Department : Water Affairs
and Forestry

Integrated Water Resources Management

Groundwater Management Strategy
Full Guidelines

DEPARTMENT OF WATER AFFAIRS AND FORESTRY

INTEGRATED WATER RESOURCES MANAGEMENT

GROUNDWATER MANAGEMENT STRATEGY

INTEGRATED WATER RESOURCE MANAGEMENT
STRATEGIES, GUIDELINES AND PILOT IMPLEMENTATION
IN THREE WATER MANAGEMENT AREAS, SOUTH AFRICA

DANIDA

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DOCUMENTS FOR OUTPUT 7: STRATEGIES, TOOLS AND SYSTEMS APPLIED WITHIN THE THREE SELECTED WMAS TO ACHIEVE SUSTAINABLE GROUNDWATER DEVELOPMENT AS AN INTEGRAL PART OF IWRM:

1. a. **Groundwater Management Strategy for National Water Resource Strategy, DWAF/DANCED, 2001**
   b. Groundwater Management Strategy: Summary, DWAF/DANCED, 2002
   c. Groundwater Management Strategy: Executive Summary, DWAF/DANCED, 2002

2. a. Guidelines for Groundwater Management in Water Management Areas, South Africa, Carl Bro a/s, IZNA Consortium, February 2002
   b. Guidelines for Groundwater Management in Water Management Areas: Summary, South Africa, Carl Bro a/s, IZNA Consortium, February 2002
   c. Guidelines for Groundwater Management in Water Management Areas: Executive Summary, South Africa, Carl Bro a/s, IZNA Consortium, February 2002

RELATED DOCUMENTS:

First Edition National Water Resource Strategy, DWAF 2002

Integrated Water Resources Management Communication Strategy, DWAF

Generic Communication Strategy for IWRM, DWAF/DANCED, December 2001.

Institutional Roles and Linkages: Phase 1 Report, Carl Bro a/s, IZNA Consortium, February 2002.

Guidelines for Stakeholder Participation in Integrated Water Resources Management in Water Management Areas in South Africa, Carl Bro a/s, March 2001.

Evaluation of the involvement of Previously Disadvantaged Individuals in the Catchment Management Agency establishment process the three Water Management Areas, date.

Capacity Building Overview Assessment Vol.1, Carl Bro a/s, IZNA Consortium, October 2001.

Capacity Building Overview Assessment Vol.2, Specific Capacity Building Requirements of Role-Players, Carl Bro a/s, IZNA Consortium, October 2001.

Capacity Building Implementation Plan, Carl Bro a/s, IZNA Consortium, April 2002

Guideline on the Viability Study for the Establishment of a Catchment Management Agency, Carl Bro a/s, Pegasus Strategic Management, February 2002.

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ACRONYMS

CCGET	Co-ordinating Committee for Groundwater Education and Training
CMA	Catchment Management Agency
DANCED	Danish Co-operation for Environment and Development
DWAF	Department of Water Affairs and Forestry
EIA	Environmental Impact Assessments
IWRM	Integrated Water Resource Management
NGDB	National Groundwater Database
NGO	Non Governmental Organisation
NWRS	National Water Resource Strategy
UNCED	United Nations Conference on Environment and Development
WRC	Water Research Commission
WUA	Water User Association

1 INTRODUCTION

1.1 Preamble

South Africa is a developing country with limited water resources, where effective water resource management is critical (DWAF, 2000a). Agenda 21, prepared at UNCED in Rio de Janeiro in 1992, describes Integrated Water Resource Management (IWRM) as a primary tool for management of the resource. This concept is embedded in the National Water Act (Act 36 of 1998) as the avenue through which the objective of enhanced water management can be attained.

The Danish Co-operation for Environment and Development (DANCED) is providing financial assistance to the Department of Water Affairs and Forestry (DWAF) to develop IWRM strategies and guidelines. The strategies and guidelines will subsequently be implemented on a pilot basis in three selected water management areas. Catchment management institutional structures are also to be implemented and pilot tested in the same programme. Experience gained in establishment of catchment management agencies (CMAs) in the three water management areas during pilot testing will be transferred to other water management areas in South Africa. The DANCED programme comprises two phases:

- Development of strategies, approaches and systems, and preparation for Phase 2.
- Pilot testing and implementation of IWRM in three water management areas.

Because of past neglect and groundwater's private status under the previous Water Act (Act 54 of 1956), groundwater aspects have not been an integral part of the development and management of the country's water supply. Consequently, strategies to include groundwater into the National Water Resource Strategy (NWRS) were included in Phase 1 of the DANCED-assisted programme. The overall objective of the groundwater component of the programme is to develop and test national strategies, guidelines and tools for groundwater resource management as an integral part of IWRM.

The National Water Act (Act 36 of 1998) clearly includes groundwater in the hydrological cycle and in the definition of a water resource. However, the characteristics of groundwater sometimes require it be considered or managed differently to other water resources. It is for this reason that groundwater issues need to be clearly addressed by the NWRS, so that integration can be achieved and efficient management of all water resources ensured.

The National Water Act (Act 36 of 1998) requires regular review of the NWRS, including the groundwater management strategy. Thus groundwater management in South Africa will be reviewed every five years. This strategy document, therefore, provides a dynamic framework subject to regular review, rather than a rigid master plan.

1.2 Terms of Reference

The NWRS is a statement of how South Africa's water resources will be managed to achieve the objectives of the National Water Act (Act 36 of 1998). The objective of this component of the DANCED programme was to formulate a national strategy for the sustainable management of groundwater resources within the new IWRM framework and its integration into the NWRS. It was envisaged the resultant strategy document would serve two purposes:

- It would act as a stand-alone strategy document, which will help take groundwater from a neglected private water status to that of a significant resource that is managed as part of IWRM.
- It would provide groundwater input into the NWRS, as required by the National Water Act (Act 36 of 1998) and co-ordinated by DWAF's Directorate of Strategic Planning.

1.3 Guiding Principles

Though this document focuses almost exclusively on groundwater issues, the strategies proposed are based on guiding principles presented by DWAF (1997) during the Water Law Review, and included in the Water Services Act (Act 108 0f 1997) and the National Water Act (Act 36 of 1998) as well as guidelines presented in the draft national water resource management strategy document (Rowlston, 2000). Key guiding principles for this work included:

- The purpose of the National Water Act (Act 36 of 1998) must be followed, including redressing the results of past racial and gender discrimination.
- Water resource management is based on principles of equity, optimal use, sustainable use and IWRM.
- The government, through the Minister of DWAF, is the public trustee of South Africa's water resources.
- Water resources will be managed by decentralised CMAs, which will be responsible for the water resources in the 19 demarcated water management areas.

Transformation, both within DWAF and the broader water sector, is an issue currently receiving attention. This issue will be addressed by the NWRS and has not been directly addressed in this document. However, it is an inherent assumption in all strategies presented that racial and gender transformation will form part of the future management of the country's water resources and that the water sector must reflect the demography of the country.

Further, all strategies are required to follow the letter and spirit of the Constitution (Act 108 of 1996), which is the highest law of the land. The Bill of Rights in the Constitution states:

- Everyone has the right to have access to sufficient food and water.
- Everyone has the right to an environment that is not harmful to their health and well-being.
- Everyone has the right to an environment protected, for the benefit of present and future generations, through legislative and other measures that
  - prevents pollution and ecological degradation;
  - promotes conservation, and
  - secures ecologically sustainable development and use of natural resources while promoting justifiable economic and social development.

Development and management of groundwater is essential for supporting these rights, particularly with respect to rural water supply, helping women in their position as suppliers of water in many communities, and poverty eradication.

2 PROJECT METHODOLOGY

A team of hydrogeologists from four organisations undertook this project. Input was also obtained from DWAF's Directorate of Geohydrology. The project was carried out in a phased manner, based on the following key steps:

- An initial project meeting was held to clarify the aims and objects of the project;
- Background documents and other literature were read, and an initial set of strategies prepared;
- The project team held a series of formal and informal meetings with various water resource managers to identify issues and constraints with respect to groundwater's inclusion in IWRM;
- Team members were assigned specific issues to address, and each prepared notes, which were incorporated into a single document;
- The document was then discussed and reworked into a draft report, which was then submitted to the Directorate of Geohydrology for comment, and
- Comment received from the Directorate was considered by the project team and this groundwater strategy report revised.

When undertaking the project, the project team recognised management of water resources in South Africa was in a state of transition and many policies, strategies and guidelines were still being developed (DWAF, 1996, 2000c; 2000d; Rowlston, 2000). Concern exists that strategies presented in this report will get lost in the plethora of past, current and future policies and strategies being developed. Thus, it was decided that the only key practical strategies would be presented; i.e. those that are readily implementable and would have the most effect on including groundwater use in IWRM.

Cognisance was also taken of earlier efforts focusing on groundwater policy, strategy and management (Braune, 1992, 1993, 2000a, 2000b; DWAF, 1992, 2000b; Parsons and Tredoux, 1993; Moss et al, 1996; Lazarus, 1997). These prior efforts assisted the project team to focus on including groundwater management into IWRM and formulating strategy to ensure groundwater was effectively considered in the NWRS.

3 BACKGROUND INFORMATION

3.1 Preamble

Groundwater is a major source of water in South Africa and a powerful tool for creating a better life for many people living in the country. As a result of democratisation in 1994, South Africa is in a period of transition and strategies are required to help implement change. It is beyond the scope of this report to present a comprehensive situational analysis of groundwater and the use of groundwater in South Africa. However, the following background information provides a brief review of the occurrence, use and management of groundwater in the country and legislation that guides the manner with which it will be managed in future. The vision and strategies presented in Sections 4 and 5 of this document have been developed to overcome the limitations and constraints that impact the potential of groundwater.

