

# A Guideline for the Assessment, Planning and Management of Groundwater Resources in South Africa



**water & forestry**

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DEPARTMENT WATER AFFAIRS AND FORESTRY  
Water Resource Planning Systems

**A Guideline for the Assessment,  
Planning and Management of  
Groundwater Resources in South Africa**

MARCH 2008

*Cover photos:*

<i>Top left:</i>	Well 6 at Caroluspoort Scheme east of De Aar. 2000
<i>Top right:</i>	Riet Scheme booster pump station southeast of De Aar. 2000
<i>Bottom left:</i>	Electronic water level logger hut on the farm Plessisdam, north of De Aar. 2000.
<i>Bottom middle:</i>	Caroluspoort Scheme reservoir east of De Aar. 2000.
<i>Bottom right:</i>	Caroluspoort Scheme booster pump station west of De Aar. 2000.

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## REPORT OBJECTIVES

The objectives of a Guideline for the Assessment, Planning and Management of Groundwater Resources in South Africa are:

- To provide assistance and guidance to all role-players involved in the assessment, planning and management of the groundwater resources of South Africa, and
- To ensure that all role-players in the management of groundwater resources of the country have clear guidance on the processes to follow.

The Guideline will therefore assist in ensuring that the water management function in the above areas is streamlined and meets the objectives of both the Department and other role-players.

# ACRONYMS

ARD	Acid Rock Drainage
BM	Benchmarking
BPG	Best Practice Guidelines
BWS	Bulk Water Supplier
CMA	Catchments Management Agency
CMS	Catchment Management Strategy
EC	Electrical Conductivity
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
GMP	Good Management Practices
ICM	Integrated Catchment Management
IDP	Integrated Development Plan
ISP	Internal Strategic Perspective
IWRMP	Integrated Water Resources Management Plan
IWRM	Integrated Water Resources Management
km <sup>2</sup>	Square Kilometer
L/s	Litres per second
mamsl	Metres above mean sea level
Ml/d	Megalitres per day
m	Metre
mm	Millimetre
mm/a	Millimetres per annum
mS/m	Milliesiemens per metre
m <sup>3</sup>	Cubic metre
MAP	Mean Annual Precipitation
MPRDA	Mining and Petroleum Resources Development Act (Act No. 73 of 2002) 1989)
NEMA	National Environmental Management Act (Act No. 107 of 1998)
NWA	National Water Act (Act No. 36 of 1998)
NWRS	National Water Resource Strategy
NWC/WDMS	National Water Conservation/Water Demand Management Strategy
ppm	Parts per million
RDM	Resource Directed Measures
RQO	Resource Quality Objective
RWQO	Resource Water Quality Objective
TDS	Total Dissolved Solids
TMG	Table Mountain Group
WMA	Water Management Area
WSA	Water Services Act (Act No. 108 of 1997)
WMI	Water Management Institution
WMP	Water Management Plan
WSDP	Water Services Development Plan
WSI	Water Services Institution
WSP	Water Service Provider
WUAu	Water Use Authority
WUA	Water User Association

## GLOSSARY OF TERMS

### **AQUICLUDE**

A geologic formation, group of formations, or part of formation through which virtually no water moves.

### **AQUIFER**

A geological formation which has structures or textures that hold water or permit appreciable water movement through them. Source: National Water Act (Act No. 36 of 1998).

### **BOREHOLE**

Includes a well, excavation, or any other artificially constructed or improved underground cavity which can be used for the purpose of intercepting, collecting or storing water in or removing water from an aquifer; observing and collecting data and information on water in an aquifer; or recharging an aquifer. Source: National Water Act (Act No. 36 of 1998).

### **BOUNDARY**

An aquifer-system boundary represented by a rock mass (e.g. an intruding dolerite dyke) that is not a source of water, and resulting in the formation of compartments in aquifers.

### **CONE OF DEPRESSION**

The depression of hydraulic head around a pumping borehole caused by the withdrawal of water.

### **CONFINING LAYER**

A body of material of low hydraulic conductivity that is stratigraphically adjacent to one or more aquifers; it may lie above or below the aquifer.

### **DOLOMITE AQUIFER**

See "Karst" Aquifer

### **DRAWDOWN**

The distance between the static water level and the surface of the cone of depression.

### **FRACTURED AQUIFER**

An aquifer that owes its water-bearing properties to fracturing.

**GROUNDWATER**

Water found in the subsurface in the saturated zone below the water table.

**GROUNDWATER DIVIDE or GROUNDWATER WATERSHED**

The boundary between two groundwater basins which is represented by a high point in the water table or piezometric surface.

**GROUNDWATER FLOW**

The movement of water through openings in sediment and rock; occurs in the zone of saturation in the direction of the hydraulic gradient.

**HYDRAULIC CONDUCTIVITY**

Measure of the ease with which water will pass through the earth's material; defined as the rate of flow through a cross-section of one square metre under a unit hydraulic gradient at right angles to the direction of flow (m/d).

**HYDRAULIC GRADIENT**

The rate of change in the total hydraulic head per unit distance of flow in a given direction.

**INFILTRATION**

The downward movement of water from the atmosphere into the ground.

**INTERGRANULAR AQUIFER**

A term used in the South African map series referring to aquifers in which groundwater flows in openings and void spaces between grains and weathered rock.

**KARST (KARSTIC)**

The type of geomorphological terrain underlain by carbonate rocks where significant solution of the rock has occurred due to flowing groundwater.

**KARST (KARSTIC) AQUIFER**

A body of soluble rock that conducts water principally via enhanced (conduit or tertiary) porosity formed by the dissolution of the rock. The aquifers are commonly structured as a branching network of tributary conduits, which connect together to drain a groundwater basin and discharge to a perennial spring.

**MONITORING**

The regular or routine collection of groundwater data (e.g. water levels, water quality and water use) to provide a record of the aquifer response over time.

**OBSERVATION BOREHOLE**

A borehole used to measure the response of the groundwater system to an aquifer test.

**PHREATIC SURFACE**

The surface at which the water level is in contact with the atmosphere: the water table.

**PIEZOMETRIC SURFACE**

An imaginary or hypothetical surface of the piezometric pressure or hydraulic head throughout all or part of a confined or semi-confined aquifer; analogous to the water table of an unconfined aquifer.

**POROSITY**

Porosity is the ratio of the volume of void space to the total volume of the rock or earth material.

**PRODUCTION BOREHOLE**

A borehole specifically designed to be pumped as a source of water supply.

**RECHARGE**

The addition of water to the saturated zone, either by the downward percolation of precipitation or surface water and/or the lateral migration of groundwater from adjacent aquifers.

**RECHARGE BOREHOLE**

A borehole specifically designed so that water can be pumped into an aquifer in order to recharge the ground-water reservoir.

**SATURATED ZONE**

The subsurface zone below the water table where interstices are filled with water under pressure greater than that of the atmosphere.

**SPECIFIC CAPACITY**

The rate of discharge from a borehole per unit of drawdown, usually expressed  $\text{asm}^3/\text{d}\cdot\text{m}$ .

**SPECIFIC YIELD**

The ratio of the volume of water that drains by gravity to that of the total volume of the saturated porous medium.

**STORATIVITY**

The volume of water an aquifer releases from or takes into storage per unit surface area of the aquifer per unit change in head.

**TRANSMISSIVITY**

Transmissivity is the rate at which water is transmitted through a unit width of an aquifer under a unit hydraulic gradient. It is expressed as the product of the average hydraulic conductivity and thickness of the saturated portion of an aquifer.

**UNSATURATED ZONE (also termed VADOSE ZONE)**

That part of the geological stratum above the water table where interstices and voids contain a combination of air and water.

**WATERSHED (also termed CATCHMENT)**

Catchment in relation to watercourse or watercourses or part of a watercourse means the area from which any rainfall will drain into the watercourses or part of a watercourse through surface flow to a common point or points. Source: National Water Act (Act No. 36 of 1998).

**WATER TABLE**

The upper surface of the saturated zone of an unconfined aquifer at which pore pressure is equal to that of the atmosphere.

## EXECUTIVE SUMMARY

The National Water Act (Act 36 of 1998) (NWA) was promulgated to provide for reform of the law relating to water resources, recognising that water is a scarce and unevenly distributed national resource that belongs to all people. The NWA provides the Department of Water Affairs and Forestry (the Department) with a mandate to protect, use, develop, conserve, manage and control South Africa's water resources in an integrated manner (NWRS, 2004).

The aquifers of South Africa represent important water resources that are relied on by many users for their water use. The development and protection of these groundwater resources are currently being undertaken in response to local pressures and decisions, potentially taking cognisance of the NWA but without the benefit of standard procedures. The Department therefore identified the need to develop a guideline document (referred to as the Guideline) that can be followed and adhered to when undertaking assessment, planning and management of groundwater resources within the country. The Guideline will assist in the sustainable development, protection and management of the groundwater resources and will assist in achieving the overall goal of integrated water resources management (IWRM) within the Department. Although the assessment, planning and management of groundwater resources are seen as important within the overall scope of IWRM, the Guideline is presented as a separate document.

The importance of assessment, planning and management of the groundwater resources in South Africa are highlighted by the following:

- No such guideline currently exists to guide the Water

Manager/Service Provider in the procedures required for the assessment, planning and management of the groundwater resources

- Groundwater represents an important water resource as part of conjunctive use for bulk and local use, as well as for extensive irrigation. In some areas, groundwater from various aquifers represents the sole source of water use or is a critical resource in times of drought. In these areas or circumstances, the such aquifers would be considered to be of strategic importance
- Overall planning and management of aquifers are essential to ensure their sustainable development. Individual private abstractions often take no account of the impact of these abstractions on the total resource
- Past experiences have indicated that a lack of effective assessment, planning and management of the resource can result in significant detrimental impacts on the aquifer systems. For example, unmanaged and uncontrolled abstraction and/or dewatering of the aquifers can lead to boreholes, wetlands and springs drying up; and in the case of karst aquifers, sinkhole formation.
- Potential groundwater yields from certain aquifer systems (i.e. karst formations) can be significantly higher than yields from other rock formations. However, these same characteristics that allow high borehole yields (e.g. fracture flow) can also be responsible for

sudden failure of the resource (e.g. dewatering of a fracture).

- Aquifer systems can be, due to the physical characteristics of the host rock, vulnerable to over-exploitation, unsustainable practices and pollution. This vulnerability aggravates the potential impact of land use on the groundwater resources
- The direct interaction between aquifer systems and adjacent ecosystems makes these ecosystems particularly vulnerable to pollution and abstraction impacts, to the same degree as the aquifers themselves. Protection of the aquifers will therefore lead to the protection of these ecosystems

The Guideline is presented in three separate chapters to improve user-friendliness. The details included in each of the chapters, and their proposed use, are:

- **Chapter 1:** Provides a conceptual overview of the Guideline in terms of the purpose of the guideline, the location of the groundwater resources, the regulatory framework, principles and approaches, and the institutional arrangements. Chapter 1 can be used by role-players who seek to gain an initial insight into the assessment, planning and management of groundwater resources
- **Chapter 2:** Provides details of the process and related activities that should be followed during the assessment, planning and management functions. This chapter is aimed at the role-players who require a detailed understanding of the processes to be followed during assessment, planning and management, to

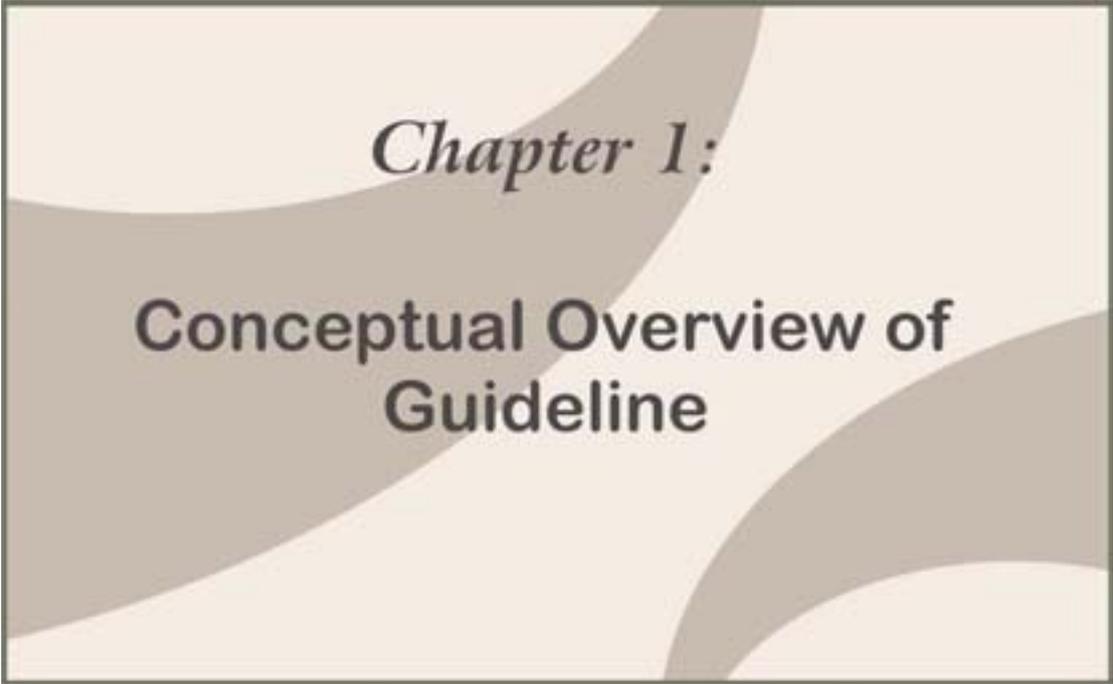
enable the overall management, integration and control of these processes, and

- **Chapter 3:** Provides detailed procedures, in the form of check-lists with guiding notes, for carrying out the assessment, planning and management functions. This chapter is aimed at those role-players tasked with the operational aspects of these functions.

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*Chapter 1:*

**Conceptual Overview of  
Guideline**

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# CHAPTER 1. CONCEPTUAL OVERVIEW OF GUIDELINE

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## 1.1 Introduction and context

### 1.1.1 Context

The National Water Act (Act 36 of 1998) (NWA) was promulgated to provide for reform of the law relating to water resources, recognising that water is a scarce and unevenly-distributed national resource that belongs to all people. The NWA provides the Department of Water Affairs and Forestry (the Department) with a mandate to protect, use, develop, conserve, manage and control South Africa's water resources in an integrated manner (NWA, 1998).

The aquifer systems of South Africa represent important water resources that are relied on by many. Water users include the ecology (wetland areas around springs and surface water flow originating from the groundwater), urban and rural dwellers, irrigation and livestock farmers, industry and mining.

Development and protection of the groundwater resources is currently being undertaken in response to local pressures and decisions, potentially taking cognisance of the NWA but without the benefit of standard procedures. The Department therefore identified the need for the development of a guideline document that can be followed and adhered to when undertaking *assessment, planning and management* of the groundwater resources of the country. This document will assist in the sustainable development, protection and management of the groundwater resources, and will assist in achieving the overall goal of integrated water resources management (IWRM) within the Department.

This Guideline is aligned to, and integrated with, other guidelines prepared by the Department, which together aim to address the overall objectives of IWRM. The Guideline is presented as a separate document, albeit within the context of IWRM, because:

- The assessment, planning and management of groundwater resources are seen as important functions within the overall scope of IWRM. Of equal importance is the interaction between surface and groundwater and the contribution of groundwater to baseflow in many instances, and
- Although a significant amount of information is available on the assessment, planning and management functions as it pertains to groundwater resources, this has not been collated into a single co-ordinated series of documents. The Guideline series addresses this need.

