Africa will have worked together to ensure that the necessary quality and quantity of capacity exists in all relevant institutions to fully implement the National Water Policy of 1997, the National Water Act of 1998 and Water Services Act of 1997." (DWAF, 2001).

Despite the carrot of significant financial and know-how support from the Netherlands, this initiative also fizzled out, because there was no body to carry it forward and maintain the mobilization of stakeholders, ideas and resources.

While there are strategies for the implementation of most technical aspects of the Act in place or under development, there is still no strategy to develop the human resources that must implement IWRM. In the past, at least 30 South Africans underwent post-graduate education in water and environmental management in the Netherlands every year. An objective of the high-level workshop in 2000 between the two countries was to transfer this capacity-building to South Africa with the help of the Netherlands. The basis for this was to be a National Water Sector Capacity Strategy for South Africa. However, 16 years later there is still no such strategy – and this despite a widespread recognition for its need. This situation can be illustrated with a remark by the Deputy Director-General of DWAF in 2006 at the World Water Forum in Mexico, "with the implementation of the Act we all have to do new things every day, but nobody is trained for it".

The key challenge in this regard is probably that such a strategy must be driven by the IWRM line function. Academics can provide the pieces, and the Human Resources Management (HR) function can add its HR policies and tools, but the drive and direction must come from those who have to implement IWRM and understand the needs. Up to now no component in DWA has been given a mandate to undertake this water sector cross-cutting function on a strategic and ongoing basis.

4.2 Practical level initiatives

South Africa's progressive water policies and legislation created a lot of momentum and interest, both national and international. Only two of many initiatives of practical capacity building are briefly discussed here as examples of approaches and the related challenges - one addressing the building of capacity for IWRM implementation and the other for community water supply from groundwater sources.

DWAF DANCED IWRM PROJECT (DWAF DANCED, 2001)

The cooperative project was intended to support the implementation of programs towards achieving IWRM in three selected Water Management Areas (WMAs):

WMA No 3	Crocodile (West) and Marico
WMA No 11	Mvoti to Uzimkulu
WMA No 17	Olifants-Doorn

The vision of the project was to develop IWRM from a strategic level to implementation level, and that IWRM would be used to empower previously disadvantaged groups and encourage participation in the management of water resources in South Africa.

The project addressed a high priority need of DWAF and became fully integrated into the implementation of CMA establishment of DWAF in a 2 year inception period and 2 project phases. It piloted many practical aspects of CMA establishment and had a strong focus on capacity building, both individual and institutional.

The project had a very practical groundwater component in all three WMAs as part of the overall IWRM learning and implementation. This did not have the same impact on the DWAF organization as the CMA establishment, because it was limited in scope and groundwater was not yet established as a resource needing ongoing mobilization. A groundwater strategy developed as part of this project had no impact in DWAF and nationally because it was premature, poorly stakeholder-consulted and came at the time of the demise of the Directorate: Geohydrology in DWAF (DWAF DANIDA, 2004).

THE NORAD-ASSISTED PROGRAMME FOR THE SUSTAINABLE DEVELOPMENT OF GROUNDWATER SOURCES UNDER THE COMMUNITY WATER AND SANITATION PROGRAMME IN SOUTH AFRICA (DWAF NORAD, 2004)

The programme, managed by the Department of Water Affairs and Forestry (DWAF) between 2000 and 2004, undertook a series of inter-related projects aimed at enhancing capacity of water services authorities and DWAF to promote and implement sustainable rural water supply schemes based on groundwater resources and appropriate technologies. The activities were piloted in three of the recently established local government Districts:

- Capricorn District Municipality, Limpopo Province
- Chris Hani District Municipality, Eastern Cape Province
- Uthukela District Municipality, KwaZulu-Natal Province

The programme addressed a national need, because water services had recently been devolved from national to local government level and more than 60% water supply schemes country-wide were from groundwater sources. In the pilot areas of the respective district municipalities the programme had a major impact in introducing appropriate groundwater source management practices and training local personnel. However, the multiplication impact of this intensive and high cost programme was limited. Some key reasons for this are summarised below to illustrate a 'groundwater and development' capacity situation in South Africa which has not yet changed significantly.

- The programme was driven from the side by a fairly stable Directorate: Geohydrology of DWAF;
- It had strong contracted implementation support from a significant part of the groundwater NGO and private sector;
- The DWAF lead agent for water services and link to local government was its Water Services component, which was deeply involved in the roll-out of the Masibambane programme (meeting the massive water and sanitation backlogs), and which was willing, but had little time for a learning initiative;

- Implementation of the programme was through the DWAF regional offices, where groundwater capacity was extremely thin in most regions and support from the regional Water Services organization very difficult to secure under the prevailing priorities;
- District municipalities had no appropriate institutional structures to start accommodating groundwater source management in any sustainable way;
- The overall driver of the programme, the Directorate Geohydrology ceased to exist following the restructuring of DWAF in 2003, and the programme had to be rounded off by tasked individuals. As a result there was no DWAF follow-up programme for this strategic initiative.

The programme has had an excellent knowledge output in the form of a 'Toolkit for Water Services', with local level strategies and a variety of best practice documentation and software (DWAF NORAD, 2004). Because of the complete lack of follow-up, this documentation is already largely forgotten, despite irregular requests for it from elsewhere on the continent.

5. WRC role in capacity building

5.1 WRC role and functioning

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:

- Promoting co-ordination, co-operation and communication in the area of water research and development.
- Establishing water research needs and priorities.
- Stimulating and funding water research according to priority.
- Promoting effective transfer of information and technology.
- Enhancing knowledge and capacity-building within the water sector.

In a major organisational transformation in 2002, the WRC streamlined its business and narrowed down its 18 research fields (including groundwater research) to 5 KSAs:

KSA 1: Water Resource Management

KSA 2: Water-Linked Ecosystems

KSA 3: Water Use and Waste Management

KSA 4: Water Utilisation in Agriculture

KSA 5: Water-centered Knowledge

Furthermore, the four cross-cutting Impact Areas below were established to create further integration of activities towards national development objectives:

Water and Society

Water and the Economy

Water and the Environment

Water and Health

Knowledge created through WRC funds strongly supports DWA's overarching objective, i.e. water for economic growth and sustainable development. The WRC continues to support the water sector and all its relevant institutions and partners by providing them with knowledge aimed at informing their decision-making processes, improving their monitoring and assessment tools and making available a new and improved range of technologies related to water resource management and the provision of water and sanitation services.

5.2 WRC role in capacity/competence development

The WRC undertakes its mandate of 'Enhancing knowledge and capacity-building within the water sector', both complementary to its research activities and as a specific focus of KSA: Water-centered Knowledge:

STUDENTS

By increasing the number of students conducting water research, the WRC provides South Africa with a good basis for future researchers as well as a source of skilled human capital for other institutions within the water sector. Currently about 664 students are supported by WRC projects, of whom about 65% are from disadvantaged backgrounds (2007/08 Knowledge Review).

HIGHER LEVEL ACADEMIC QUALIFICATIONS

The achievement of post-graduate qualifications is strongly encouraged as part of research projects and has become a standard requirement in project proposals. A typical overall output was summarized for the 2003/04 report year.

Table 1 : Higher-level academic qualifications output (2003/2004)

Research area	Number of projects completed	Project outputs			
		Masters degrees	PhD degrees	Refereed publications	Conference presentations
TOTAL	**122**	**103**	**33**	**175**	**421**

As part of transformation of the water sector the WRC has placed particular emphasis on the support of historically disadvantaged students and researchers.

WIN-SA

One of the important areas requiring the building of competence is that of local government. The WRC serves as the implementing agent for DWA with regard to WIN-SA. WIN-SA is aimed at knowledge sharing and capacity building for local government.

FETWATER

Another key capacity-building area in the development of competencies and capacity regarding water resource management is FETWater. The WRC continues to co-lead the activities of the **Framework for Education and Training in Water (FETWater)**, a joint UNESCO, Belgian and South African programme aimed at building improved capacity in integrated water resource management. During 2008, the WRC assumed the position of implementing agent for Phase II of the programme.

BUILDING CAPACITY IN AFRICA

The WRC's capacity-building activities continue to address both support for Africa and participation in global initiatives aimed at building capacity: Some examples include:

- NEPAD – Support of NEPAD process to establish a network of centres of excellence for water research in Africa;
- UNEP – MOU with WRC to lead assessment of freshwater resources in Africa.
- Water Research Fund of Southern Africa (WARFSA) – involvement in steering and coordination;
- Streams-Africa – leadership in an Africa-wide network of capacity-building organisations, focused on water and sanitation.

6. Impact of WRC groundwater research

6.1 Groundwater research at WRC

The WRC has been commissioning groundwater research since 1975, initially discipline-focused under a groundwater research field, and since the institutional refocus in 2002 it has mainly been taking place under KSA 1, which has the following thrusts as depicted in **table 2** (note: the thrusts are reviewed annually):

6.2 Indicators of research impact

To be able to undertake an assessment of the impact groundwater research in South Africa, a framework of impact areas has been postulated, as shown below, and populated with appropriate indicators, some numerical, but largely narrative, which are shown in Appendix 3. These represent the authors' best understanding of the elements for capacity building for the groundwater sector. This framework was used for the questionnaire action discussed in 6.3.2

Framework for Groundwater Capacity Building
Inputs (R&D inputs by various stakeholders)
Knowledge Creation
Human Resources Development
Research Capacity Building
Knowledge Transfer
Impacts (manifested impacts on water sector)

Table 2 : Water Research Commission – KSA 1 Research Thrusts	
Thrust 1: Water Resource Assessment and Planning	• Catchment data and information systems • Surface water / groundwater hydrology • Water resource planning • Water resource development • Climate change and hydro-climatic variability • Water resource quality management.
Thrust 2: Management of Natural and Human- Induced Impacts on Water Resources	• Developing mitigation and adaptive measures for global climate change • Human-induced effects • Integrated flood and drought management.
Thrust 3: Water Resource Protection	• Protection and management of surface water and groundwater quality • Urban and rural water resource management • Integrated river flow and catchment hydraulics.
Thrust 4: Water Resource Institutional Arrangements	• Institutional governance and reforms • Compliance and enforcement • Pricing and financing of IWRM • Transboundary water resources • Future scenarios.

6.3 Analysis of groundwater research input and impact

6.3.1 INPUTS

There has been an ongoing funding of groundwater research for the last 30 years plus - Appendix 1: WRC Groundwater Research Funding (1974 -2008). Funding has varied between 6 and 16% of total annual WRC research spending. During the most recent recorded year (2008), funding stood at R 7.4 million (7.9%). The level of funding for groundwater appears to have stayed the same since the change from a specific groundwater research field to Key Strategic Areas in 2002 (Appendix 1).