3.2 Groundwater Resources of South Africa

3.2.1 Groundwater occurrence

The groundwater resources of South Africa differ from those elsewhere in the world, with about 98% of groundwater is found in fractured, hard rock aquifer systems (Kok and Simonis, 1989). Major primary aquifers are restricted to coastal sand deposits along the west and south coast of the Cape and along the KwaZulu Natal coast. Good examples include aquifers at Atlantis, on the Cape Flats and around Richards Bay. Secondary aquifers, whose hydrological properties are enhanced by weathering, fracturing and faulting of hard rock are the most dominant, with major aquifers being associated with dolomitic rocks, quartzite and sandstone of the Table Mountain Group and sandstone and shale of the Karoo Sequence.

The implication of the dominant occurrence of groundwater in secondary aquifers is that secondary aquifers are more difficult to manage and protect than primary aquifer systems. It is also more difficult to generalise about appropriate drilling sites, aquifer yield and local management requirements. It is only in recent years that an attempt has been made to characterise groundwater resources on a national or regional scale. Publication of a set of national-scale hydrogeological maps by Vegter (1995) provided impetus to the mapping initiative currently being completed by DWAF. Twenty-three regional hydro-geological maps are being prepared. An information booklet, in which issues such as groundwater occurrence, quality, yield and development are addressed, accompanies each map (Haupt, 1995; Smart, 1998; Meyer, 1999).

The maps have already been used to generate additional information sets. For example, maps prepared by Vegter (1995) were used to generate national aquifer classification and vulnerability maps (Parsons and Conrad, 1998) and a harvest potential map (Baron et al, 1998). The latter is considered a first attempt to provide water resource planners with information about the sustainable yield of aquifers across the country. As a result of these mapping initiatives, more and more information about South Africa's valuable groundwater resources is becoming available. The challenge remains for this information to be provided to water resource planners and decision makers so they understand and take cognisance of the information provided (Section 5.5).

Using the classification developed by Parsons (1995), about 18% of aquifers in South Africa are categorised as major aquifer systems.

Such aquifers are distinguished by high-yielding boreholes that produce good quality water. They consist of mainly primary coastal aquifer systems, dolomitic rocks, rocks of the Table Mountain Group and some parts of the Karoo Sequence. Cities and towns dependent on groundwater from major aquifer systems include Pretoria, Atlantis, St Francis Bay, Beaufort West and Graaff-Reinet.

Poor aquifer systems, comprising 15% of the total, are found mainly in the dry northern and western parts of the country. Though boreholes sited in such aquifers are generally very low yielding and/or produce poor quality water, they could still play a critical role in supplying water to small rural communities in the arid parts of South Africa.

Minor aquifer systems are widely spread and comprise 67% of South Africa's aquifer systems. Rocks of the Karoo Sequence and older rocks in the north-eastern parts of the country dominate. Borehole yields and groundwater quality are variable, but these aquifers have proven themselves capable of producing sufficient quantities of water of acceptable quality for both domestic and agricultural purposes. Towns dependent on minor aquifer systems include Nylstroom, Williston, Carnavon and Richmond.

Strategies that address groundwater occurrence and the collection and provision of information on groundwater occurrence are presented in Sections 5.4, 5.5, 5.10 and 5.12.

3.2.2 Groundwater use

No definitive study has been undertaken to quantify groundwater use in South Africa. However, it is widely held that groundwater accounts for approximately 13% of all water used in the country while some 320 towns and villages are dependant on groundwater to some degree. Recent work by DWAF suggests that almost 60% of rural communities are groundwater dependent.

It is further quoted that urban groundwater use accounts for only about 4% of groundwater abstracted, while the agricultural sector abstracts about 84% for irrigation and stock-watering. It has been estimated that groundwater contributes about 16% of all water used for irrigation in South Africa (DWAF, 1986).

The validity of these estimates is questionable, particularly in light of the recent development of groundwater resources to supply about 4 million people with water as part of the Reconstruction and Development Programme. Vegter (2000) estimated that groundwater use may have doubled between 1980 and 1999 (Table 1). Recent estimates of groundwater use made by Baron (pers.comm.) and Haupt (2000) differ significantly. Baron estimated current groundwater use in South Africa is in the order of 1 920 m^3 while Haupt estimated it may be as much as 3 200 m^3.

Haupt (2000) set the groundwater harvest potential at 19 250 Mm^3/a, suggesting that less than 20% of South Africa's available groundwater resources are currently used. Because of the low level of confidence in the estimate of groundwater use and the need to consider local conditions when abstracting groundwater, these estimates should be treated with caution. However, they support the recognition that groundwater will play a significant part in attaining DWAF's vision of "some, for all, forever."

As groundwater considerations have gradually been included in water resource management, it has become clear that it is not the volume of groundwater contributed that is important, but rather the role and timing of the contribution. It is accepted that groundwater cannot compete with the volume of water supplied from large surface water supply schemes. However, the groundwater contribution to streams during low flow periods, for example, plays a critical role in sustaining the ecological function of streams during such periods.

TABLE 1: HISTORIC PERSPECTIVE OF GROUNDWATER ABSTRACTION IN SOUTH AFRICA (AFTER VEGTER, 2000; HAUPT, 2000 [(1)] AND BARON, PERS.COMM.[(2)]).

YEAR	TOTAL GROUNDWATER ABSTRACTION (MM^3/A)	GROUNDWATER AS A PERCENTAGE OF TOTAL WATER USED IN SA (%)	GROUNDWATER USED FOR URBAN SUPPLY, AS A PERCENTAGE OF TOTAL GROUNDWATER USED (%)	GROUNDWATER USED BY THE AGRICULTURAL SECTOR, AS A PERCENTAGE OF TOTAL GROUNDWATER USED (%)
1950	684			71
1960	1 062	11		68
1970	1 128		4	84
1980	1 790	15		
1990				
2000	3 500[(1)] / 1900 [(2)]			

Similarly, the location of groundwater resources in relation to potential users and the cost of developing groundwater are also factors requiring consideration. Use of groundwater to supply water to De Aar was an example of the value of groundwater, as the cost of developing a pipeline from the Orange River was prohibitive.

Development of groundwater, either using springs or boreholes, is the only viable means of supplying basic human water needs to millions of rural South Africans who currently do not have adequate access to potable water. This, it is believed that groundwater can play an important role in the national government's initiative to eradicate poverty. Integration of groundwater and hydrogeological expertise into CMAs is considered critical if the water resources of a catchment are to be managed in a sustainable and cost effective manner.

Strategies that address groundwater use are presented in Sections 5.4, 5.6, 5.10, 5.11 and 5.12.

3.2.3 Groundwater management and protection

The reform of water management in South Africa is a key issue in the NWRS. The National Water Act (Act 36 of 1998) requires water resources be managed so that a balance is obtained between optimum use and protection. The Act further requires the NWRS form the framework for protection, use, development, conservation, management and control of water resources as a whole. Several management tools are currently being developed and implemented to manage the country's water resources.

At present, groundwater management is driven at a national level. The National Water Act (Act 36 of 1998) requires water management to be driven at a local level, which is more in keeping with the local nature of South Africa's aquifer systems.

Although research and ambient monitoring of the country's groundwater resources could be managed at a national level, most groundwater management issues need to be dealt with locally. These include:

- Resource assessment;
- Reserve determinations;
- Setting resource quality objectives;
- Development of catchment management plans;
- Licensing and allocation;
- Management and monitoring of groundwater abstraction schemes, and
- Management and monitoring of groundwater contamination problems.

Strategies to address the change from national to regional groundwater management are addressed throughout Section 5, with Sections 5.2, 5.3, 5.7, 5.8 and 5.9 being most relevant. When developing these strategies, cognisance was taken of strategies proposed by DWAF (200b) with respect to the management of groundwater quality. These included:

- A precautionary approach, which allows for current knowledge gaps;
- Differentiated protection, which recognises that since groundwater resources cannot all be protected to the same level, important or vulnerable resources must receive priority, and
- General awareness-building.

These strategies are applicable to groundwater management as a whole and, accordingly, form an important approach to groundwater management nationally.

3.3 Legislation

3.3.1 New legislation

There has been a complete revision of legislation related to water and the environment in South Africa over the past 5 years. As a result, new legislation has not been fully implemented nor tested in the courts. Much of the current change in the water sector has been driven by the new legislation. As the legislation has only recently been promulgated and still needs to be fully implemented, this strategy document does not include any strategies for legislative change, but focuses on implementation of the new laws.

This section briefly addresses legislation that affects groundwater use in the context of IWRM. Beyond the Constitution (Act 108 of 1996), important legislation in this regard includes:

- National Water Act (Act 36 of 1998);
- Water Services Act (Act 108 of 1997);
- Environment Conservation Act (Act 73 of 1989), and
- National Environmental Management Act (Act 107 of 1998).

Principles of these Acts that are relevant to the current project are addressed briefly in Section 1.3.

Because of the array of South African legislation that covers the use and protection of water resources, co-operative governance has to form a core mechanism for effective control and protection of the nation's water resources.

These Acts provide a framework through which groundwater can be included into IWRM. Because of linkages between the Acts and the number of provisions under which groundwater management and integration can be considered, a comprehensive assessment of the legal framework cannot be presented here. This task should be undertaken once the NWRS is put in place, institutional structures and responsibilities developed, and the Acts implemented. However, some important provisions are briefly presented below.

3.3.2 National Water Act

The National Water Act (Act 36 of 1998) is considered to be one of the most modern and comprehensive pieces of legislation anywhere in the world. Yet while the Act refers to water resources, which include groundwater, it seldom addresses specific groundwater issues. This is because the Act recognises a unitary hydrological cycle and embraces the concept of IWRM. The Act requires a NWRS be compiled, and stipulates issues to be addressed by such a strategy. These issues include water use for strategic purposes, and promotion of holistic and integrated water management in a catchment.