### 1.1.2 Importance of assessment, planning and management

The assessment function is required to enable and inform the planning and management functions. Information of sufficient accuracy is currently unavailable to ensure integrated water resource management. Assessment also provides a better understanding of the local interactions between people and the water resource and provides details on current impacts and the use/abuse of the resource. The integration of the assessment, planning and management functions is important because:

- These functions are linked in the management of the groundwater resources. Thus, if assessment is undertaken poorly, then the planning will also be poor. In turn, poor planning can lead to the adoption of unsuitable options and hence the unsustainable use of the resource.
- Given the linked nature of the functions, poor assessment, leading to poor planning can result in the inefficient use of the Department's assessment, planning and management budgets.

### 1.1.3 Importance of developing the guideline

The overall rationale and motivation for developing a guideline for the assessment, planning and management of groundwater resources include the following factors:

- No such guideline currently exists to guide the Water Manager/Service Provider in the procedures required for the assessment, planning and management of the groundwater resources
- Groundwater represents an important water resource as part of conjunctive use for bulk and local use, as well as for extensive irrigation. In some areas, groundwater from various aquifers represents the sole source of water use or is a critical resource in times of drought. In these areas or circumstances, the such aquifers would be considered to be of strategic importance
- Overall planning and management of aquifers are essential to ensure their sustainable development. Individual private abstractions often take no account of the impact of these abstractions on the total resource
- Past experiences have indicated that a lack of effective assessment, planning and management of the resource can result in significant detrimental impacts on the aquifer systems. For example, unmanaged and uncontrolled abstraction and/or dewatering of the aquifers can lead to boreholes, wetlands and springs drying up; and in the case of karst aquifers, sinkhole formation.
- Potential groundwater yields from certain aquifer systems (i.e. karst formations) can be significantly higher than yields from other rock formations. However, these same characteristics that allow high borehole yields (e.g. fracture flow) can also be responsible for sudden failure of the resource (e.g. dewatering of a fracture).

- Aquifer systems can be, due to the physical characteristics of the host rock, vulnerable to over-exploitation, unsustainable practices and pollution. This vulnerability aggravates the potential impact of land use on the groundwater resources
- The direct interaction between aquifer systems and adjacent ecosystems makes these ecosystems particularly vulnerable to pollution and abstraction impacts, to the same degree as the aquifers themselves. Protection of the aquifers will therefore lead to the protection of these ecosystems

#### 1.1.4 Use of the Guideline

The Guideline is aimed primarily at the Water Manager/Planner and Service Provider in a Water Management Area (WMA) who will be responsible for the assessment, planning and management of the groundwater resources in the area. The responsible person will thus make comprehensive use of Chapters 2 and 3 of the Guideline to enable him/her to undertake these functions. The Guideline is presented in three separate chapters to improve user-friendliness. The details included in each chapter, and the proposed use, are:

- **Chapter 1:** Provides a conceptual overview of the Guideline in terms of the purpose of the guideline, the location of the groundwater resources, the regulatory framework, principles and approaches, and the institutional arrangements. Chapter 1 can be used by role-players who seek to gain an initial insight into the assessment, planning and management of groundwater resources
- **Chapter 2:** Provides details of the process and related activities that should be followed during the assessment, planning and management functions. This chapter is aimed at the role-players who require a detailed understanding of the processes to be followed during assessment, planning and management, to enable the overall management, integration and control of these processes, and
- **Chapter 3:** Provides detailed procedures, in the form of check-lists with guiding notes, for carrying out the assessment, planning and management functions. This chapter is aimed at those role-players tasked with the operational aspects of these functions.

Various other stakeholders may have different uses for the Guideline, depending on their specific organisational positions, work areas and responsibilities. In particular:

- Personnel at management level within the Department's Head Office, Regional Office and within the CMA are likely to make use of Chapter 1 to obtain an overview of the nature and applicability of the Guideline
- Water Resource Management personnel involved in assessment, planning and management for the sustainable use of water resources will make use of Chapters 2 and 3, and

- Water User Associations, Aquifer Management Committees, Water Service Providers, task teams and water users themselves will find Chapters 2 and 3 useful, especially the technical specifications in the appendices.

## **1.2 Purpose of the Guideline**

The purpose of the Guideline can be described briefly as follows:

- To provide assistance and guidance to all role-players involved in the assessment, planning and management of the groundwater resources of South Africa, and
- To ensure that all role-players in the management of groundwater resources of the country have clear guidance on the processes to follow.

The Guideline will therefore assist in ensuring that the water management function in the above areas is streamlined and meets the objectives of both the Department and other role-players.

## **1.3 Goals of the Guideline**

The goals of the Guideline are presented in terms of strategic, operational and other goals in Table 1.1. Key success factors are also provided for each of the Guideline goals.

*Table 1.1: Goals of the Guideline*

Level	Goals	Role-players involved in meeting the goals	Key success factors
Strategic	Provide guidance for sustainable development and management of the resource	<ul style="list-style-type: none"> <li>▪ DWAF Head Office</li> <li>▪ DWAF Regional Office</li> <li>▪ CMA management</li> <li>▪ Other national departments</li> </ul>	<ul style="list-style-type: none"> <li>▪ Increased understanding and appreciation of sustainable development and management of the resource</li> <li>▪ Improved development and management techniques</li> </ul>
	Assist in ensuring equitable access to the resource		
Management	Enable optimum management, protection and use of the resource to ensure sustainable development	<ul style="list-style-type: none"> <li>▪ DWAF Regional Offices</li> <li>▪ CMA management</li> <li>▪ Water User Associations</li> <li>▪ Water Forums and reference groups</li> </ul>	<ul style="list-style-type: none"> <li>▪ Sustainable use of the resource</li> </ul>
	Integrated water resources management		
Operational	Provide information that will feed into the Department's planning process	<ul style="list-style-type: none"> <li>▪ CMA operational level</li> <li>▪ Water User Associations</li> <li>▪ District and local municipalities</li> <li>▪ Water Boards</li> <li>▪ Individual users (e.g. irrigation farmers, mines and industrial enterprises)</li> </ul>	<ul style="list-style-type: none"> <li>▪ Operational guidelines that are:</li> <li>▪ Clear, concise and user-friendly</li> <li>▪ Contain sufficient details to be used as a primary information reference by role-players</li> </ul>
	Ensure the sustainable use of the resource according to guidance given.		
Other	Integration with existing and new initiatives within the Department	<ul style="list-style-type: none"> <li>▪ DWAF Head Office</li> </ul>	<ul style="list-style-type: none"> <li>▪ Inclusion of links to other relevant initiatives</li> </ul>

#### **1.4 Overview of Aquifer Types in South Africa**

Most South African aquifers occur in fractured rock ranging in age from earliest Pre-Cambrian to Jurassic. Aquifers consisting of recent to Tertiary formations are restricted to coastal dune belts and unconsolidated deposits associated with rivers and Aeolian sands. The aquifer regions developed by DWAF are:

- Intergranular Aquifers,
- Fractured Aquifers,
- Karstic Aquifers and
- Intergranular and Fractured Aquifers.

Figure 1.1 shows the aquifer types. Table 1.2 summaries these aquifer types.

Please note that 1 : 500 000 scale Hydrogeological map series is available from DWAF.

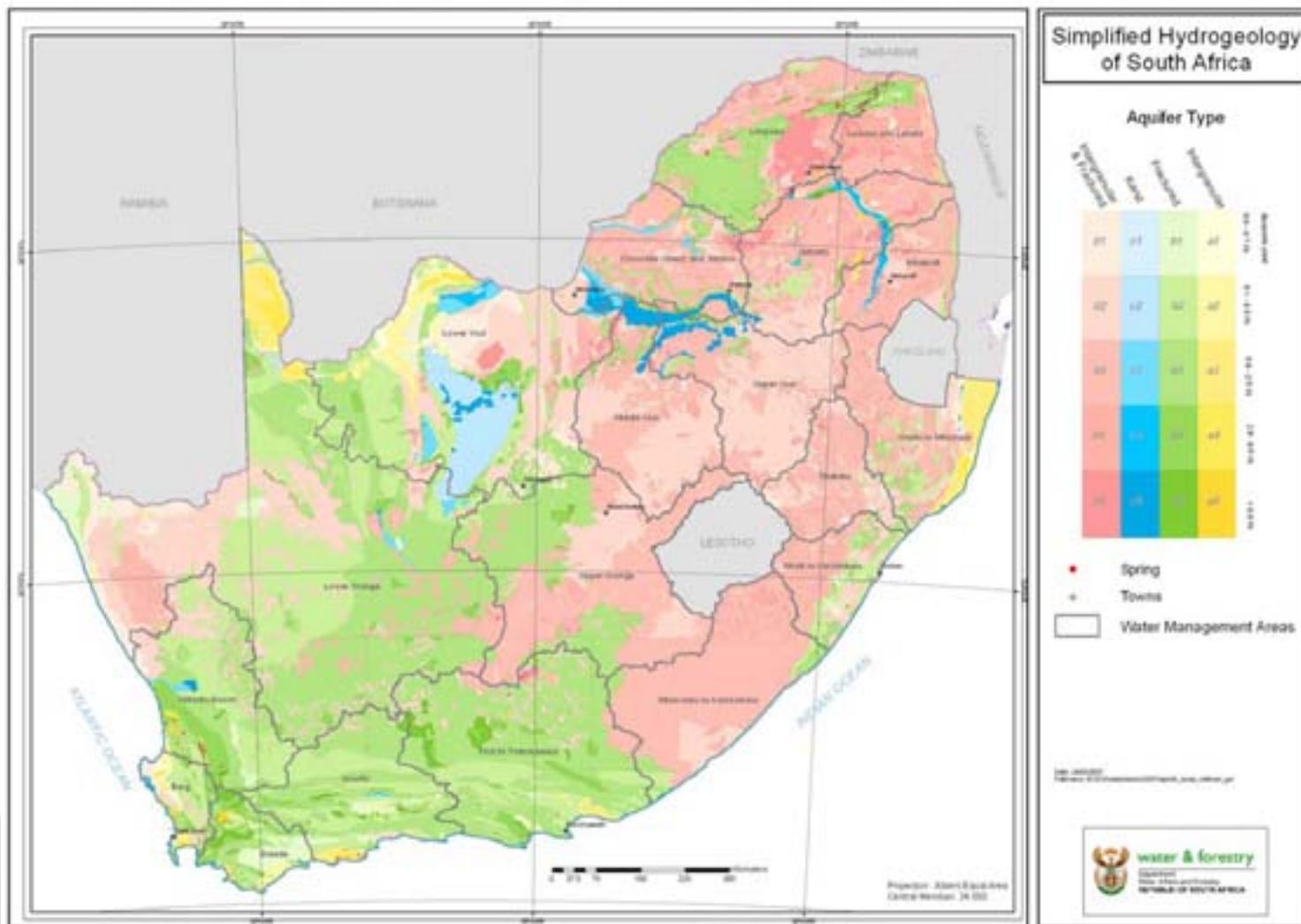


Figure 1.1: Aquifer types of South Africa

*Table 1.2: Summary of aquifer types*

Aquifer Type	Basic Information
Intergranular Aquifers	<ul style="list-style-type: none"> <li>▪ Generally unconsolidated but occasionally consolidated.</li> <li>▪ Groundwater within interstices in porous medium and in basal conglomerate. Moderate areal extent.</li> <li>▪ Examples include Tertiary-Quaternary coastal deposits and alluvial deposits along river terraces.</li> </ul>
Fractured Aquifers	<ul style="list-style-type: none"> <li>▪ Fissured and fractured bedrock resulting from decompression and/or tectonic action. Groundwater occurs predominantly within fissures and fractures.</li> <li>▪ Extensive in area.</li> <li>▪ Examples include sedimentary and metamorphic rocks within limited overlying unsaturated residual weathered products.</li> </ul>
Karstic Aquifers	<ul style="list-style-type: none"> <li>▪ Water-bearing properties depend on fractures, joints and cavities in Namibian ages calcareous rocks.</li> <li>▪ Very limited in areal extent.</li> <li>▪ Examples included limestone and interbedded shale is particularly groundwater bearing in valleys where sizable alluvial deposits occur.</li> </ul>
Intergranular and Fractured Aquifers	<ul style="list-style-type: none"> <li>▪ Largely medium to coarse grained granite, weathered to varying thicknesses, with groundwater contained in intergranular interstices in the saturated zone and in jointed and occasional fractured bedrock.</li> <li>▪ Occurs extensively throughout South Africa but its characteristics varies in space and time.</li> </ul>

### **1.5 Overview of the Regulatory and Policy Framework**

It is not intended in this section of the Guideline to provide comprehensive details of the various acts, policies and strategy documents that make up the regulatory framework of the water sector in South Africa. It is assumed that role-players using the Guideline have sufficiently detailed knowledge of the regulatory framework to understand where and how the Guideline fits in. Table 1.3 provides an overall summary of the regulatory and policy framework for South Africa. It should be noted, however, that this summary does not represent an exhaustive list of all acts, policies and strategies, but rather a summary of those relevant to the assessment, planning and management of groundwater resources. Other useful references relating to the assessment, planning and management of groundwater resources are provided in the bibliography at the end of the Guideline.

*Table 1.3: Summary of the regulatory and policy framework in South Africa*

National Department	Act/Policy/Strategy	Act No.	Key details/principles
Water Affairs and Forestry	National Water Act	36 of 1998	<ul style="list-style-type: none"> <li>▪ Promulgated to provide for reform of the law relating to water resources</li> <li>▪ Recognises that water is a scarce and unevenly distributed national resource belonging to all people</li> <li>▪ Provides mandate to protect, use, develop, conserve, manage and control the water resources in an integrated manner</li> <li>▪ Key principles: <ul style="list-style-type: none"> <li>- Ultimate aim: Sustainable use of water for the benefit of all users</li> <li>- Protection of water quality is necessary to ensure sustainability</li> <li>- Integrated management is required, with delegation to regional or catchment level where appropriate</li> </ul> </li> </ul>
	Water Services Act	108 of 1997	<ul style="list-style-type: none"> <li>▪ Key principles: <ul style="list-style-type: none"> <li>- Rights of access to basic water use and sanitation</li> <li>- Duty of government, through co-governance, to ensure efficient, equitable and sustainable water use services</li> <li>- All spheres of government to work towards this objective</li> </ul> </li> <li>▪ Goals: <ul style="list-style-type: none"> <li>- Provide for rights of access to basic water use and sanitation</li> <li>- Set and provide the national standards and norms</li> <li>- Provide framework and details for developing Water Services Development Plans (WSDP)</li> <li>- Provides the regulatory framework for water services institutions</li> <li>- Provide the mechanisms for the establishment and dis-establishment of water boards</li> <li>- Monitoring of water services</li> <li>- Financial assistance to institutions</li> <li>- General powers of the Minister</li> <li>- Information-gathering in national information system</li> </ul> </li> </ul>