For a more detailed analysis, one list has been compiled for all projects and consultancies - Appendix 2: Project and researcher list (1974 -2008). The main benefactors in terms of research projects allocated are shown in the two following tables:

Table 3a: Main benefactors in WRC research projects and consultancies (1974-2008)

Institutions	Number of institutions	Total number of projects + (consultancies)	Total value of projects (R 1 000 000)
Academic institutions	10	59 + (8) = 67	40
Science Councils	3	51 + (9) = 60	21
Consultants	19	35 + (24) = 59	29

Consultancy projects are in brackets

Table 3b: Main benefactors in WRC research projects including consultancies (1974-2008)		
Institutions	**Total number of projects**	**Total value of projects (R 1 000 000)**
Academic institutions		
IGS	40	19
UWC	9	12
UWits	5	1
UP	5	3
Science Councils		
CSIR	47	15
CGS	11	5
Consultants		
SRK	9	10
Pulles, Howard & De Lange	3	3
Umvoto	4	2
Parsons and Associates	6	1

The institutions that have received the most ongoing research funding have been the CSIR and the Institute for Groundwater Studies at the University of the Freestate from the beginning in 1975. At the time they were the only groundwater specialist groups together with the consultants, Steffen Robertson and Kirsten (SRK). As more players entered the field, the projects were distributed wider, especially in the consultant group. **However, most of the projects are of a collaborative nature and the statistics shown indicate only the main contractor and/or project leader.**

From the 1990s, the UNESCO Chair in Geohydrology at the University of the Western Cape (UWC) entered as a further major academic player.

Research focus was initially determined by a study group and their master plan and from 1987 by a, now defunct, Coordinating Committee for Geohydrological Research (CCGR) and strategic plans. The changing focus over time is illustrated in **table 4**.

Table 4: Changing focus of groundwater research under the Coordinating Committee for Geohydrological Research		
Date	**Groundwater Research Priorities**	
1987	**Research aspects under CCGR**	
	Process studies; Location and development of groundwater resources; Geohydrological studies and modelling of specific groundwater systems;	Regional geohydrological studies; Pollution of groundwater; Effects of mining activities; Artificial recharge; Instrumentation, methods and techniques.
1994	**CCGR priorities and primary goal** Identification and characterization of groundwater resources in terms of their occurrence, quality and development potential to: • significantly contribute towards the provision of community water supplies; • support DWAF's regional groundwater characterisation programme.	

2000	**Strategic Plan for next 5 years** Refocus groundwater characterization within the context of IWRM; Manage groundwater quality with emphasis on the prevention of contamination/pollution; Support research that develops appropriate institutional and management practices for achieving IWRM; Encourage lateral thinking and innovative and imaginative research with the potential to contribute to meeting the identified vision for groundwater research: *"The realisation, through excellence in research, of the full potential of groundwater in contributing to equitable and sustainable development in Southern Africa."*

The shift in research focus from general resource assessment to systematic country-wide assessment in support of resource management, to resource management itself is clearly visible in the CCGR objective and has been broadly in line with the changing objectives within the groundwater function in DWAF. In 2000 a strong capacity-building focus was added when the CCGR was reconstituted to:

- assist in closing the knowledge gap which affects the sustainable use of groundwater resources;
- guide the transfer of information and technology;
- develop young (and new) researchers;
- promote capacity-building initiatives;
- advocate trans-discipline and programme interaction.

In 2006, under the new Key Strategic Area structure, a greater end-user focus was introduced:

- End-user awareness and capacity is essential.
- Deeper understanding of water issues needs to be developed in end-users rather than only a notional understanding.
- Awareness building needs to support the implementation processes.
- Knowledge is required about local issues, areas and systems.
- The WRC needs to coordinate and engage with partners to promote training in the water sector (including capacity building projects between government departments).
- Technology transfer to implementers.
- The research portfolio need to incorporate tools for transferring and sharing knowledge i.e. training programmes, models and decision support systems, special events, case studies, pilot applications, media, etc.
- Research projects need to define the end at the beginning and involve end-users in the research process.
- International partnerships to increase the impact beyond South Africa's borders.

This focus is in line with the outcomes of a strategic workshop reported in the 2005/06 WRC Knowledge Review:

Critical basic functions for success for achieving the stated objective	Secondary causal functions
Develop Understanding, Promote Excellent Outcomes Develop People.	Translate Knowledge, Improve Resource Use, Promote Institutional Capacity, Customise Research Develop Coping Mechanisms

6.3.2 QUESTIONNAIRE ACTION

A questionnaire based on the above framework plus the indicators shown in Appendix 3 and with a summary of the WRC research inputs was provided to 25 past recipients of WRC research funding, including consultants, academics and from science councils. A response was obtained from 11 (44%). The questionnaire provided for a lot of narrative to highlight and explain capacity building successes and failures. This facility was virtually not used so that the analysis had to rely mainly on an interpretation of the response classes (none to major), clarification at a follow-up workshop (6.5) and personal experience. A summary of the responses is shown in Appendix 4 and an overall interpretation of the responses in **table 5.**

Two areas were looked at in greater detail subsequently, namely research capacity building and manifested impact, because the questionnaire could not probe deep enough.

Table 5: Outcomes of WRC Groundwater research investment

	Major (%)	Signifi-cant (%)	Minor (%)	None (%)	Comment
Knowledge Creation	33	30	23	13	Large number of WRC reports produced
Human Resources Development	13	30	32	23	Significant number of post-grad. degrees produced
Research Capacity Building	14	35	28	21	Good South African networking; limited leveraging of own resources
Knowledge Transfer	6	34	29	29	Focus on publications and conferences; no strategy for knowledge transfer
Manifested impact	9	28	30	31	Successes in terms of researched technologies adopted; limited influence on policy; some awareness creation;

6.3.3 RESEARCH CAPACITY BUILDING

The establishment of strong (ground)water centres had political backing, as can be seen from a signed agreement in the seventies between the then Minister of Water and the newly established Institute for Groundwater Studies at the University of the Free State. Similarly, the establishment of a UNESCO Chair at the University of the Western Cape came as a result of a request in 1996 of the then Minister of Water to the visiting Secretary-General of UNESCO. Helping to build the capacity of

these two groundwater centres has been an unwritten WRC policy since their establishment. The evolution of these two centres is summarized in Appendix 5.

Their impact in terms of students graduated, post-graduate studies undertaken and short courses provided is very significant. At the same time both centres are very vulnerable, because of very small permanent academic staff numbers. Broadening the academic capacity across more institutions has only had limited success, largely because of a limited groundwater research budget and no sector approach in this regard as well as the programme or thrust priorities within universities. Growing the smaller players through the larger ones should receive further attention. UWC in their early days, for example, started as a partner of the CSIR, whose Stellenbosch campus was only some 40km from UWC.

6.3.4 MANIFESTED IMPACT

Impact of recently completed research can be best illustrated by the selected brief case studies following:

FRACTURED ROCK AQUIFERS (SEE IMPACT CASE STUDY IN APPENDIX 6)

Fracture rock aquifer systems predominate in South Africa and have had an ongoing research investment since the beginning of the WRC. All the major institutions have been involved and have benefited. Impact has been across the spectrum of knowledge creation, human resources development, knowledge transfer and impact on water resources management.

Systematic research of the main aquifer provinces of South Africa has led to the production of Synthesis books (Handbooks) for the Table Mountain Group and Karoo aquifers, and one for the Basement rock aquifers is under production. The international impact of this research could have been larger if there had been a more concerted effort in publishing in some of the leading international journals.

ARTIFICIAL GROUNDWATER RECHARGE

Research on artificial groundwater recharge in fractured-rock aquifers has provided a clear indication of the potential of artificial recharge technology, both as an effective means of contributing to sustainable development of groundwater resources in such aquifers, and augmentation of water resources in general.

Furthermore, the resulting success in piloting several artificial groundwater recharge schemes in fractured-rock aquifers in southern Africa has culminated in the production of a booklet, titled *Artificial Groundwater Recharge: Wise Water Management for Towns and Cities.* In 2008 the Department of Water Affairs & Forestry (DWAF), with support from the Water Research Commission (WRC), produced a detailed strategy on artificial recharge to encourage optimum use of aquifers. Besides the ongoing artificial recharge practice in South Africa at Atlantis near Cape Town and near Polokwane, new initiatives have already been triggered in the West Coast District as well as Prince Albert. The capacity developed has also been exported to Namibia which is operating a very successful artificial recharge scheme.

RESOURCE-DIRECTED MEASURES FOR GROUNDWATER

The Reserve is the major resource-directed measure for the protection of water resources under the National Water Act, *1998*. The WRC initiated ongoing research since 2001 to understand and quantify the groundwater component of the Reserve. This work has been taken up to a training manual stage through the FET-Water Programme. The manual is currently being updated through support from DWA.

HYDROGEOLOGICAL MAPPING

This case illustrates the benefits of cooperating with a lead client in a project of national importance.

1990: Strong need for a hydrogeological map of SA expressed by users.

1991: Establishment of task groups to develop a groundwater mapping strategy and the formulation of a proposal together with Dr W Struckmeier of the International Association of Hydrogeologists;

1993: DWAF launches an ambitious programme of regional hydrogeological mapping;

1994: Draft Pietersburg 1: 500 000 hydrogeological mapsheet completed with a WRC contract;

1995: National Hydrogeological Map, started 1991, completed with a WRC contract;

1995-2003: Production of a set of 21 hydrogeological maps covering the country at a scale of 1:500 000 undertaken by DWAF, based on the piloting support through WRC research.

2001-2006: The WRC is pursuing the production of the Vegter's groundwater regions reports:

Vegter JR (2000). Groundwater development in SA and an introduction to the hydrogeology of groundwater regions. WRC Report TT 134/00.

Vegter JR (2000). Hydrogeology of groundwater region 1 Makoppa Dome. WRC report TT 135/00.

Vegter JR (2000). Hydrogeology of groundwater region 3 Limpopo granulite-gneiss belt. WRC report TT 136/00.

Vegter JR (2003). Hydrogeology of groundwater region 7 Polokwane/Pietersburg Plateau. WRC Report TT 209/03.

Vegter JR (2003). Hydrogeology of groundwater region 19 Lowveld. WRC Report TT 208/03.

Vegter JR (2007). Hydrogeology of groundwater region 26 Bushmanland. WRC Report TT 258/06

Hydrogeology of groundwater region 10 Karst Belt is currently being funded.

GROUNDWATER QUALITY MANAGEMENT

The same type of cooperation is illustrated for the field of groundwater quality management.

1991: A number of groundwater quality projects culminated in a document 'Groundwater Quality Management Policies and Research Needs for SA';

1993: Dr. Andrew Skinner from NRA, UK participates in discussions towards a groundwater protection policy and strategy for SA; WRC launches a number of projects to support such a strategy.

2000: Based on close cooperation with the WRC and its network of groundwater specialists, DWAF develops a policy framework entitled 'Policy and Strategy for Groundwater Quality Management' in South Africa.

2004: A major WRC project on the transport and fate of dense-aqueous liquids (DNAPLs) as foundation for possible regulation of a significant impactor of groundwater quality. This thrust did not bring the desired impact because of loss of critical capacity in DWAF in both the geohydrological and water quality management fields, following the 2003 DWAF restructuring. A link has still been maintained through a UWC project for DWAF on groundwater protection zoning, but it also suffering from the lack of appropriate counterparts in DWAF.