The use and protection of groundwater is controlled by numerous sections of the Act. It is beyond the scope of this report to address these in any detail. However, certain aspects need to be highlighted because of their direct relevance to groundwater management. For example, general authorisation of groundwater use differs from that of surface water because of the divergent characteristics of the two resources. Various groundwater abstraction zones have been demarcated nationally, in which the rate of abstraction (expressed as m^3/ha/a) has been set.

The National Water Act (Act 36 of 1998) requires the Reserve (that part of the groundwater system which supports aquatic ecosystems) to be determined prior to issuing water use licenses. Integrated tools have been developed for setting the Reserve (DWAF, 1999) and its surface water, groundwater, wetland and estuarine components. However, setting Resource Quality Objectives is considered a more appropriate tool for managing and protecting groundwater resources.

From a hydrogeological perspective, the change in status of groundwater from 'private' to 'public' is considered significant. Historically, little control was exercised over the private use of groundwater. Under the new Act groundwater is considered an integral part of a catchment's resources. Furthermore, all resources are required to be managed for the good of the catchment.

3.3.3 Water Services Act

The Water Services Act (Act 108 of 1997) requires water service authorities to provide water service development plans. These will be of great value in terms of promoting proper management of a catchment's water resources. However, it is proposed the authorities involved (DWAF and the CMAs) ensure these service plans adequately cover the sustainable management and monitoring of groundwater. It is also proposed that catchment management plans include groundwater, specifically to ensure groundwater is integrated into a catchment's water resources management (Section 5.2.2).

3.3.4 Environment Conservation Act

Environment Impact Assessment (EIA) regulations prescribe the process for undertaking EIAs, which are compulsory for listed activities. Listed activities that could have a direct bearing on groundwater include electricity generation facilities, nuclear reactors, transportation and storage of hazardous waste, wastewater treatment works, waste disposal sites and dams. Experience shows that possible groundwater sources are overlooked during some EIA processes, partly due to a lack hydrogeological knowledge and awareness among proponents, their consultants or the responsible authorities.

Among the listed activities are “schemes for the abstraction or use of ground or surface water for bulk supply purposes”. The appertaining guideline document defines bulk water supply as “water supplied in a significant volume to local authorities”, which could include mines, industries and agricultural schemes. This loose definition, coupled to a lack of hydrogeological knowledge among responsible authorities, has resulted in groundwater development being unnecessarily restricted while abstraction by individual farmers, recognised as the biggest users of groundwater, goes unchecked.

The above examples illustrate that, although the Act may be sound, implementation can be problematic. Furthermore, overlap with other Acts (specifically the National Water Act, 36 of 1998) requires effective co-operative governance if the objectives of the statute are to be attained. Strategies that address groundwater protection are described in Section 5.3.

3.3.5 National Environmental Management Act

The National Environmental Management Act (Act 107 of 1998), commonly referred to as NEMA, has several objectives. However, the objectives related to sustainable development are particularly relevant to integrated water resource management. NEMA requires that “environmental management must place people and their needs at the forefront of its concern.” However, the Act does not require “no-impact development” as some groups seem to believe.

3.4 Integrated Water Resource Management

IWRM is a philosophy of co-ordinated management of an area’s water, land and other resources “to maximise the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems” (Global Water Partnerships, 2000). The IWRM philosophy aims to promote efficient management of all water resources. It recognises that the various components of the hydrological cycle are intimately linked to one another, each component being affected by changes in every other component. Thus IWRM encompasses more than just preserving the environment; it emphasises a consultative approach to getting the best benefits out of a catchment’s water resources.

The principles upon which IWRM is based are described in Agenda 21 and are too numerous to mention here. However, four values highlighted in the Dublin Statement (International Conference on Water and the Environment, Dublin, 1992) provide a useful guide:

- Fresh water is a finite and vulnerable resource, essential to sustain life, development and the environment;
- Water development and management should be based on a participatory approach;
- Women traditionally play a significant role in the provision, management and safeguarding of water, and
- Water has an economic value and should be recognised as an economic good.

Given that the National Water Act (Act 36 of 1998) recognises a unitary hydrological cycle, and requires an integrated approach to water resource management, it follows that a new paradigm is needed to plan and manage catchments, water resources and water supply schemes. This will help ensure, among others, that previously marginalised groundwater becomes recognised as a viable resource worthy of inclusion in an integrated catchment management approach for South Africa.

All strategies presented in Section 5 are considered building blocks to be used in including groundwater and groundwater issues in the overall management of South Africa's water resources. This will facilitate the requirement that all water resource management be based on principles of IWRM.

4 VISION

Groundwater, though not fully acknowledged or appreciated in the past, is a key water resource in South Africa. Groundwater's previous private status has hindered its inclusion in the development and management of the national water supply. Yet it is a resource that can – and does – play a vital role: sometimes it is the only available source of water; usually it is more economical and environmentally friendly to develop; and often it significantly eases the burden of the rural population, particularly women whose daily tasks include collecting water for their households. Furthermore groundwater, because of its prevalence, is an important resource for the eradication of poverty.

For groundwater to take its rightful place in the development and management of South Africa's water resources a paradigm-shift must occur and a new vision must take hold. This will create a context within which integrated water resource management, one of the tenets of the National Water Resource Strategy (NWRS), can be properly implemented. It is proposed the principles below should form the core of the new vision for integrated management of South Africa's water resources:

VISION

GROUNDWATER IS ACKNOWLEDGED BY ALL WATER MANAGERS AS AN IMPORTANT AND INTEGRAL PART OF SOUTH AFRICA'S WATER RESOURCES, AND IS MANAGED AS SUCH.

INSTITUTIONS INVOLVED IN WATER RESOURCE MANAGEMENT ABIDE BY IWRM PRINCIPLES, AND GIVE ADEQUATE ATTENTION TO THE ROLE OF GROUNDWATER IN THE ENVIRONMENT AND AS A STRATEGIC SOURCE FOR WATER SUPPLY.

For groundwater to form part of IWRM, changes are needed to the prevailing approaches to water management in general, and groundwater in particular. The requisite changes can best be effected through a set of interlocking strategies that include not just groundwater management and protection, but also a broad range of related issues (see Figure 1). The solutions to these questions, described in detail in the next section, collectively form the foundation for the incorporation of groundwater into IWRM.

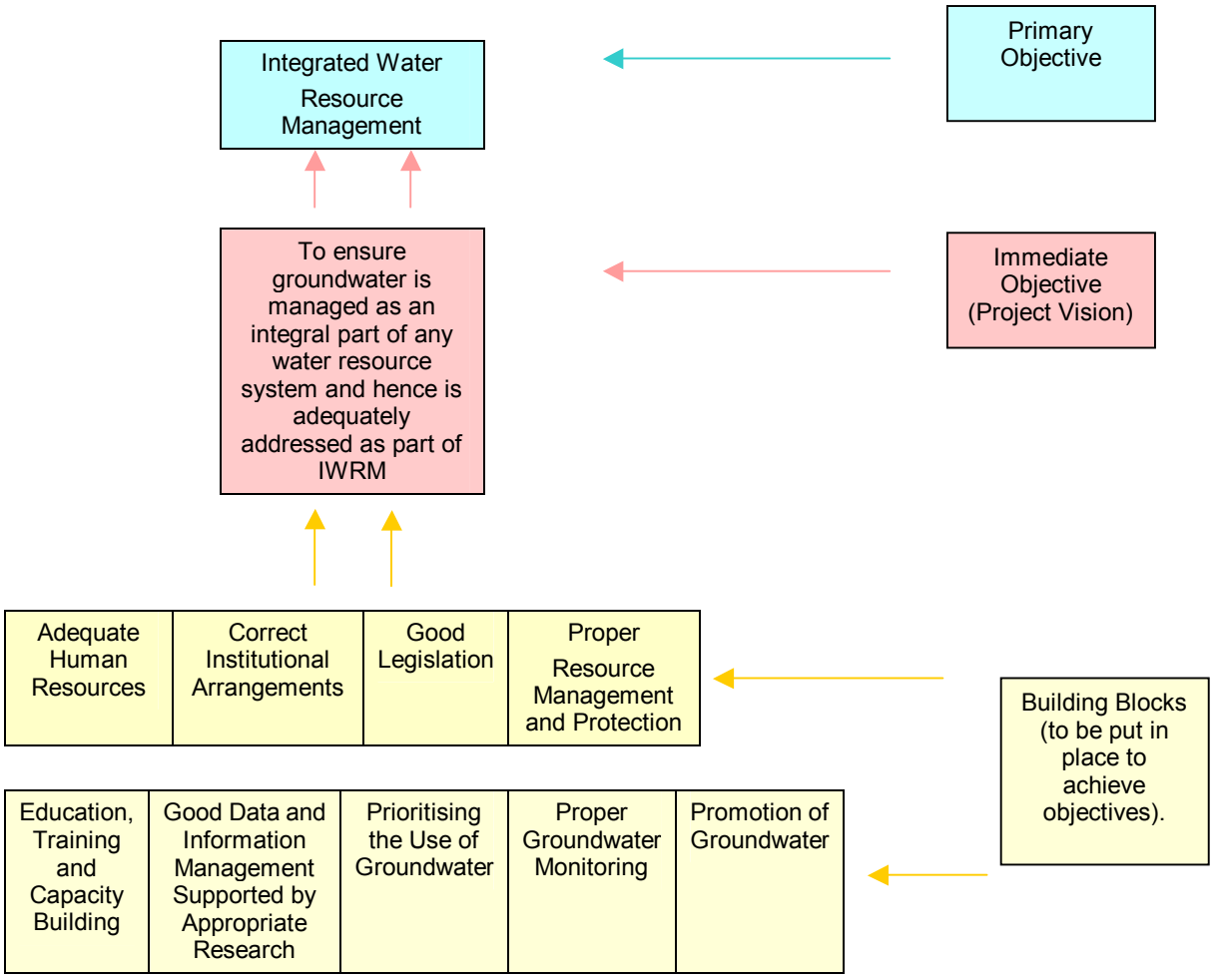

FIGURE 1: FLOW DIAGRAM OUTLINING THE FOUNDATION REQUIRED TO ENSURE THAT GROUNDWATER IS ADEQUATELY ADDRESSED IN IWRM.

