A Framework for Groundwater Management of Community Water Supply

the dwaf
DEPARTMENT OF WATER AFFAIRS AND FORESTRY

NORAD
DIREKTORATET FOR UTVIKLINGSSAMARBEID
NORWEGIAN AGENCY FOR DEVELOPMENT COOPERATION

TOOLKIT for WATER SERVICES: Number 1.1

The purpose of this document is to provide a framework for managing groundwater in rural water supply schemes. The target audience is primarily Water Services Authorities, Water Services Providers and Catchment Management Agencies.

A Framework for Groundwater Management of Community Water Supply

Published by
Department of Water Affairs and Forestry
Directorate: Information Programmes
Private Bag X313
PRETORIA 0001
Republic of South Africa
Tel: (012) 336 7500

Implemented by
CSIR

Written by
Phillip Ravenscroft and Ricky Murray

Editing
Anthea Josias and Kerry Harris

Artwork
Vusi Malindi

Layout and design
Gill McDowell

Inputs
Boniface Aleobua, Katia del Resario, Hugh Sussens, Eddy van Wyk, Abri Vermeulen
The municipalities of Chris Hani, Capricorn, uThukela and Kamiesberg

Produced under:
The NORAD-Assisted Programme for the Sustainable Development of Groundwater Sources under the Community Water and Sanitation Programme in South Africa

Foreword

Toolkit for Water Services

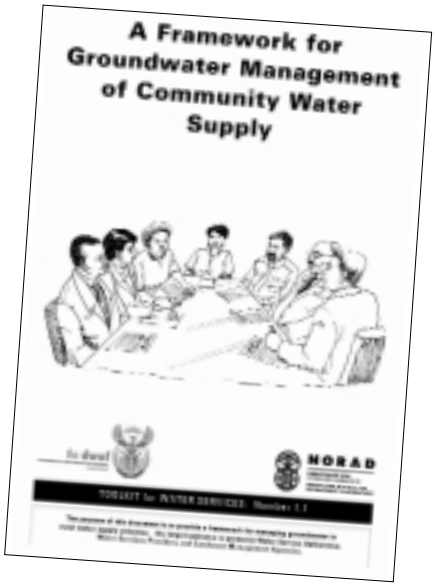
Groundwater has historically been given limited attention, and has not been perceived as an important water resource, in South Africa. This is reflected in general statistics showing that only 13 % of the nation's total water supply originate from groundwater. However, because of the highly distributed nature of the water demand in rural and informal peri-urban settlements, regional schemes are, in most instances, not economically feasible. And because of generally increasing water scarcity and decreasing available river and spring flows during low flow and drought periods, as well as wide-spread problems of surface water pollution in rural areas, groundwater will be the most feasible option for a large part of the new water demand. Already it is estimated that over sixty percent of community water supply is from groundwater, making it a strategically important resource.

The NORAD-Assisted Programme for the Sustainable Development of Groundwater Sources under the Community Water and Sanitation Programme in South Africa was managed by the Department of Water Affairs and Forestry (DWAF) between 2000 and 2004. The Programme undertook a series of inter-related projects aimed at enhancing capacity of water services authorities and DWAF to promote and implement sustainable rural water supply schemes based on groundwater resources and appropriate technologies.

Page 2 has a full list of the Programme outputs. The formats for these range from documents to software programmes and an internet portal, to reference sites where communities have implemented appropriate technologies. For more information on the "package" of Programme outputs contact your nearest DWAF Regional Office or Head Office in Pretoria.

It is our sincere hope that this Programme will contribute to the body of work that exists to enable more appropriate use and management of groundwater in South Africa.

A Framework for Groundwater Management of Community Water Supply is Number 1.1 in the Toolkit for Water Services. The purpose of this document is to provide a framework for managing groundwater in rural water supply schemes. The target audience is primarily Water Service Authorities, Water Services Providers and Catchment Management Agencies.



Toolkit for Water Services

1 Overview documentation

1.1 A Framework for Groundwater Management of Community Water Supply

1.2 Implementing a Rural Groundwater Management System: a step-by-step guide

2 Descriptors

2.1 Standard Descriptors for Geosites

3 Groundwater Protection

3.1 Involving community members in a hydrocensus
3.2 Guidelines for protecting springs
3.3 Guidelines for protecting boreholes and wells
3.4 Guidelines on protecting groundwater from contamination
3.4.1 Animal kraals, watering points and dipping tanks
3.4.2 Burial sites
3.4.3 Informal vehicle servicing, spray painting and parts washing facilities
3.4.4 Pit latrines
3.4.5 Runoff water
3.4.6 Subsistence agriculture
3.4.7 Informal waste disposal

4 Maps

4.1 Thematic Groundwater Maps

5 Software

5.1 Sustainability Indexing Tool (SusIT)
5.1.1 SusIT User Guide
5.1.2 SusIT Field Data Capturer's User Manual
5.1.3 SusIT Questionnaire
5.1.4 SusIT Information Brochure
5.2 AquiMon Management System
5.2.1 AquiMon Information Brochure
5.3 Geohydrological Data Access System (GDAS)
5.3.1 GDAS Information Brochure

6 Monitoring

6.1 Groundwater Monitoring for Pump Operators

7 Sustainability

7.1 Sustainability Best Practices Guidelines for Rural Water Services
7.2 Introductory Guide to Appropriate Solutions for Water and Sanitation
7.3 Decision Making Framework for Municipalities

8 Reference Sites

8.1 Genadendal Information Brochure
8.2 Kammiesberg Information Brochure
8.3 Maputaland Information Brochure

Table of Contents

Acronyms

CBO	Community-Based Organisation
CMA	Catchment Management Agency
CWSS	Community Water Supply and Sanitation
DPLG	Department of Provincial and Local Government
DWAF	Department of Water Affairs and Forestry
O&M	Operation and Maintenance
SABS	South African Bureau of Standards
SANS	South African National Standards
SSA	Support Services Agent
WMA	Water Management Area
WRM	Water Resource Management
WSA	Water Services Authority
WSDP	Water Services Development Plan
WSP	Water Services Provider
WSPC	Water Services Provision Contract
WUA	Water User Association

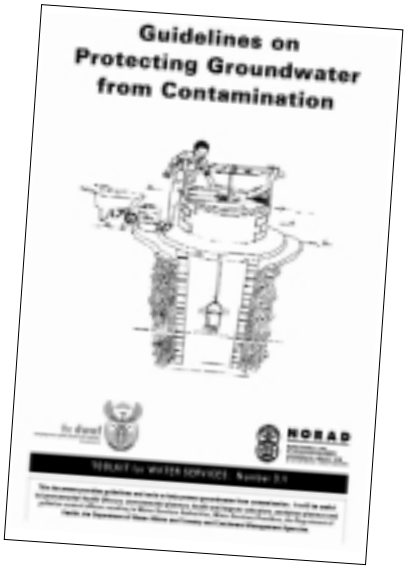
1 Introduction

The need for rural groundwater management

Since 1994, when the Department of Water Affairs and Forestry (DWAF) published the first *White Paper on Water Supply and Sanitation* under the new government, significant changes have been made in the rural water supply and sanitation sector. Initially the focus was on service delivery. Whilst this remains a key priority, it has become evident that increasing emphasis needs to be placed on the institutions responsible for managing water services. This is recognised in the *Strategic Framework for Water Services* (DWAF, 2003) and the *Proposed National Water Resource Strategy* (DWAF, 2002) as an area that needs more attention if water resources, the foundation of thousands of rural water supply schemes, are to be managed in a sustainable manner.

Groundwater management can be grouped into five main areas:

i. Fulfilling legal obligations (i.e. ensuring use and protection of groundwater according to national and international laws).
ii. Monitoring and analysing data (e.g. groundwater levels and abstraction).
iii. Optimising groundwater usage.
iv. Protecting groundwater from contamination.
v. Creating awareness and educating people about sustainable groundwater use.