6.3.5 OVERALL EVALUATION

Systematic and ongoing funding of groundwater research by the WRC has taken place over the last 35 years. It represented on average about 9% of the overall research spending of the WRC and stood at around R7 million in 2008.

Research was strategically targeted through a Coordinating Committee for Geohydrological Research and regular strategic plans.

The research priorities over many years were of a resource characterization and groundwater technology nature. Since 2000 a greater resource management focus within an IWRM framework was added. This progression in research focus reflects the progression of groundwater attention nationally, before and after the National Water Act, 1998.

A significant impact of the research investment was obtained in terms of knowledge creation and transfer as well as institutional capacity building for groundwater research and education.

The two main institutions established largely through the WRC research support, i.e. the Institute for Groundwater Studies at the University of the Free State and the UNESCO Chair for Geohydrology at the University of the Western Cape, have grown to become significant national as well as regional resources. The Water Research Commission is currently supporting the groundwater research at the following universities: Fort Hare, Venda, Pretoria, Kwazulu-Natal and Witwatersrand.

The groundwater research undertaken in South Africa could generally be classified as applied research. Little of the research outcomes could be viewed as cutting edge research, the fractured rock analysis and modelling at IGS probably coming closest to it. A general shortcoming has been the lack of publishing in relevant international journals. Also missing have been longer-term research partnerships with leading international researchers. When this happened, eg IGS with the ETH in Zürich or UWC with the Universities of Leuven and Gent in Flanders, this has been very fruitful.

Good knowledge transfer has taken place where key Africa groundwater issues were addressed comprehensively by a number of authors and published in book form by leading science publishers. Three such books were launched by UWC in the last four years, covering the topics of recharge assessment, pollution and community water supply.

The highest impact on improving groundwater resource development, utilization and management was obtained when there had been a planned synchronization of research and national development objectives, eg in the case of hydrogeological mapping and aquifer artificial recharge.

The impact on groundwater awareness raising could have been more significant if this had been addressed more systematically. Successful approaches included PRO initiatives by consultants and regular publication in Water Wheel.

Impact of research is presently hampered by a serious lack of capacity and leadership in DWA in the groundwater and related resource management fields. This has been particularly felt in the groundwater quality management field.

7. Vision and elements of a groundwater capacity building strategy in South Africa

7.1 National Groundwater Strategy

Any WRC groundwater capacity building strategy/approach should ultimately be anchored in a national groundwater strategy.

The recent development of a groundwater strategy for South Africa began with the commissioning of a National Groundwater Strategy (NGS) development project in year 2000 by the Department of Water Affairs and Forestry, with the intention of providing inputs to the National Water Resources Strategy (NWRS). This resulted in a strategy commonly referred to as the DWAF/Danida strategy (DWAF, 2001), with development supported by Danida. The strategy was useful but could not claim to be national in scope or content, nor was it broad-based and participatory in its development.

A framework was therefore developed in 2007, aimed at providing the building blocks upon which a truly national strategy, which can serve the needs of all groundwater stakeholders, including the research and information sectors, and which integrates with the NWRS, can be constructed. The aims and objectives of such a new national groundwater strategy are currently seen as (DWAF, 2007):

AIMS OF THE NATIONAL GROUNDWATER STRATEGY:

- Groundwater as a resource is given its rightful status alongside surface water, helping to meet the growing water demand as a recognised strategic resource within an integrated water resource management approach.
- The knowledge and use of groundwater is increased along with the capacity to ensure sustainable management.
- Pro-active groundwater management programmes are developed and implemented at required water resource management levels, focusing on both quantity and quality aspects.

OBJECTIVES OF THE NATIONAL GROUNDWATER STRATEGY:

- Assess and describe the broader strategic aspects shaping the groundwater sector, with an emphasis on integrated water resource management.
- Appraise the ability of existing water resource management institutions to coordinate and administer all aspects of groundwater management at all three levels of water resource management.
- Bring about a change in mindset. Attitudes towards groundwater, at all levels, must change fundamentally.
- Bring groundwater within the reach of those who do not have ready access to water – particularly resource poor farmers and the very poor that require sufficient water to achieve a reasonable standard of living.

- Grow investment in groundwater. Ensure that sufficient funds are allocated to the development and use of the groundwater resource at all levels; research, information, development and use.
- Improve knowledge of the resource, reliability of information and access to information. Improve information sharing between groundwater management and water services institutions.

7.2 Capacity building objectives of National Groundwater Strategy

The Framework document is expressing concern that South Africa is fast losing hydrogeological skills and management capacity, at the time when these are most needed.

Therefore, capacity building has been embedded in the above aims and objectives for a National Groundwater Strategy. More specific capacity building objectives, expressed in the Framework document, include:

- Attract and retain the required capacity (both in terms of experience and skills) within national and regional institutions.
- Facilitate national capacity building and training in groundwater, and encourage better integration of groundwater training with other programmes.

Capacity building for research is also important if there is to be an adequate knowledge base within the country. In a first part report towards the capacity building component of the National Groundwater Strategy, the authors stress the many benefits of partnerships and networks for capacity building, some which are operative already (DWAF, 2008):

- Enabling of staff to participate in teaching, research and other related activities in institutions in the SADC region, thereby enhancing interaction between staff and students in the region.
- The reduction in training cost through sharing of training resources.
- Enhancement of the capacity to address cross-border (transboundary) water issues.
- Increased chances of attracting funding through multi-institutional research and teaching activities.
- Achievement of synergies of capacity and expertise.
- Attainment of better leverage in addressing groundwater problems.

However, there are many identified constraints to networking. These include:

- Weak IT infrastructure in some SADC countries.
- Lack of adequate human capacity to roll out regional and Africa-wide initiatives.
- Lack of technical and administrative manpower to sustain these networks.

7.3 Capacity building in AMCOW groundwater vision

As further background direction, the AMCOW groundwater vision and proposed main thrusts are incorporated here (AMCOW, 2008). It is important to note that a large proportion of students

currently enrolled for higher degrees at South African universities are from Africa and is often involved with WRC research projects.

Need for Action

The challenge is immense and to turn around the present ineffective and unsustainable use of groundwater throughout Africa will require national, regional and international actions on a number of fronts. These are highlighted here in a vision and three major thrusts of action, all underpinning the African Water Vision.

Vision

"An Africa where groundwater resources are valued and utilized sustainably by empowered stakeholders."

Thrusts for Action

AWARENESS

This thrust must result in widespread awareness of key stakeholders at all levels about groundwater, its developmental role, it's hydrological and ecosystem function, its vulnerability to human impacts and approaches to its sustainable utilization.

CAPACITY

This thrust must result in appropriate capacity, including policy and legislation, appropriate institutions and human resources to plan and implement sustainable groundwater utilization at all levels.

KNOWLEDGE

This thrust must result in the knowledge base, including monitoring networks, resource assessment, best practices for management, information systems and fundamental sciences, all to enable the optimal utilization of groundwater within an Integrated Water Resources Management framework.

7.4 Directions from WRC workshop

A workshop of groundwater researchers and stakeholders was held in March 2009 to provide input for a vision and way forward for future groundwater resources management capacity building through the WRC together with other strategic partners. Critical aspects from the various presentations and from the follow-on discussions were captured as Strengths, Weaknesses, Opportunities and Threats relating to the capacity building process (SWOT) (summary in Appendix 7) as well as strategy elements relating to groundwater capacity building in South Africa (see **table 6**).

Table 6: Strategy elements relating to groundwater capacity building in South Africa	
Capacity Building Framework	**Strategy Elements**
Input	**Planning** A proper capacity gap analysis is urgently required. This should be linked to the institutional analysis done as part of the Groundwater Strategy development; Capacity building initiatives exist in different sectors – there is a need to identify and link to them; Even highly developed countries experience groundwater capacity gaps at present, e.g. USA – we need to learn from their experience; Link the groundwater capacity building strategy to the WRC cross-cutting assessment presently undertaken; DWAF groundwater strategy development and master planning in regions should be strongly endorsed as main pull factor for capacity building; The outcome of the GW capacity strategy should become part of the Groundwater strategy (e.g. is the case in Australia) and at a higher level to the Water for Growth and Development Strategy; Upfront criteria will have to be set to achieve significant capacity building outcomes through WRC-funded research; A proposal writing workshop should be considered.
Input	**Pooling of resources** Capacity building should be seen as a social responsibility; There should be a much greater emphasis on the strategic leveraging of resources and harmonising complimentary relationships for support, in particular WRC/DWAF/NRF/Private Sector; There should be a lot more effort to achieve cooperative projects between stakeholders – Umbrella MOUs between them would ease the way; There should be some umbrella cooperation strategy between WRC and NRF which would make research cooperation in the water (groundwater) field more efficient; The private sector needs to play a much larger role in education & training, like is happening in the mining sector; The Groundwater Division should play a stronger role in mobilizing the groundwater sector as R&D supporter; The Public Sector should strategically plan for capacity building (incorporate into GW strategy and GW Master plans) and anchor it in MOUs or MOAs (see example of Minister and UFS signing agreement in the early years of groundwater at UFS); Capacity building and training is not the WRC main mandate and the other key players involved in this need to be identified and engaged in a common way forward; Universities are clearly a key player and need to take the lead to bring further resources on board, especially for historically disadvantage students; Key partners of leading centres in SA (e.g. UNESCO and VLIR for UWC) should be brought into the centre strategy development; this is particularly important as new institutions, e.g. water institute, are developed; Linkage to the DWAF Learning Academy, a Ministerial Flagship programme, will be crucial; Create synergy between groundwater capacity building and water supply and sanitation (see AMCOW recommendation).
Knowledge Creation	WRC- need more focus on peer review. (international review of research work) There needs to be a more concerted effort to publish research findings in leading international journals.

Human Resources Development	There should be a rethink on the role of universities and technikons to cater for different capacity gaps that various part of the water sector experience; Local government has a big need for technically qualified persons – SA has no common strategy to produce such persons for the market; A strategy is required for the development of technician level capacity; Professional registration should become an important element of a capacity building strategy to ensure capacity building in the employer environment.
Research Capacity Building	SA needs its own groundwater centre of excellence to undertake the required leadership and coordination outlined above; Both the main groundwater centres in South Africa are operating beyond the limits of their supervisory capacity already and preparing them for an increased responsibility should be part of the capacity building strategy; The campus test sites developed at IGS and UWC are key elements of developing a sustainable research and E&T capacity; Post-Docs are a way of complimenting limited research and supervisory capacity; Get further Best Practice ideas from the Canadian International Development Agency.
Knowledge Transfer	The WRC will have to address knowledge transfer even more strategically and systematically, including the already existing knowledge. (Toolboxes developed through WRC - who will take it forward? technologies for knowledge transfer & uptake - knowledge banks?); Awareness-building is becoming increasingly important, given the many new players participating in water service delivery and in devolved management of water resources. This should be a key focus of any research project and consultancy. There should be more publishing of research summaries in sector media rather than just those of the WRC (as was done with the propagation of artificial recharge in local government media); For communities the print media are not necessarily the right media; take training to headmen in villages; as first prize and next move, have community participatory projects.