National Department	Act/Policy/Strategy	Act No.	Key details/principles
Water Affairs and Forestry	National Water Policy for South Africa	1997	<ul style="list-style-type: none"> <li>▪ Key principles:               <ul style="list-style-type: none"> <li>- Formalise water as an indivisible national asset</li> <li>- Only water required to meet basic human needs and to maintain environmental sustainability will be guaranteed as a right</li> <li>- Riparian system of allocation is abolished</li> <li>- Pricing to include full financial costs (infrastructure and catchment management activities)</li> <li>- Pricing may be waived to promote equitable access to water for disadvantaged groups</li> <li>- Major water users to develop water use, conservation and protection policy</li> <li>- Management of water through the Catchment Management Agency (CMA)</li> </ul> </li> <li>▪ Goal:               <ul style="list-style-type: none"> <li>- Some water, for all, growing prosperity and equity</li> </ul> </li> </ul>
	National Water Resource Strategy	2004	<ul style="list-style-type: none"> <li>▪ Details how the Department plans to give effect to the principles and policies in the NWA</li> <li>▪ Key sections:               <ul style="list-style-type: none"> <li>- Objective: manage water resources in an integrated way to ensure equitable, sustainable social and economic transformation and development</li> <li>- Progressive decentralisation: Head Office as policy-maker, regulator and monitor; CMAs will take on operator responsibilities</li> <li>- Description of aggregated estimates of present water availability and requirements</li> <li>- Details on strategies, objectives, plans, guidelines and procedures required to implement the NWA</li> <li>- Broad overview of methods to build capacity</li> <li>- Indicative programme of capital development</li> </ul> </li> </ul>
	Integrated Catchment Management (ICM)	2004	<ul style="list-style-type: none"> <li>▪ Central Government role in ICM:               <ul style="list-style-type: none"> <li>- Leadership, aimed at facilitating and coordinating the development and transfer of skills set</li> <li>- Institutional arrangements required for effective inter-government collaboration</li> <li>- Landowners and communities to be seen as competent partners</li> <li>- Lead agent to assist in developing skills, where lacking</li> </ul> </li> </ul>

National Department	Act/Policy/Strategy	Act No.	Key details/principles
Environment and Tourism	National Environmental Management Act (NEMA)	107 of 1998	<ul style="list-style-type: none"> <li>▪ Promulgated to give legal effect to the principles of sustainability</li> <li>▪ Purpose:               <ul style="list-style-type: none"> <li>- Give effect to the vertical application of Section 24 of the Constitution, guaranteeing the right to all people of a healthy and safe environment</li> <li>- Create an enabling framework for cooperative governance in environmental matters</li> <li>- Establish a legislative framework for environmental management principles and integrated environmental management</li> </ul> </li> <li>▪ Legislation for compulsory Environmental Impact Assessments (EIA), promulgated in terms of Sections 21, 22, and 26 of the Environmental Conservation Act</li> <li>▪ Objectives:               <ul style="list-style-type: none"> <li>- Thorough and uniform control of the environmental impact of development projects</li> <li>- Promote a sustainable development</li> <li>- Ensure that social and economic interests are taken into account</li> <li>- Regulate the process and reports required</li> </ul> </li> </ul>
Minerals and Energy	Minerals and Petroleum Resources Development Act (MPRDA)	73 of 1989	<ul style="list-style-type: none"> <li>▪ This Act requires the provision of an Environmental Management Programme (EMP) for all mining activities and an Environmental Impact Assessment (EIA) for proposed new mines</li> <li>▪ These programmes and reports regulate environmental management and protection for all mining activities, including the management and protection of water resources</li> </ul>

## 1.6 Principles and Approaches

The guidelines, operational procedures and detailed practices included in this Guideline are aligned to the principles and approaches included in the various acts, policies and strategies that are summarised in Table 1.3.

Some of the key principles adopted are:

- **Equity:** Fairness to people and communities who do not have equal access to natural resources and/or to social and economic goods.
- **Participation:** All interested and affected parties have a right to participate in the management of water resources; participation includes meaningful, timely and representative consultation with interested and affected parties in order to contribute to effective and informed decision-making.
- **Freedom of information:** Openness and transparency in decision-making and information dissemination.
- **Sustainable development:** Promotion of actions and practices that focus on conservation and sustainable use of the water resource, such that future generations have access to the resource and that it meets their needs.
- **Stewardship:** All water users are required to ensure and strive for the same water quantity and quality goals at agreed risk levels.
- **Flexibility:** In undertaking the management of the dolomite water resource, the regulator has the flexibility to consider the application of different alternatives and approaches, provided that each of these is capable of meeting the desired objectives and requirements of the NWA.
- **Continual improvement:** The policies, strategies and guidelines developed by the Department focus on encouraging continual improvement in the water resource management actions and practices of both government and the regulated community.
- **Delegated responsibility:** The Department focuses on placing responsibility for achieving the goals and objectives of the NWA at the lowest (most local) level possible while maintaining effective performance.

The procedures and practices in the Guideline are also based on the following key approaches:

- **Precautionary approach:** The regulatory system adopts a risk-averse and cautious approach to water management, recognising that the water resource is vulnerable to threats from pollution and that there are certain constraints to the current knowledge base. Active measures are therefore required to be taken to avert or minimise the potential risk of undesirable impacts on the water resource. The implications of the precautionary approach include:
  - Avoiding potential risks to the water resource, wherever possible

- Minimising risks to the water resource by being conservative in all decision-making steps on water resource management, and
- Encouraging conservation and sustainable use of the water resource to reduce the need to develop new resources.
- **Prevention approach:** The Department's strategies on water resource management include a hierarchy of control measures that will govern such management, including, in order of priority:
  - Waste elimination, substitution, recycling, re-use and disposal, effected through the adoption of Best Practice guidelines and cleaner technology, and
  - Control, through the water use authorisation process, either of developments taking place, or of the use of procedures, processes, activities or substances that produce discharges or emissions of water containing waste where there is an unacceptably high risk to the water resource.
- **Differentiated approach:** This approach recognises that applying the same degree of management input to all water resources can be both inefficient and wasteful. South Africa's water management policy and strategy do not aim to prevent impacts to the water resource at all costs, since this could hinder much needed social and economic development. The approach rather calls for a differentiated level of management effort in order not only to use the available resources most effectively but also to meet the water resource objectives.
- **Integration:** Integration ensures uniformity and consistency of approach between departments, eliminates duplication, ensures cooperation, rationalises resources and ensures the consideration of all media. Integration aims to ensure effective enforcement of regulations through a coordinated regulatory and enforcement interface with the regulated community.
- **Risk-based approach:** This approach recognises the need for a link between the level of control required to manage resource development and the risks posed on the resource by that development. A lower level of control can be motivated if it can be demonstrated that the risks posed by the development are within acceptable limits, and vice versa. The risk-based approach allows for the identification of areas of risk and impact mitigation in these risk areas in order to achieve focussed and effective water resource management actions.

## 1.7 Institutional Arrangements

### 1.7.1 Description of the Role-Players

The various role-players involved in the assessment, planning and management of groundwater resources are:

- National institutions: Department of Water Affairs and Forestry (Head Office) and Department of Environmental Affairs and Tourism
- Regional institutions:
  - Department of Water Affairs and Forestry (Regional Offices)

- Catchment Management Agencies (CMAs)
- Aquifer Management Committees
- Department of Agriculture
- Provincial Environmental Offices
- Local institutions:
  - Catchment Committee(s)
  - Water User Associations (WUAs)
  - District and local municipalities
  - Water Boards
  - Water forums and reference groups (groups of forums)
  - Ward Councillors and Ward Committees, and
  - Specific task teams or technical committees.

### 1.7.2 Roles and Responsibilities

Table 1.4 summarises the roles and responsibilities of the institutions at the various levels of government and society. The table also describes the opportunities and challenges facing the various institutional bodies in the assessment, planning and management of groundwater resources.

*Table 1.4: Institutional roles, responsibilities, opportunities and challenges*

Level	Institution	Roles and responsibilities	Opportunities	Challenges
National	Department: Water Affairs and Forestry (National Office)	<ul style="list-style-type: none"> <li>▪ Responsibility to “protect, use, develop, conserve, manage and control water resources in a sustainable manner, for the benefit of all”</li> <li>▪ Develop policies, strategies and guidelines for effective resource management</li> <li>▪ Organisational approach:                             <ul style="list-style-type: none"> <li>- Centralised planning and policy-making</li> <li>- Support function to Regional Offices</li> <li>- Decentralised implementation, regional and catchment level</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>▪ Integration of resource management functions at a high level</li> </ul>	<ul style="list-style-type: none"> <li>▪ Ensuring Strategic goals are met</li> <li>▪ Participation of stakeholders in initiatives</li> <li>▪ Developing relevant useful tools for implementation of policies &amp; strategies</li> </ul>
	Department of Environment and Tourism	<ul style="list-style-type: none"> <li>▪ Protection, conservation and maintenance of terrestrial and aquatic ecosystems and water resources</li> </ul>	<ul style="list-style-type: none"> <li>▪ Protection of the national water resource</li> </ul>	<ul style="list-style-type: none"> <li>▪ Integration of stakeholders</li> </ul>
Regional	Department: Water Affairs and Forestry (Regional Offices)	<ul style="list-style-type: none"> <li>▪ Delegated responsibility of water resource management</li> <li>▪ Implementing agents for the Department of water resources policy and strategy</li> <li>▪ Audit of CMA with its related functions and responsibilities</li> </ul>	Pivotal role in decentralised water resources management, having greater knowledge of the groundwater resource issues at regional level <ul style="list-style-type: none"> <li>▪ Opportunities from decentralised strategy:</li> <li>▪ Enhanced groundwater management</li> <li>▪ Increased participation</li> </ul>	Limited geohydrological capacity and skills in Regional Offices to take on the decentralised responsibilities: <ul style="list-style-type: none"> <li>▪ Institutional capacity</li> <li>▪ Historic neglect of groundwater in overall water management</li> <li>▪ Lack of clear integrated management structure</li> </ul>
	Catchment Management Agency (CMA)	<ul style="list-style-type: none"> <li>▪ Responsible for the day-to-day management of groundwater resources</li> <li>▪ Delegated responsibility for some water management activities, including water use allocation</li> <li>▪ Delegation managed and monitored against a specific catchment management strategy for each WMA</li> </ul>	<ul style="list-style-type: none"> <li>▪ Pivotal role in the day-to-day management of water related issues in the WMA</li> <li>▪ Opportunities from decentralised strategy</li> </ul>	<ul style="list-style-type: none"> <li>▪ WMAs defined according to surface water systems</li> <li>▪ Aquifers extend over a number of WMAs, leading to complex trans-boundary management issues</li> </ul>

STRATEGY AND GUIDELINE DEVELOPMENT

CHAPTER 1 : CONCEPTUAL OVERVIEW

Level	Institution	Roles and responsibilities	Opportunities	Challenges
	Environmental section of the Department of Agriculture and Land Affairs	<ul style="list-style-type: none"> <li>Protection, conservation and maintenance of terrestrial and aquatic ecosystems and water resources</li> </ul>	<ul style="list-style-type: none"> <li>Protection of the national water resource</li> </ul>	<ul style="list-style-type: none"> <li>Integration of stakeholders</li> </ul>
	Aquifer Management Committee	<ul style="list-style-type: none"> <li>Responsible for cross-boundary coordination where the aquifer spans more than one WMA</li> </ul>	<ul style="list-style-type: none"> <li>Pivotal institutional role for the coordination of the management of the water resources</li> </ul>	<ul style="list-style-type: none"> <li>Institutional capacity</li> <li>Knowledge base – user defined</li> </ul>
Local	Catchment Committee	<ul style="list-style-type: none"> <li>Responsible for day-to-day management of the groundwater resources within the WMA or local catchment</li> </ul>	<ul style="list-style-type: none"> <li>Key role in ensuring optimum sustainable development</li> </ul>	<ul style="list-style-type: none"> <li>Licensing</li> <li>Resource assessment</li> <li>Management of the available resources</li> </ul>
	Water User Association	<ul style="list-style-type: none"> <li>Responsible for the management of the water resources being utilised, including groundwater resources</li> </ul>	<ul style="list-style-type: none"> <li>Key role in the institutional structure for the management and use of water</li> <li>Major users of water</li> </ul>	<ul style="list-style-type: none"> <li>Lack of capacity and financial resources</li> <li>Lack of clarity in terms of divisions of roles and responsibilities</li> </ul>
	District and Local Municipalities	<ul style="list-style-type: none"> <li>Planning and developing water services and infrastructure to ensure acceptable minimum levels of provision to their constituents</li> <li>Management of local water source</li> </ul>	<ul style="list-style-type: none"> <li>Key role in the institutional structure for the management and use of water</li> <li>Major users of water</li> </ul>	<ul style="list-style-type: none"> <li>Lack of capacity and financial resources</li> <li>Lack of clarity in terms of divisions of roles and responsibilities</li> </ul>
	Water Boards	<ul style="list-style-type: none"> <li>Organs of state established to provide water services to other water services institutions</li> </ul>	<ul style="list-style-type: none"> <li>Strategic and operational management input</li> </ul>	<ul style="list-style-type: none"> <li>Future role unclear: Economic viability of Water Boards as opposed to Local and District Councils in providing the service is being debated</li> </ul>
	Water forums and reference groups	<ul style="list-style-type: none"> <li>Monitoring and management of water resource development schemes</li> </ul>	<ul style="list-style-type: none"> <li>Local water resource management</li> </ul>	<ul style="list-style-type: none"> <li>Representation on water institutions</li> </ul>
	Ward Councillors and Ward Committees	<ul style="list-style-type: none"> <li>Representation of communities' needs</li> <li>Local management of water schemes</li> <li>Set up and operate water management committees</li> </ul>	<ul style="list-style-type: none"> <li>Local water resource management</li> </ul>	<ul style="list-style-type: none"> <li>Representation on water institutions</li> </ul>
	Task teams	<ul style="list-style-type: none"> <li>Responsible for specific projects of a short-term nature, relating to assessment, planning and management of water resources</li> </ul>	<ul style="list-style-type: none"> <li>Focussed input to water management issues</li> </ul>	<ul style="list-style-type: none"> <li>Retention of institutional memory</li> </ul>

### 1.7.3 Structure and the Integration of Functions

Figure 1.2 indicates the proposed institutional framework for the assessment, planning and management of water resources in South Africa. This framework is underpinned by the formation of Aquifer Management Committee (AMC) in areas where the aquifer(s) span(s) more than one WMA and Catchment Committees for addressing site-specific issues.

#### Aquifer Management Committee (AMC)

The AMC will be an advisory body (not legislated) set up by the various role-players in the catchments to provide strategic input to the assessment, planning and management of the groundwater resources in the affected areas.

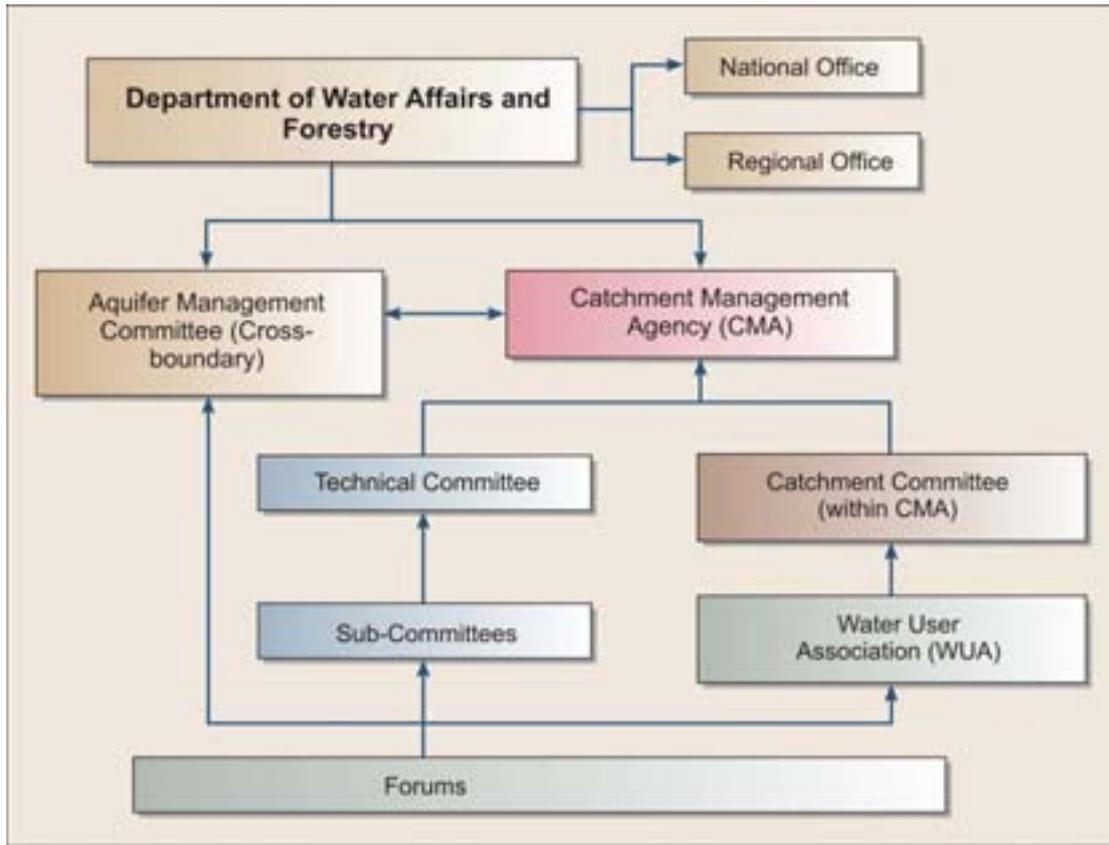
The primary representation on each of the established AMCs will be from the various CMAs where the aquifer(s) span(s) more than one WMA. Other representation will be from the Department's National Office, Regional Office/CMA, Water User Associations, Water Boards, District and Local Municipalities, as well as other relevant government Departments with an interest in the specific area. The representatives should be sufficiently or appropriately informed and knowledgeable about the area. The AMC will:

- Ensure the integration of the different functional groups for the assessment, planning and management of the groundwater resources in the specific area
- Provide all necessary strategic and operational input to ensure that the use of the aquifers is planned and managed on a sustainable basis. Ensure cooperative governance with other spheres of government, for example, in respect to land-based activities and zoning within important/significant groundwater resources.
- Assess the cumulative impacts of water use together with stakeholder groups on the integrity of the groundwater resources and devise action plans to mitigate this impact, if required, and
- Receive assistance and input on the assessment, planning and management of the water resources from Catchment Committees and task teams.