This document focuses on defining groundwater management responsibilities for community water supply purposes. In particular, it describes the actions needed to prevent over-abstraction (i.e. items ii and iii above). The document also describes the legal obligations of relevant institutions (item i above), but does not include the legal and managemen requirements for licensing, monitoring and assessing polluting activities in rural areas (such as mining, industry and agriculture). Guidelines for protecting groundwater from various sources of contamination are covered in the ***Groundwater Protection*** Toolkit for Water Services, Number 3.

This document presents a system for groundwater resource management of rural water supply schemes. It describes how data should be collected in rural areas, and how this information should be transferred to those people who are capable of, and have the authority to, make water resource management (WRM) decisions. It describes the roles and responsibilities of each institution in the WRM chain. Although a single groundwater management system is recommended, different models are presented to accommodate differences in institutional capacities and institutional preferences regarding water management roles and responsibilities.

The groundwater management system has a dual function.

The first is groundwater resource (or aquifer) management. That is, to provide data to ensure that the aquifer is not being over-pumped. Over-abstraction not only implies non-sustainability, but the effect of excessive pumping may also induce poorer quality water into the wellfield / boreholes. It is unlikely that a large aquifer that is penetrated by a single borehole will be over-pumped. However, where aquifers are of limited extent, or where a number of competing users depend on a single aquifer, they can be over-pumped. This problem is most likely to occur during droughts when the effect of mismanagement is most severe.

The second function is to provide data that will be of use in optimising the operation of the scheme. That is, it will contribute to the information needed to ensure sustainable Operation and Maintenance (O&M). A key issue here is to ensure that pumps are set at the appropriate discharge rates for a borehole. This prevents excessive heads and pump failures.

The success of this system depends heavily on whether WRM can be successfully integrated into the O&M schedule of groundwater supply schemes. Fundamental to this, is that the proposed groundwater management system provides an appropriate and robust mechanism for recommendations, to be transferred into actions at the pump operator level.

This document presents a groundwater management system for rural water supply schemes. It is hoped that the system is flexible enough to accommodate all areas within South Africa, and that it will be appropriate irrespective of the institutional model of any given area.

Whilst this document provides the framework for groundwater management, a supporting document entitled ***Implementing a rural groundwater management system: a step-by-step guide*** (Toolkit for Water Services, Number 1.2) provides a detailed description on how to set up, support and operate a rural groundwater management system.

The origin of this document

In 1998 the CSIR circulated a discussion document entitled *Towards a framework for rural groundwater management* (Murray and Dindar, 1998). This discussion document recommended a groundwater management system, despite the fact that there was a lack of clarity at the time as to who was legally responsible for groundwater management in rural water supply schemes. Since 1998, the roles and responsibilities of water services institutions have been clarified and, in some cases, changed. Although the responsibility for rural groundwater management has not been spelt out in either the Water Services Act (1997) or the National Water Act (1998), it is now clearer from licensing conditions and recently defined responsibilities of Water Services Authorities (WSAs), where this responsibility should reside.

The conceptualisation and implementation of the NORAD-Assisted Programme for the Sustainable Development of Groundwater Sources under the Community Water and Sanitation (CWSS) Programme in South Africa, in 2000, has enabled a revision of the CSIR document. This revision, while based on the Murray and Dindar (1998) document, contains new recommendations for a framework for rural groundwater management. It has taken cognisance of developments in the water sector since 1998, and is based on field experiences in three pilot study areas (the Chris Hani District Municipality in the Eastern Cape Province, the Capricorn District Municipality in the Limpopo Province and the Uthukela District Municipality in the KwaZulu-Natal Province).

The aims of this document

The aim of this document is to provide a framework for managing groundwater in rural water supply schemes. The target audience is primarily WSAs, Water Services Providers (WSPs) and Catchment Management Agencies (CMAs).

It covers:

- DWAFs vision for rural groundwater monitoring and management.
- The need for rural groundwater management.
- Institutions' legal responsibilities relating to groundwater management in rural community water supplies.
- A proposed groundwater management system.
- The tasks required for groundwater management.

Not covered in this document, but included in the Toolkit for Water Services (documents numbers in brackets), and relevant to groundwater management, are:

- Implementing a rural groundwater management system: a step-by-step guide (including a description of tools required for recording and analysing data; and resources needed to facilitate the implementation of a rural groundwater management system; (Number 1.2).
- A computer-based management tool (Number 5.2).
- A guide to assist pump operators in the monitoring of groundwater (including guidelines on how to collect groundwater information; basic information on types of pumps; and basic information on types of electric switches) (Number 6.1).
- Information packs on contaminant sources in rural areas and "best practice" guidelines on minimising pollution (Number 3.4).

Groundwater management in the broader context of WRM is described in DWAF (2002a), a guideline document focusing on integrated groundwater management at a regional and Water Management Area (WMA) level, and aimed at catchment managers.

2 The Legal Framework

The legal framework for the provision of water services[1]

Legislation concerning the water and local government sectors have been finalised in recent years. The most important laws are:

- The Constitution of the Republic of South Africa (1996), which assigns the responsibility of ensuring access to water services to local government. The role of the national and provincial spheres of government is to support, monitor an regulate local government.
- The Water Services Act (1997) further defines the municipal functions of ensuring water services provision.
- The National Water Act (1998) defines a new way of managing South Africa's scarce water resources. This Act states that water is an indivisible national resource for which national government is the custodian.
- The Local Government: Municipal Demarcation Act (1998) provides a legal framework for defining and implementing a post-transitional system of local government.
- The Local Government: Municipal Structures Act (1998) defines types and structures of municipalities. Three categories of municipalities exist in South Africa: Category A (Metropolitan), Category B (Local), Category C (District).
- The Local Government: Municipal Systems Act (2000) defines how local government should operate, and allows for various types of partnership arrangements that a municipality may enter into to ensure delivery of services.
- The Local Government: Municipal Structures Amendment Act (2000) places the function of ensuring access to water services (as well as health, electricity and waste disposal) at a district level, unless a local municipality is authorised to perform this function.

In addition to these legal documents, a guideline on implementing the division of powers and functions for water and sanitation services has been drafted (Department of Provincial and Local Government and DWAF, 2003).

1 Vermeulen, 2002

The legal framework for monitoring

i. Abstraction

The National Water Act (1998) sets the framework for CMAs to stipulate that groundwater abstraction and quality be monitored. Currently all users that abstract more than 10kL of water per day from one or more boreholes are required to register this water use (DWAF 2000a). In addition to registration, they will have to obtain an abstraction license, unless they are covered by a general authorisation (section 39 of the National Water Act, 1998). The conditions of the license will include the requirement that the user monitor the quantity and quality of water abstracted, and report this information to the CMA.

ii. Groundwater level monitoring

The DWAF guideline document entitled *Minimum Standards and Guidelines for Groundwater Resource Development for the Community Water Supply and Sanitation Programme* (1997), stipulates that a borehole should be fitted with a piezometer tube (section 4), and it stipulates the extent of groundwater monitoring training that should be provided (section 5).

The National Water Act (1998) specifies that national monitoring systems on water resources must be established with the purpose of, among other matters, assessing the quantity of water in various water resources and compliance with resource quality objectives. This implies that groundwater levels need to be monitored, but the Act is not specific on monitoring requirements. The Act allows for such requirements (and reporting to the CMA) to be specified in the license conditions.

iii. Water quality monitoring

The Compulsory National Standards (section 9(1)) were published as a Government Notice (No. 22355) on 8 June 2001. These standards are regulations from the Minister of Water Affairs and Forestry, and are in line with the provisions made in the Water Services Act (1997). In terms of these regulations, all WSAs must have a programme for sampling the quality of supplied water, by June 2003, and this should be included in the Water Services Development Plan (WSDP) of the WSA.

Since "supplied water" is the focus of water-sampling programmes in WSDPs, most samples will be taken from standpipes. It is likely that samples of groundwater prior to conveyance and storage will be left out of these sampling plans. The license agreement, as stipulated in the National Water Act (1998), however, will contain conditions regarding water quality monitoring at the borehole(s).

3 DWAFs Vision for Groundwater Monitoring

Water services institutions

In terms of the government legislation listed above, the responsibility for the provision of water services is located with the WSA. In metropolitan areas, the WSA is the Metropolitan Municipality, while in most other areas, the WSA is the District Municipality. A number of Local Municipalities have been authorised to execute WSA functions (DPLG and DWAF, 2003).