7.5 International Best Practice

Besides the South African experience, the report has drawn on some international experience, in this case not comprehensive, but incidental information on good practices packed into the proposed capacity building framework under the relevant impact.

Impact Area	Best Practice	Country/Institution
Input	It is essential to bring national and stakeholders to work together in more effective collaborative ways, and to prepare a long-term vision for water, life and the environment, respectively(for this purpose UNDP helped develop the Global Water Partnership and the World Water Council)	UNDP
	The Australian Government is driving water reform through knowledge and capacity building and is contributing funds to support a range of activities to address specific areas identified for attention under the National Water Initiative	National Water Commission, Australia
	Having organisations and partners working together from the outset is vital to ensure activities occur in a way that supports all the partners	National Land & Water Resources Audit and ANZLIC – the Spatial Information Council, Australia
	Building networking and partnership development are two essential elements for delivering capacity building in IWRM;	

	Upfront planning is essential to replicate the acquired knowledge and implement actions targeted to different audiences; A critical mass of expertise is formed in active support for the water resources sector	Cap-Net
Knowledge Creation	Strong focus on awareness raising Advance the knowledge and capacity building requirement of the National Water Initiative	Cap-Net National Water Commission, Australia
Human Resources Development	Contribute to increased skills and capacity across the water sector which, over time, is expected to lead to improved water management and decision-making. The integrated management solution needs to be accompanied by a training strategy to build and sustain capacity Capacity-building linked to water sector strategy;	National Water Commission, Australia National Land & Water Resources Audit and ANZLIC - the Spatial Information Council, Australia UNDP
Research Capacity Building	The Netherlands has developed a unique and coherent knowledge infrastructure, comprising prominent government and private research centres, technological and educational institutes and several universities Networks have proven to be effective at promoting the understanding of integrated water resources management and play a key role in supporting the development of IWRM	The Netherlands Cap-Net
Knowledge Transfer	Build networks of people and technology to share information and improve its usefulness and accessibility Creation of a network for capacity builders which would not only allow the sharing of information and expertise but also become proactive in synthesizing experience and lessons learned, identify research areas and encourage virtual exchange of views Dutch research is internationally orientated and the institutes have built up considerable networks and experience in water-related issues at international level To increase their reach, the institutes have formed close connections with internationally oriented private sector companies.	National Land & Water Resources Audit and ANZLIC - the Spatial Information Council, Australia UNDP The Netherlands
Outcomes	Development of a consistent, coherent and integrated basis for decision-making in support of planning and management activities and business interests Provide the states and territories with a shared knowledge base on which to identify further means for achieving the objectives of the National Water Initiative Help create appropriate institutions with right capacity required at all levels for IWRM	National Land & Water Resources Audit and ANZLIC - the Spatial Information Council, Australia National Water Commission, Australia Cap-Net
Critical Success Factors	Designated Lead Agency for coordination, outputs and thus outcomes. Performance indicators measuring National and Administrative Effectiveness and Efficiency Finding adequate capacity building indicators is one the challenges which needs to be responded The (gradual) involvement of all stakeholders, from the central government to the communities, from the public and private sector alike, has come to be seen as the critical factor in a long-term sustained process to strengthen institutions, develop human resources and create a favourable policy and legal environment.	National Land & Water Resources Audit and ANZLIC - the Spatial Information Council, Australia National Water Commission, Australia Cap-Net UNDP

8. Recommendations for the WRC role in groundwater capacity building

8.1 Strategic recommendations

COOPERATION TOWARDS GROUNDWATER CAPACITY BUILDING OBJECTIVES

It is essential, from the outset, to bring national partners and stakeholders to work together in more effective collaborative ways, to ensure momentum towards the capacity building objectives and achieve benefits for all the partners. Upfront planning is essential to replicate the acquired knowledge and implement actions targeted to different audiences; Networking and partnerships are two essential elements in this regard; Capacity building initiatives exist in different sectors and there is now a need to identify and link to them; In particular, synergy needs to be created between groundwater capacity building and water supply and sanitation (Masibambane programme), most probably the largest groundwater infrastructure investment (AMCOW recommendation).

NATIONAL GROUNDWATER STRATEGY

A National Groundwater Strategy is presently under development to ensure groundwater its rightful status within integrated water resource management. The strategy also aims to increase the knowledge of groundwater along with the capacity to ensure sustainable management. The ongoing roll-out of this strategy across the whole water sector will not succeed without a lead agent (champion) specifically tasked for this purpose in DWAF. The WRC, as key player in groundwater resources capacity building, needs to actively promote and help develop this strategic approach and align its plans regularly with the above strategy.

NATIONAL CAPACITY BUILDING STRATEGY

South Africa's water reform needs to be driven by knowledge and capacity building. This needs to be addressed strategically, with the Department of Water Affairs taking the lead. A national capacity building strategy as key component of the National Water Resources Strategy is required. The WRC, as key player in water resources capacity building, needs to actively promote and help develop this strategic approach.

AWARENESS BUILDING

Effect still needs to given to the WRC's recent policy emphasis of greater end user focus. Awareness building should be strategically addressed on an ongoing basis and as a deliverable of every programme and project .This is particularly important in the case of groundwater, the least understood resource, and given the many new players participating in water service delivery and in devolved management of water resources.

EMPHASISING GOVERNMENT ROLE

The public sector should strategically plan for groundwater capacity building (incorporate into Groundwater strategy and Groundwater master plans) and anchor it in MOUs or MOAs (see example of agreement between Minister and Institute for Groundwater Studies in the 70s).

EMPHASISING ACADEMIC SECTOR ROLE

Universities are clearly a key player and need to take the lead to bring further resources on board, especially for historically disadvantaged students.

Key partners of leading centres in SA (e.g. UNESCO and VLIR for UWC) should be brought into the centre strategy development; this is particularly important as new institutions, e.g. water institutes, are developed.

There should be a rethink on the role of universities and technikons to cater for different capacity gaps that various part of the water sector experience.

EMPHASISING PRIVATE SECTOR ROLE

The private sector needs to play a much larger role in education & training, like is happening in the mining sector.

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

INTERNATIONAL COOPERATION

South African water research should become more Africa-orientated. The WRC should address this through its own networks and partnerships as well as by means of stated objectives and individual research project requirements.

LEVERAGING OF RESOURCES

There should be a much greater emphasis on the strategic leveraging of resources and harmonising complimentary relationships for support, in particular WRC/DWAF/NRF/Private Sector. The WRC should pro-actively work and cooperate towards creating a leading knowledge infrastructure in South Africa. There should be a lot more effort to achieve cooperative projects between stakeholders – Umbrella MOUs between them would ease the way; this particular niche for FET-Water needs to be urgently developed. There should be some umbrella cooperation strategy between WRC and NRF.

PRIORITIZING HUMAN RESOURCES DEVELOPMENT

The WRC should continue to prioritize human resources development in its research planning and individual project output requirements;
The WRC should promote other critical aspects of human resources development, which are not in its mandate, in particular staff retention strategies, career planning, professional registration and job readiness training.
The WRC should consider the real opportunities in dealing with the capacity gap in South Africa that lie in regional, continental and international initiatives.

KNOWLEDGE TRANSFER

The WRC will have to address knowledge transfer even more strategically and systematically, including the already existing knowledge. (e.g. toolboxes developed through WRC; technologies for knowledge transfer & uptake);
Networking across the sector will be at the heart of better sharing of information and improving its usefulness and accessibility.

RESEARCH CAPACITY DEVELOPMENT

SA needs its own groundwater centre of excellence to undertake the required leadership and coordination required for the strategic, but long neglected resource; It should be a centre pulling together the main groundwater research and education capacity in the country;

Both the main groundwater centres in South Africa are operating beyond the limits of their supervisory capacity already, and preparing them for an increased responsibility should be part of the capacity building strategy;

Helping to create a groundwater industry-supported chair or centre could be an appropriate approach.

UTILIZATION OF SYNERGIES

Working in concert with other significant national, regional and international initiatives could greatly add to the impact and continuity of the WRC groundwater thrust.

Nationally

Strategic attention to water resources with strong groundwater focus in the Water for Growth and Development Framework and National Groundwater Strategy;

Renewed interest in water sector capacity building in DWAF (Vision 2025, Human Resources Development Strategy, Municipal Skills Indaba, Learning Academy), in Rand Water (Graduate School), in WISA (possible coordination role).

Regionally

AMCOW Africa Groundwater Initiative and the creation of the Africa Groundwater Commission to direct the initiative; SADC and its International Development Partners taking the lead with the above initiative as part of its Regional Strategic Action Plan, with its newly established SADC Groundwater Management Institute as lead agent;

Various water networking activities and the recent establishment of the African Groundwater Network (AGW-NET);

Focus on groundwater as part of transboundary basin management, supported by AMCOW, ANBO, UNESCO ISARM;

Establishment of NEPAD Centres of Excellence, with water one of the flagship programmes.

Internationally

UNESCO's International Hydrology Programme (IHP) with its particular focus on Africa in its IHP VII and a new interagency programme of 'Groundwater and Human Security';

There is strong interest internationally in Africa and southern Africa groundwater (International Association of Hydrogeologists, World Bank – GW_MATE, Europe – BGR, BGS, BRGM)

8.2 Recommendations for practical joint action

Actions	DWA	WRC	Academic institutions	Private/NGO Sector
Visioning	Ensure that the National Groundwater Strategy (NGS) becomes a sector vision; Continue to push for a Water Sector Capacity-building Strategy.	Become a leading partner in the NGS initiative; Align the WRC groundwater R&D and capacity-building strategy to the NGS; Continue to push for a Water Sector Capacity-building Strategy.	Actively contribute to and take ownership of vision and strategy; Debate strategy issues in respective institutions and host strategy workshops.	Help build and support a strong Groundwater Division as leader and voice to reinvigorate the groundwater sector; Actively contribute to and take ownership of vision and strategy; Support initiatives to open up and raise the strategy debate.
Planning	Pro-actively, and jointly with the other players, plan for the required groundwater capacity inside and outside government.	Plan together with DWA; Support the academic institutions in their assessment of needs and in positioning themselves to address these; Plan with DST/NRF for support for the water sector as a whole (research priorities, institutional development, i.e. Chairs) to open the door to individual applications; FET-Water funds should be used to develop common research and capacity building strategies, based on which bidding partnerships could be planned.	Strategize together to make water and groundwater for development a high priority on individual and groups of campuses; Develop various national and international partnerships to strengthen individual efforts. Use WRC and other projects to leverage university support, in particular posts for greater continuity; Address niche areas and achieve inter-disciplinary and development focus.	Plan for financial and in-kind contributions to capacity-building in own and in the national interest; Open up own projects as opportunities for capacity building for other players.