#### Catchment Committee

The Catchment Committee will be a legal entity, set up by the Catchment Management Agency (CMA) in accordance with Section 82(5) of the National Water Act and will:

- Be delegated powers from the CMA for the day-to-day management of the water groundwater resources,
- Be responsible for management functions, such as water use control, resource assessment and management of the available resources, and report to the CMA on a regular basis on the effectiveness of management of the water resources. Correspondence, reports and minutes of the Catchment Committee activities should also be provided to the CMA and Department's Regional Office, and
- Integrate the management functions between a Water User Association (if a WUA is in place) and other stakeholders in the area.



*Figure 1.2: Proposed institutional framework*

#### 1.7.4 Reporting and Auditing Functions

Regular (monthly) operational reporting will primarily be from the Catchment Committee to the CMA. These reports will be collated and summarised into quarterly reports to be submitted to the CMA and AMC. The CMA will then provide an audit function of the effectiveness of management of the groundwater resources.

### 1.8 Public Participation

Public participation in this project will serve as a vehicle to provide assistance and guidance both to the Water Manager and all other role-players involved in the assessment, planning and management of water (including groundwater) resources within the country. If conducted effectively, public participation will contribute to informed and integrated decision-making aimed at achieving sustainable development.

### 1.8.1 What is Public Participation?

Public participation is the involvement of all parties who may potentially have an interest in a development or project, or be affected by it. It entails a wide range of activities, ranging from providing information, through consultation to direct involvement of the public in aspects of the decision-making process.

The Department of Water Affairs and Forestry's Generic Guidelines for Public Participation (September 2001) defines public participation as the *“ongoing interaction between role-players that is aimed at improving decision-making during the planning, design, implementation and evaluation of the Department’s development projects and processes. It requires the involvement of all stakeholders, including groups that are often marginalised, such as women and the youth. Decision-makers have to consider the views of stakeholders during the decision-making process.”*

### 1.8.2 Benefits of public participation

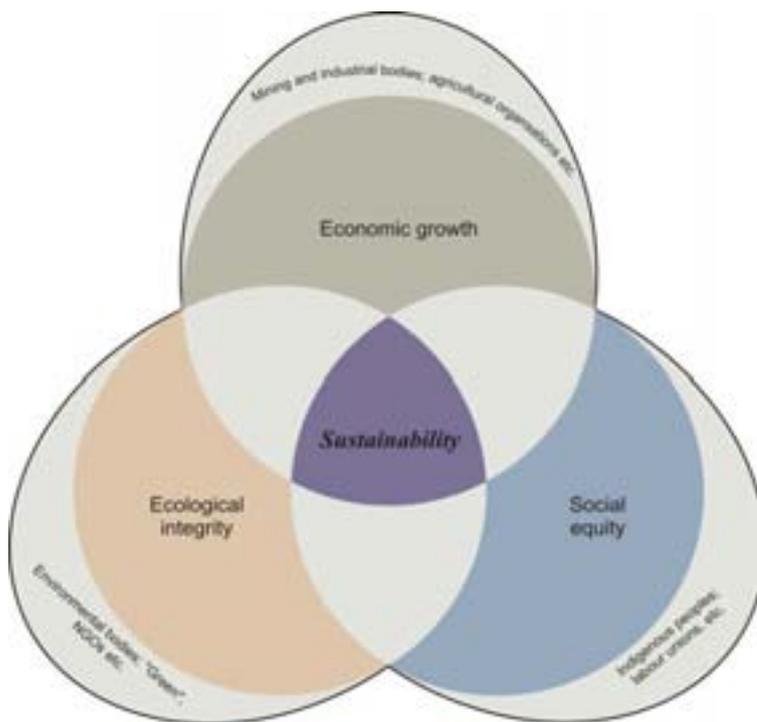
In its submission to the World Summit on Sustainable Development, the International Association for Public Participation (IAP2) described the benefits of public participation:

- Builds public understanding of the need for a proposed policy, programme, plan or project and leads to better and more durable decisions
- Creates trust in decision-makers and their processes, leading to stable policies and enduring decisions
- Provides an early warning of issues that require mitigation
- Builds public ownership and a stronger stake in initiatives leading to participants carrying out their responsibilities during implementation – they do not want to be seen letting their co-participants down
- Identifies local customs or institutions that could be barriers to implementation, with opportunities to adapt the activity before the implementation begins
- Creates opportunities for stakeholders to discuss their differences directly, often leading to creative new solutions
- Manages single-issue viewpoints through an interactive process which allows a broad range of balancing perspectives and values
- Enriches decision-making through a diversity of opinion and the local and traditional knowledge and collective wisdom of a range of stakeholders, and
- Builds “legitimacy” for decisions that allows them to withstand changes in government or company policy and leadership.

### 1.8.3 Public participation's role in achieving sustainable development

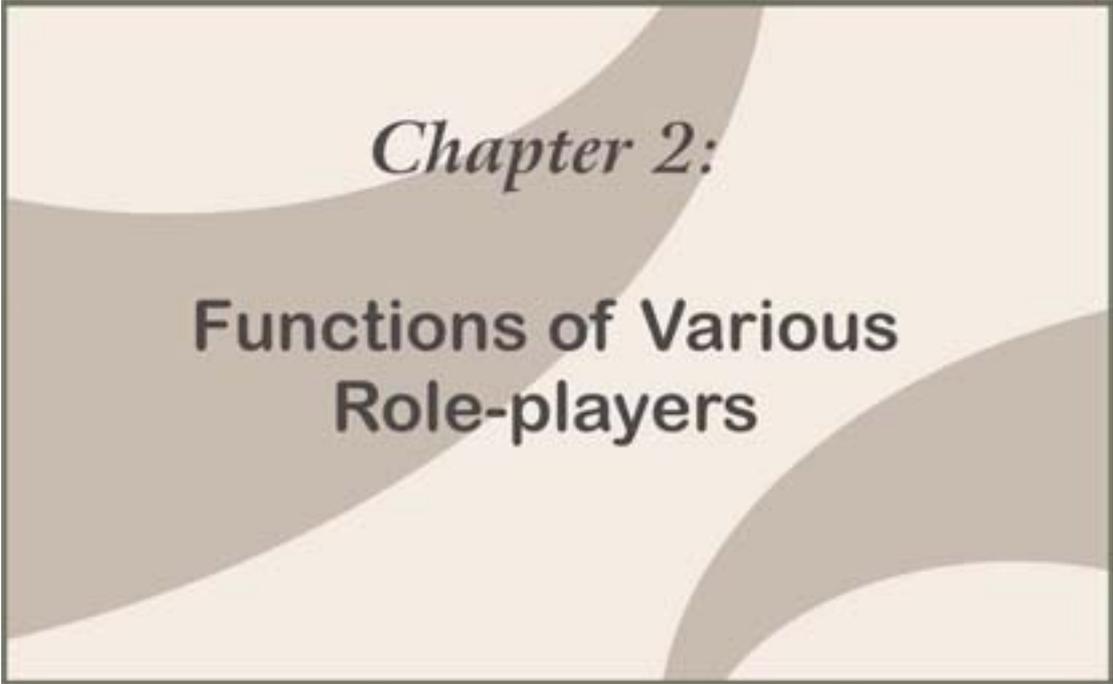
The greatest benefit of public participation is its contribution to achieving sustainability. For a project, policy or programme to be sustainable, it has to take into consideration all three dimensions of sustainability, namely, economic growth, social equity and ecological integrity.

These three dimensions are seldom in balance as there are always trade-offs based on local needs and circumstances, and the point of sustainability differs from project to project. Public participation assists decision-makers to establish the point of sustainability for each project. It contributes essential local knowledge and wisdom to project assessment, planning and design, and management, and clarifies the degree to which stakeholders are willing to accept, or live with, the trade-offs (Figure 1.3). Thus, public participation assists decision-makers to make informed and integrated decisions about the sustainability of a proposed project, policy, programme or plan.



*Figure 1.3: Contributions to sustainability*

Public participation therefore assists in achieving sustainable development through stakeholders deliberating the trade-offs between ecological integrity, social equity and economic growth.

The graphic features a rectangular frame with a light beige background. Overlaid on this background are several large, overlapping, curved shapes in a darker beige or taupe color, creating a layered, abstract effect. The text is centered within this frame.

*Chapter 2:*

**Functions of Various  
Role-players**

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## CHAPTER 2. FUNCTIONS OF VARIOUS ROLE-PLAYERS

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### 2.1 *Various Role-players*

A structured approach to the effective assessment, planning and management of the groundwater resources is required. Efforts to coordinate the assessment, planning and management of groundwater resources may be led at a local, catchment or national level.

#### 2.1.1 **Water Manager/Planner**

The typical role of a Water Manager/Planner at catchment or local level is to assess the water use requirements and to identify target areas within the aquifer system(s) where these needs can be addressed. This may be based on advice from national level or arise directly from local requirements. The responsibilities of the Water Manager/Planner include the following tasks, among others:

- Reconcile water availability and demand
- Assess water requirements
- Identify target areas within the aquifer system(s) for potential resource development and requirements for the protection of the resource
- Prepare the Scope of Work of the identified task(s)
- Determine what hydrogeological expertise is available and required
- Determine whether a specialised hydrogeological consultant is needed
- Be able to assess proposals and tenders
- Appoint a recognised specialised hydrogeologist, and
- Appoint an experienced contractor on the basis of a tender and technical specification.

#### 2.1.2 **Water Boards**

Water Boards are organs of state that are established to provide water services to other water services institutions. Water Boards may be responsible for implementing and maintaining water use schemes, based on abstraction from aquifers that have been identified through the assessment and planning process. Where this is the case, the responsibilities of the Water Board will be similar to those detailed for the Water Manager.

### 2.1.3 Water Services Authority

The Water Services Authority is responsible for the provision of water services to the end user. The Water Services Authority is responsible for preparing a Water Services Development Plan (WSDP) within its area of jurisdiction. This plan will include details on the use of water from and the expected development of the aquifer system(s). The Water Services Authority will appoint a Water Manager or Water Board.

### 2.1.4 Catchment Committee

The Catchment Committee is responsible for day-to-day management of the water resources within a WMA or local catchment. The Committee will be responsible for management functions, such as water use control (including licensing), resource assessment, and management of the available resources.

### 2.1.5 Water User Association

The Water User Association is responsible for the day-to-day management of the water resources being utilised, including abstraction from aquifer systems. The primary functions of the Water User Association will include monitoring and management of the water resource, enforcement, and groundwater protection.

This will be undertaken in consultation with the Catchment Committee.

### 2.1.6 Hydrogeologist

The specialist knowledge to undertake groundwater investigations may be available within the institutional framework of the Department's National Office and/or Regional Offices, WSPs, CMAs or WUAs. Such expertise may also be obtained from an external Professional Service Provider.

The Hydrogeologist would typically undertake the following tasks:

- Report to, and liaise with, the Water Manager, Water Planner and Water Users, as applicable
- Draw up a suitable programme of work to fulfil the objectives of the Scope of Work as specified by the Water Manager/Planner
- Ensure the application of correct scientific assessment/development methods
- Prepare technical specifications for borehole drilling, testing and equipping
- Recommend the appointment of contractors, as applicable
- Ensure adherence to the technical specifications by the appointed contractor by being responsible for field supervision

- In the event that the drilling of new boreholes is required, select drilling locations according to the application of sound scientific principles and techniques, as described in Section 2.4.3 of this Guideline, and
- Make recommendations based on the technical specifications.

One of the most critical functions of the Hydrogeologist is to prepare technical reports and to make recommendations on development, target areas, sustainable aquifer resources, sustainable borehole yields, well-field configuration, monitoring protocols and potential environmental and other impacts that could arise as a result of using groundwater resources. The exact nature of any assessment, however, will be based on the original Scope of Work.

### 2.1.7 Hydrologist

Because of the large surface water – groundwater interaction component associated with certain aquifer systems (e.g. primary aquifers and dolomites) the Hydrologist is described as a specific role player. The Hydrologist is responsible for reviewing and assessing the surface water requirements and potential impacts. The hydrologist will form part of the team assessing the integrated use and protection of the water resources. Interaction between the Water Manager, the Hydrogeologist and the Hydrologist is essential in the assessment, planning and management of the aquifer system(s).

### 2.1.8 Drilling/Testing Contractor/Operator

The Drilling/Testing Contractor/Operator is responsible for:

- Undertaking the drilling and construction of boreholes according to the applicable technical specification, and
- Test pumping boreholes according to the applicable technical specification.

The technical specifications must detail what is required of the contractor. Model drilling and testing specifications are described in Appendix A.1 and Appendix A.2 respectively.

The contractor will typically report to the Water Manager or the appointed Hydrogeologist.

### 2.1.9 Other Role-players

The roles and responsibilities of other role-players (District and Local Municipalities, Water Forums, ward councillors and task teams) are summarised in Section 1.7.2 of this Guideline. The task teams in particular will provide technical input for the management of the groundwater resources.

## 2.2 Public Participation

The Department has developed *Generic Guidelines for Public Participation* (September 2001) which provide a generic approach to understanding the value of public participation in decision-making processes and assisting the Department in implementing public participation in its activities. These Generic Guidelines highlight the objectives and benefits of public participation, the principles, methods and tools for public participation, generic processes and guidelines for implementation, contribution of public participation towards sustainable development, as well as recommendations to the Department on how to improve public participation. The Generic Guidelines therefore serve as the main reference for conducting public participation processes.

An introduction on how to conduct public participation for groundwater development is included in Section 1.8, and provides definitions of public participation and its benefits. This Chapter has been designed to assist the Water Manager, in all aspects of public participation. It describes how to engage the public (i.e. authorities, water users, directly affected parties and other interested and affected parties) to participate in the management of these water resources in order to achieve sustainability.