Although the WSA is responsible for ensuring that everyone has access to water services, it can appoint WSPs and water services intermediaries to provide water services on its behalf.

Current status of water services provision

While the legislative framework is clear, the practical realities are more complex. Many DWAF-implemented water projects have yet to be transferred to the responsible WSAs. A similar situation exists for projects implemented through other implementing agents and non-governmental organisations. DWAF has a programme in place for transferring schemes, and it is envisaged that the projects (and in some cases the operating divisions responsible for them) will be transferred within the next few years. A contentious issue in the transfer process relates to those projects which are not fully functional.

Uncertainty in ownership and O&M responsibilities in the area of water services provision to rural communities has contributed towards little effective O&M management and even less so to groundwater management. The free basic water policy has also complicated the management issue, particularly for community-operated schemes where knowledge of free basic water in some instances, appears to have contributed to non-payment and the subsequent disuse of schemes.

DWAFs vision for groundwater monitoring

DWAF recognises four “types” of groundwater monitoring (simplified in **Table 1**). These are based on the monitoring guidelines of the UN / ECE Task Force on Monitoring & Assessment (2000) and are defined according to the purpose of monitoring. In most cases, the level of monitoring for community water supplies will fall into Type 2 (Regulatory Monitoring).

Table 1: DWAFs monitoring types (simplified)

Reference number	Type	Objectives	Purpose
1	Reference (natural conditions)	To establish the background (reference) situation.	To determine, for example: - the status of natural conditions (i.e. conditions not impacted by humans) - natural groundwater behaviour and long-term trends - the relationship between surface and groundwater.
2	Regulatory monitoring (compliance)	To monitor authorised activities that affect groundwater, e.g. groundwater usage, waste management, potential polluting activities, etc.	To determine the impact of anthropogenic activities on groundwater, and to control these activities according to management objectives and regulations (such as license conditions).
3	Specific purpose monitoring	To meet specific objectives not covered in Types 1,2 and 4.	To meet particular objectives, for example: - to research specific aspects of groundwaterflow or chemistry; - to establish surface-groundwater interactions (not under natural, Type 1 conditions); - to fill in data gaps needed for modeling, for monitoring contaminant plumes, for determining water balances, etc.
4	Early warning and surveillance	To provide information for an emergency response.	To obtain information, for example, where an accidental pollution spill may affect a drinking water supply.

4 The Need for Groundwater Management

For rural water supply purposes, there are four reasons why groundwater should be managed:

i. To prevent the aquifer from being over-pumped.
If an aquifer is over-pumped, a long-term depletion of the groundwater results throughout the entire aquifer. This over-abstraction can negatively affect all users of the aquifer, including aquifer dependant ecosystems.

ii. To optimise individual borehole pumping rates.
If individual borehole pumping rates are too high, a localised depletion of groundwater results. Energy is also wasted, since the pumping head is unnecessarily high; and if the water level in the borehole is drawn down to the pump intake, a combination of air and water will be pumped. Pumps can be damaged in this way.

iii. To prevent poor quality groundwater from entering the aquifer.
If abstraction from the aquifer is too high, poor quality groundwater can be drawn into the aquifer.

iv. To minimize groundwater contamination from surface sources such as pit latrines, animal kraals, fertilizers and dipping tanks.

Points i, iii and iv are not only important with respect to maintaining the water resource for human consumption, but also to protect aquatic ecosystems which could be dependant on groundwater sources. The National Water Act (1998) recognises a "Reserve", which includes "the quantity and quality of water required to: i) satisfy basic human needs and ii) protect aquatic ecosystems".

5 Guiding Principles for Groundwater Management

The following four points provide the basis for the recommendations provided in this document.

i. Integration with O&M activities.

The monitoring activities at both the local and management level need to be integrated with the O&M activities of the WSA or WSP. At the local level, it is recommended that the monitoring and recording of water levels and abstraction be part of the ongoing activities of the pump operator.

ii. Groundwater monitoring should be part of a monitoring system that includes all aspects of a scheme's operation.

In order to promote a sustainable scheme, groundwater, together with all other key activities, needs to be monitored. These activities include the servicing of diesel engines, determining the water balance and water losses, cleaning reservoirs, establishing tap water quality, general network maintenance activities, etc.

iii. Only process data that is necessary for groundwater management.

Logbooks should be kept for all boreholes, but detailed analyses of the data is only necessary for selected boreholes, where there is a potential for over-abstraction or water quality problems.

iv. Integrate with other WRM institutions.

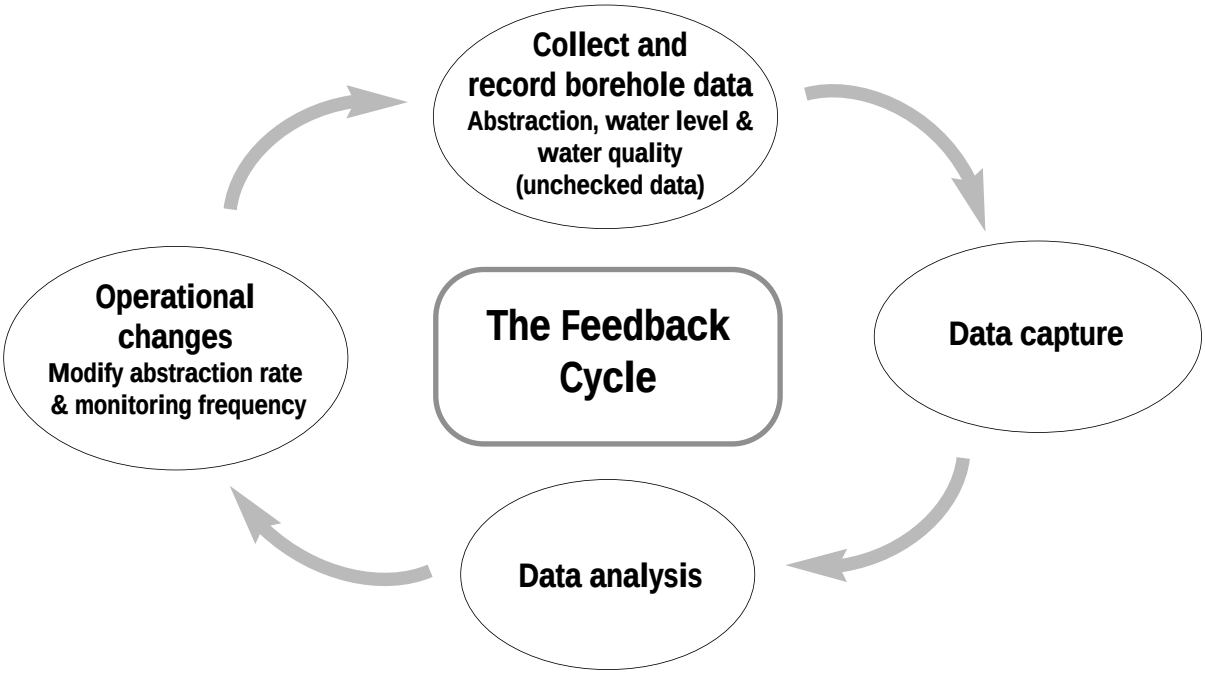
The CMAs need to know what data is available from monitoring at the local level, and they need to have access to this data if and when needed. It is, however, important not to overload CMAs with data that they do not need and cannot process.
Only summary data should be provided to the CMA. This would typically contain the following:

- What data is available for each borehole.
- Annual total abstraction and daily average per borehole.
- Maximum and minimum water levels recorded and the dates recorded per borehole.
- Borehole water quality changes.

6 Groundwater Management - what does it involve?

Figure 1 shows the principal tasks of groundwater management in the context of community water supply. These tasks are described in Section 7, and the institutions responsible for these tasks are defined in Section 8.

Figure 1: Principal groundwater management tasks



Groundwater management for community water supply purposes requires maintaining a groundwater management system and integrating it into O&M activities. Different institutions need to contribute to the operation of the system. Their responsibilities will include one or more of the following:

- Responsibility for data collection.
- Responsibility for ensuring that the data is analysed by an experienced groundwater professional (which includes payment for this service if consultants are used).
- Responsibility for ensuring that the data is passed on to relevant authorities, such as DWAF and CMAs.
- Responsibility for ensuring that the management recommendations are heeded.