5 STRATEGIES

5.1 Preamble

If groundwater is to be integrated successfully in water resource management in South Africa, a suite of practical, feasible and affordable strategies must be developed and implemented. The strategies presented below focus on including groundwater in a NWRS based on the principals of, and a framework for, integrated water resource management. It is believed that by doing so, groundwater will be managed at all levels in a sustainable manner for the benefit of all South Africans.

Management and protection strategies form the main pillars of the vision presented in Section 4. These are supported by several enabling strategies in areas such as institutional structures, human resources, research, data and information management and groundwater promotion.

To provide impetus to the adoption and implementation of the proposed strategies, implementation plans are proposed with each strategy. Many aspects are interlinked; therefore extensive use is made of cross-referencing.

5.2 Groundwater Management

5.2.1 Background

In future, management of South Africa's water resources will take place at three levels: national, catchment and local (Section 5.7). Effective management (in context of IWRM) requires trained and experienced staff, proper planning and data upon which management can be based. While ultimately the national government is the public trustee of the nation's water resources, water resource management in the future is to be delegated to regional or catchment levels. Within the catchments, water service authorities (usually municipalities) are to be responsible for ensuring access to water services.

The national government has the obligation to ensure that water is protected, used, developed, conserved, managed and controlled in a sustainable and equitable manner (Rowlston, 2000). Consequently, the NWRS is being developed as the framework for water use in the country as a whole. It will be reviewed at 5-yearly intervals.

Through the process of developing the NWRS in South Africa, groundwater has a unique possibility to become an equal partner with other water resources. This will be made possible through several planning, institutional and administrative changes that will take place during the next 10 to 20 years. It is imperative the NWRS adequately recognises the vital role that groundwater plays, both in catchment management and as a strategic resource, especially in the drier areas and in smaller-scale water supply schemes.

A key element of the NWRS is the establishment of decentralised catchment management authorities (CMAs). These will take over the responsibility for managing water resources in 19 water management areas. Sustainable use of water resources will not take place unless resources are well managed, a fact well recognised in the National Water Act (Act 36 of 1998). Consequently, all CMAs will be required to develop and implement catchment management strategies.

Historically, groundwater has been very poorly managed in South Africa, resulting in the resource being wrongly discredited as unsustainable. Various factors account for the history of poor management. These include:

- A lack of hydrogeological knowledge on the part of most users; and
- The historical private status of groundwater, which resulted in limited control of abstraction.

Management of a catchment's water resources is discussed below, while education of groundwater users and managers is addressed in Section 5.10. Central issues related to catchment management include principles of IWRM, sustainable catchment use, and conjunctive harnessing of surface and groundwater resources.

Integrated catchment management is a tool aimed at conserving all resources within a catchment, and securing water availability for both human consumption and environmental needs on a sustainable basis. Groundwater plays a crucial role in complex natural systems by:

- Providing baseflow to rivers;
- Supporting aquatic ecosystems as well as riparian and terrestrial vegetation;
- Maintaining a geochemical balance; and
- Preventing earth subsidence.

Sustainable use of groundwater has to consider the effects of water usage on the environment. In terms of the Environment Conservation Act (Act 73 of 1989), environmental impact assessments (EIAs) are required to ensure abstraction for bulk water supply does not unduly affect the environment (Section 3.2.3).

The nature of aquifer systems requires groundwater management remains essentially a local issue, while research and strategic planning be undertaken on a regional or national level. Local aquifer management includes monitoring of groundwater abstraction, groundwater level fluctuations, groundwater quality changes (including pollution problems), rainfall recharge and environmental impacts. This complex matrix of issues necessitates inclusion of hydrogeological expertise in all tiers of water resource management (also see Section 5.7).

Development of groundwater resources is not only a question of finding and using new resources, but rather introducing sustainable use of groundwater that has already been discovered. Prevention of depletion or damage to the Reserve has high priority in sustainable abstraction. It is essential, therefore, that local water resource managers fully understand the implications of over-abstraction and the necessity for monitoring the aquifer status. The risk of over-use must be taken seriously, and appropriate management plans for each borehole or well field must be formulated. Proper authorisation and licensing of abstraction will protect the resource against unauthorised over-exploitation. To assist in minimising abstraction-induced stress on an aquifer, the following could be introduced:

- Water demand management, to reduce total consumption by introducing various incentives to save water;

- Technical solutions, to reduce loss and leakage and improve the usefulness of the same volume of water;
- Realistic tariffs, to put water in line with other commodities and encourage consumers to find ways to reduce water consumption, and
- Involvement of all stakeholders in decision-making, especially at local level through user associations.

Conjunctive water use is the simultaneous use of both surface and groundwater as a source of water and clearly subscribes to the principles of IWRM. Inclusion of this practice in the NWRS will stimulate awareness of how conjunctive use can be applied to water supply systems and promote greater discussion about alternative solutions to water problems facing South Africa. Conjunctive use could be used to address several issues, including: the development of more groundwater-based urban water supplies; land subsidence; groundwater quality deterioration, and provision of water during periods of prolonged drought when surface water supplies are diminished.

The Water Services Act (Act 108 of 1997), which requires development of a water services plan, is a tool CMAs will use to ensure proper planning and management of municipal groundwater resources. The CMAs and DWAF must ensure local water services plans have adequate monitoring provisions to ensure sustainable use.

5.2.2 Strategy

Implementation of appropriate groundwater management at catchment level is an important step in attaining IWRM. In this regard the following strategies are envisaged:

Base all water resource management at national, catchment and local levels on the principles of IWRM.

Recognise groundwater as an integral part of a catchment's water resources, and manage it properly according to sound scientific assessments and participative planning.

Require each CMA to include a groundwater management plan as part of the catchment management framework.

Require each CMA to have sufficient groundwater specialists available to oversee sustainable development, monitoring and management of groundwater resources. Such specialists can be either employed by the CMA or outsourced when required.

5.2.3 Implementation plans

- Water user associations (WUAs) must be established and encouraged to assist CMAs with joint management of communal aquifers;
- Guidelines for adequate aquifer management should be established and distributed by DWAF. Guidelines should cover, among others, sustainable use, abstraction scheduling, pump settings and monitoring requirements;
- The number of Reserve determinations being undertaken should be increased. This will reduce or eliminate the current backlog in Reserve determinations, which is retarding the issuing of licenses for groundwater use;

- A clearer definition of bulk water supply should be developed, possibly at CMA level, after consultation with environmental authorities;
- Guidelines related to EIAs for groundwater must be formulated as educational tools for both the groundwater and environmental management communities;
- Research related to the impact of groundwater abstraction on ecosystems, together with the identification of groundwater dependant ecosystems, must be undertaken, and
- DWAF and CMAs should proactively participate in the decision process related to land-use planning. In general, the aim should be to place high-risk activities in areas with no or little groundwater potential.

5.3 Groundwater Protection

5.3.1 Background

Groundwater protection and conservation are essential components of groundwater management, and relate to both quantity and quality issues. Groundwater protection will occur within an IWRM framework through prescribed tools such as a resource classification system and the Reserve (Braune, 2000b).

Pollution of groundwater resources affects both groundwater and surface water quality in streams fed by baseflow. Further, remediation of polluted aquifers is expensive and technically difficult. As a result, groundwater quality management and protection should be proactive. As protection of all aquifers is considered impossible in South Africa, a differentiated protection policy, where priority is given to important and vulnerable aquifers, has been proposed as the optimum solution (DWAF, 2000b).

The National Water Act (Act 36 of 1998) introduces several useful instruments to protect and conserve groundwater. These include both source-based and resource-based tools. Source-based measures include licensing and authorisations. These focus on controlling groundwater users, polluters and potential pollutants. Resource based measures relate to managing aquifers, and include the Reserve, resource quality objectives and classification. Important groundwater protection procedures include:

- Public involvement – public awareness is seen as the only permanent guard against degradation of groundwater resources. This requires the public to understand hydrogeological issues and appreciate the value of the resource;
- Reserve determinations – these allow for the role of groundwater in sustaining aquatic ecosystems to be understood and promoted within the context of a balance between use and protection;
- Aquifer classification – this provides a framework for implementing differentiated protection, and should be implemented at a catchment level;
- Land-use zoning – this is an effective source-based control that restricts potentially polluting developments on important or sensitive aquifer systems. Urban planners, for example, must be made aware of risks related to groundwater pollution and encouraged to plan town developments with due regard for hydrogeological issues; and
- Environmental management plans and environmental impact assessments – these should be mandatory for activities known to induce groundwater contamination, or in areas of important or sensitive aquifer systems.

Processes involved in aquifer depletion and pollution, and related aquifer protection and conservation, are complex and require specialist input for correct management. IWRM is considered essential, therefore, to protect the country's groundwater resources. Aquifer protection, however, is a public issue, and all water and land users have a role to play therein.

5.3.2 Strategy

Improve public awareness and involvement as a guard against degradation of groundwater resources. Empower the public to understand groundwater issues and appreciate the value of the resource.