Awareness Building	As part of the NGS there should be a planned approach to groundwater awareness building. This should be pursued jointly with the partners.	Awareness building should be a deliverable of every programme and project and should be pro-actively supported and led by the WRC; Systematic focus on parliamentary decision-makers (national, provincial and local).	Academic institutions and individual specialists should do a lot more to showcase and promote groundwater and development on campus and externally, in particular through various media.	The private sector and individual specialists should do a lot more to showcase and promote groundwater and development in their sphere of influence and externally, in particular through various media; Achieve much stronger groundwater advocacy role through NGOs.
Research & Development	Help identify critical needs – programmes rather then just projects; Partner in research projects of the WRC and others, wherever appropriate; Make this participation an opportunity for practical experience for DWA learners.	A more programmatic approach to R&D should be attempted to allow partnership- and institution-building as well as planned capacity development; Do knowledge transfer through partners, e.g. SALGA, WISA, regional networks; Plan for skills transfer from R&D projects (together with DWA) and not just knowledge transfer.	Make academic excellence a priority, e.g. through publishing in refereed publications and obtaining a NRF rating; Be more strategic in research proposals to achieve national development and institutional objectives.	The private sector should always try to have partnerships with academic institutions for both WRC and other contracts.
Education & Training	DWA bursaries should largely go to the groundwater academic institutions for the selection of the most appropriate candidates; Groundwater should become a priority in the DWA Learning Academy programme.	The WRC should set capacity-building, and specifically E&T targets, in their research planning and in individual contracts; Help water science education by systematic introduction of water science themes into school curricula.	Academic institutions should provide the highest standard groundwater E&T and through this attract many Africa and even international candidates; This should be done by networking the best training teams together, facilitated by FET-Water.	Provide individual bursaries and learnerships as well as industry-coordinated ones via the Groundwater Division; Work together on an endowment for a South African Groundwater Chair.

Ongoing Learning	Strongly encourage on-going learning.	Convert project/programme outcomes into short courses as part of knowledge transfer.	Put special emphasis on client-focused short courses; Target Africa rather than just South Africa.	Strongly encourage on-going learning in your constituency.
Staff Retention	Develop and maintain a strong drive towards groundwater career development in DWA in support of own (HO + Regions; local government and CMAs); Introduce professional scientist registration in the Department.	Initiate a WRC study on career development and staff retention in the groundwater and related fields.	Academic institutions should provide visible support for its specialist centres and individuals; Various measures should be systematically developed and promoted to make an academic career attractive; Staff exchange agreements should be achieved with government and private sector.	Good science should be strongly promoted in the private sector.
Institutional Development	DWA could play a major role in academic institution building through MOUs with national as well as more local institutions; This would provide continuity in groundwater science inputs into DWA policy development and water resources studies.	Take the lead towards agreements with DWA and larger groundwater academic institutions to make South African groundwater COEs viable.	Create partnerships (e.g. with Technology institutions, major national and regional development programmes; international partners, UN Agencies, IHE); Create visible centres through appropriate facilities, activities, partners and promotion.	Have industry-university partnerships to have top groundwater expertise available to a company and to help create continuity in funding of academic positions.

9. Conclusions and Recommendations

Capacity building is a key component of the WRCs mandate. This report represents an assessment of the impact its investment in groundwater research has created on capacity in the water sector.

WRC investment into groundwater research in South Africa has been strategic and ongoing for 35 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; Through the academic institutions that have developed and that had the benefit of this research investment, a significant human resources development impact has also been achieved nationally, in the southern African region and on the continent as a whole.

Already the importance of groundwater has grown significantly in legal status under the National Water Act, 1998 and in practice through its role in the massive community water supply and sanitation programme. Its role is expected to become strategic in the Water for Growth and Development framework now conceptualized by the water sector in response to the development challenges of the country. While growing in strategic importance, groundwater has, for a variety of reasons, experienced a serious decline in capacity for its sustainable utilization and management, particularly in the government sector (national and local) as well as in the academic sector.

Considerable weaknesses are apparent in the capacity building process in South Africa, these appear to be amenable to positive change if there was a much greater and strategic cooperation in the water sector.

A number of strategic recommendations have been made, based on South African experience and international best practice, for collaborative ways of working to achieve national capacity building objectives for groundwater resources management. In order to help create some momentum, a series of action recommendations have also been made, illustrating practical collaboration between the DWA, the WRC, academic institutions and the private/NGO sector.

Given this situation, it is imperative that the WRCs investment into groundwater research and capacity building is continuing and is made even more effective and efficient than it has been to date. Opportunities to move in this direction present itself at this point in time with all the major players, both nationally and on the continent.

> Given its mandate, resources and excellent track record, the WRC should play a critical facilitation role to bring the key players with their respective roles and resources together for the common objective of growing the capacity for the sustainable utilization of groundwater resources in South Africa and beyond. This should include improving ways to measure capacity, setting objectives in this regard, monitoring progress towards its achievement and sharing the results widely in the sector.

10. References

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Appendix 1: WRC Groundwater research funding (1975 2008)[1]

Year	Total Research Allocation (R x 10^3)	Allocation to Groundwater research (R x 10^3)	Allocation to Groundwater research as percentage of total WRC research expenditure (%)
1972		-	-
1973		-	-
1974		-	-
1975		252	16.0
1976		458	14.0
1977		448	15.5
1978		586	18.5
1979		345	13.0
1980		238	9.0
1981		202	6.0
1982		96	2.0
1983		102	2.0
1984		456	7.0
1985		610	8.3
1986		805	8.2
1987			9.4
1988			9.8
1989			9.3
1990			11.7
1991			9.6
1992			9.8
1993			8.5
1994			7.5
1995		2312	6.1
1996		3866	9.8
1997		3079	7.6
1998		3062	6.9
1999	48 260	4370	8.2
2000	62 069	4971	8.0
2001	59 065	4552	7.7
2002	62 400	4900	7.8
2003	70 000	9400	12.2
2004	72 700	6500	8.9
2005	88 300	7000	7.9
2006	85 500	5200	6.1
2007	99 200	6100	6.1
2008	92 800	7400	7.9

[1] Data was compiled from various WRC sources

Appendix 2(a): Project and researcher list (1975 -2008)

Thrusts[1]	Contractor	Title	Start Date
2	CSIR	Artificial recharge –Cape Flats	1974
1	CSIR	Development potential of Doornberg fault zone	1975
1	UWits	Environmental isotopes in Gamagara catchment	1975
1	UFS	Development potential in S Freestate and NW Cape	1975
1	UFS	Groundwater models for 3 different areas	1981
1	UFS	Development of national databank	1983
2	SRK	Groundwater recharge	1983
1	UFS	Exploitation Potential of Karoo aquifers	1985
1, 3	UFS	Modelling gw quality Atlantis aquifer	1985
1	CSIR	Geo-electrical methods	1987
1	UP	Electromagnetic techniques	1987
1, 3	UFS	Management of contamination in OFS goldfields	1988
1	CSIR	Zululand coastal aquifer	1988
1	CSIR	Geophys. techniques for characterizing gw pollution	1989
1	UFS	Oscillation method for aquifer transmissivity	1989
1	CSIR	Pesticide surveys in intensive agricultural areas	1989
1	SRK	Remote sensing for fracture zone identification	1989
1	CSIR	Guideline for gw sampling	1990
1	SRK	Integration of RS, GIS for gw resource estimation	1990
1, 3	UFS	Groundwater quality deteriorationin Olifants river u/s of Loskop Dam	1990
1, 3	UWits & AEC	Geoh. and isotope hydrology techniques for waste site waste site evaluation	1990
1	UFS	GIS and computer-aided drafting for geohydrological map production	1991
1; 3	CSIR	Health impacts relating to domestic and industrial waste disposal	1991
3	CSIR	Methodology for landfill site selection	1991
1; 3	CSIR	Nitrate content of groundwater & its limitation	1991
1, 3	UFS	Techniques for risk analysis and management of SA aquifers	1991
1	CSIR	Geochemistry & isotopes for resource evaluation in fractured rock (TMG)	1992
1	AEC	Identification of polluted areas in PWV dolomitic aquifer	1992
1	AEC	Integrated hydrodynamic/geophysical approach to coastline groundwater exploration	1992
1; 3	CSIR	Site suitability for waste disposal based on geohydrological criteria	1992
1	CSIR	Strategy to monitor groundwater quality at national scale	1992
1	UFS	Analysis of aquifer tests in secondary aquifers	1992
3	UFS	Catchment water quality impact as a result of water level recovery in abandoned mines	1992
1	Vegter	Compilation of a hydrogeological map of SA	1992
1, 3	CSIR	Determination of leachate generation at waste disposal sites	1993
	UWits	Recharge assessment of Karoo aquifers in the Kalahari using various methods	1993
	D:Gh of DWAF and CGS	Regional characterization and mapping of Karoo fractured rock aquifer systems (GIS and digital image processing systems)	1993
1	UWits	Response of multi-layered aquifers to abstraction (hydrogeol., hydrochemical and isotope)	1993
1, 3	CSIR	Contaminant attenuation capacity of vadose zone	1993
2	SRK	Groundwater abstraction in PE area	1993
1	UFS	Conversion of software packages to UNIX operating system	1993
	Vegter	Monograph on SAs groundwater resources	1994
1	UFS	Windows-based system for hydrogeologists (WISH)	1995