Thus, groundwater management for rural water schemes involves the management of data collection, transfer and analysis, and the implementation of recommendations. Key to the success of this is training pump attendants to collect reliable and accurate data, and training administrators in local government and water services institutions. Another key factor is the availability of funds. Groundwater management does not need to be expensive. It is far cheaper to manage groundwater than to deal with a crisis, which may result from a lack of management.

7 Groundwater Data Requirements

Summary of data needs

Groundwater should be managed in terms of its quantity and quality. This would ensure that the resource is used efficiently, to its potential, and it would minimise the risk of deteriorating quality or availability. Besides the basic borehole information such as location, depth, diameter, etc., the following data should be recorded on a regular basis:

i. Borehole water levels

This is to establish whether the aquifer is being over-pumped, and to establish an efficient pumping rate for individual boreholes. In certain areas it may be necessary to monitor water levels of non-utilised boreholes as well as production boreholes. The units of measurement are in metres below ground level, measured to the nearest centimetre. A dip meter, which consists of an electrical cable and a multimeter or a light, is used for measuring borehole water levels.

Water levels should be obtained on a monthly basis. In order to establish a routine, however, it may be advisable to collect the data on a daily or weekly basis. The data only needs to be interpreted once or twice a year, depending on the vulnerability of the aquifer to over-utilisation.

ii. Groundwater abstraction rate

This is to relate abstraction to water levels. Abstraction is measured in m^3/day with a flow-meter, or by recording the discharge rate and the number of hours pumped per day. In the absence of a flow-meter, daily abstraction needs to be monitored. Regular manual flow readings with a stopwatch and container are needed to verify the flow-meter's accuracy.

iii. Groundwater quality

This is to assess whether the aquifer is being over-pumped, and to assess whether any contaminants have entered the aquifer. It may be necessary to analyse for specific determinands or micro-organisms on a regular basis (such as electrical conductivity, fluoride, nitrate and faecal coliforms). However, it is important to obtain at least one comprehensive "background" analysis. The frequency of analyses should largely be based on the ambient groundwater quality (see page 18).

Although the "background" analysis should be taken from the borehole (a tap next to the pump), it is recommended that on-going sampling be done at the point of use (mostly taps), since knowing the quality of supplied water (which can be contaminated in pipelines, reservoirs and at taps) is more important for water services institutions than knowing the quality of the groundwater. A proposed sampling guideline is presented later in this section.

iv. Potential pollutants

While it is not necessary to collect data on potential sources of groundwater pollution, it is necessary for staff in all institutions involved in groundwater management to look out for, and report on, potential contamination sources.

v. Rainfall

It is not necessary to monitor rainfall at every production borehole. Accurate correlation of water level with rainfall is required in Type 1 and possibly Type 3 and 4 monitoring, depending on the specific monitoring purpose. For Type 2 monitoring, monthly data from the nearest rain gauge station should be used if water levels, or water quality and rainfall, need to be compared.

Frequency of groundwater monitoring for rural groundwater supply schemes

The frequency of groundwater monitoring at a borehole should be based on the likelihood of groundwater problems occurring.

The following sections suggest how the frequency of water level monitoring can be established, and gives guidance on the frequency of water quality monitoring.

Water level monitoring

The frequency of water level monitoring will need to be assigned on a borehole-by-borehole basis, by a person with the relevant skills or experience. This may be a hydrogeologist or a water resource engineer / technician with local groundwater knowledge.

Until this has been done, it is best to monitor water levels on a monthly basis.
More frequent monitoring is recommended if it is suspected that the water level is being drawn down to the pump inlet on a regular basis; or, in the case of an automated pumping system, the pump is frequently being switched on and off (since this implies rapid water level fluctuations within the borehole as a result of a pumping rate that exceeds the capacity of the borehole).

A possible way of establishing the necessary frequency of water level monitoring would be to install electronic data loggers in the boreholes for a limited period (a few weeks to a few months), until the effect of abstraction has been established. By reviewing this data, it would be possible to optimise the pumping rate and pumping cycle, and recommend a monitoring programme.

By doing so, a number of boreholes could be assessed per annum with a single data logger. Aquifers, boreholes and pumps are placed under less stress by 24-hour a day pumping. For example, it is better practice to abstract non-stop at 1 L/s than at 3 L/s for eight hours a day.

A further benefit of low-rate, extended abstraction is that water quality changes are kept to a minimum. This is because less oxygen is introduced into the borehole, since the pumping water levels are not drawn-down as much as they would be with high-rate abstraction.

Water quality monitoring

i. Legal framework

The Compulsory National Standards (Section 9(1)) were published as a Government Notice (No. 22355) on 8 June 2001. These standards are regulations from the Minister of Water Affairs and Forestry, and are in line with the provisions of the National Water Act (1998). In terms of these regulations, by June 2003 all WSAs were to have a programme for sampling the quality of supplied water, and this information should be included in the WSDP of the WSA.

Specific requirements of the regulations

The water quality sampling programme must meet the requirements of the license conditions and must specify:

- **Where** ➔ Specify the sampling points.
- **When** ➔ Specify how often samples will be taken.
- **What** ➔ Specify the determinands and substances that will be tested.

The results must be compared with either:

SABS 241:2001

DWAF (1996): *SA Water Quality Guidelines. Volume 1. Domestic Use*.

ii. Previous recommendations regarding sampling frequency

Generic guidelines for sampling frequency are provided in: *Quality of Domestic Water Supplies Volume 2: Sampling Guide* (DWAF, 2000). The following sampling frequency is recommended:

Table 2: Sampling frequency for chemical sampling

Sampling point	Minimum per point		Recommended per point	
	Number of samples per year	Sampling frequency	Number of samples per year	Sampling frequency
Source: river / spring / dug-well	4	3-monthly	26	2-weekly
Source: dam	2	6-monthly	12	2-monthly
Source: borehole	1	yearly	6	6-monthly
Treatment works	4	3-monthly	12/52/365	Monthly / weekly / daily **
Point of use	4	3-monthly	12/52/365	Monthly / weekly / daily **

** Also refer to SABS Code of Practice, SABS 241 - 2001

** Depends on size of treatment works, the variability of water quality and the number of people supplied.

In addition, the guide recommends the following frequency for microbiological sampling:

Table 3: Sampling frequency for microbiological sampling

Sampling point	Recommended per point	
	Number of samples per year	Sampling frequency
Surface water	52	weekly
Distribution system	52	weekly
Borehole	2	6-monthly

SABS 241 gives the following table of suggested frequencies and refers to a further guide, SABS ISO 5667-1 to 11 for guidance on the design of sampling programmes and detailed sampling guides.

Table 4: Design of sampling programmes and detailed sampling guides

Population served	Frequency
More than 100 000	10 every month per 100 000 people
25 001 - 100 000	10 every month
10 001 - 25 000	3 every month
2 500 - 10 000	2 every month
Less than 2 500	1 every month

No distinction is made between chemical and microbiological sampling frequency.

For logistical and financial reasons, it is unlikely that these recommended sampling frequencies are appropriate in many of South Africa's rural water supply schemes. While WSAs should be strongly encouraged to sample at the points of use as frequently as possible, it is not necessary to sample all boreholes at the frequency suggested above. For this reason, it is recommended that the borehole sampling frequency be based on the likelihood of groundwater quality problems arising at each site.

It is worth noting that the necessary frequency of water quality monitoring may become less with time, if the variability in water quality is observed to be low.

iii. Recommended borehole sampling frequency for rural groundwater supply schemes

General guidelines

All boreholes should be sampled at least once to obtain a comprehensive "background" analysis. They should also (preferably) be sampled before and after the rainfall season to establish seasonal trends. Sampling procedures need to comply with recognized sampling guidelines (Weaver, 1992; SABS, 1993 & DWAF, 2000).