Protect water resources using instruments such as land-use zoning, classification of aquifers, environmental management plans and EIAs.

Involve groundwater institutions and specialists in the debate and decision-making processes regarding South Africa's resources and environment.

5.3.3 Implementation plan

- Information about pollution, as well as pollution prevention must be included in a general awareness campaign regarding water use and water resources;
- National aquifer classification and Reserve determinations should be used by CMAs to identify important areas requiring more detailed classification. Special attention must be paid to sole-source aquifers (aquifers that are the only source of water supply) and those where groundwater is important for aquatic and terrestrial ecosystems;
- Water and land-use licensing should be enforced vigorously, particularly in areas underlain by important or vulnerable aquifers;
- The regional offices of DWAF and the CMAs should, in a proactive manner and in co-operation with other authorities, track all new developments in areas underlain by important or vulnerable aquifers. They should participate in the evaluation of EIAs and intervene when impact assessments identify the potential for neglect or damage;
- DWAF, CMAs and groundwater specialists should pro-actively participate in land-use planning and strive to influence the planning so activities with a high groundwater pollution risk are placed in areas with low or no groundwater potential, and
- Compulsory environmental management plans (including groundwater) must be provided for potentially polluting enterprises such as heavy industry, mining, waste disposal and waste water treatment.

5.4 Monitoring

5.4.1 Background

Sound management of all water resources depends on decisions being based on facts rather than beliefs and assumptions. For this reason, monitoring and information systems are critical for successful resource management. Efficient and sustainable use of a catchment's groundwater resources cannot take place without adequate monitoring. Groundwater monitoring in South Africa traditionally has been limited. This has been a major reason for unsustainable groundwater use and failure of groundwater supply schemes. Further, lack of national-scale monitoring has made it difficult to identify emergent trends.

Parsons and Tredoux (1993) and Moss *et al.* (1996) addressed the need for groundwater monitoring, and proposed strategies for implementing national-scale monitoring programmes. Strategies presented by these authors are probably still valid, though cognisance must be taken of the fact that groundwater is now a public resource; resource management will be decentralised and IWRM will form the cornerstone of future resource management. Key strategies presented by the authors included:

- A long-term commitment must be made to implement a national groundwater monitoring programme;
- All national water monitoring networks should be integrated;
- DWAF must make adequate financial and logistical provision to establish and maintain a national groundwater monitoring network;
- Monitoring should be implemented first in priority areas;
- Water users could be used to collect field data;
- Where possible, existing boreholes should be used for monitoring, and
- A national network manager should be appointed to implement the monitoring programme.

Two levels of monitoring are required. Ambient groundwater level and quality fluctuations must be monitored at a catchment level by CMAs. Collected data must be stored and managed by the central authority. Linkage to other national or catchment scale hydrological monitoring is essential if hydrogeological monitoring is to be implemented at an affordable cost. Monitoring of aquifer response to abstraction and potential pollution on a local or site-specific scale may be driven through conditions to licenses and permits. The user undertakes actual data collection while the CMA is responsible for managing the data. Clear guidelines are required regarding monitoring protocols and requirements.

5.4.2 Strategy

To ensure proper management, the following monitoring strategy is proposed:

Implement an ambient hydrogeological monitoring network at a catchment level, with data storage and management facilitated by the central authority.

Drive the monitoring of aquifer response to abstraction and potential pollution by means of licensing and permitting, with the CMA responsible for implementation.

Provide central authority guidance regarding monitoring protocols and requirements, and audit monitoring undertaken at a local scale.

5.4.3 Implementation Plan

- DWAF must establish guidelines for developing catchment level groundwater monitoring networks;
- An integrated water resource monitoring programme should be implemented, allowing for rationalisation of monitoring activities;
- Each CMA must develop and implement a regional aquifer monitoring system;
- Water service development plans must address management and monitoring required for sustainable groundwater use;
- All water use licenses, including bulk water supply, must require groundwater users to monitor static groundwater levels as well as monthly abstraction, and provide the collected data to CMAs every quarter;

- An annual aquifer status report should be compiled by all licensed groundwater users and submitted to the CMA, and
- Monitored data should be readily available to all stakeholders.

5.5 Data and Information Management

5.5.1 Background

Information is the cornerstone of the new water policy and legislation (Braune, 2000b). Availability of timely, adequate, relevant and valid hydrogeological information will be crucial for the future management of South Africa's groundwater resources. It is imperative that collection of new hydrogeological and monitored data (Section 5.4) be accompanied by development of powerful and robust information tools such as databases, information systems, maps, reports and booklets. These are used to provide hydrogeological information to hydrogeological specialists, water resource managers, decision makers and the public, and can greatly support groundwater awareness and promotion campaigns.

Early efforts with respect to hydrogeological information systems included development of the National Groundwater Database (NGDB) and Hydrocom, a package used to interpret data abstracted from the NGDB. This was followed by development of WISH, AQUABASE, MUNIWATER and AGRIWATER. More recently, DWAF investigated implementing REGIS, a Dutch-developed groundwater data storage and interpretation system. A problem with these initiatives is that they have been slow and not fully supported by the hydrogeological community. This has resulted in many practitioners using their own systems, which in turn has led to a very fragmented approach.

Current technology allows for the rapid exchange of data and information over the Internet. This provides an opportunity to collect and disseminate good quality data from groundwater practitioners, CMAs, WUAs and others. However, for an Internet-based system to become a powerful tool, DWAF needs to consider not just its own requirements but also those of the system users. It is logical the central authority should lead and facilitate the development and maintenance of a national hydrogeological information system. Key aspects to be considered include:

- User-friendliness;
- Provision of training and support;
- Standardisation of data formats, units and co-ordination systems;
- Compatibility and integration with other information systems;
- Requirements of a wide range of stakeholders (groundwater practitioners, CMAs, WUAs etc) as well as the central authority;
- Facilitation of data capture from regional or remote stations, as well as exchange of data among organisations; and
- Data authentication and verification.

It is a matter of some urgency that a hydrogeological information system be implemented and used. It will remain DWAF's role to facilitate implementation and promote use amongst the groundwater fraternity.

As data management and information dissemination are envisaged as a national responsibility, these functions are seen as among the major future roles of the Directorate of Geohydrology.

Once an information system has been developed and is being used to capture, exchange and interpreted data, the focus could shift to provision of hydrogeological information to a wider range of stakeholders. These could include water supply managers, agriculturalists, education institutions and the public.

5.5.2 Strategy

Developed and implement a national hydrogeological information system urgently.

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

5.5.3 Implementation Plan

- Continue development and implementation of the National Groundwater database and hydrogeological information systems. These should address national, catchment and local information needs, and promote exchange of data among organisations;
- Establish the information needs of practicing groundwater specialists as well as CMAs, WUAs and other stakeholders;
- Promote the widespread use of the information systems by distributing the software, presenting training courses and providing ongoing support;
- Develop an on-line information service to provide the public with hydrogeological data and information;
- Expand the existing aquifer classification to include regional hydrogeological maps and meet CMA requirements, including identification of priority aquifers and protection needs; and
- Upgrade general authorisation maps on a CMA basis, taking into account local hydrogeological knowledge and a larger scale of delineation.

5.6 Priority Use of Groundwater

5.6.1 Background

In some cases, use of groundwater holds many advantages over surface water, yet groundwater is usually the less preferred option. For this reason promotion of groundwater and its strategic value is proposed as an important strategy (Section 5.11).

The high cost of dam development, surface water treatment and pipeline reticulation result in surface water resources being more expensive to develop than groundwater. This is particularly true in the case of small and medium size water supply schemes. However, groundwater has been valued at unrealistically low levels in the past (Table 2).

Table 2 shows that water costs less in many smaller towns in the drier parts of the country, which rely on groundwater than water supplied from surface water schemes. On average, domestic water use of between 6 and 30 Kℓ supplied from surface water costs approximately R2.50 / Kℓ, while groundwater costs about R1.85 / Kℓ *(Note - the cost of the Klein Karoo Rural Water Supply Scheme was excluded from calculation of the groundwater average as it reflects the difficulty of securing water for the surrounding community)*.

This has led to an under-appreciation of the value of groundwater by local authorities and, in turn, hindered implementation of proper aquifer management and monitoring by the authorities. Realistic and comparable pricing is required to ensure the value of groundwater is properly understood, and to promote appropriate conservation and water demand management.

In spite of current debate about the impact of groundwater abstraction on the environment, groundwater is considered the more environmentally friendly option. According to the World Commission on Dams report, development of surface supply dams has caused enormous environmental damage and resulted in the displacement of 60 million people worldwide. Controlled groundwater abstraction, on the other hand, can have limited effect on the environment. Environmental impacts related to groundwater abstraction are not well understood and require further research (Section 5.12).

TABLE 2: EXAMPLES OF THE UNIT COST OF DOMESTIC WATER (TARIFF STRUCTURES HAVE BEEN ALTERED TO ALLOW FOR COMPARISONS BETWEEN DIFFERENT ORGANISATIONS).