The following sections provide a brief summary (the details are contained in the Department's *Generic Guidelines for Public Participation*) on aspects such as: when to undertake public participation; at what level to pitch it; how to identify stakeholders; how to analyse the stakeholder profile; what methods to adopt to engage stakeholders; and how to deal with stakeholders' issues of concern. Also described are the principles of risk communication, ongoing awareness creation and building and maintaining good relations with water users and communities depending on groundwater resources.

### 2.2.1 Who is "the public"?

There is no single "public." The public is made up of many different and diverse groups. Some may participate throughout a process, while some may only participate during part of the process. Some may enter the process late or leave early.

The International Association for Public Participation (IAP2) defines "the public" as: "*Any individual or group of individuals, organisations or entities with an interest in the outcome of a decision. They are often referred to as stakeholders. They may be, or perceive that they may be, affected directly or indirectly by the outcome of a decision. Internal stakeholders (individuals who work for or with the decision-making organisation) are also part of the public.*"

"Stakeholders" are those individuals, groups, communities, organisations, associations or authorities whose interests may be positively or negatively affected by a proposal or activity, and/or who are concerned with a proposal or activity and its consequences. The term therefore includes the proponent or developer, the authorities and all interested and affected parties (I&APs).

“Directly affected parties” are those people who will or may be directly impacted (e.g. farmers using water from aquifer systems for irrigation).

### 2.2.2 Why do public participation?

Public participation involves stakeholders representing different sectors of society, technical specialists, authorities and project proponents who work together in a joint effort to produce better decisions than if they had acted independently. Public participation is mainly conducted to:

- Satisfy local regulatory requirements (e.g. South African Constitution, National Water Act, Environment Conservation Act, National Environmental Management Act)
- Satisfy Departmental specific guidelines (e.g. the Department of Water Affairs and Forestry’s Generic Guidelines for Public Participation)
- Satisfy international Best Practice principles for public participation
- Enrich decision-making processes, and
- Add value beyond the lifespan of a project, that is, to achieve and/or contribute to sustainable development.

The value of public participation to developers and the authorities is that stakeholders often help them to think through a proposed project, its implementation and management. Stakeholders can often give an up-front indication of environmental or social issues that may cause project difficulties at a later stage. Through the public participation process, stakeholders therefore provide their input and advice “free of charge” and assist developers and authorities to understand the environmental and social consequences of their decisions.

### 2.2.3 When is public participation required?

As mentioned in the Department’s *Generic Guidelines for Public Participation*, “the Constitution of South Africa sets out the Government’s responsibility to provide the public with the opportunity to be involved in Government decisions that affect their lives.” Thus, the Constitution lays the foundation for the necessity of public participation in any future development project, and this responsibility is reflected in many, if not all, of the South African Government’s regulations. In particular, public participation, or the requirement for public participation, is an integral part of the Department’s acts, policies, strategies and regulations, and other non-regulatory processes (see **Box 1** for examples of legislative, regulatory and non-regulatory processes).

From an international perspective, the training guideline, Southern African Institute for Environmental Assessment (SAIEA) 2005 *Training Course: Public Participation in Environmental Assessment in Southern Africa*, contains an extensive list of Southern African Development Community’s Protocols, Declarations, Charters and Memoranda of Understanding, Agreements, Treaties and International Conventions that underpin the

importance of public participation, particularly in cases where water resources are shared by different countries (see **Box 2**).

Apart from all the above regulatory requirements for public participation, it is always beneficial to adopt it as a Best Practice principle as part of the process to assess, plan and manage groundwater resources. For example, public participation is vital in the following situations:

- When planning the development of a waste site close to a groundwater resource
- When planning to abstract water from a groundwater resource close to a sensitive ecological system
- When planning a housing development close to a potentially vulnerable aquifer system (e.g. primary or dolomitic water resource)
- When communicating potential or actual risks associated with aquifer system(s) such as subsidence due to dewatering aquifers, and
- When there is a need to create awareness and build understanding about groundwater resources in order to plan and manage the resource.

These are just a few examples from an extensive list of when to conduct public participation. If there is uncertainty as to when to conduct public participation, it is best to consult the Department: Water Affairs and Forestry.

The following section provides some references that can be used to design a public participation process.

***Box 1: Examples of legislative, regulatory and non-regulatory processes***

***Regulations:***

- *Constitution of the Republic of South Africa (Act 108 of 1996)*
- *National Water Act (Act 36 of 1998) and the White Paper on Water Policy (30 April 1997)*
- *Water Services Act (Act 108 of 1997) and the White Paper on Water Use and Sanitation (November 1994)*
- *National Forests Act (Act 84 of 1998)*
- *National Veld and Forest Fire Act (Act 101 of 1998)*
- *National Environmental Management Act (NEMA) (Act 107 of 1998)*
- *Environment Conservation Act (Act 73 of 1989)*
- *Promotion of Access to Information Act (Act 2 of 2000)*
- *Minerals and Petroleum Resources Development Act (Act 28 of 2002).*

***Policies and Strategies:***

- *White Paper on Water Policy (30 April 1997)*
- *White Paper on Water Use and Sanitation (November 1994)*
- *Batho Pele – White Paper on Transforming Service Delivery (September 1991)*
- *National Water Resource Strategy (2004)*

- *Draft Position Paper for Water Allocation Reform (2005).*

#### **Non-regulatory requirements:**

*In addition to the above-mentioned policies, other non-regulatory processes within the Department require public participation, including:*

- *Waste Management and the Minimum Requirements (DWAF, First Edition, 1998)*
- *CMA/WUA Guide 4: Public Participation for Catchment Management Agencies/ Water User Associations (DWAF, 2000)*
- *Water Quality Management Series, Volumes 1-3 (Sub-series No MS 8.2, Edition 1, March 2003).*

#### **Box 2: SADC Protocols, Declarations, Charters, Memoranda of Understanding, Agreements and Treaties**

*The importance of public participation is underpinned by the existing SADC Protocols, Declarations, Charters, Memoranda of Understanding, Agreements and Treaties, as listed below<sup>1</sup>. Web addresses are also supplied.*

#### **SADC Protocols**

- *Protocol on Control of Firearms, Ammunition and other related materials*
- *Protocol Against Corruption*
- *Protocol on Culture, Information and Sport*
- *Protocol on Illicit Drug Trafficking*
- *Protocol on Education and Training*
- *Protocol on Energy*
- *Protocol on Extradition*
- *Protocol on Fisheries*
- *Protocol on Forestry*
- *Protocol on Health*
- *Protocol on Immunities and Privileges*
- *Protocol on Legal Affairs*
- *Protocol on Mining*
- *Protocol on Mutual Legal Assistance in Criminal Matters*
- *Protocol on Politics, Defence and Security Cooperation*
- *Protocol on Shared Watercourse Systems Revised*
- *Protocol on Trade*
- *Protocol on Transport, Communications and Meteorology*
- *Protocol on Tribunal and Rules of Procedure Thereof*

<sup>1</sup> Adapted from Southern African Institute for Environmental Assessment (SAIEA) 2005. Training course - Public Participation in Environmental Assessment in Southern Africa. Developed as part of the SAIEA Calabash Project. First Edition, 2005.

- *Protocol on Tourism*
- *Protocol on Wildlife Conservation and Law Enforcement*

<http://www.sadc.int/index.php?lang=english&path=legal/protocols&page=index>

#### **SADC Declarations**

- *Declaration and Treaty of SADC*
- *Declaration on Gender and Development*
- *Declaration on Information and Communications*
- *Declaration on Productivity*
- *Declaration on HIV/AIDs*

<http://www.sadc.int/index.php?lang=english&path=legal/declarations&page=index>

#### **SADC Charters**

- *Charter of the Regional Tourism Organisation of Southern Africa (RETOSA)*
- *Charter of Fundamental Social Rights in SADC*

<http://www.sadc.int/index.php?lang=english&path=legal/charters&page=index>

#### **SADC Agreements**

- *Agreement Amending the Treaty of SADC*

<http://www.sadc.int/index.php?lang=english&path=legal/agreements&page=index>

#### **SADC Memoranda of Understanding**

- *Memorandum of Understanding on Macroeconomic Convergence*
- *Memorandum of Understanding on Cooperation in Taxation and Related Matters*
- *Memorandum of Understanding on SQAM*

<http://www.sadc.int/index.php?lang=english&path=legal/moa&page=index>

#### **SADC Treaties**

- *Declaration and Treaty of SADC*
- *Amended Declaration and Treaty of SADC*

<http://www.sadc.int/index.php?lang=english&path=legal/treaties&page=index>

### **2.2.4 How to design a public participation process**

Public participation processes are not carved in stone, nor is there a blue-print for such processes. A public participation process must be designed to satisfy local regulatory requirements, and international requirements if conducted across the borders of different countries. These may include one or more of the National Water Act, the EIA Regulations, the National Environmental Management Act, the Environment Conservation Act and international best practice principles as proclaimed by the International Association for Public Participation (IAP2) and other applicable legislation and/or protocols (see **Box 2**).

Very few of these regulations and best practice principles provide guidelines on how to conduct public participation. The Department's *Generic Guidelines for Public*

*Participation* (September 2001), specifically Section 4, describe the sixteen principles of public participation that must be considered when designing a process to engage stakeholders. Another valuable resource on how to conduct public participation, albeit in Environmental Assessment, is the training guideline by the Southern African Institute for Environmental Assessment (SAIEA) 2005, *Training course - Public Participation in Environmental Assessment in Southern Africa*.

It is important to note that the context to public participation at national level is different to that at catchment and site-specific levels. Each has different requirements and these must be borne in mind when designing a public participation process and when implementing methods to achieve desired outcomes. However, certain of the guidelines must be considered and certain generic steps must be followed when conducting an effective public participation process, whether undertaken on a national, catchment or site-specific level. These generic steps are outlined in Figure 2.1 and are briefly discussed in the following sections. More details are contained in Section 5 of the Department's *Generic Guidelines for Public Participation*.

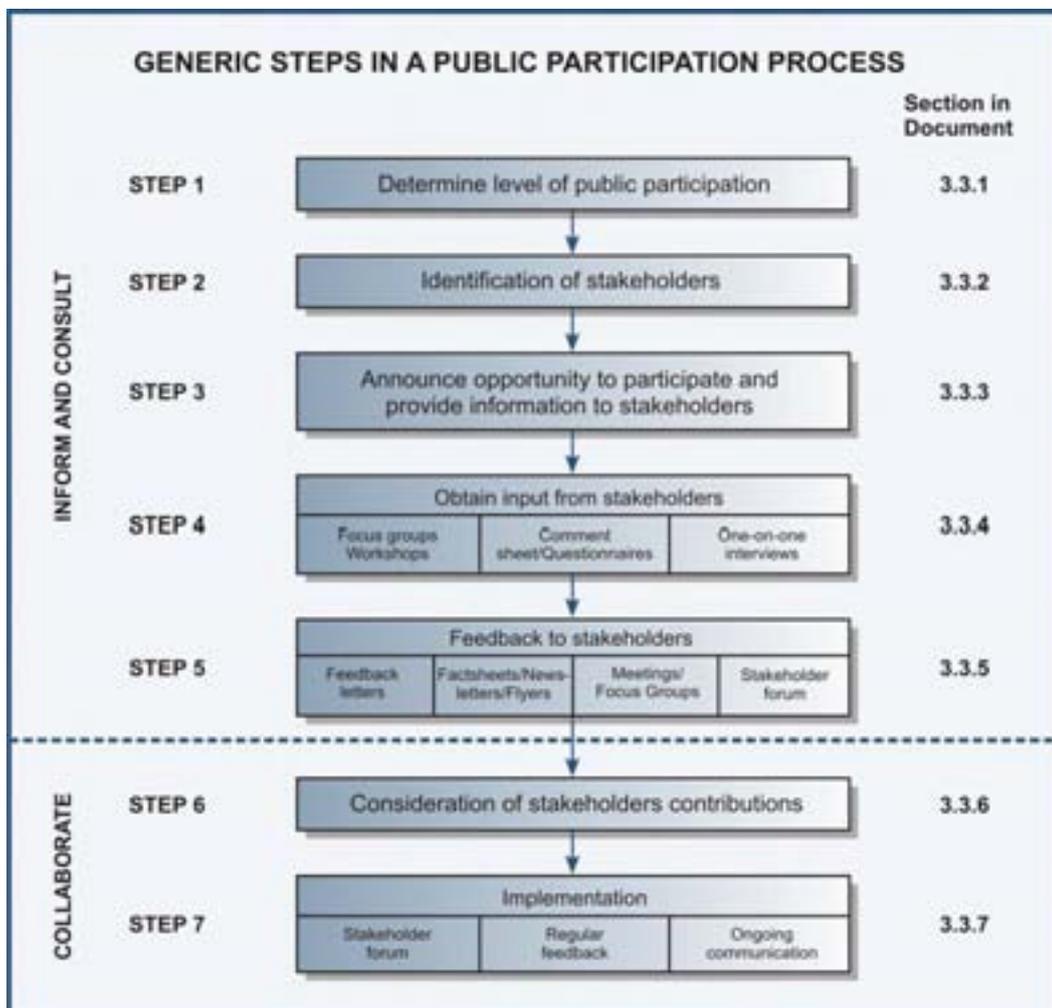


Figure 2.1: Generic steps in a public participation process

**Step 1: Determine the level of public participation**

A confusing aspect about public participation is that different parties have different definitions and use different terminology. What is important is that most organisations recognise public participation as a spectrum or a continuum rather than an absolute (Southern African Institute for Environmental Assessment (SAIEA) 2005, *Training course - Public Participation in Environmental Assessment in Southern Africa*).

The International Association of Public Participation (2005) differentiates between five levels of public participation in its Spectrum of Public Participation, each with different objectives and each with increasing public impact on decision-making:

- **Inform:** The objective is to provide the public with balanced and objective information to enable people to understand the problem, alternatives and/or solutions
- **Consult:** The objective is to obtain public feedback on analysis, alternatives and/or decisions, in particular those points that are relevant to the subject at hand. It involves acknowledging concerns and providing feedback on how public input has influenced the decision
- **Involve:** The objective is to work directly with the public throughout the process to ensure that public issues and concerns are understood and considered at every stage and are directly reflected in a particular proposal or activity
- **Collaborate:** The objective is to work with the public as a partner on each aspect of the decision, including the development of alternatives and the identification of the preferred solution; and
- **Empower:** The objective is to place final decision-making in the hands of the public.

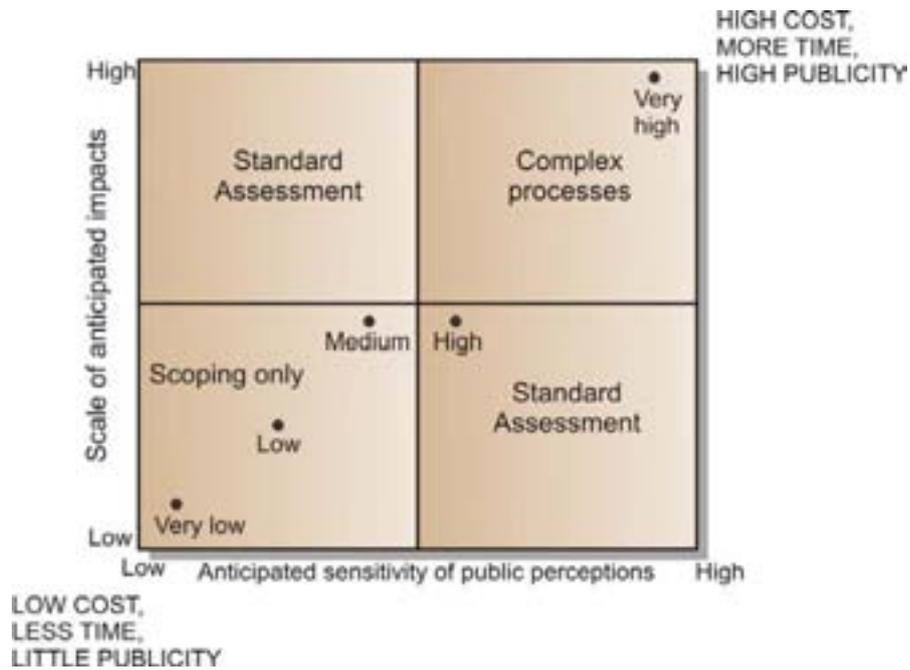
In the development of policies, strategies and guidelines, public participation mainly takes place at the “Inform” and “Consult” levels of the continuum, and sometimes at the “Collaborate” level. As an example, the national policy consultation process for the National Water Resource Strategy (NWRS) evolved from the consult level to a collaborative level due to the nature of the project. A project does not necessarily need to remain at a specific level but can grow from one level into another depending on the type of the project, its sensitivity and the interest generated by the project.