The borehole sampling frequency and the determinands to be analysed should be governed by the results of the "background" groundwater quality unless:

i. There is a potential polluting source nearby, or
ii. Micro-organism contamination has been traced to the borehole or aquifer.

If either of these are the case, a person with water quality expertise will need to determine the sampling frequency as well as which determinands and / or micro-organisms need to be analysed.

Guidance on sampling procedures is given below, applicable if the water quality at the point of use is found to be unsuitable.

Proposed sampling frequency based on "background" groundwater quality:

i. Groundwater with determinands that only fall into Class 0 and I (see Appendix 1: Drinking water specification) should be sampled once a year.

   In most cases it will only be necessary to analyse specific determinands such as electrical conductivity, fluoride and nitrate, depending on the geological setting. In certain geological settings, it may be advisable to analyse for more toxic determinands such as arsenic. This would need to be established by a person with local groundwater quality knowledge, a geochemist or a hydrogeologist.

ii. Groundwater with any determinands that fall into Class II should be sampled at least every six months. A person with water quality knowledge should give guidance on the frequency on a site-by-site basis.

iii. Groundwater with any determinands that fall into Class III and IV should not be supplied without treatment. If this water is being used for domestic water supply, then a person with water quality knowledge should give guidance on the determinands / micro-organisms to be sampled and the sampling frequency.

iv. Groundwater that has any faecal coliforms should be re-sampled immediately. Should failure re-occur, reasonable treatment options should be followed or alternative arrangements made (see page 21 for specific guidelines).
   If chlorine is used to disinfect the water, chlorine residuals should initially be checked on a daily basis. With time, this can be done less frequently, providing the chlorine residual remains within the desired range.

   Once the source of contamination has been identified and the problem solved, the sampling frequency for faecal coliforms can be extended to monthly for several months, and then every six months if no faecal coliforms are detected. The frequency should, however, be determined by a person with expertise in water quality.

Note that it is advisable to consult a person with local groundwater quality expertise, a hydrogeologist, or a geochemist, to establish whether additional determinands over and above those commonly analysed, should be assessed on a regular basis. In specific geological settings, it is advisable to test for fluoride and arsenic.

Proposed strategy for sampling water quality

The responsibility for ensuring the provision of potable water lies with the WSA. The practicalities of supplying potable water could, however, be transferred to the WSPs in the WSA-WSP contract.

Regular groundwater quality monitoring must not duplicate the existing monitoring performed by the health officers of the municipality. Communication channels in the municipality need to exist so that the results of the health officers' analyses become available to the technical department. This is also needed to ensure that multidisciplinary actions can be taken if a water quality problem arises in a scheme.

Considering that the WSPs or WSAs need to monitor the water supplied to their consumers, they will, in most cases, only sample from standpipes. The sampling procedure for cases where a water quality problem is detected, is outlined below.

Water can be contaminated in the aquifer, in pipelines, in reservoirs and at taps; it can also be contaminated during sampling. Furthermore, mistakes can be made during analyses, and samples can be incorrectly labeled. It is therefore necessary to have a sampling procedure that caters for these potential sources of contamination and errors.

The proposed sampling procedure is as follows:

i. Regular monitoring of water quality (especially microorganisms) at standpipes within villages at the frequency defined in the sampling plan.

ii. When a sample fails the minimum standards, the first step is to take a second sample to ensure that the first sample was not contaminated during sampling. If the second sample also fails, then the source of contamination needs to be traced.

iii. In order to trace the contamination, samples must be taken at various node points such as the reservoir outlet, the reservoir inlet and at the borehole.

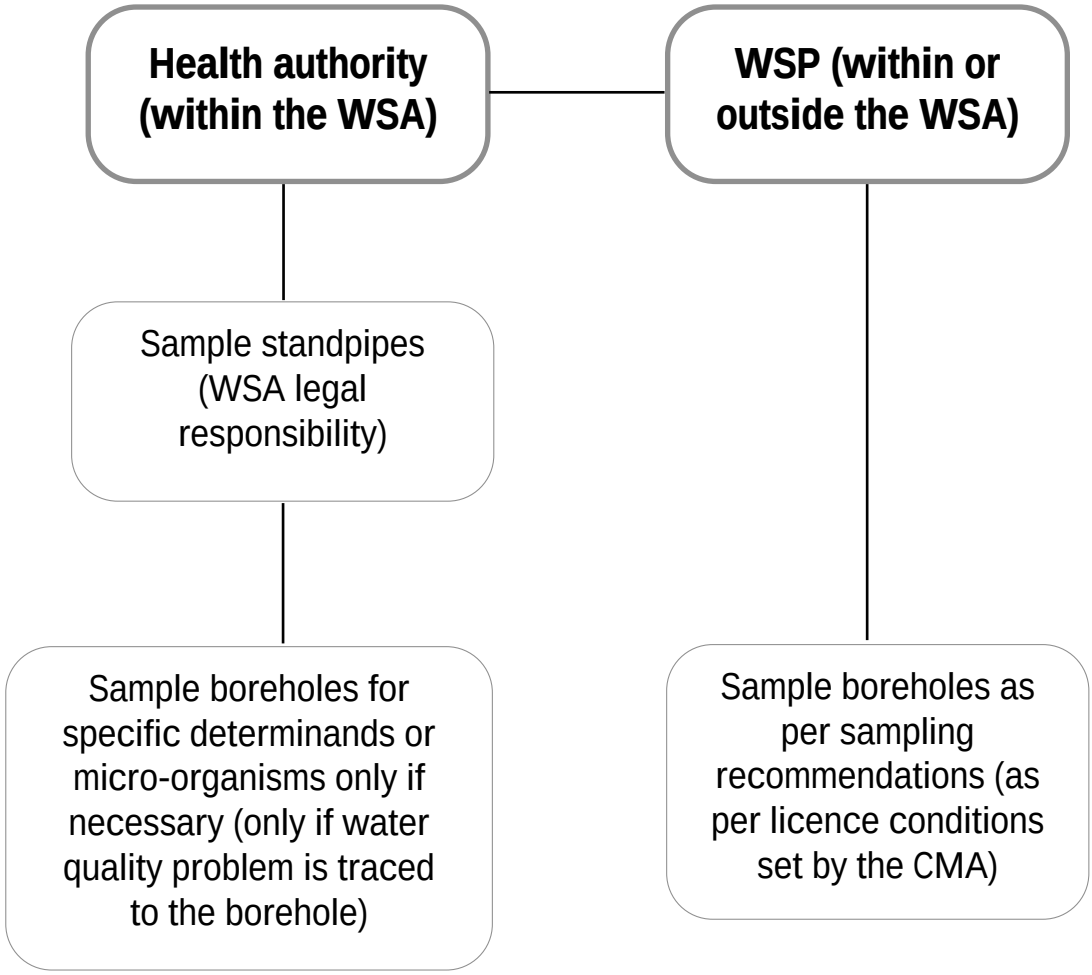
iv. Assess the health risk, and if it is unacceptable, decommission the water supply scheme until the water has been adequately treated. Tanker in potable water and resolve the contamination problem.

v. Increase the frequency of monitoring until the source and supply infrastructure yields potable water on a regular basis.