SURFACE WATER	DOMESTIC WATER COST		GROUNDWATER	DOMESTIC WATER COST	
	USAGE RATE (KL)	UNIT COST (R/KL)		USAGE RATE (KL)	UNIT COST (R/KL)
Cape Town	<6 6-30 >30	1.08 2.51 5.46	Beaufort West	< 6 6-30 >30	1.88 2.26 2.56
East London	<6 6-30 >30Kl	1.69 2.32 3.55	Albertinia	<6 6-30 >30	1.65 1.90 4.00
Durban	<6 6-30 >30	0.00 3.27 6.54	Graaff-Reinet	<6 6–30 >30	1.33 1.79 3.99
Pretoria	<6 6-30 >30	2.62 3.44 4.20	Klein Karoo Rural Water Supply Scheme	< 6 6-30 > 30	0.90 3.51 15.34
Rand Water Board	bulk supply	2.04	Tarkastadt		1.74
Amatola Water Board	bulk supply	2.35	Victoria West		1.60
Nelspruit	<6 6-30 >30	1.20 1.73 2.11			

Rural water supply schemes in drier or inaccessible areas are best served by groundwater, as they can be developed close to the point of demand. Aquifers are natures own pipeline system, and the community can undertake management and maintenance of such small groundwater schemes. However, lack of ownership has been identified as a factor in scheme failure, and appropriate training and capacity building are required to address this issue (see Sections 5.9 and 5.10).

Conjunctive use of surface and groundwater maximises the efficient use of a catchment's resources. Conjunctive use management offers promising opportunities to improve the security and future of South Africa's water supply system, particularly in the drier parts of the country, to rural communities and many small towns. Inclusion of artificial recharge could further enhance this approach. Conjunctive use is currently used to only a limited extent. Examples include coastal towns that receive a large influx of visitors during the summer holidays, and use of groundwater and dams in the drier parts of the country like Beaufort West and Graaff-Reinet.

Groundwater can be the better source of water in many instances. When assessing potential sources of water, the option of groundwater must be included. Water resource managers and planners, therefore, need hydrogeological information and expertise available to them so they can consider groundwater options as part of IWRM.

5.6.2 Strategy

Use groundwater in instances where comparison to surface water resources shows it to be economically and environmentally superior.

Promote conjunctive use as a part of integrated water resource management.

5.6.3 Implementation Plan

- Groundwater resources must be realistically costed and aligned with other water sources in a catchment;
- Where appropriate, water management plans should promote conjunctive use of surface and groundwater resources, and
- Assessment of the use of a catchment's surface or groundwater resources must compare the economic and environmental consequences of use for each resource and must use the best resource.

5.7 Institutional Arrangements

5.7.1 Background

Based on the National Water Act (Act 36 of 1998), the NWRS will provide a framework for water resource management at national and regional levels (Rowlston, 2000). The Act also provides for three levels of water management:

- National government (the central authority);
- CMAs; and
- WUAs acting cooperatively at a local level.

CMAs in each of the 19 water management areas will be responsible for water resource management at regional or catchment level. Water service authorities at local government level will be responsible for providing equitable access to water services. Integration of water resource management at all three levels will be achieved through the national water resources strategy, catchment management strategies and water services development plans (Rowlston, 2000). To ensure that groundwater is properly integrated into the future management of South Africa's water resources, the current Directorate of Geohydrology will have to be restructured in accordance with the NWRS.

According to Lazarus (1997), devolution of groundwater management functions to the lowest technically competent level should be encouraged, while retaining a strong central authority for management of the national water resources. The central authority will be required to focus on development of national groundwater management policy and strategy, development and maintenance of databases and information systems, and development of tools and guidelines required for implementation.

When required, the central authority can provide assistance to water resource managers at a catchment or local level. It is envisaged the current Directorate of Geohydrology will fulfill this role.

It is essential each CMA should have its own hydrogeological capabilities to ensure groundwater management is an integral component of any IWRM programme. Exclusion of hydrogeological expertise from the CMA structure will only perpetuate the current situation where groundwater is often excluded from planning and management. It is proposed in Section 5.8 that each CMA have an experienced hydrogeologist in its management structure. This is considered a minimum. Until such time CMAs are established, it is proposed hydrogeologists in DWAF's regional offices assist with the planning and establishment of CMAs. This function could also be outsourced to consultants familiar with the CMA.

The need for the central authority to have representatives in the region (as per the current DWAF structure) is unclear. There is little doubt that CMAs will require hydrogeological support, particularly during the early stages of operation.

Hence it is proposed that Groundwater Advisory Groups be established to provide hydrogeological advice, and help review groundwater reports and management plans to CMAs or groups of CMAs. In addition to the hydrogeologist in the CMA management structure, the Groundwater Advisory Group could comprise hydrogeologists from the central authority and / or consultants. Some small regional presence of the central authority, therefore, will still be required.

A two-tiered institutional model, consisting of a central pool of hydrogeological expertise at national level and hydrogeological expertise incorporated into CMA structures, is proposed. The core function of the national body will be to develop policy, strategies and guidelines, and maintain a hydrogeological information system (implementation and management will be the task of hydrogeologists within CMAs). Groundwater advisory groups are to be established to provide assistance to the CMAs when required.

5.7.2 Strategy

In addition to the strategy to enable hydrogeologists to function within CMAs (Section 5.8), the following stratagems are presented:

Integrate groundwater management with other activities of CMAs.

Establish Groundwater Advisory Groups to provide assistance and guidance to CMAs or groups of CMAs.

Deploy groundwater expertise within the appropriate line functions of the central authority.

5.7.3 Implementation Plan

- Restructuring of the DWAF Directorate of Geohydrology should be in accordance with the NWRS, with hydrogeological expertise being included in all aspects of water resource planning and management at national and catchment level;
- The central authority must facilitate establishment of Groundwater Advisory Boards to provide assistance at catchment and local levels;
- Opportunities must be created for hydrogeologists to be appointed and promoted outside of their line function, either within DWAF, CMAs or other agencies responsible for water resource management, and
- Water Boards and CMAs should be encouraged to appoint hydrogeologists to their staff, while WUAs should liaise with hydrogeologists when required.

5.8 Human Resources

5.8.1 Background

Availability of sufficiently qualified and experienced hydrogeologists is an important requirement for proper implementation of the National Water Act (Act 36 of 1998) and related legislation. An informal survey was undertaken to try to quantify human resources in South Africa that are capable of undertaking groundwater investigations (Tables 3 and 4). Total groundwater expertise in the country comprises about 250 people, of which 77% have university qualifications. At present, 23 students are registered for groundwater-related postgraduate degrees. The survey confirmed that insufficient hydrogeological expertise is available for proper development and management of the nation's groundwater resources.

TABLE 3: KEY STATISTICS REGARDING HYDROGEOLOGICAL EXPERTISE IN THE DIRECTORATE OF GEOHYDROLOGY

	PROFESSIONAL AND TECHNICAL STAFF				NUMBER
	Professional		Technical		
OVERALL GROUNDWATER COMMUNITY (%)	77		23		243
DIRECTORATE OF GEOHYDROLOGY (%)	56		44		57
	PROFESSIONAL QUALIFICATIONS				
	B.Sc	B.Sc (Hons)	M.Sc	Ph.D	
OVERALL GROUNDWATER COMMUNITY (%)	5	35	46	14	171
DIRECTORATE OF GEOHYDROLOGY (%)	9	38	47	6	32
	TECHNICAL QUALIFICATIONS				
	Nat.Dip		B.Tech	M.Tech	
OVERALL GROUNDWATER COMMUNITY (%)	69		27	4	48
DIRECTORATE OF GEOHYDROLOGY (%)	65		30	4	23
	EXPERIENCE				
	<5 yrs	5 – 10 yrs	10 – 15 yrs	>15 yrs	
OVERALL GROUNDWATER COMMUNITY (%)	21	28	13	38	221
DIRECTORATE OF GEOHYDROLOGY (%)	29	29	9	33	45

TABLE 4: DISTRIBUTION OF HYDROGEOLOGICAL EXPERTISE IN THE VARIOUS SECTORS

STATE (%)	PUBLIC CORPORATIONS (%)	UNIVERSITIES (%)	CONSULTANTS (%)	INDUSTRY (%)	TOTAL (N)
27	11	6	54	2	243

The distribution of qualifications and experience within the State is similar those of the overall groundwater community in South Africa. Most groundwater specialists work for the Directorate of Geohydrology. However, 7 staff in the Directorate of Water Quality Management have a tertiary hydrogeological education, while two technically trained personnel work for the Directorates of Water Conservation and Macro Planning & Information Support. It makes sense that the specialised skills remain within a line function. However, it is also critical that groundwater skills and knowledge are spread throughout DWAF to promote a broader acceptance and consideration of managing the country's water resources.

Attrition in the groundwater industry has been relatively high during the past 10 years. Major causes of this include:

- Retirements – 12;
- Emigration – 15; and
- Left industry – 18.

However, the number of students studying groundwater at South African universities has balanced the attrition. On average, some 6-8 students graduate with B.Sc (Hons) degrees each year and about 4 with groundwater-related M.Sc degrees.

Irrespective of future institutional arrangements (Section 5.7), there will be a shortfall of groundwater expertise and experience in all sectors. This is particularly true if the following requirements are considered:

- National policy making and administration;
- Integration of groundwater expertise into all levels of water management;
- Development of groundwater resources to satisfy basic human needs, help alleviate poverty and address imbalances of the past;
- Regional or catchment level groundwater resource development and management;
- Local level resource protection and conservation, including impact assessment and land-use planning;
- Data capture, Reserve determinations and groundwater monitoring, and
- Public awareness and education, including extension to the broad community.

An initiative is required to develop hydrogeological capacity in this country. This will require universities and technikons produce sufficient good quality students (Section 5.9), while the public and private sectors provide attractive opportunities for employment as well as personal growth and development.

5.8.2 Strategy

Strategies required to address the lack of groundwater capacity in South Africa are addressed in Sections 5.9, 5.10 and 5.12. However, two strategies are proposed here as means of ensuring that groundwater is effectively included in IWRM:

Ensure active participation of experienced hydrogeologists in the planning and management hierarchies of both DWAF and CMAs.

Integrate at least three hydrogeologists into each CMA (senior professional, junior professional, senior technician), although these resources can be outsourced when required.