Thrusts[1]	Contractor	Title	Start Date
	UWC	Groundwater supply assessment and strategy for the Western Karoo, Namaqualand and Bushmanland	1995
	UZ	Geohydrological modelling of the Richardsbay area	1995
1	AECI Ltd	An integrated multidisciplinary geodynamic/geophysical approach to groundwater exploration around the South African coastline	1995
	SRK	Modelling of groundwater flow in TMS in the Little Karoo region	1995
1	UP	Geotechnical and hydrogeological properties in vadose zone	1995
	Hydromedia Solutions& DWAF	Assessment of ambient groundwater quality on a national scale	1996
1, 2	UFS	Tracer experiments in secondary aquifers in support of rural water supply	1996
1; 3	CSIR	CFCs and groundwater dating in fractured rock	1996
1	WSM	Cost-effective development of groundwater in problematic terrain	1996
2	CSIR	Artificial recharge for community water supply	1997
1; 2	CSIR	GIS for determination of sustainable exploitability of SA aquifers	1997
1; 3	CSIR	Impact of agricultural practices on groundwater quality	1997
1	Various	Synthesis of TMG hydrogeology	1997
1	CSIR	The reliability of small spring water supply systems for community water supply projects, and the enhancement of flows from springs	1997
1	UWC	A groundwater supply assessment and strategy for the Western Karoo, Namaqualand and Bushmanland	1997
1	UFS	Amalgamation of WISH and MuniBase into a user-friendly software package	1998
1	CSIR	Evaluation of nuclear magnetic resonance (NMR) for groundwater exploration in fractured rock	1998
	CGS	Groundwater development in complex and problematic terrain	1998
	CGS	Influence of dolorite ring structures on occurrence of groundwater	1998
2	CSIR	Pilot artificial recharge scheme	1998
1	UFS	Flow and transport characteristics in fractured rock	1998
1	UFS	Flow and transport characteristics of groundwater in Karoo formations	1998
	UFS	Development of a Windows-based 3D visualization programme	1999
1	CSIR	Evaluation of groundwater resources in fractured-rock aquifers at a catchment scale using evidence of mixing of groundwater from CFC and isotope data	1999
1; 3	CSIR	Nitrate and associated groundwater hazard quantification and strategies for protecting rural water supplies	1999
1	UWC	Fluoride in drinking water and its effects on human health and nutrition	1999
1	UFS	Decision tool establishing a strategy for protecting groundwater	1999
1	UWC	Groundwater recharge to basement aquifers	1999
3	CSIR	Classification of groundwater-dependant ecosystems	1999
1	CSIR	Groundwater mixing assessment through CFCs and isotopes	1999
2; 3	CSIR	Groundwater reserve: delineation, reference conditions and classification.	1999
1; 3	CSIR	Protocols for assessing groundwater pollution impacts	1999
	Toens & Partners	Handbook on the hydrogeology of the Karoo Supergroup	1999
	UFS	Enhancement of the WISH software package	1999
2	UFS	Modelling decision-support system for groundwater reserve	1999
	UCT	Distribution of fluoride-rich groundwater in Bophuthatswana.	2000
	UFS	Guidelines for aquifer parameter estimation with computer models	2000
	UFS	Manual on pumping test analysis in fractured-rock aquifers	2000
1	Metago Environmental Eng	The assessment of short, medium and long term impacts on groundwater quality associated with the filling of dolomite cavities	2000
2	Technikon SA	Impact of groundwater abstraction on ecosystems in the Kammanassie nature reserve and environs	2000

Thrusts[1]	Contractor	Title	Start Date
1	UWC	Sustainable groundwater management & utilisation in Northern Cape	2000
1	UZ	Development of a coupled surface groundwater interactive modelling system	2000
1	GEOSS	The application of internet-based interactive mapping technologies for geohydrological research purposes	2001
1	DWAF	A strategy for future investigations of deep groundwater systems in South Africa	2001
1	CGS	Mapping of naturally occurring hazardous trace constituents in groundwater	2001
1	CGS	The assessment of current and future water pollution risks due to gold mining in dolomitic areas	2001
1	CSIR	Extension of the South African national microbial water quality monitoring programme to include groundwater	2001
1	CSIR	Guidelines to set resource quality objectives for groundwater	2001
1	CSIR	The determination of recharge and contribution of groundwater to baseflow (Phase 1)	2001
3	Pulles, Howard & de Lange	Evaluation and validation of geochemical production techniques for underground coal mines in the Witbank highveld region	2001
3	UFS	An investigation of water decant from underground colliers in Mpumalanga and Free State, with special emphasis on predictive tools and long-term water quality management	2001
3	UFS	The quantitive evaluation of the modal distribution of minerals in coal deposits in the highveld area and the associated impact on the generation of acid and neutral mine drainage	2001
1	Umvoto Africa (Pty) Ltd.	Deep artesian groundwater exploration	2001
1	Univ Venda	Groundwater in the Olifants River basin: Assessing viable alternatives for small-scale irrigation	2001
	CSIR	Determination of recharge and contribution of groundwater to baseflow (phase I)	2001
1	CSIR	Analysis of groundwater level time series and the relation to long-term climatic conditions, climate change and recharge	2002
1	CSIR	Feasibility study on the use of chemical geothermometers for tracing deep groundwater flow	2002
1	SRK	Identification & prioritisation of type areas for detailed research in terms of regional variability of aquifer systems	2002
1	Umvoto Africa (Pty) Ltd.	Geothermal studies of TMG aquifer systems	2002
3	Wates, Meiring & Barnard	Investigation into the depth and rate of weathering on gold tailings dam surfaces as key information for long-term AMD risk assessments	2002
1	CGS	Hydrogeology of fractured aquifers and related ecosystems with dolerite ring and sill systems in the Eastern Cape	2002
1	UWits	A multitracer study of the origins, systematics & hydrological linkages of high nitrate concentrations in Bochum District, Northern Province	2002
1	CSIR	Ecological and environmental impacts of large -scale groundwater development in TMG aquifer systems	2002
1	UWC	Recharge mechanisms in TMG aquifer systems	2002
3	Wates, Meiring & Barnard	An empirical assessment of post-closure flushing effects on Gold Mine decant water quality in the West Rand Dolomitic region	2002
2	CSIR	Groundwater-dependent ecosystems	2002
1	CGS	A synthesis of the hydrogeology of basement aquifers in Southern Africa: Research needs and priorities*	2003
1	CGS	To calibrate and verify a predictive model for the occurrence of naturally occurring hazardous trace constituents in groundwater*	2003
1	Parsons and Associates	Pilot study: Setting resource-directed measures for groundwater*	2003
3	Pulles, Howard & de Lange	Development of water balances for operational and post-closure situations for gold-mine residue deposits to be used as input to pollution prediction studies for such facilities	2003
1	CSIR	Improved methods for aquifer vulnerability assessments and protocols for producing vulnerability maps, taking into account soils information*	2003

Thrusts[1]	Contractor	Title	Start Date
1	UWC	Flow conceptualisation and storage determination in TMG aquifer systems*	2003
3	UFS	Investigation into the long-term impact of inter-mine flow in the Mpumalanga Collieries	1998
1	UFS	Quantification of the impact of irrigation on the groundwater resource underlying the Vaalharts irrigation area	2002
1	UFS	Groundwater protection in urban catchments (a) identification (b) guidelines (c) determining standards of pollution in Southern Africa	2002
1	IUCN	Institutional arrangements for groundwater management in dolomitic terrains: Phase 2	2002
1	CSIR	Microbial groundwater monitoring protocols refinement	2004
1	Parsons and Associates	Quantification of the groundwater contribution of baseflow	2004
1	UFS	Mine-water irrigation return flow	2004
1	Parsons and Associates	Approval and licensing of groundwater development and use	2004
3	Pulles, Howard & de Lange	Study of the kinetic development of oxidation zones of tailings dams with specific reference to the Witwatersrand gold mine tailings dams	2004
1	UFS	Field investigations to study the fate and transport of dense-aqueous liquids (DNAPLs) in groundwater	2004
1	Maluti Water	Protocols assessing the sustainability of springs	2004
1	SRK	Water Resources of South Africa, 2005 study (WR2005	2004
3	Golder Associates Africa (Pty) Ltd	Prediction of how different management options will affect drainage water quality and quantity in the Mpumalanga coal mines up to 2040	2005
1	SRK	Flow conceptualization, recharge and storativity determination in Karoo aquifers	2005
2	North-West University, Zoology Department	Framework development for the sampling, classification and geographical occurrence of stygobiont amphipods in South Africa	2005
1	CSIR	Nitrogen dynamics in catchment landscapes cleared of alien vegetation and impacts on water quality (NS)	2006
2	UCT - Geology Dept	Biochemical processes in a groundwater fed inter-tidal Ecosystem	2006
3	University of Fort Hare/Department of Geology	Origin of sodium and its applications to water quality prediction in the South African coal mine environment.	2006
1	CGS	Remote sensing as a tool to determine the legal compliance of surface and groundwater users in a catchments (NS)	2006
1	CSIR	The use of 222Rn as a hydrological tracer in natural and polluted environment (NS)	2006
1	UWC	Sampling and monitoring protocol for radioactive elements	2006
1	UP	Basement aquifers in support of rural communities in Limpopo, North-West and Mpumalanga Provinces (with special emphasis on transboundary aquifer systems) (S)	2006
1	Groundwater Africa	The identification and delineation of high-yielding well-field areas in Karoo aquifers as future water supply options to local authorities.(s)	2007
1	UFS	Field investigations to study the fate and transport of light non-aqueous phase liquids (LNAPLs) in groundwater (S)	2007
1	UFS	Measurement of the bulk flow and transport characteristics of selected fractured rock aquifer systems in South Africa (S)	2007
1	CSIR	Nitrate removal for groundwater supply to rural communities (NS)	2008
1	CSIR	Optimised monitoring of groundwater - surface water - atmospheric parameters for enhanced decision making at a local scale (S)	2008
1	Umvoto Africa (Pty) Ltd.	Development and Application of Global Navigational Satellite Systems (GNSS) Methodology for Groundwater Resource Assessment (NS)	2008
1	UFS	Contribution of groundwater to salt load of Breede River	???
1	UFS	Technological transfer of all information necessary for the use, management and protection of Karoo aquifers	

Appendix 2(b): Consultancy Projects (1990 -2008)

Contractor	TITLE	Start Date
Mnr JR Vegter	Samestelling van 'n monografie oor Suid-Afrika se grondwaterbronne	1990
Prof J Bear	Ground-water contaminant transport phenomena in porous media	1990
Prof FDI Hodgson	An assessment of the contribution of mining and power generation to ground-water contamination	1990
Dr FW Struckmeier	Die ontwikkeling van 'n hidro-geologiese Karteringstrategie	1991
Dr C Frick, Geologiese opname	Opstel van 'n landswye hidro-geologiese kaart van Suid-Afrika met verklarende notas	1992
Dr WK Boehmer	Beplanning van 'n program oor sekondêre akwifere	1992
WNNR & Dept van Waterwese en Bosbou	Isotopic and chemical signatures of water in the Transvaal dolomite springs	1992
WNNR & Dept van Waterwese en Bosbou	Development of a methodology and protocol for hydrochemical characterization of South African aquifers	1993
Mr G Jacobson	Hydrogeological mapping	1993
Geological Society of South Africa	Production of a text book on South African Hydrogeology	1993
Dept of Water Affairs and Forestry	Provision of Cartographic expertise for the hydrogeological mapping programme	1993
Dr DB Bredenkamp, Water Resources Evaluation and Management cc	Preparation of a manual and quantitative estimation of ground-water recharge and aquifer storativity	1993
DWT	The development of an aquifer classification system for South Africa	1994
Dept of Water Affairs and Forestry	Structural geological analysis of the Natal/ KwaZulu province for the purpose of aiding hydrogeological mapping	1995
Univ vd OVS	Further development of a three-dimensional saturated groundwater flow model for understanding the behavior of Karoo aquifers	1996
Institute for Groundwater Studies	Conversion of software program RPTSOLV from Dos to Windows	1996
Partners in Development cc	A study to investigate the contamination of shallow groundwater by pit toilets	1999
Council for Geoscience	Integrated multidisciplinary geodynamic/geophysical approach to groundwater exploration around the South African Coastline	1999
Tom Hatton	Determination of the groundwater component of the ecological reserve - interactions with CSIRO, Australia	2000
Council for Geoscience	A synthesis of the hydrogeology of the Table Mountain Group	2000
Parsons and Associates	A synthesis of the hydrogeology of the Table Mountain Group	2000
Umvoto Africa cc	A synthesis of the hydrogeology of the Table Mountain Group	2000
SRK	A synthesis of the hydrogeology of the Table Mountain Group	2000
Toens and Partners	A synthesis of the hydrogeology of the Table Mountain Group	2000
Environmentek: CSIR	A synthesis of the hydrogeology of the Table Mountain Group	2000
Groundwater Consulting Services	A synthesis of the hydrogeology of the Table Mountain Group	2000
Dept of Environmental Science - Univ of Cape Town	A synthesis of the hydrogeology of the Table Mountain Group	2000
IUCN	Institutional arrangements for groundwater management in dolomitic terrains	2001
JR Vegter	Hydrogeology of groundwater Region 7 Pietersburg Plateau	2002
Parsons and Associates	Technology Transfer: Handbook on surface water – Groundwater interaction in a Southern African context	2002
CSIR	Artificial recharge technology transfer	2002