The relationship between the health authority and the WSP

While the health authority only needs to be concerned with the quality of the water supplied, the WSP should be concerned with both the quality of the supplied water and the source water (see Section 4). The following sketch shows the relationship between these two bodies:

Figure 2: The relationship between the health authority and the WSP



Monitoring and management responsibilities in rural groundwater supply schemes

Table 5: Monitoring and management responsibilities in rural groundwater supply schemes

Activity	Person responsible	Skills and qualifications required	Resources, tools and equipment	Remarks
1 Measuring and recording of water levels	Pump operator	Literacy, numeracy, trained in measuring water levels	Dip meter, ruler, logbook, pen	Done as part of operators' regular O&M activities
2 Measuring and recording abstraction	Pump operator	Literacy, numeracy, trained in reading water meters	Logbook, pen	Done as part of operators' regular O&M activities
3 Providing data to WSA on regular basis (a minimum of every 2 months is recommended)	Pump operator and pump operator supervisor	Literacy, numeracy, keeping records	Fax, postal service or public transport	Included as part of the reporting requirements of the pump operator
4 Taking water samples	WSA staff or WSP staff where delegated by WSA	Trained in taking water samples, driver's license	Transport, sample bottles, cooler box	Sampling routine defined by sampling plan as required by Government Notice no. 22355
5 Sending water samples for testing	WSA staff or WSP staff where delegated by WSA	Keeping records	Transport to laboratory	Sent to nearest accredited laboratory
6 Defining the monitoring requirements of an individual borehole	Technical manager of operations or hydrogeologist	Hydrogeological degree or diploma, experience of hydrogeological conditions	Reports and records on borehole, monitoring data	
7 Ensuring that boreholes are equipped with piezometer tubes for measuring water levels and water meters for measuring abstraction	WSA staff or WSP staff where delegated by WSA	Project management	In-house technical staff, suppliers, contractors, specifications	See *Implementing a rural groundwater management system: a step-by-step guide* (NORAD-DWAF Toolkit for Water Services 1.2)
8 Ensuring that operators have the equipment and skills to do monitoring	WSA staff or WSP staff where delegated by WSA	Project management	Trainers, suppliers, specifications	See *Groundwater monitoring in South Africa: a guide for pump operators* (NORAD-DWAF Toolkit for Water Services 6.1)
9 Monitoring the pump operators' competence to collect and record data	Pump operator supervisor	Staff supervision, knowledge of pump operators' tasks	Transport	Done as part of the supervision of O&M activities

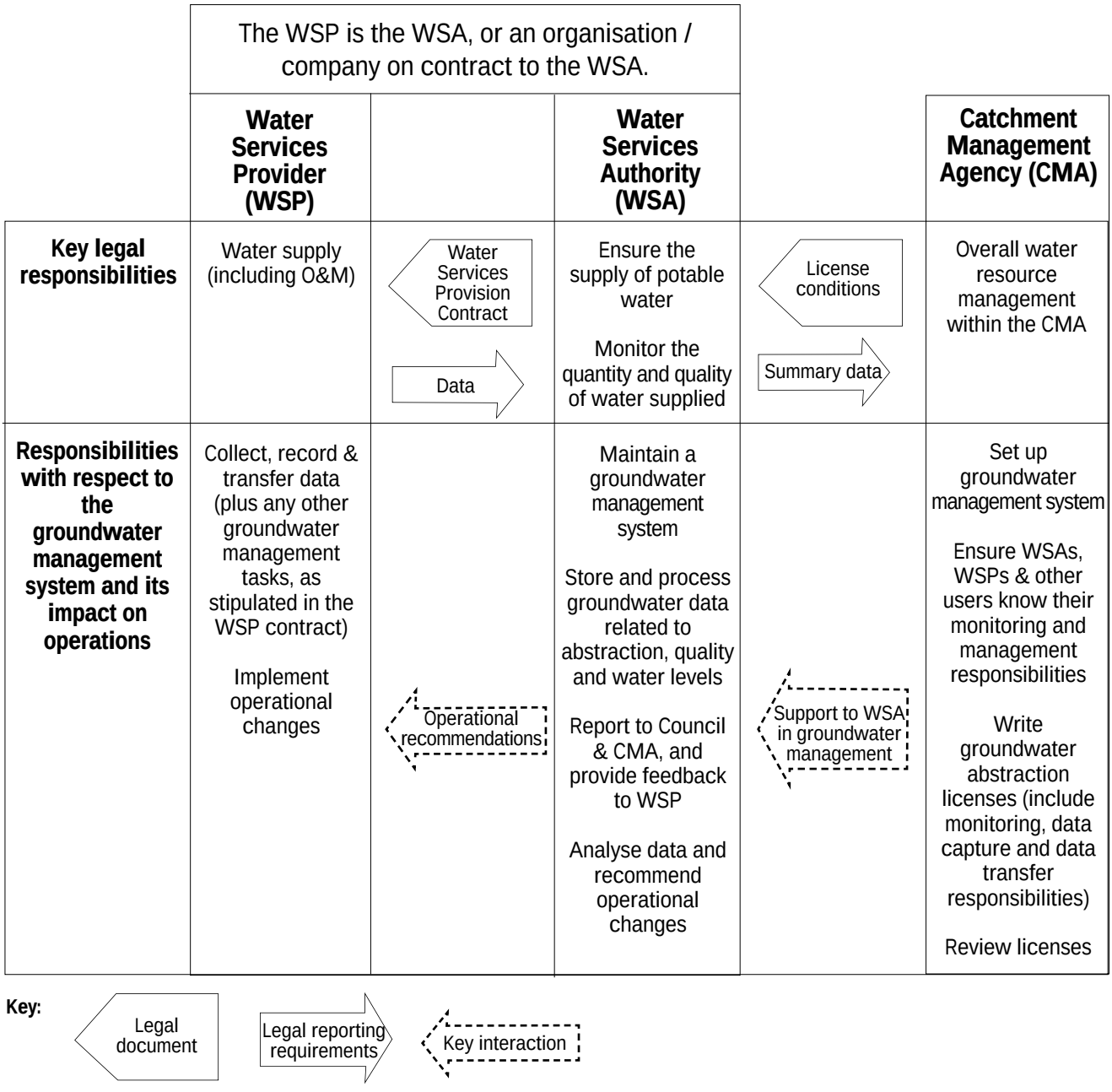
Activity	Person responsible	Skills and qualifications required	Resources, tools and equipment	Remarks
10 Processing data collected at the local level	Data clerk	Data capture, record keeping, filing, trained in operating software	Computer, spreadsheet or groundwater management software, files	Maintains an electronic and physical record of data
11 Studying water level, water quality and abstraction data on a regular basis	Technical manager of operations	Technical training, operations experience	Project files, monitoring data	Done as part of the management of O&M
12 Revising the pumping recommendations and adjusting the monitoring requirements. Ensuring that the recommendations are carried out and monitoring the implementation of the recommendations	Technical manager with hydrogeologist, as required	Technical training, operations experience	Reports on borehole, monitoring data, operational information	Ongoing management of operations and groundwater resources
13 Reporting to Council and pump operator, providing summary data to the CMA	Data clerk with supervision from technical manager	Training in operating software	Computer, spreadsheet or groundwater management software, printer	Summary data defined by license (frequency, what data, form of data)

8 Proposed Institutional Framework

The proposed institutional model for groundwater management is presented in Figure 3. This model is based on existing legal requirements (Section 2) and the guiding principles (Section 5).

This model is specific to community water supply, and details the relationships between CMAs, WSAs and WSPs. Where the user is a farmer, industry or a Water User Association (WUA), the license agreement is directly between these "users" and the CMA, and is not described in this model. The role of WUAs in the community water supply context is described by Pegram and Mazibuko (2003).

Figure 3: Proposed institutional framework for community-level groundwater management



Main institutional tasks and responsibilities based on the proposed model (from the proposed model):