5.8.3 Implementation Plan

Given the current state with respect to the availability of human resources, it is unlikely the above two strategies can be implemented in the short to medium term. As a means of starting to address the above needs, the following shorter term action plan is proposed:

- Hold a strategic planning workshop with a view to attain the following: identify CMAs with the greatest need for hydrogeological expertise; evaluate human resources available for deployment to the CMAs; and consider methods of recruiting personnel with the required expertise and experience, so that priority human resource needs can be met;
- Give priority to education and training of a hydrogeological workforce (see Section 5.9). This will require financing and other support to tertiary institutions, which should be judged on the number and quality of postgraduate students produced;
- Develop, as a partnership between public, private and academic institutions, a national strategy with regard to human resource development in the water sector;
- Second one experienced hydrogeologist to the Chief Directorate: Planning as a means of promoting integrated water resource management within DWAF, and
- Create a reliable database of available hydrogeological expertise in South Africa, which can be used as a basis for outsourcing.

5.9 Education and Training

5.9.1 Background

This section relates specifically to education and training of specialist hydrogeologists. Section 5.10 deals with building hydrogeological capacity within the broader hydrological community as well as other stakeholders.

The National Water Act (Act 36 of 1998) recognises groundwater as an integral part of hydrologic cycle. The white paper on a national water policy for South Africa states as one of its principles that “in a relatively arid country such as South Africa, it is necessary to recognise the unity of the water cycle and the interdependence of its elements, where evaporation, clouds and rainfall are linked to groundwater, rivers, lakes, wetlands and the sea, and where the basic hydrological unit is the catchment” (DWAF, 1997). Introduction of new water resource management terminologies, not specific to a single discipline, requires a broader understanding of multidisciplinary concepts. Hydrogeological education and training need to take cognisance of this, so hydrogeologists can function effectively in an IWRM environment.

Education and training are considered key to ensuring sustainable management of groundwater resources. However, specialist groundwater tertiary education is not widely offered in South Africa. Only the universities of the Orange Free State and Western Cape offer postgraduate hydrogeology courses. Some undergraduate and less specialised postgraduate training is offered at the University of Natal, University of the North, University of Pretoria, University of Venda and University of Zululand, but is included in general curricula related to geography, geology or hydrology. Only one technikon offers any formal groundwater training.

Given the lack of sufficient hydrogeological expertise (Section 5.8), an in-depth assessment of current education and training capacities and approaches is required. Though there is a need for the two specialist universities to retain a strong focus on groundwater training, curricula at these universities need to include IWRM in their courses. Similarly, institutions that present more general hydrology courses need to improve the standard of groundwater training in their programmes. Inter-university collaboration with respect to both lecturing and research is proposed as a means to improve the standard of hydrogeological training and promote a broader understanding of cross-disciplinary understanding. To promote collaboration and ensure a co-ordinated approach to groundwater training in South Africa, it is proposed a Co-ordinating Committee for Groundwater Education and Training (CCGET) be established.

A key aspect to be addressed is the development of recently qualified graduates. Internships or mentorship programmes are required, so recently qualified students can effectively help in the proper management of the country's groundwater resources as soon after graduation as possible. Traditionally, many graduates joined DWAF or public corporations where they acquire experience under the supervision of experienced hydrogeologists. With the function of DWAF changing, and economic pressure placed on public corporations, this is unlikely to continue. Therefore, it is proposed that an internship programme be established so recent graduates, particularly those who join the central water authority and CMAs, can develop practical skills as quickly as possible.

Continuing education of already qualified hydrogeologists is also required. To ensure the level of hydrogeological expertise available in the country remains at an appropriate standard, continuing hydrogeological education programmes are required. These include both conferences and specialised short courses. Here the learned societies, such as the Ground Water Division and International Association of Hydrogeologists, in collaboration with universities and public and private sectors, could play an important role. The CCGET could also fulfill a meaningful part in this regard.

5.9.2 Strategy

Two strategies were identified regarding educational and training needs for the groundwater sector:

Develop and promote specialist groundwater education and training programmes, which include an IWRM component.

Include principles of IWRM in all water related education and training curricula.

5.9.3 Implementation Plan

- Redesign groundwater education and training activities to include IWRM principles;
- Establish a Co-ordinating Committee for Groundwater Education and Training (CGET) to promote collaboration between education and training institutions;

- Establish a national discussion forum to assist with development of a consistent set of terms to be used for water resource management education and training at tertiary institutions;
- Develop and present continuing groundwater education and training programmes, and
- Develop and promote links between the groundwater industry and tertiary education institutions with a view to establish internships for undergraduate and postgraduate students.

5.10 Capacity Building

5.10.1 Background

The term 'capacity building' has a wide range of meanings. In a South Africa context, it often refers to training and skills development of members of previously disadvantaged groups or women. However, in context of this report, it refers to development of non-specialist groundwater skills within the broader hydrological community and the public. Further, the term refers to both individuals and institutions.

Groundwater training programmes are available at universities and technikons (Section 5.9). Training, in the form of short courses, is also offered by the groundwater industry. A concerted effort is required to develop tailored courses to enable capacity building among the broader hydrological community and stakeholders in general. Courses need to target: undergraduate and postgraduate programmes (agriculture, engineering, environmental, geography, hydrology, limnology etc); graduates currently active in the sphere of water (agriculture, engineers, environmentalists; water resource planners; water utility companies, etc.) and stakeholders outside the profession (community leaders, NGOs, politicians). Capacity building should be linked to initiatives to promote groundwater (Section 5.11), and should be considered important for those involved with the establishment of CMAs.

The groundwater community must play an important role in developing an understanding of groundwater by those outside the profession. Hydrogeologists must regularly interact with their colleagues. This is particularly true of DWAF and the soon to be instituted CMAs. By merely exchanging thoughts and ideas, hydrogeologists could help to ensure that their colleagues consider groundwater and that they have a better understanding of the role and mechanics of subsurface systems. In the same way, by regularly presenting talks to schools, community groups and professional societies, the groundwater community could readily help build capacity.

5.10.2 Strategy

Enhance the capacity of non-specialists with respect to groundwater management as an integral part of IWRM.

Enable institutions, including historically disadvantaged institutions, to sustain development of well-qualified water managers.

5.10.3 Implementation Plan

- Improve the capacity of non-specialists, through various education and training programmes with respect to groundwater management as part of IWRM, and
- Develop guidelines to strengthen water research capabilities at various institutions, including the historically disadvantaged, consistent with national research needs and priorities.

5.11 Promotion of Groundwater

5.11.1 Background

Unfortunately, groundwater resources are poorly understood or appreciated by people outside the profession. This includes both water resources professionals and the general public. Yet about 15-million South Africans rely on groundwater to some degree, particularly in the drier western portion of the country. As part of the RDP programme, the basic water needs of some 4-million South Africans have been met in the last 6 years by groundwater supplies.

It is beyond the scope of this document to address the reasons for groundwater's Cinderella status. Fortunately, however, there is a growing realisation that groundwater has a key role in the attainment of the country's RDP goals. Prominence of groundwater as an environmental issue has also increased in recent times, albeit often as a means of blocking a particular development. Awareness among the public is seen as the only permanent guard against degradation of groundwater. Though it is perceived the role of groundwater is gradually being appreciated, the resource is still not effectively integrated into water resource management, environmental planning or land-use management.

Groundwater has several important features and characteristics that must be conveyed to decision makers, resource managers and planners, as well as to the public. These include:

- Groundwater is often present where surface water is not. Consequently, groundwater is an ideal source of water for small rural communities, villages, small towns and coastal holiday resorts with high summer demand;
- It is usually significantly cheaper to develop and manage groundwater resources than surface water;
- The quality of groundwater is such that it does not generally require treatment prior to reticulation, particularly if protected against contamination;
- It is generally far more environmentally friendly to develop groundwater resources than dams; and
- Groundwater usually is less susceptible to variations in rainfall and periods of drought.

Based on a series of interviews during the current project, decision-makers and managers complained that hydrogeologists seldom present information that can be understood readily by the layman. Another criticism was that most hydrogeologists fail to provide clear guidance with respect to groundwater resources. Though a clear need exists for groundwater-related information systems, an even greater need exists to communicate easily understandable information to decision-makers, water resource managers and the public.

Recent publication of national and regional scale hydrogeological maps supplied the first mechanism for easily providing hydrogeological information in a systematic manner. As the regional mapping exercise draws to completion, the focus needs to shift towards providing more detailed information, as well as providing data and information by electronic means. Information should be presented in a generic format for use in schools and by the broader populace, as well as in a sufficiently technical format for use by water resource planners and decision makers. This issue is also addressed in Section 5.5.

Though no study has been done to assess the chief cause of groundwater supply scheme failure, it is suspected by the groundwater professionals that poor scheme management is the chief cause of failure. Lack of information and inadequate training probably contribute to this. A need for ongoing extension, similar to that provided by the Department of Agriculture, could be a means of reducing failure and improving the image of groundwater.

A major multilevel groundwater promotion drive is required to empower people to use and protect groundwater resources, and to promote integrated water resource planning, development and management. The American Groundwater Trust provides an example of the sort of vehicle that can be used to promote the resource. The Rennies Wetland Project is a local example of how to grow public awareness effectively. During a recent workshop to discuss groundwater education, a number of tactics were identified which would facilitate successful promotion and awareness. These include:

- The promoter should be independent of other organisations;
- Groups with similar interests, values and objectives should be involved; and
- The resource should be promoted such that people clearly understand *what* is being promoted so they can support the programme with commitment and passion.

The promotion and awareness campaign should include information about the resource as well as successful use of groundwater resources. In this way the value of the resource, economically and otherwise, could be both demonstrated and established. Such a campaign, which has strong support from the groundwater community, would greatly assist in capacity building addressed in Section 5.10.