With regard to the assessment, planning and management of groundwater resources in highly impacted and sensitive areas (e.g. where water has been over-abstracted by farmers, or slimes dams built), public participation should be pitched at the “Inform”, “Consult” and “Collaborate” levels. This will ensure the involvement of stakeholders in the management and protection of the resource. However, in areas where impacts to water resources are low, public participation needs to take place only at the “Inform” level. This approach applies equally to the national, catchment and site-specific levels.

The level of public participation is dependent on the anticipated scale of impacts and sensitivity of public perceptions, as illustrated in Figure 2.2.

**NOTE:**

For more information or a guideline to implementation, refer to section 6.2.2 of the Department’s Generic Guidelines for Public Participation (September 2001). Section 7 of this volume also provides information on the methods of public participation.



*Figure 2.2: Level of public participation*

**Step 2: Identification of stakeholders**

When identifying stakeholders with whom to consult, It is important to bear in mind the scale of the process (i.e. national, catchment and/or site-specific) and to be sensitive to the power relationships within the stakeholder groups (SAIEA 2005, *Training course - Public Participation in Environmental Assessment in Southern Africa*). This can play a vital role in the degree to which stakeholders will actively participate in the project. Up-front knowledge about the dynamics in stakeholder groups can also determine the success of the process. Before identifying stakeholders in the project area, it is important to consider the following questions (SAIEA 2005, *Training course - Public Participation in Environmental Assessment in Southern Africa*):

- Is there an existing stakeholder profile in the project area?
- Who needs to be informed of the process and brought on board?
- What are the traditional systems of power, government and authority?
- What languages are spoken?
- What specific cultures, traditions or rituals are important?
- What are the mechanisms of communication in the community?
- Who are the dominant individuals and groups among the stakeholders or community?
- What are the correct channels to use when engaging with stakeholders?
- Are there any special interest groups that need to be involved in the project and how can women, the youth, the disabled and people with HIV/AIDS be incorporated into the public participation process?
- Are there any specific marginalised people in the project area who may need special assistance to attend meetings (e.g. transport)?
- What capacity to participate does community and civil society groups have? For example, do they have access to time, finances, knowledge and skills to enable them to get involved? Do they lack access to these resources and/or have limited resources to get involved? What can be done to overcome this problem?
- What lessons can be learned from previous experience?
- Who will benefit from the planning, assessment and management of groundwater resources?
- Who might be negatively affected by the regulation of use of groundwater resources?
- Who might stand in the way or obstruct the process of licensing water use from groundwater resources?
- Who may have resources, such as skills and finances, to contribute to the planning, assessment and management of groundwater resources?
- Who are the relevant decision-makers in the process?

To ensure that no group of stakeholders has been left out, categorise the list of stakeholders into different sectors of society. These sectors are listed in **Box 3**. They may not all be relevant but the list can be used for cross-checking purposes. Every area has a unique group of stakeholders (e.g. some areas may have more rural communities than others) and it is important to identify the right people to participate in the project. Take care not to exclude marginalised people merely because they may need extra care and attention.

**Box 3: List of sectors of society**

- National government
- Provincial government
- Local government
- Tribal authorities
- Mining
- Industry
- Financial institutions
- Business and commerce (e.g. farmers' cooperatives involved in the sale of centre pivot irrigation systems to farmers)
- Transport
- Agriculture (e.g. farmers associations)
- Environmental bodies, incl. NGOs and conservation groups
- Water users (e.g. individual farmers and landowners) and user associations
- Community-Based Organisations, residents' associations, women's groups, the youth, disabled, people with HIV/AIDS
- Labour unions
- Power
- Health
- Education
- Religious groups, churches
- Other, as applicable.

**NOTE:**

*For more information on how a final stakeholder list might look, see Section 6.2.3 (Boxes 9 and 10) of the Department's Generic Guidelines for Public Participation (September 2001).*

The stakeholder list should include marginalised groups such as women, the youth, the poor, disabled people, rural people, emerging farmers/ etc.

When developing the stakeholder database, and to ensure that all relevant stakeholders are included, it is important to network with the Department's Regional Offices. Comprehensive existing stakeholder databases developed for other processes are held by the Department and these can be used for public participation. These processes included developing the following Public Participation databases which are available:

- The National Water Resource Strategy
- Water allocation
- NORAD
- KOSH study, and

- DANIDA-funded Integrated Water Resource Management process
- Conference databases e.g. Water Summit, Groundwater conferences.

***Step 3: Announcing the opportunity to participate and providing information to stakeholders***

Several techniques are available to announce the opportunity for stakeholders to participate in the assessment, planning and management process of groundwater resources. These include:

- Announcement letters
- Paid advertisements in national, regional or local newspapers (preferably placed in the main body of the newspaper and not in the classifieds or legal sections)
- Mail-drops
- Newspaper inserts, and
- Press releases.

Techniques to share information include:

- Printed material (e.g. fact sheets, newsletters, brochures, posters, flyers)
- Information repositories at public places (e.g. libraries, distribution centres, community centres, schools)
- Technical reports (e.g. proposed Management Plan for specific aquifer systems)
- Electronic information
- Poster displays
- Briefing meetings/workshops (this technique worked well in developing this guideline document and works well when one needs to obtain stakeholder input), and
- Industrial theatre (this technique works especially well in rural areas where literacy levels are low and in dealing with young stakeholder groups).

As previously mentioned, there is no “blueprint public participation process” as each geographical area has its own unique group of stakeholders. The social profile of these stakeholders should be well-known to the public participation practitioner or the Water Manager. For example, when convening meetings with people living in remote rural areas, it would be considered impractical to invite them by letter to a meeting 100 kilometres from where they live. One should be aware that such cases may involve considerable additional effort. There may often be a need to first create awareness about the groundwater resource(s), and to provide people with sufficient information in a way that is applicable to their level of comprehension (e.g. visual posters with photographs,

community theatre) in order to build trust and to capacitate them to contribute meaningfully.

The Water Manager, who has on-going contact with stakeholders in his area, generally tends to know stakeholders' preferences in how they like to be consulted. Thus, certain groups may prefer informal discussions around a table with key representatives, while other groups may prefer formal workshops. It may sometimes be necessary to combine techniques to share information.

#### **Step 4: Obtaining input from stakeholders**

Obtaining input from stakeholders will not only enrich the public participation process but will build understanding, trust, ownership and a willingness to work together. However, one will need to be sensitive to the methods adopted when communicating with different stakeholder groups. For some groups, a document describing the project may be sufficient, while others may require small meetings with visual presentations and illustrations.

Many techniques are available to obtain input from stakeholders, including one or a combination of the following techniques:

- Information hotline
- Electronic media
- Comment sheets and questionnaires
- Community facilitators visiting communities
- Site visits
- Focus group meetings
- Open houses
- Public meetings and workshops, and
- One-on-one interviews.

**NOTE:**

*Section 6.2.3.2 and Boxes 13, 14, 15 and 16 of the Department's Generic Guidelines for Public Participation (September 2001) provide more information about how to convene meetings with stakeholders.*

Note that the advantage of bringing people together in a meeting, workshop or open house exposes the different viewpoints of different groups to each other. This has the benefit of creating better understanding and appreciation of each other's situations and challenges, and developing new ideas and solutions.

**Step 5: Feedback to stakeholders**

Regular feedback (every three months) to stakeholders is an essential part of the public participation process. It ensures that stakeholders are constantly aware of new information, decisions and the consequences of the decisions and/or activities. It also encourages their continued involvement in the process. Feedback to stakeholders can be by means of:

- Feedback letters
- Issues and Response Reports
- Media releases
- Fact sheets, newsletters, brochures, flyers
- Meetings, workshops, open houses, focus groups, and
- Stakeholder forums.

**NOTE:**

*See Section 6.2.3.3 and Box 17 of the Department's Generic Public Participation Guidelines (September 2001) for information on how to solicit feedback from stakeholders.*

**Step 6: Consideration of stakeholders' contributions**

The international Best Practice guidelines for public consultation specifically note that stakeholders should have the opportunity to verify that all comments they have raised have indeed been considered. Stakeholders' contributions should be reflected back to them after each milestone in the process. They need to feel heard, otherwise they either lose interest or mistrust the process. In particular, they must be able to see *where* their issues have been taken up in the process, and if not, must receive an explanation as to why not. Experience also shows that, once stakeholders have the opportunity to consider the diversity of views raised by the various sectors of society, it is easier to accept trade-offs as a result of conflicting views.

An Issues and Response Report is useful in this regard. This report should be expanded as the process progresses, and serves to provide feedback to stakeholders as well as acting as a useful record of all contributions.

Acknowledgement of stakeholders' contributions is important. Written contributions can be acknowledged in writing (letter) and contributions at meetings by distributing the proceedings within one month of the meeting, formally asking those who attended to

ensure, within five working days of receiving the proceedings, that their contributions have been captured accurately.

### **Step 7: Implementation**

To ensure sustainability of the process, stakeholder involvement should continue into the implementation phase, in this case the implementation of a management plan for groundwater resources. This can be achieved through:

- Ongoing regular feedback
- Ongoing communication and awareness creation, and
- Formation of a Stakeholder Forum or a Stakeholder Monitoring Committee.

#### **2.2.5 Risk communication principles**

Conducting public participation in sensitive areas with sensitive stakeholders can pose a challenge to those involved in the process and may require conflict resolution skills or knowledge of the main principles of risk communication. For example, dolomites occurring in urban areas are considered to be a sensitive matter, therefore the application of risk communication principles may be valuable to Water Resource Managers.

More than three decades of research and hundreds of articles published in scientific journals underpin the science of risk communication. Sandman (1986) says that *“the most common sources of risk information are people who are professionally inclined to ignore feelings (technical specialists, engineers, scientists). And how do people respond when their feelings are ignored? They escalate — yell louder, cry harder, listen less — which in turn stiffens the experts, which further provokes the audience. The inevitable result is the classic drama of stereotypes in conflict: the cold scientist or bureaucrat versus the hysterical citizen.”*

Water Managers who have contact with stakeholders can reduce the Department’s social risk by becoming familiar with and applying the basic principles of risk communication. Trust, credibility, personal contact and control form the basic foundation for risk communication. Some pointers are listed:

- Meaningfully interfacing with third parties requires experts and technical specialists to switch from right brain (content, data, statistics, science, facts) to left brain (feelings, empathy, respect; collaborative problem-solving)
- Accept and involve the public as a legitimate partner; listen to their specific concerns
- Understand that the risks that kill people and the risks that upset people are often completely different

- Do not use the DAD model: Decide, Announce, Defend. Leave room for dialogue and resolving disputes before decisions are implemented, otherwise costly delays may result later on
- Express caring, empathy and commitment, and respond humanely. Do not trivialise people's feelings. These attributes account for more than 50 percent of trust in high-concern situations. When people are worried and upset, they don't care what you know until they know that you care. People often decide if a person is caring within as little as nine seconds
- Show respect. Do not negate people's concerns just because you are not of the same political orientation as they are. Their concerns may be real and sufficiently substantial to support legal action; listen first, then formulate your response
- Adapt to the fact that many people use health, safety and environmental risks as a proxy or surrogate for other social, political or economic concerns. Sometimes it is the only way they know how. Assist them to express their unspoken but real concerns
- Do not use complex and difficult probabilistic or technical language to communicate information about risks. Keep it simple. Avoid technical jargon and any words that teenagers won't understand
- When people speak emotionally, do not immediately respond with data, but with sympathy and caring; breaking a conflict is often "a matter of explicitly acknowledging the feeling (and the legitimacy of the feeling) before trying to explain anything substantive — because any effort to explain substance first will be experienced by people as just another way of not noticing how they feel"
- Be honest, frank and open. Openly acknowledge past misbehaviour and current problems. Explain plans and financial commitment in place to rectify current problems and ask for suggestions
- Coordinate and collaborate with other credible sources. If air quality is the problem, compare emissions to international standards and guidelines. Indicate that the company will be guided by the country's Air Quality Authority. If environmental management is the problem, make it known that the plant environmental management certification/ accreditation is being obtained, and explain what it means (continuous environmental improvement)
- Do not use the "wrong" public relations techniques. While public relations textbooks may highlight the need for quality information and mutually beneficial relationships, public relations often employ techniques such as stonewalling, smoke-screening, whitewashing and blaming someone else (Susskind and Field, 1996)
- Let go of some control. Allow stakeholders to select the dates and times of meetings, to indicate the language of their choice, to indicate by what methods they would like to receive their information, to assist in listing criteria for making choices, and to assist in exploring alternatives. Lay people, "undeterred by conventional expert wisdom, often have good ideas that experts can adapt to the situation at hand; as a minimum, lay people are the experts on what frightens them and what would reassure them"
- Discuss achievements with humility, and

- Honour commitments, and if not possible, be open and transparent about the problems.

### 2.2.6 Monitoring and evaluation of the public participation process

The monitoring and evaluation of a public participation process is an important component of the process, as it not only determines the way forward but also allows valuable lessons to be learned for future reference. Moreover, it can indicate the value that it has added to the assessment, planning and management of the water resource, and can provide water managers with an idea of the main challenges and how to manage these proactively.

A Public Participation Evaluation Report should be compiled, and should include important considerations in the evaluation process, for example:

- Did the public participation process meet the statutory and other requirements?
- Was the public participation process regarded as sufficient, that is, was it conducted with fairness, in an efficient manner, and with wisdom and stability? Did the outcomes lead to better decisions or management than the stakeholder groups would have been able to achieve individually?
- Did everyone gain something from the process (e.g. increased understanding, access to information, increased capacity to contribute/participate, enhanced partnerships)?
- Was the public participation process conducted well, adequately or incompletely?
- Were there any significant omissions from the process? What were the reasons for these omissions? And
- What are the pointers for improving the public participation process?

Relevant references to existing reading material on monitoring and evaluation of the public participation process are:

- Southern African Institute for Environmental Assessment (SAIEA) 2005. Training course - Public Participation in Environmental Assessment in Southern Africa. Developed as part of the SAIEA Calabash Project. First Edition, 2005.
- Southern African Institute for Environmental Assessment (SAIEA) 2004. A One-Stop Participation Guide. A Handbook for Public Participation in Environmental Assessment in Southern Africa.
- Greyling T and Pietersen T 2006. Guide to Public Participation in Environmental Authorisation: Theory and Practice. Golder Associates Africa, Midrand, South Africa.
- Web sites: International Association for Public Participation – <http://www.iap2.org>.

## 2.3 Assessment, Planning and Management

### 2.3.1 Introduction

Section 1.1.3 summarises the importance of integrating the assessment, planning and management functions as follows:

- Assessment that is undertaken poorly can lead to poor planning. In turn, poor planning can lead to the adoption of unsuitable options and hence the unsustainable use of the groundwater resource, and
- Poor management is an inefficient use of the time and budget of the Department's operational personnel. However, given the linked nature of the functions, poor assessment, leading to poor planning, can result in the inefficient use of the assessment, planning and management budgets. This should clearly be avoided.