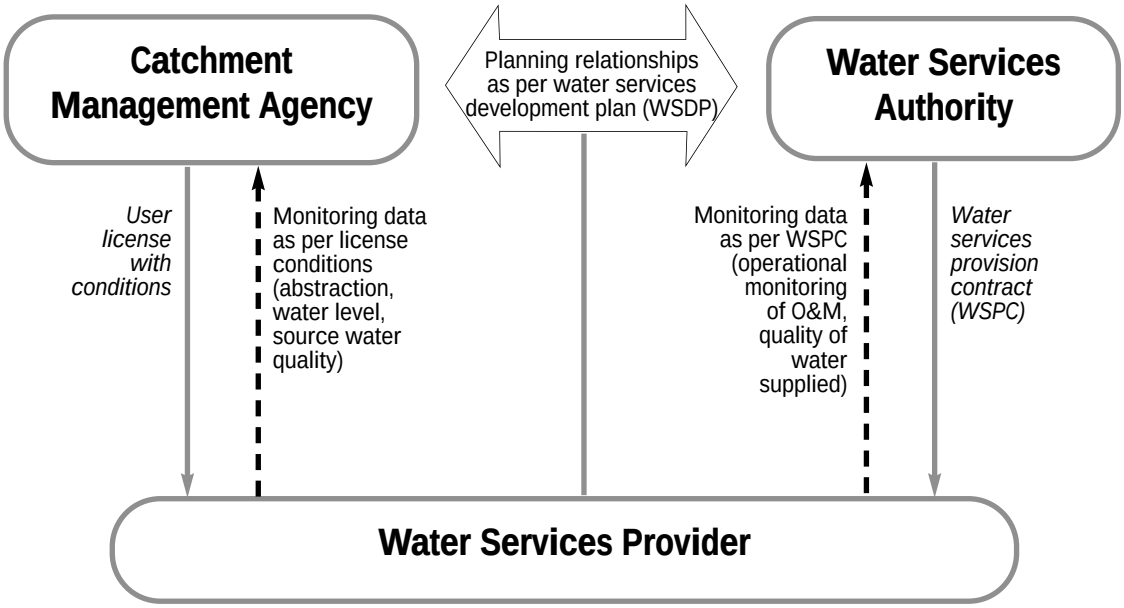
- The CMA is responsible for setting up the groundwater management system. It may do this with in-house personnel, or with support from the DWAF Regional Office or consultants.
- The WSA will effectively be the groundwater manager for rural water supply. This is because groundwater management and O&M (ultimately, a WSA responsibility) are closely linked. The CMA will assist the WSA in setting up the groundwater management system and training staff in specific tasks.
- The WSA may delegate some or all of the groundwater management responsibilities to WSPs. If so, this would be incorporated into the water services provision contract (WSPC). The nature of the responsibilities that can be delegated would depend on the capacity of the particular WSP.
- The WSP will collect relevant groundwater data and pass it on to the WSA. This should be included in the WSP contract, together with scheduling O&M activities and monitoring scheme performance.

  The additional tasks involved with groundwater monitoring are small in comparison to the necessary tasks required for on-going O&M and scheme performance assessment. By including groundwater monitoring scheduling in the WSP contract a comprehensive O&M monitoring plan can be developed.
- The WSA will analyse the data (possibly with assistance from the CMA, DWAFs Regional Office or consultants).
- The WSA will inform the WSP of operational improvements that should be made such as modifying pumping schedules.
- The WSA will provide the CMA with a summary report on groundwater use and quality.
- The WSA will provide the Council with a report on the effectiveness of rural groundwater supply schemes.

The problem of a possible dual reporting system

The Water Use Registration Guide (a guide for the registration of water use under the National Water Act (1998), first edition, March 2000) refers to the licensee as a water user and the WSP as a water user (section 2). Where an external WSP is appointed by the WSA, the license would be between the WSP and the CMA. The WSP would thus have to report directly to the CMA on abstraction and any other monitoring conditions contained in the license. This could potentially create a parallel reporting system for WSPs without a clear relationship defined between the CMA and the WSA. This dilemma is illustrated in Figure 4.

Figure 4: Potential dual reporting systems for WSPs



9 Groundwater Monitoring within the Context of Water Services Provision Models

While there are numerous potential WSP options, they are broadly divided into internal and external service delivery mechanisms. The external services delivery mechanism refers to the situation where the WSP is not the WSA.

Internal Service delivery

Where the WSA is the WSP, all the roles and functions of groundwater monitoring would be retained by the WSA. The WSA can enter into service contracts with external organisations to assist them with specialist tasks and this could include some of the functions of groundwater monitoring and reporting.

External Service delivery mechanisms

The draft consolidated guideline for Water Services Authorities relating to selecting Water Services Providers (Part B) identifies the following specific external water services provider options:

- Local Municipality (where the Local Municipality is not the WSA)
- District Municipality (where the District Municipality is not the WSA)
- Business units within a municipality
- DWAF
- Municipal entities (external organisations owed by one or more municipality)
- Water boards
- Regional WSP's
- Private sector WSP's
- Community-based WSP's

Common to all of the external mechanisms is the need for a water services provision contract (WSPC) between the WSA and the WSP.

With an external services delivery mechanism, the level of monitoring that would be delegated to the WSP would depend on the capacity of the individual WSP. In the case of community based WSP's, the following would typically be delegated to the WSP and these delegated functions would be detailed in the WSPC between the WSA and the WSP:

- Measuring and recording water levels.
- Measuring and recording abstraction.
- Providing monitoring data to the WSA on a regular basis (a minimum of every two months is recommended).
- Facilitating access to the infrastructure for water quality monitoring.

Functions that would remain with the WSA would include:

- Sampling and testing water quality.
- Collating and processing the monitoring data.
- Interpreting the monitoring data.
- Providing feedback and recommendations regarding the operation of the infrastructure.
- Reporting to the CMA.

The WSA may choose to enter a service contract (not a WSP contract) with a service provider to provide some or all of these functions.

In cases where the external WSP's have sufficient capacity, most of the monitoring functions could be delegated to the WSP and would be contained in the WSPC. Typically, such a contract would specify the reporting required by the WSA to adequately monitor the functioning and compliance of the WSP.

In particular, the WSA would want to ensure that the WSP is fulfilling the requirements of water use licenses and that the water supplied complies with the water quality plan of the WSA.

References

Murray, E C and Dindar, M (1998). *Towards a framework for rural groundwater management*, CSIR, Stellenbosch

Pegram, G and Mazibuko, G (2003). *Evaluation of the role of Water User Associations in water management in South Africa*, Water Research Commission report no. TT 204/03, Water Research Commission, Pretoria

South Africa: Department of Provincial and Local Government (2000). *Municipal Structures Amendment Act*

South Africa: Department of Provincial and Local Government (1998). *Municipal Demarcation Act*

South Africa: Department of Provincial and Local Government (1998). *Municipal Structures Act*

South Africa: Department of Provincial and Local Government; and Department of Water Affairs and Forestry (2003). *Guideline for implementing the division of powers and functions for Water and Sanitation Services*, Reworked Draft, 19 January 2003. DPLG and DWAF, Pretoria

South Africa: Department of Water Affairs and Forestry (2003). *DRAFT Consolidated Guideline For Water Services Authorities Relating To Selecting Water Services Providers: Part B*. DRAFT. DWAF. Pretoria

South Africa: Department of Water Affairs and Forestry (2003). *Strategic Framework for Water Services*. DWAF. Pretoria

South Africa: Department of Water Affairs and Forestry (2002). *Proposed National Water Resource Strategy*. First Edition. DWAF. Pretoria

South Africa: Department of Water Affairs and Forestry (2002a). *Integrated Water Resource Management: Guidelines for Groundwater Management in Water Management Areas of South Africa*. Working Draft. DWAF. Pretoria

South Africa: Department of Water Affairs and Forestry (2001). *Regulations under the Water Services Act, 1997 (Act 108 of 1997)*, Compulsory National Standards (Section 9(1)). Government Notice No. 22355. DWAF. Pretoria

South Africa: Department of Water Affairs and Forestry (2000). *Quality of Domestic Water Supplies. Volume 2: Sampling Guide*. DWAF, Water Research Commission, Department of Health. Pretoria

South Africa: Department of Water Affairs and Forestry (2000a). *A Guide to the Registration of Water Use under the National Water Act (Act 36 of 1998)*. DWAF. Pretoria

South Africa: Department of Water Affairs and Forestry (1998). *National Water Act. No 36 of 1998*

South Africa: Department of Water Affairs and Forestry (1997). *Minimum Standards and Guidelines for Groundwater Resource Development for the Community Water Supply and Sanitation Programme*. First edition. DWAF. Pretoria

South Africa: Department of Water Affairs and Forestry (1997). *Water Services Act. No. 108 of 1997*

South Africa: Department of Water Affairs and Forestry (1996). *South African Water Quality Guidelines*. (second edition). Volume 1: Domestic Use. DWAF. Pretoria

South Africa: Office of the President (1996). *Constitution of the Republic of South Africa. Act No. 108 of 1996*

South African Bureau of Standards (1993). SABS ISO 5567-11 South Africa Standard: Water Quality – Sampling. Part 11: *Guidance on sampling of groundwaters*. SABS. Pretoria

South African Bureau of Standards (2001). SABS 241 Edition 5 *Drinking Water Specification*. SABS. Pretoria