Dissemination of information and popularisation of groundwater could have an important positive benefit in that more students could be attracted to the discipline. In turn, this could help alleviate the human resource shortages addressed in Section 5.8, as well as increase funding to tertiary education institutions that provide groundwater training. Introducing high school students to the subject of groundwater could be an important tactic in the overall campaign.

Funding for such a promotional campaign will be critical. In the long term, the campaign should be self-funding. However, seed money will be required for about five years to establish the campaign. It is proposed that DWAF and the WRC be approached to initiate the campaign, but the campaign manager or co-ordinator be tasked to solicit sponsorship from industry in general and the groundwater fraternity in particular.

5.11.2 Strategy

Four formal strategies have been identified to promote groundwater. However, it is felt the groundwater fraternity in general also needs to adopt a policy and practice of promoting groundwater at every opportunity.

Initiate a multilevel information campaign to promote knowledge and awareness of groundwater. Popularise groundwater among the upper DWAF hierarchy.

Establish a South African Groundwater Trust to develop and lead a multilevel awareness and education campaign, both inside and outside the public sectors.

Disseminate information about successful groundwater schemes, while offering reasons for the failure of less successful projects.

Encourage the hydrogeological fraternity to regularly present lectures and talks to schools, business organisations, learned societies, environmental societies etc.

A fifth strategy relating to inclusion of short courses on groundwater in engineering, hydrology, limnology, agriculture, environmental and related curricula is addressed in Section 5.10.

5.11.3 Implementation Plan

As custodians of South Africa's groundwater resources, DWAF would benefit significantly if groundwater were effectively promoted. Thus it is proposed DWAF play an important role in initiating the groundwater promotion campaign. It is proposed public corporations; universities, consultants and NGOs active in the groundwater arena should also participate. It is further proposed a public-private partnership be established, which should include professional and learned societies. The following plan is proposed to initiate the promotion campaign:

- Universities and technikons should include water resource planning, integrated water resource management principles and communication skills (both written and verbal) in their curricula;
- Information packs and practical demonstrations should be prepared and distributed to high school teachers;
- A research project should be undertaken to quantify groundwater use in South Africa. This research should form the basis of a 'popular' document recording successful groundwater supply schemes in the country;
- Professional societies and employers should encourage and support efforts to disseminate information to the broader public. Some funding will be required to generate and distribute materials such as posters, booklets and other promotional material;
- Practitioners need to adopt a positive and proactive approach when interacting with other water resource managers. Both public and private sectors require a high level of commitment and passion if groundwater is to be promoted as viable source of water;
- The American Groundwater Trust should be approached to help set up a similar organisation in South Africa. A suitable director will have to be appointed and funding secured to make this initiative viable; and
- An investigation should be launched into the establishment of groundwater extension services in all (or priority) CMAs.

5.12 Research Needs

5.12.1 Background

Groundwater research in South Africa is guided, to a large degree, by the Water Research Commission. Most research is undertaken by universities and public corporations and, to a lesser extent, consultants and non-government organisations. Little is known about groundwater-related, in-house research undertaken by the mining and industrial sectors. Universities that have undertaken groundwater-related research in the recent past include the University of the Free State, University of the Western Cape, University of Zululand, Witwatersrand University and University of the North.

Public corporations that undertake groundwater research include the CSIR, Council for Geoscience and Agricultural Research Institute. These organisations obtain external funding as well as fund research projects internally. In-house funded projects are undertaken at the discretion of the organisation, the results of which tend to remain proprietary.

The Co-ordinating Committee for Groundwater Research, a committee constituted by the Water Research Commission, assesses groundwater research needs. The committee comprises a diverse range of groundwater scientists as well as scientists and engineers from related disciplines. A recent meeting of the committee addressed the need to change the focus of groundwater research in response to national priorities to eradicate poverty and promote economic development. Provision of basic needs for all South Africans and equity are key issues.

It is beyond the scope of this report to give a detailed account of groundwater research needs in South Africa. However, several research needs that are specific to integrating groundwater into the NWRS have been identified. These include:

- Development of hydrogeological handbooks and best practice guides;
- Quantification of groundwater use in South Africa;
- Investigation into the impact of groundwater abstraction on the broader environment;
- Development of interactive hydrogeological information systems, and
- Development and implementation of a national hydrogeological monitoring system.

In addition, research requirements and issues resulting from the democratisation of South Africa in 1994, and the promulgation of the National Water Act (Act 36 of 1998), resulted in the identification of an additional set of groundwater research needs. Implicit was the need to integrate groundwater into water resource management. This is probably best highlighted by groundwater tools required to quantify the Reserve and set resource quality objectives.

Recognition of a unitary hydrological system and groundwater as a public resource has led to all components of a water resource being included in the definition of water resources (Section 3.2). By definition, the Water Act requires an integrated approach to water resource management. This requires a paradigm-shift from current methods of planning and managing catchments, water resources and water supply schemes. Breaking traditional disciplinary boundaries is an important challenge to be addressed before true integration can be achieved.

Any research undertaken in South Africa must take cognisance of the need to accelerate development of hydrogeological skills within the country, as well as the need to develop groundwater capacity within the broader hydrological community. Further, research can play an important role in facilitating racial and gender transformation in the hydrological community in general, and the hydrogeological community in particular. These aspects are addressed in Sections 5.9 and 5.10.

5.12.2 Strategy

Funders of research must be made aware of the need for integrated water resource management. Strategies to attain awareness include:

Promote relevant and applied groundwater-related research, so that practicing hydrogeologists have both knowledge and the appropriate tools to manage South Africa's groundwater resources in an integrated manner.

Use research as a vehicle to accelerate education, capacity building, transformation and implementation of integrated water resource management.

5.12.3 Implementation Plan

Promotion of the need for integrated research can be included in the strategy to promote groundwater (Section 5.11). It will be important to ensure funders of research are aware of the need for integrated water resource management. They should be encouraged to favour multidisciplinary research teams that aim to promote integrated water resource management. Researchers, however, can use this strategy to overcome current limitation on groundwater research imposed by limited funding by:

- Form integrated and collaborative research teams, and submit proposals to target different areas of research funding;
- Develop interactive database systems for easier access and exchange of information;
- Target other sources of funds, local and international, which traditionally do not support groundwater related projects, and
- Encourage CMAs to undertake collaborative research with universities.

5.13 Summary of Strategies

Integration of groundwater into IWRM is the philosophy upon which the NWRS is to be based. In this report, twenty-nine strategies aimed at attaining integration are presented. It is clear groundwater can only be properly incorporated into national or catchment scale water resource management when most, if not all, of these strategies have been addressed. Implementation of the National Water Act (Act 36 of 1998) and establishment of CMAs provide a unique opportunity to instigate the paradigm-shift necessary to optimally develop and manage water resources in South Africa. The following five core strategies have been identified as the most important with regard to initiating the required change:

- Integrate groundwater into the management of water resources for the benefit of all of South Africa's peoples;
- Promote groundwater so that water resource managers, water users and the public are more aware of the role, occurrence and value of groundwater;
- Encourage and enable hydrogeologists to work outside their line function, and be integrated into the broader water resource planning and management functions;
- A larger, skilled and experienced specialist hydrogeological workforce is required, and
- Groundwater monitoring, and development of a hydrogeological information system, are required to assist in the provision of data to those who need it.

6 IMPLEMENTATION

If groundwater is to be included in IWRM, management of groundwater has to comply with the policy, strategy and practice of water resource management in South Africa. Where management practices must differ from, or be modified to accommodate unique hydrogeological characteristics, a clear statement is required from the Directorate of Geohydrology as to why the policy, strategy or practice applied in IWRM cannot be applied to the management of groundwater.

It is interesting to note a series of issues raised by Lazarus (1997) relating to practical problems experienced in managing South Africa's groundwater resources. Many of the problems, still relevant today, relate largely to the separate manner in which groundwater is managed. In essence, five core strategies are proposed to change the traditional approach and ensure successful implementation of IWRM in South Africa:

- Integrate groundwater into the management of water resources for the benefit of all of South Africa's peoples;
- Promote groundwater so that water resource managers, water users and the public are more aware of the role, occurrence and value of groundwater;
- Encourage and enable hydrogeologists to work outside their line function, and be integrated into the broader water resource planning and management functions;
- Develop a larger, skilled and experienced specialist hydrogeological workforce, and
- Develop a groundwater monitoring network and a hydrogeological information system to assist in the provision of data to those who need it.

By focusing on these core strategies, groundwater can be included into IWRM in South Africa. Implementation of CMAs in three priority catchments, as part of the DANCED-funded project, provides an opportunity to implement and test many of the strategies presented in this report. Secondment of an experienced hydrogeologist to form part of the management team of each CMA, and inclusion of a groundwater component in the required catchment management plans will go a long way to ensure correct IWRM implementation.

At a national (or central authority) level, it is proposed that an experienced hydrogeologist be seconded to the DWAF Directorate of Strategic Planning. In this way, groundwater considerations can be included during the early stages of planning. The hydrogeologist, however, will have to maintain a strong link to the Directorate of Geohydrology to ensure the Directorate can provide hydrogeological input and support to the national water resource management effort. Similarly, the Groundwater Advisory Group should be established to provide support to the CMAs.

The fact that groundwater is used as a source of water for more than 15-million South Africans clearly demonstrate the importance of the resource. It is no longer acceptable to manage groundwater in a separate manner. Bold initiatives are required to ensure IWRM can be implemented at a national, catchment and local level. Implementation of the strategies presented in this report, and particularly the five core strategies identified in this section, will provide a mechanism for attaining the required paradigm shift.

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