It is thus important that the assessment, planning and management functions are integrated, both vertically (between functions) and horizontally (between national, catchment and site-specific levels).

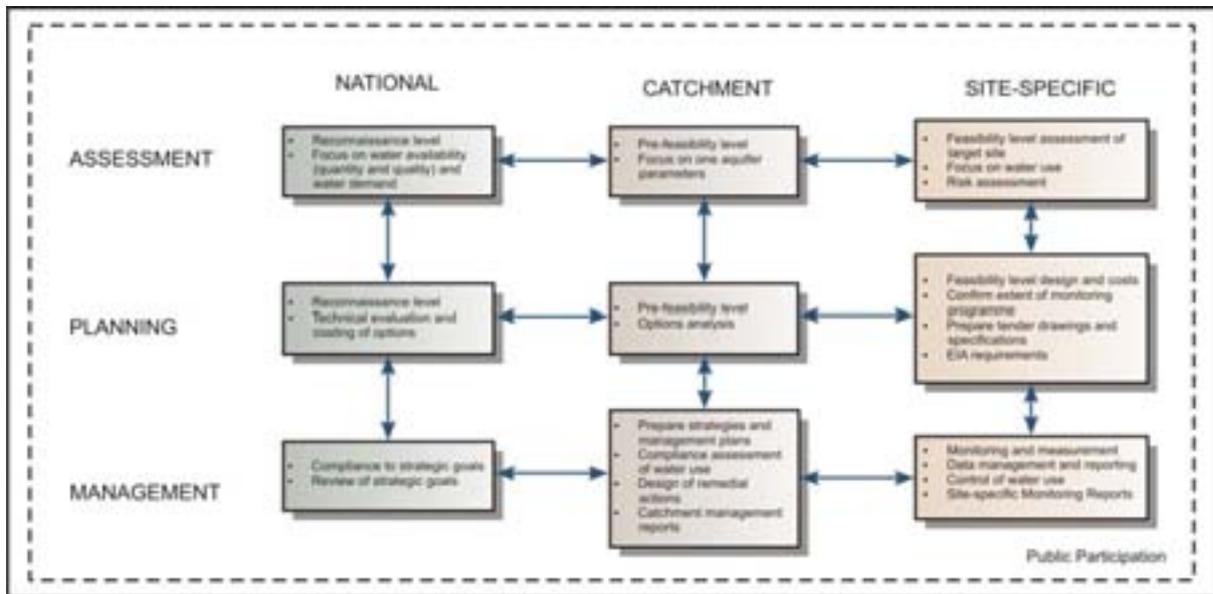
Figure 2.3 illustrates this integration, with the national, catchment and site-specific levels defined as follows:

- **National level** is not necessarily a geographic descriptor, but rather indicates the level and type of issues that need to be addressed. For groundwater resources in numerous areas, these are typically cross-boundary issues, reconciliation of demand and availability or the interests of different stakeholder groups. These functions and responsibilities may be addressed by Departmental personnel in the National Office or by delegated groups.
- **Catchment level** includes functions and responsibilities that are focussed on aquifer potential and those measures that are required to ensure sustainable development and use. These will include such aspects as defining the water balance, rate of recharge to the aquifer, storage and exploitation potential, Resource Quality Objectives, accessibility of the resource to various users or stakeholder groups, and monitoring procedures. Catchment level functions will also include such issues as defining possible target areas that are suitable for the identified water use needs, and taking into consideration the impacts/unacceptable risks to the environment. These functions will generally be assigned to Departmental personnel in the Regional Offices, or to the CMAs when established and operational. In certain instances, these functions may be delegated to, and undertaken by, the AMC or Catchment Committees.

- **Site-specific level** includes site-specific functions for a particular target area. These will be the responsibility of the Water Service Provider, User Group, private organisation or individual. The users will be responsible for determining the site-specific aquifer potential, water balance, potential impacts, etc. Various well-fields could thus exist and be developed for use in one target area of the aquifer.

Figure 2.3 indicates the linkages between the various functions. The functions are summarised as follows:

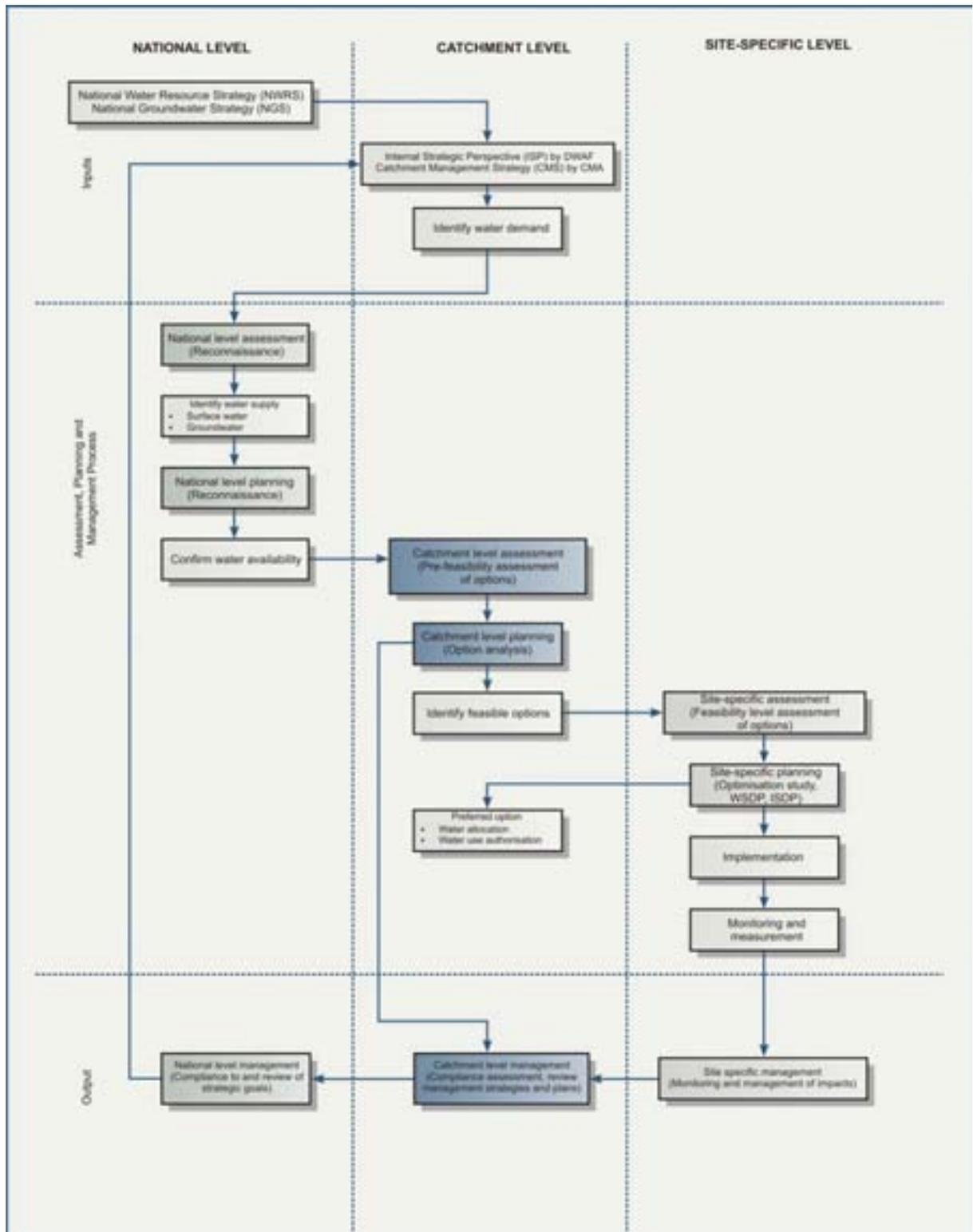
- Assessment to a reconnaissance level (desk-top) of detail is undertaken at the national level, where the focus is on water availability (both quantity and quality) and water requirements in an area that typically spans more than one WMA. This assessment is refined to a pre-feasibility level at the catchment level, where the focus will be on defining the resource capability of the target aquifers in the geographical area of interest. A feasibility level assessment of the target area for development (and the ability to use the resource) is the focus at the site-specific level,
- Planning is undertaken at a reconnaissance level of detail at the national level where various options are weighed for further detailed study. The level of detail and accuracy is improved during a pre-feasibility study at the catchment level, where specific options are assessed. A full feasibility study and optimisation of designs is undertaken at the site-specific level, and
- Management of water resources is enabled through water allocation and water use authorisation. Management at site-specific level entails, among others, maintenance and control, monitoring and measurement, data management and reporting, auditing and management of impacts. Review of compliance with water use authorisation conditions is undertaken at the catchment level, as well as managing the cumulative impacts of the various water user groups on the system. The auditing of compliance with strategic goals and strategic reviews is undertaken at the national level.



*Figure 2.3: Linkages between assessment, planning and management*

### 2.3.2 Integration between Assessment, Planning and Management

Figure 2.4 illustrates the overall recommended process in the integration of the assessment, planning and management functions at the various levels. The diagram illustrates the inputs (from the various catchment level ISPs), the process for assessment, planning and management, and the outputs. In reality, not all steps may need to be followed. For example, the reconnaissance level national assessment may provide sufficient catchment information for the site-specific planning functions. However, if more data is needed for site-specific planning, then it will be gathered at the site-specific level, due to the scale of the area and the level of detail that is required.



*Figure 2.4: Process for the integration of assessment, planning and management*

## **2.4 Assessment**

### **2.4.1 What is meant by assessment?**

Assessment is the first step in the IWRM process. It determines the status quo (in terms of both water quantity and quality) of the groundwater resources in a particular WMA or catchment, and defines the geographic extent of the aquifer system(s). Assessment includes the determination of the aquifer resource capability with respect not only to sustainable, economic and technically feasible abstraction but also to the impact of such abstraction on spring and river flow (i.e. ecological requirements). Assessment also summarises existing water requirements for all sector users, taking into account demographic and socio-economic changes.

### **2.4.2 Why is Assessment Important?**

The assessment function is important because:

- The groundwater resource has a high potential availability with good water quality
- Information is not currently, or readily, available in the correct detail and format to answer questions on groundwater availability and quality
- It enables the planning and management functions
- It helps to understand local dependence on the groundwater resource
- It confirms the current impact on, and use or abuse of, the groundwater resource
- It helps to determine what questions are to be addressed at the various levels, and
- It enables risk management (e.g. the use of groundwater during severe drought).

### **2.4.3 Methodology and Details for Assessment**

The steps required to assess the groundwater resources and to prepare inputs for the subsequent planning phases are similar irrespective of the scale (i.e. national level, catchment level or site-specific/local level). The process includes such aspects as existing use, development potential as a bulk or local water supply, importance of springs and baseflow, dependence of ecology and identifying potential impacts. This common methodology and the steps involved are described below. It should be noted that the application of this methodology will vary at the national, catchment or site-specific level due to the scale and/or spatial intensity of the investigations.

National level assessment is likely to be undertaken by personnel of the Department's National Office, with assistance from the Water Manager/Planner. The assessment includes a desk study to obtain information on water availability and requirements over various catchments/ compartments. Depending on the amount and nature of the data

available it might be necessary to undertake the collation of information from boreholes and springs. From this study, the Water Manager will be able to identify issues, areas of water shortage and areas where additional information is required.

Catchment level assessment has its focus on one or more aquifers in a catchment. The aim is to determine the parameters of the target aquifer(s) in sufficient detail to enable catchment level planning (pre-feasibility) studies of these aquifers. Catchment level assessment will therefore require the collection of information from existing boreholes and the siting, drilling and testing of exploratory/monitoring boreholes in key localities to provide the necessary data.

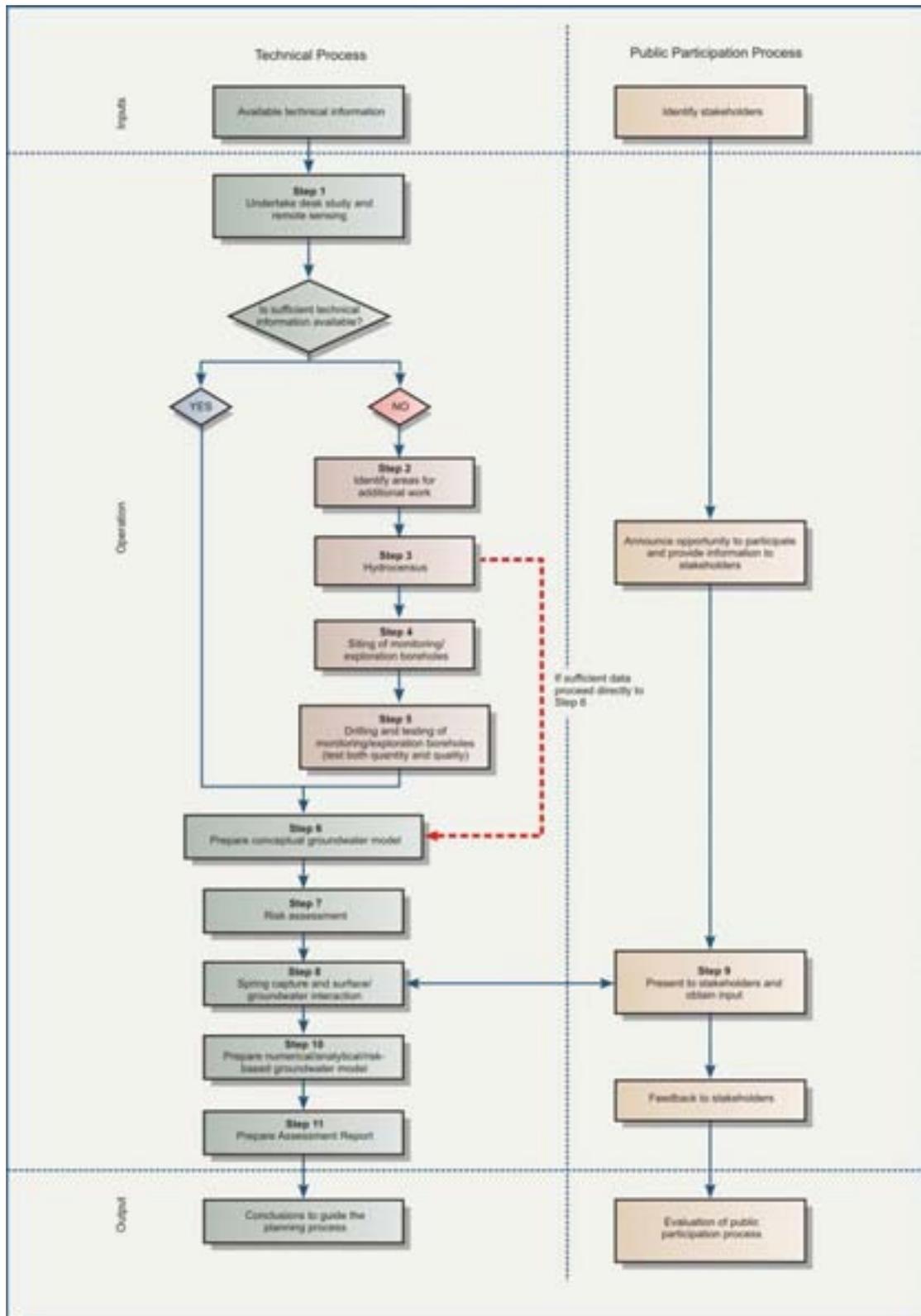
Site-specific assessment includes a detailed assessment of the target area to determine the ability of the aquifer in that area to support the requirements on a sustainable basis. Site-specific assessment thus involves substantial on-site drilling and testing, and may include detailed numerical groundwater modelling.