South African National Standards (2002). SANS 10299-0:2002. Development, maintenance and management of groundwater resources. Part 0: *Glossary of terms*. SANS. Pretoria

UN/ECE Task Force on Monitoring & Assessment (2000). *Guidelines on monitoring and assessment of transboundary groundwaters*. Institute for Inland Water Management and Waste Water Treatment. Lelystad, Netherlands

Van Wyk, E (2002) (Work in progress). *Towards the establishment and implementation of groundwater quantity and quality monitor networks in DWAF regions*. Department of Water Affairs and Forestry. Pretoria

Vermeulen, A (2002). *Institutional framework for water services provision in rural areas*. Department of Water Affairs and Forestry. Pretoria

Weaver, J M C (1992). *Groundwater sampling*. Water Research Commission report No TT 54/92. Water Research Commission. Pretoria

Appendix 1

Drinking Water Specifications
SABS 241:2001

Determinands	Units	Upper limit and ranges		
		Class O (Ideal)	Class I (Acceptable)	Class II (Maximum allowable)
Physical and organoleptic requirements				
Colour	mg/1 Pt	15	20	50
Conductivity at 25°C	mS/m	70	150	370
Dissolved solids	mg/1	450	1 000	2 400
Odour	TON	1	5	10
pH value at 25°C	pH units	6,0 - 9,0	5,0 - 9,5	4,0 - 10,0
Taste	FTN	1	5	10
Turbidity	NTU	0,1	1	10
Chemical requirements: Macro-determinands				
Ammonia as N	mg/1	0,2	1,0	2,0
Calcium as Ca	mg/1	80	150	300
Chloride as Cl	mg/1	100	200	600
Fluoride as F	mg/1	0,7	1,0	1,5
Magnesium as Mg	mg/1	30	70	100
Nitrate and nitrite as N	mg/1	6,0	10,0	20,0
Potassium as K	mg/1	25	50	100
Sodium as Na	mg/1	100	200	400
Sulphate as SO_4	mg/1	200	400	600
Zinc as Zn	mg/1	3,0	5,0	10,0
Chemical requirements: Micro-determinands				
Aluminium as Al	µg/1	150	300	500
Antimony as Sb	µg/1	5	10	50
Arsenic as As	µg/1	10	50	200
Cadmium as Cd	µg/1	3	5	10
Chromium as Cr	µg/1	50	100	500
Cobalt as Co	µg/1	250	500	1 000
Copper as Cu	µg/1	500	1 000	2 000
Cyanide (free) as CN	µg/1	30	50	70
Cyanide (recoverable) as CN	µg/1	70	200	300

Determinands	Units	Upper limit and ranges		
		Class O (Ideal)	Class I (Acceptable)	Class II (Maximum allowable)
Chemical requirements: Micro-determinands (cont)				
Iron as Fe	µg/1	10	200	2 000
Lead as Pb	µg/1	10	50	100
Manganese as Mn	µg/1	50	100	1 000
Mercury as Hg	µg/1	1	2	5
Nickel as Ni	µg/1	50	150	350
Selenium as Se	µg/1	10	20	50
Vanadium as V	µg/1	100	200	500
Chemical requirements: Organic-determinands				
Dissolved organic carbon as C	mg/1	5	10	20
Total trihalomethanes	µg/1	100	200	300
Phenols	µg/1	5	10	70
Note: The limits for iron are based on aesthetic aspects				

Class 0 = ideal drinking water, closely comparable to current international standards for water quality
Class I = known to be acceptable for lifetime consumption
Class II = maximum allowable for short-term consumption

Microbiological Requirements

Determinands	Units	Allowable compliance contribution [1]		
		95% min.	4% min.	1% min.
		Upper limits		
Heterotrophic plate count	count/ml	100	1 000	10 000
Total coliform	count/100ml	Not detected	10	100
Faecal coliform	count/100ml	Not detected	1	10
E. coli	count/100ml	Not detected	Not detected	1
Somatic coliphages	count/10ml	Not detected	1	10
Enteric viruses	count/100 l	Not detected	1	10
Protozian parasites (*Giardia/Cryptosporidium*)	count/10 l	Not detected	1	10

[1] The allowable compliance contribution shall be at least 95% to the limits indicated in column 3, with a maximum of 4% and 1% respectively, to the limits indicated in columns 4 and 5. The objective of disinfection should, nevertheless, be to attain 100% compliance to the limits indicated in column 3.

Glossary and definitions

Aquifer

Defined by the National Water Act (1998) as a geological formation which has structures or textures that hold water or permit appreciable water movement through them.

Ambient groundwater quality

Background water quality. It reflects the groundwater quality of the area at a specific time.

Borehole

Defined by the National Water Act (1998) as a well, excavation or any artificially constructed or improved underground cavity which can be used for the purpose of:

(a) Intercepting, collecting or storing water in or removing water from an aquifer;
(b) Observing and collecting data and information on water in an aquifer; or
(c) Recharging an aquifer.

Catchment Management Agency (CMA)

CMAs are responsible for regional water resource management (National Water Act, 1998).

Determinands

Variables such as ions, pH and temperature to be included in a water quality assessment.

Dip meter

The instrument used to measure the depth to the water level in a borehole.

Groundwater

Water held within a saturated soil, rock-medium, fractures or other cavities within the ground (SANS, 2002).

Groundwater level

The depth to the water level in a borehole or well from the ground.

Groundwater management

Groundwater management for Community Water Supply involves taking responsibility for protecting groundwater from contamination and ensuring its sustainable use.
The main responsibilities are:

(a) Data collection, capture and analysis, and recommendations for operational or behavioural changes based on the data analyses. Operational changes may be, for example, to reduce the abstraction rate. Behavioural changes may include, for example, the restriction of groundwater polluting activities or increasing the monitoring frequency.
(b) Making operational or behavioural changes based on the data analyses.

Groundwater monitoring

Groundwater monitoring forms part of the groundwater management function. Specifically, it includes data collection and capture. Boreholes need to be properly equipped in order to make monitoring possible. A description of all the necessary tools for groundwater monitoring is described in the ***Toolkit for Water Services***.

Groundwater monitoring tools

Tools used in monitoring groundwater, like a water level meter, a flow-meter, a logbook and computer software.

Observation or monitoring borehole

A borehole used to measure changes in groundwater levels (often in response to a nearby pumping borehole), and / or to monitor changes in water quality (either through the collection of water samples or by means of a "down-the-hole" electronic sensor).

Piezometer tube

A tube (manometer), usually a plastic pipe having a diameter of 15 to 25 millimetres, which is inserted into a borehole with the pump, so that groundwater levels can be measured using a dip meter or electronic sensor.

Water board

Defined by the Water Services Act (1997), as "an organ of state established or regarded as having been established in terms of this Act to perform, as its primary activity, a public function"; and the Act further states that the primary activity of a water board is to "provide water services to other water services institutions within its service area".

Water pollution

Defined by the National Water Act (1998) as the direct or indirect alteration of the physical, chemical or biological properties of a water resource so as to make it:

(a) Less fit for any beneficial purpose for which it may reasonably be expected to be used;

or (b) Harmful or potentially harmful:

i) to the welfare, health or safety of human beings;

ii) to any aquatic or non-aquatic organisms;

iii) to the resource quality; or

iv) to property.

Water services

Defined in the Water Services Act (1997) as covering both water supply and sanitation.

Water Services Authority (WSA)

Municipality responsible for ensuring access to water services (Water Services Act, 1997).

Water services institution

These include Water Services Authorities, Water Services Providers, water boards and water services intermediaries (Water Services Act, 1997).

Water services intermediary

An institution or individual who provides water to consumers but whose primary function is not water services provision. For example, a farmer who provides water to staff as part of a contract of employment, is a water services intermediary (Water Services Act, 1997).

Water Services Provider (WSP)

Any institution that is appointed by a Water Services Authority to provide water services to consumers or to another water services institution (Water Services Act, 1997).

Water table

The surface of a groundwater body at which the water pressure equals atmospheric pressure, i.e. the uppermost level of the groundwater body beneath the land surface.

Water User Association (WUA)

An association of water users, for example, farmers who share a common water resource.