Contractor	TITLE	Start Date
Geohydrological and Spatial Solutions	Developing a new approach to groundwater recharge and groundwater/surface water interaction in South Africa	2003
CSIR	Groundwater sampling manual – revision of the 1992 Guide and International Publication with IAN	2003
RAU (Dept of Zoology)	Method development for the sampling of stygobiont amphipods as part of a bio-assessment framework for boreholes in SA: Applied field technique	2003
Parsons & Associates Specialist Groundwater Consultants	Development of FET-Water Groundwater Resource Directed Measures Training Manual	2003
JR Vegter	Hydrogeology of groundwater region 26 Bushmanland	2004
University Free State	Integration of the groundwater decision tool (GDT) as part of integrated water resource planning	2004
Groudwater Africa	Developing a national approach to implementing artificial recharge as part of DWAF's planning strategy	2004
CSIR	Managing anthropogenic nitrogen input for protecting groundwater resources: (Technology transfer proposal see K5/1058 and K5/1325)	2005
CSIR	National monitoring of viruses in groundwater	2005
IUCN	Compilation of a synthesis document on the water resources and water-linked ecosystems of the Karst system of the cradle of humankind world heritage site	2005
?	Downhole geophysical logging of pilot boreholes, dageos project, Oudtshoorn	2005
University of Free State	Determination of S-Values in the Karoo aquifers through the use of resonant ultrasound spectroscopy	2005
Groundwater Africa	Development of a GIS-based approach for identifying high-yielding municipal groundwater and artificial recharge target areas	2005
Jasper Muller Associates	Review of groundwater protection research programme - (Letter of Agreement - done by KSA1 on 20.07.2005)	2005
Dr Hans E Beekman	Rapid assessment of the vulnerability of Southern Africa's water resources of selected river and groundwater basins to environmental change	2005
Water Geoscience Consulting	Transfer and sharing of knowledge from groundwater research undertaken in the central Namaqualand region to end-users and local authorities	2006
UP	Vulnerability mapping in Karst terrains, exemplified in the wider Cradle of Humankind World Heritage Site	2006
UP	Regional Description of the Groundwater Chemistry of The Kruger National Part	2007
UWC	African Groundwater Resources Management Scoping Study in the SADC Region: South Africa Component	2007
M Nel	Walking on water: A journey about groundwater in South Africa	2008
Water Geoscience Consulting	Improving access to African groundwater data held overseas	2008
The University of Fort Hare	Development of an excel-based borehole logging software	2008
E Braune	WRC's role in building capacity in the groundwater sector	2008

Appendix 3: Capacity building framework with indicators

Capacity Building Elements	Indicator
Input	Number of participating institutions Number researchers involved Number of graduate students involved Other resources leveraged Projects leveraged with national/regional development objectives up front Projects developed upfront towards maximizing benefits, particularly to the poorest of the poor
Knowledge Creation	Number of WRC project reports
Human Resources Development	Number of graduates (MSc, PhD) produced Special focus on technicians New focus on communities Number from previously disadvantaged population groups Judgement development (requires adequate periods of field observation, training and experience) Leadership development Stakeholder linkages and impacts Development of related E&T Training of trainers programmes Skills transfer rather than just knowledge transfer
Research Capacity Building	Existing strategy for institutional capacity building Creation of synergies (e.g. UNESCO IHP, NRF) Attracting high quality researchers Local (SA) networking Regional (Africa) networking International (discipline leaders) networking Leveraging of additional resources and Organisational development
Knowledge Transfer	Existing strategy for knowledge transfer Creation of synergies (e.g. link to DWAF programme) Effective knowledge management (depository, access, searchability, etc.) (own and/or central) Effective communication between disciplines/sectors Discipline cross-cutting impact Number of publications in each area Number of conference presentations Development of intellectual property (e.g. number of patents)[1] Involvement of media Impact on technical knowledge base and capacity of the previously disadvantaged population groups. Broadening the foundation to provide science and technology education at school level *[1]R&D undertaken is intended mainly to produce results for the public domain, but there is also a focus on R&D which has the potential of producing commerciable intellectual property and R&D in which specific industries have an interest and which therefore enjoys their partial support (e.g., the mining and energy sectors).*
Outcomes (Knowledge application)	Regulator / service provider awareness creation regarding wise use and management Public awareness creation regarding wise use and management Research team membership in water resource management programmes Development and improvement of monitoring and assessment programmes Regulatory capacity building as integral to the development of regulations themselves Enhanced ability to protect/conserve water ecosystems in the interests of sustainability Greater adequacy of water, of suitable quality, supplied and equitably distributed Adoption of methods/technologies developed for maximizing the use/benefits of water for various uses Number of SA technologies used globally Contribution to development of effective and functional new water management institutions; Instances of policy implementation based on R&D Legislation based on R&D

Appendix 4: Summary of responses to Questionnaire

(Responses on an average of 16 projects)

	Categories	No. of indicators			YES	NO		
Inputs	**Input**	**5**	Number of participating institutions	**44**				
			Number researchers involved	**95**				
			Number of graduate students involved	**41**				
			Other resources leveraged		6	9		
			Own indicator	5 comments	3	7		
Outcomes	**TOTAL RESPONSE PER CLASSIFICATION INDICATOR:**				**MAJOR**	**SIGNIFI-CANT**	**MINOR**	**NONE**
	Knowledge Creation	**2**	Number of WRC project reports	**5**	4	6	4	1
			Own indicator	10 comments	6	3	3	3
	Human Resources Development	**11**	Total number of graduates (MSc, PhD) produced	**16**	2	5	3	4
			Number from previously disadvantaged population groups	**9**	1	4	4	6
			Any special focus on technicians	**1**	2	1	6	6
			Any focus on communities	2 comments	1	5	5	4
			Development of public sector capacity	4 comments	0	8	6	1
			Development of private sector capacity	4 comments	3	4	7	1
			Development of leadership in water sector	4 comments	2	4	7	2
			Stakeholder linkages and impacts related to the project(s)	3 comments	4	4	4	3
			Development of E&T programme based on the research	4 comments	2	6	4	1
			Development of Training of trainers programme	1 comment	2	4	2	7
			Own indicator	0 comments	2	3	2	2
	Research Capacity Building	**9**	Did your institution have a strategy for institutional capacity building?	4 comments	2	6	3	3
			Creation of synergies (e.g. UNESCO IHP, NRF)	2 comments	3	1	4	6
			Attracting high quality researchers through the project(s)	5 comments	3	6	4	1
			Local (SA) networking	4 comments	2	8	3	1
			Regional (Africa) networking	2 comments	0	2	6	6
			International (discipline leaders) networking	4 comments	4	5	3	2
			Leveraging of additional resources	3 comments	1	4	4	5
			Organisational development (describe successes/difficulties)	6 comments	2	7	5	0
			Own indicator	0 comments	0	4	2	2

Impacts	Categories	No. of indicators	TOTAL RESPONSE PER CLASSIFICATION INDICATOR:		MAJOR	SIGNIFI -CANT	MINOR	NONE
	Knowledge Transfer	**11**	Number of publications in each area MOVED	**8**	1	7	5	1
			Number of conference presentations	**9**	0	7	6	1
			Did your institution have a strategy for knowledge transfer	3 comments	1	5	7	1
			Creation of synergies (e.g. link to DWAF programme)	4 comments	1	8	5	0
			Effective knowledge management (depository, access, searchability etc) (own and/or central)	4 comments	2	5	6	1
			Discipline cross-cutting impact	5 comments	2	6	5	1
			Development of intellectual property (e.g. number of patents)[1]	1 comment	1	1	2	10
			Involvement of media	2 comments	0	2	0	12
			Impact on technical knowledge base and capacity of the previously disadvantaged population groups.	3 comments	1	7	2	4
			Provision of science and technology education at school level	1 comment	0	0	3	11
			Own indicator	0 comments	0	3	3	2
	Impact (Manifested)	**11**	Regulator / service provider awareness creation regarding wise use and management	3 comments	2	8	3	1
			Public awareness creation regarding wise use and management	2 comments	0	5	6	3
			Development and improvement of regulator monitoring and assessment programmes	4 comments	2	4	7	0
			Enhanced ability to protect/conserve water resources in the interests of sustainability	3 comments	1	7	5	1
			Greater availability of water, of suitable quality, supplied and equitably distributed	3 comments	1	8	2	3
			Adoption of methods/technologies developed for maximizing the use/benefits of water for various uses	2 comments	0	5	5	3
			SA technologies used globally	3 comments	1	1	8	3
			Contribution to development of effective and functional new water management institutions	2 comments	2	1	2	8
			Instances of policy implementation based on R&D	2 comments	2	0	2	10
			Legislation based on R&D	1 comment	2	0	0	12
			Own indicator	0 comments	0	2	4	1

Appendix 5: Evolution of strong groundwater centres in SA

UNESCO CHAIR IN GEOHYDROLOGY, UNIVERSITY OF THE WESTERN CAPE

Growth of institution

1995: Mr R Titus, Department of Earth Science, started with the first WRC project entitled "Groundwater supply assessment and strategy for the Western Karoo, Namaqualand and Bushmanland" with the CSIR **1998:** The UNESCO Chair in Geohydrology was established, with Prof. Y. Xu as Chair Holder.

2000-2009: Two further WRC projects followed in Namaqualand after which a new series of WRC projects started in the TMG aquifer system, linked to the TMG groundwater exploration by the Cape Metro.

2007: The WRC funded a groundwater resources management scoping study in the SADC region, which the UNESCO Chair had solicited through their UN Africa network involvement with AMCOW.

2008: A Water Institute is established on the UWC campus through initiative of the UNESCO Chair; In a SADC-wide bid for a SADC groundwater centre of excellence, UWC was short listed and achieved second place behind IGS.

Present capacity to do groundwater R&D and E&T

STAFF:

Number of permanent - academic:	2
other:	1
Number of temporary - academic	1
other:	1

FUNDING:

(different sources-as percentages of total):

WRC	30%
NRF	5%
Short courses	5%
MOUs	5%
Consultancies	25%
University	30%

Outputs

CONTRIBUTIONS TO GROUNDWATER SCIENCE:

Number of refereed publications:	24 papers and 2 edited books
Other significant impacts on capacity in country:	5 short courses annually

STUDENTS:

Total number of students graduated (approximate):	
Total number of students graduated	**240**
Number of students graduated through WRC projects:	20
Total number of Masters - graduated:	15
presently studying:	12
Total number of PhDs - graduated:	05
presently studying	10

Ways to boost R&D/E&T capacity (own assessment)

The major success factors to date have been the ongoing research funding and the establishment of the UNESCO Chair on groundwater at UWC. A chair, however, needs support, ideally from several partners, to maintain it, and if this is not happening, the situation can rapidly deteriorate.

To ensure good quality students to be enrolled, funding is needed to support research and equipment.

To ensure collaboration with partners like IGS, a fund for joint research (IGS and UWC) would be a good start, as such a fund would bring researchers from different institutes together.

INSTITUTE FOR GROUNDWATER STUDIES, UNIVERSITY OF THE ORANGE FREE STATE

Growth of institution

1973: The first negotiations concerning the IGS occurred in 1973. The negotiations were between the University of the Free State and the Minister of Water Affairs and Forestry (Mr Fanie Botha). The Minister realized the importance of groundwater and the need for groundwater capacity. The Minister was at the same time busy with the development of the Water Research Commission and requested that the two bodies be initiated at the same time. He wanted the IGS to train potential researchers which could contribute to the working of the WRC.

1974: The final agreement between the UFS and government was approved on 24 November 1974.

1987: Initially the IGS formed a sub-department under the Geology Department, however in 1987, the IGS started to function independently of Geology. The IGS has two main focuses namely: academics and research.

1990-: The IGS started to slowly grow in the early 1990s. A sponsorship from the Carl Duisberg Gesellschaft (CDG) from 1995 to 2000 allowed more than 70 students from various African countries to study at the IGS. The economic boom in the early 2000's (especially in the mining sector) led to a demand for geohydrologists. In the last 3 years the student numbers have been doubling every year. Currently there are 98 post graduate students registered at the IGS.

Present capacity to do groundwater R&D and E&T

STAFF:

Number of permanent -	
academic:	1
other: (laboratory lady)	1
admin. support staff:	3
Number of temporary -	
academic:	9
other: (laboratory ladies)	3
A number of PhD/MSc students that help with field work and teaching	

FUNDING:

(different sources-as percentages of total):

WRC	7.3%
NRF	0.2%
Short courses	2.9%
MOUs	1.2%
Consultancies	60.4%
University	8.1%
Water analyses	18.9%
Software sales	0.9%

Outputs

CONTRIBUTIONS TO GROUNDWATER SCIENCE:

Number of refereed publications:	250 (incl. conf.)
Other significant impacts on capacity in country:	1. IGS produces most of SA's geohydrologists 2. Many of our past students run consultancy firms (e.g. ERM, AGES, SRK, etc.) 3. Many of our past students are assistant directors, directors and chief directors in government 4. At least a quarter of our students are working internationally – which is good exposure for our country

STUDENTS:

Total number of students graduated (approx.):	
Total number of students graduated	550
Number of students graduated through WRC projects: (incl. current students still busy)	65
Total number of Masters -	
graduated:	100
presently studying:	34
Total number of PhDs -	
graduated:	28
presently studying	11

Ways to boost R&D/E&T capacity (own assessment)

1. More equipment (e.g. for geophysics and other field equipment)
2. More on-site training in the field
3. Additional staff to assist with the academic load
4. Improving the awareness of groundwater at schools
5. More interaction and support between universities and other tertiary bodies involved in groundwater
6. DWAE and municipalities need to recognize the importance of groundwater
7. More international exposure and collaboration.

Appendix 6: Fractured Rock Hydrogeology in South Africa:

CAPACITY DEVELOPMENT CASE STUDY

INPUTS	
Projects	57
Funds	R 38 Million
Period of investment	1975-2009
Participating institutions	4 universities, 1 technikon, 3 science councils, 6 consultants
OUTCOMES	
Knowledge creation	Systematic research of the main aquifer provinces of South Africa has led to the production of Synthesis books (Handbooks) for the Table Mountain Group and Karoo aquifers, and one for the Basement rock aquifers is under production. Improved understanding of structural geology in support of sustainable development of groundwater resource, e.g. dolerite ring structures, which are prominent features of the Karoo landscape, are becoming potentially fruitful drilling targets for groundwater exploitation. New technologies for fractured rock assessment developed, e.g.: • Modelling software (Aquamod); • Pumping test interpretation (FC method); • Hydraulic conductivity assessment (Tensor approach). This technology is applied in other parts of Africa.
Human resources development	All graduates at both IGS and UWC will have either worked on fractured rock hydrogeology topics or will have benefited from the pool of knowledge available at these centers.
Knowledge transfer	A book on integrated assessment of groundwater recharge in Africa has been published (with significant impact in Africa); Many short courses have been offered with participants from the whole continent; Publication in reputable international journals has been very limited. South Africa can therefore not yet be seen as a world leader in this field.
Manifested impact on management	The Cape Metro introduced the TMG groundwater into their water plans and initiated an exploratory deep drilling programme worth R30 million to assess the feasibility of its exploitation and potential environmental impacts of such use. The understanding gained of fracture rock hydrogeology has directly led to appropriate management approaches for artificial recharge, solid waste disposal and source protection zoning.

Appendix 7: SWOT analysis relating to the groundwater capacity building process

STRENGHTS	WEAKNESSESS
○ The WRC has supported groundwater capacity building on an ongoing basis for over 35 years ○ FET-Water as a separate source of E&T funding and networking support, but needs an outward look ○ South Africa has a strong groundwater private sector. They produce good research proposals, but have no capacity building responsibility ○ There is is strong support for E&T from some sectors like mining, but not from the water sector ○ Existing university research sites present a major asset for E&T and capacity development ○ There is a major demand for short courses in South Africa and the African continent. This is an opportunity for low cost training for students ○ Use of post-docs (in performing departments) ○ New focus on practical experiential learning in the Council for Geoscience	○ Capacity very thinly spread in academic institutions (Universities usually only have a small staff contingent and can be seriously impacted by the loss of even one key staff member) ○ The academic sector bleeding most of all in terms of loss of capacitated staff to other opportunities ○ Universities do not take ownership for research institutional capacity development ○ Universities do not make provision for additional staff to support R&D and E&T – the key groundwater centres in SA have reached there limit in terms of supervisory capacity ○ The private sector only provides ad hoc support for E&T, mainly in self interest (no plan for industry-one year funding) ○ It is particularly difficult to fund undergraduate students as they do not yet produce any outputs ○ It is difficult to keep control over students who have been part of a project team because there is nothing to entice them to stay once a project has been concluded ○ The quality of students entering earth science studies from the school system is a serious problem ○ Registration of professional scientists is seriously lagging. There is no match between the high registration requirements and the poor hard science standard of available graduates ○ There is little attention to career pathing ○ The academic system does not produce graduates ready for industry ○ South Africa is missing government institutions to provide the required hands-on experience to graduates ○ The DWAF internship programme for groundwater is non-existent (some regions make a big effort; the remaining focus is mainly on engineers) ○ . To apply for NRF support is usually to time consuming for individual researchers ○ Research has been too narrowly groundwater focused, not allowing direct application by decision-makers ○ Not enough attention and innovation has been put to technology and knowledge transfer ○ Identifications of capacity gaps has been inadequate

OPPORTUNITIES	THREATS
○ The new Water for Growth and Development Strategy of DWAF has a much greater need for all the water resources of the country to be able to meet national development objectives. ○ Development of a National Groundwater Strategy is underway. ○ Groundwater can be integrated into the national water resources policy framework and National Water Resources Strategy. ○ The NRF research chairs present an opportunity for groundwater but have not yet been attempted for the water resources sector. ○ The Groundwater Masterplans in a number of DWAF regions can act as basis for regional capacity-building initiatives – preferably with the local universities. ○ Already there are MOUs of the DWAF Learning Academy with 13 tertiary institutions. ○ There are 14 Naledi schools (science bridging) – they could be supported with groundwater-related projects. ○ Moves towards functioning water institutes at both UWC and UFS are underway. ○ Development of a SADC Groundwater COE at UFS with 3 full-time staff is underway. ○ New Life Science building at UWC is nearly completed. ○ New sources of funding are becoming available or could be leveraged for involving Africa students ○ There is international funding to help developing countries stop the brain drain ○ Short courses are in big demand in Africa and offer many opportunities of inter-university cooperation and low-cost training for students. ○ NRF funds are difficult to access, but Student-On-line applications are much more effective.	○ Groundwater still not recognized as the source for Community Water Supply, despite its widespread use all over Africa. ○ There is a perception that IWRM is killing groundwater science. ○ The school system is producing poor hard science candidates and groundwater science and practice is negatively impacted. ○ This also has a negative impact on professional registration. ○ The strong private sector attracts most graduates and also presents a drain of capacity from the public and academic sectors ○ The main pull factor for groundwater capacity building is missing due to a lack of capacity and groundwater leadership in DWAF. ○ No groundwater centres have the critical mass to meet the present needs of the country. ○ Research generally has a project focus and not succession planning and institution building. ○ The groundwater sector has an aging work force. ○ Upkeep of lab facilities is difficult to budget for in a university funding environment ○ Immigration of key specialists is creating a doom and gloom mentality.

Appendix 8: FET-Water Mission and Objectives (DWAF/UNESCO/WMO, 1998).

MISSION

"... through networking provide South Africa and SADC with appropriately educated and trained people to solve water-related problems and to manage, in its widest possible meaning, the water resources as and where needed."

OBJECTIVES

FET-WATER covers the initial period 1 January 1999 to 31 December 2011 and will support and complement actions of E&T by stakeholders in the whole water sector to:

- improve the quality, capacity and cost-effectiveness of E&T;
- effectively apply affirmative actions;
- foster transnational cooperation, especially within SADC; and
- devise innovative approaches to E&T methodology, content, delivery and materials, especially with regard to applications of IT.

FET-WATER will support practical measures for:

- strengthening of existing or the creation of new E&T networks of stakeholders with clear objectives and offerings for mutual benefit;
- improvement or enhancement of experiential training, on-the-job and in-house training by pooling of expertise;
- increasing mobility of teachers and students;
- cost-effective curriculum development;
- CE&T through short courses, roving seminars, open and distance learning and IT applications;
- fostering community services;
- establishing centres of excellence in an affirmative action perspective;
- analyses and surveys examining problems and issues related to gaps, needs, qualification, certification;
- accreditation, sustainable career development and remuneration;
- preparatory visits to establish new E&T networks; and
- stimulating SADC and international cooperation.

FET-WATER is open to partnerships of those actively involved in E&T in enterprises, universities and technikons, other training institutions, public authorities, NGOs and IAPs. It is intended that FET-WATER be opened up to organisations in SADC, subject to agreement on procedures and finances.