Figure 2.5 provides details on the assessment process. The various steps in the process are described in the following sections.

### **Step 1: Undertake desk study and remote sensing**

The objective of a desk study is the collation, scrutiny and evaluation of available and relevant meteorological, geographical, geological, hydrogeological and groundwater quality data. The tasks involved in gathering available data/information will typically include:

- Obtaining information related to groundwater, including:
  - Geological and hydrogeological maps
  - Hydrogeological reports
  - Borehole logs
  - Geophysical profiles of exploration and/or monitoring boreholes previously drilled in the area
  - Test pumping results
  - Groundwater quality data, and
  - Monitoring data, studied to gather direct hydrogeological information across the area of investigation



*Figure 2.5: Assessment Process*

- Collating all relevant information into a desk study report based on the Model Table of Contents (Appendix D2)
- Summarising all available information into a water balance, indicating water availability (quantity and quality) and water requirements, and
- Other aspects, including land use planning and use and potential water requirements.

Aerial photography, satellite imagery, geological and hydrogeological maps form the basis of remote sensing. These may be supplemented with airborne digital terrain mapping and aeromagnetic surveys. Airborne radiometrics may also be of value in areas where the potential of contamination by radionuclides is known or suspected.

This information is used to establish a background or baseline geological and hydrogeological reference for the identified study area. Once the desk study has been undertaken, the level of input required and the necessary programme(s) are identified for further assessment and / or the planning phases.

*NOTE:*

*Further details concerning data requirements are available in the Standard Descriptors for Geosites, DWAF/NORAD, 2004.*

*NOTE:*

*The WRC report No. 1090-2/2/03 contains details on assessing terrestrial groundwater dependent ecosystems in South Africa.*

### **Step 2: Identify areas for additional work**

Using the results from the desk study, undertake a gap analysis to identify:

- The catchment(s) where there is sufficient information with which to reconcile water availability and requirements (quantity and quality); in these instances, the personnel will proceed to Step 5; or
- The catchment(s) where there is insufficient information for the assessment of water availability and requirements; in these instances, the personnel will list the required information and the methods recommended to obtain the information.

### **Step 3: Hydrocensus**

A hydrocensus is essentially site familiarisation and the collection of data from the study area and surrounding environs. It comprises a census of key boreholes, wells, springs and any other groundwater related information. The extent (intensity and area covered)

of the hydrocensus will depend upon the level of the study (national, local or site-specific) and the particular requirements of the study, but must provide wide coverage of the catchment(s) to allow an overview of the aquifer system(s) to be captured at the necessary level of detail. The Department's National Office, CMA or Water Manager will be responsible for the hydrocensus.

The hydrocensus involves the collection of data from each facility, including:

- GPS co-ordinates
- Owner
- Current use
- Reported yield
- Reported or measured borehole or well depth
- Static water level
- Field measurements of pH and conductivity
- Collection of water samples from key selected boreholes, wells or springs for quality analysis
- Existing equipment
- Possible information that can influence measurement data, and
- Surface water quality should also be considered as part of the hydrocensus for use in surface water - groundwater interactions.

All field data must be recorded on standard hydrocensus sheets (refer to the example in Appendix B) and captured in the relevant electronic database.

The Water Manager will use the hydrocensus data to determine the prevailing hydrogeological conditions, order of magnitude of existing groundwater use and dependence, areas of intensive irrigation, etc.

The success of any hydrocensus is almost entirely dependant on the cooperation of the local communities and private landowners. The Water Manager should thus ensure that prior and considered communication is undertaken by means of public participation channels to inform landowners of the proposed hydrocensus.

If sufficient information is collected during the hydrocensus then proceed to Step 6.

**NOTE:**

*Further details are available in the DWAF/NORAD, 2004 document, Section 3.1: Involving community members in a hydrocensus.*

**Step 4: Siting of monitoring/exploration boreholes**

Monitoring and exploration boreholes may be required in order to provide sufficient information on the target aquifer(s). The number and location of these boreholes will be determined by the level of the study, the nature of the aquifer(s), the results of the desk study and the hydrocensus data.

The Water Manager will ensure that the siting of groundwater exploration and monitoring boreholes is undertaken by a qualified and experienced Hydrogeophysicist / Hydrogeologist. Siting of boreholes for any use by a diviner is **not** permitted.

The Hydrogeologist will undertake the following tasks in siting boreholes:

- Understand the scope and objectives of the assessment and the purpose of the borehole(s),
- Identify or select the general area within the aquifer where boreholes are required,
- Interpret the black and white stereo pair air photography and satellite imagery in and surrounding the area of interest to identify structural features (e.g. dykes, faults, fracture zones), weathering and other features (e.g. karst) of importance to groundwater occurrence,
- Undertake a geological appraisal and select sites for the geophysical survey, and
- Undertake a geophysical survey involving the application of proven and appropriate techniques. Such techniques will involve one or more of the following:
  - Electrical resistivity
  - Electromagnetics
  - Magnetism
  - Gravity, and
  - Seismics.

The application of seismic techniques is not recommended for groundwater exploration due to its high cost and the availability of alternative techniques (mentioned above).

**NOTE:**

*Further information concerning geophysical techniques can be found in numerous references. The recommended references are: A Practical Manual on the Resistivity Method, prepared by J S V Van Zijl, 1985, published by the CSIR.*

*The Magnetic Method, a Geophysical Field Manual for Technicians, No. 1, published by the South African Geophysical Union, and The Electromagnetic Method, a Geophysical Field Manual for Technicians, No. 3, published by the South African Geophysical Union. Applied Geophysics by W. M. Telford, L. P. Geldart, R. E. Sheriff, ISBN 0521339383.*

### **Step 5: Drilling and testing of exploratory/monitoring boreholes**

Exploratory/monitoring boreholes must be drilled to the required technical specifications by an experienced contractor. The Water Manager/Hydrogeologist will ensure that the appointed contractor understands and signs the relevant technical specifications.

Field operations should be undertaken under the supervision of the Hydrogeologist appointed by the Water Manager to ensure that the boreholes are drilled:

- In the correct location
- To the required depth, and
- According to the applicable specifications (Appendix A1 and Appendix A2).

*NOTE:  
Additional information on groundwater protection is available in the DWAF/NORAD, 2004 document: Guidelines for protecting boreholes and wells.*

The supervisor will prepare:

- A geological log of the lithology
- A construction log of the borehole, indicating drilling and casing diameters and depth, formation stabiliser inserted, grouting and completion details
- A hydrogeological log of features important to groundwater occurrence, including weathering depth, fracturing, wad, fissures, cavities, karst and information concerning depth of water strikes and blowing yield, lost circulation, and
- Signature for measured quantities agreed on site with the driller.

It is often necessary to test exploratory/monitoring boreholes to obtain information on aquifer hydraulic parameters and groundwater quality. Testing should be undertaken by an experienced contractor in compliance with the required technical specifications. The Water Manager/ Hydrogeologist will ensure that the appointed contractor has signed the relevant technical specifications.

Field operations should be undertaken under the supervision of the Hydrogeologist appointed by the Water Manager to ensure that the boreholes are tested in accordance with the required specifications. The supervisor will sign for measured quantities agreed on site with the testing contractor.

Water samples should be collected from newly-drilled exploratory/monitoring boreholes according to the protocols outlined in Appendix C in order to provide data to supplement that collected during the hydrocensus. This data is used to determine prevailing groundwater quality across the aquifer(s) within the catchment.

*NOTE:*

*Forms for capturing data are included in Appendix B.*

*Technical details concerning the testing of boreholes (both quantity and quality) are included in Appendix C. The Water*

*Manager/Hydrogeologist must ensure that the procedures described in Appendix C are adhered to.*

**Step 6: Prepare conceptual groundwater model**

The conceptual groundwater model is prepared using the data and information collected during the previous steps. Essentially, the desktop study report is updated with this new information in accordance with the model Table of Contents in Appendix D1.

In essence, the conceptual model describes the lithological composition of the aquifer, presence or absence of low permeability formations, aquifer boundaries, compartmentalising of the aquifer, fractures and faults, degree of weathering, distribution of karst features, presence or absence of surface water bodies, springs and seepage zones, recharge potential, and distribution of water levels. The model must incorporate existing abstraction and land use (e.g. irrigation, mine waste dumps), since these have an impact or may have an impact on the available sustainable resources of the aquifer.

The model constitutes the conceptual level understanding of the aquifer and its behaviour, and provides the basis for future decision-making.

**Step 7: Risk assessment**Proximity to existing boreholes

In order to minimise interference between adjacent boreholes, new abstraction boreholes in aquifers should not be drilled close to any existing borehole. Recommendations concerning the minimum distance will form one of the conclusions of the assessment study. The minimum distance can vary significantly and depends on many factors, such as the type of aquifer (karst, fractured, weathered) and permeability of the aquifer. Where a group of boreholes are drilled to form a well-field, distances should be determined by the findings of the detailed hydrogeological survey.

Minimising the risk of pollution from nearby sources of contamination

In general, no water use borehole drilled in an aquifer should be located within a minimum distance of potential sources of contamination, including:

- Pit and Ventilated Improved Pit (VIP) latrines
- Animal kraals
- Effluent discharges from chicken hatcheries and piggeries
- Dip tanks
- Cemetery/graveyard/burial site
- Mine tailings dams, waste disposal sites, or
- Any other source, or potential source, of contamination.

Recommendations concerning the minimum distance will form one of the conclusions of the assessment study. The minimum distance can vary significantly and depends on many factors, such as the type of aquifer (karst, fractured, weathered), permeability of the aquifer, vulnerability of the aquifer and type of contaminant source.

Water use boreholes should always be located up-gradient of a current or potential source of groundwater contamination. They should not be drilled within the floodline of a drainage channel, as these areas are prone to flooding.

**NOTE:**

*Valuable information on various contamination risks is available in the DWAF/NORAD, 2004 document, Section 3.4: Guidelines on protecting groundwater from contamination, especially with regard to water sources and sanitation.*

**Step 8: Spring capture and surface water - groundwater interaction**

Springs can be considered as an optional source of water to satisfy water requirements. Depending upon their yield and reliability, they can be used as stand-alone sources or in conjunction with abstraction boreholes. Springs are often vulnerable to significant variations in flow, and low-flowing springs often dry up completely during periods of drought.

Various methods of spring capture are available, ranging from small impoundments to weirs to large dams. Each method of capturing spring flow should provide protection to maintain the (pristine) water quality and impoundment.

Spring capture must involve the following considerations:

- Accurate determination of spring flow
- Seasonal/cyclic fluctuations
- Recharge to the spring flow
- Reserve requirements
- Protected areas e.g. indigenous species
- Current downstream use of spring flow
- Impact of current abstraction in the catchment/compartiment contributing to the spring flow
- Impact of impoundment on wetlands
- Impact of impoundment on surface flow
- Surface water - groundwater interaction, and
- Contribution of groundwater systems to streams, rivers and wetlands.

**NOTE:**

*Further details for spring data and classification are available in the Standard Descriptors for Geosites, DWAF/NORAD, 2004.*

**Step 9: Present to stakeholders and obtain input**

Present the outputs of the assessment of water availability and water requirements to the relevant stakeholders to obtain comment and feedback. The relevant stakeholders will have been identified as part of the public participation process (refer to Section 0).

**Step 10: Prepare numerical/analytical/risk-based groundwater model**

For some assessments, particularly at the site-specific level, it may be desirable or necessary to prepare a numerical, analytical or risk-based model of the aquifer.

Where a model is prepared, predictions of the long-term behaviour of the aquifer under the planned development can be made, and simulations of certain aspects being investigated, such as migration of pollution plumes with time, can be undertaken. Once the model has been finalised, this can be used as input to risk-based decision-making.

Various modelling packages can be selected for numerical modelling, the most common being Modflow, a three-dimensional finite difference modelling package, and FeFlow, a three-dimensional finite element modelling package.

Numerical modelling is highly specialised and will require the services of a modelling expert to advise on modelling requirements, capabilities and limitations, and to prepare and run the model. It must be noted that numerical modelling of aquifer systems have high data requirements, because of the 3D nature of the system and will thus only be effective where sufficient 3D information is available.

**Step 11: Prepare Assessment Report**

From the above assessments and consultation, identify issues with respect to IWRM and areas where the water balance indicates that there are current or potential water shortages. Possible water use options to meet current or future water requirements should also be identified. The Assessment Report will draw conclusions on the groundwater resources and applicable technical information. These conclusions will assist in guiding the planning process (see Section 2.2.5).

Finalise the assessment report detailing the conclusions reached and inputs for the planning phase. The report will include maps, borehole logs, test pumping data, water quality assessment, aquifer assessment and classification, protection zones, RDM requirements, and the delineation of potential target areas, as applicable.

**NOTE:**

*A generic Table of Contents for the Assessment Report is included in Appendix D.1.*

#### 2.4.4 Other Specialist Studies

The Water Manager must therefore consider all the above aspects when undertaking assessment, planning and management of the groundwater resources in the catchment. Accordingly, specialist studies may be required in support of any planned development of the aquifer to confirm the ability of the aquifer to deliver the required water use, and to identify and quantify impacts. Such studies could include:

- Feasibility of implementing artificial recharge
- Identification of groundwater-dependant ecosystems (Colvin *et al*, 2003)
- Direct, indirect or unique/keystone ecosystems
- Determination of sensitivity of the landscape to fluctuations in water levels and resultant ground subsidence or sinkhole formation, and
- Assessment of existing or planned infrastructure that may be affected.

These studies will require the appointment of specialist consultants and would normally form part of an overall assessment of the groundwater resources at a catchment or WMA level.

*NOTE:*

*Additional information on groundwater protection is available in the DWAF/NORAD, 2004 document: Guidelines for protecting springs.*

## 2.5 Planning

### 2.5.1 What is meant by planning?

Planning within IWRM is a process of matching water availability with water requirements. Planning typically involves the investigation of development options to meet water requirements through a predetermined sequence of increasingly detailed phases. Planning generally follows an assessment during which the various water development options (including groundwater options) are identified. Planning ensures that the information is made clear to the decision-maker.

### 2.5.2 Why is planning important?

The planning function is important because:

- It provides the rules and guidelines to enable sustainable use of the water resource, or recommends the use of existing guidelines
- It provides the “bigger picture” within which the water resources can be managed, both current and future, and
- It provides the motivation for funding for the implementation of a particular water development option.

### 2.5.3 Framework for water resource planning

Water resource planning is undertaken within the framework of integrated water resource planning (IWRP) and integrated water resource management (IWRM). These integrated processes include the sustainable utilisation of water resources and the equitable distribution of water. They acknowledge that groundwater is an important and integral part of South Africa’s water resources and its use should be planned and managed accordingly.

The Department has identified five core strategies to promote the successful implementation of IWRM in South Africa:

Groundwater must be integrated into the management of water resources for the benefit of all the people of South Africa

- Groundwater needs to be promoted so that water resource managers, water users and the public are more aware of the role, occurrence and value of groundwater
- Hydrogeologists need to be encouraged and enabled to work outside their line function and to be integrated in broader water resource planning and management functions
- A larger, skilled and experienced specialist hydrogeological workforce is required, and
- Groundwater monitoring and the development of a hydrogeological information system are required to assist in the provision of data and information to those who need it.

### 2.5.4 National level planning: Methodology and details

National level planning is undertaken at a reconnaissance level. It is an initial exploratory study that provides a preliminary examination of an area, and includes a desk-top evaluation of the water use options to meet particular requirements.

Figure 2.6 summarises the steps involved in a national (reconnaissance) level planning study. The steps are described in more detail in the following sections. The inputs into the study are:

- The recommendations from the national level assessment, and

- Details of the Resource Quality Objectives, set during a public participation and planning process. The technical contribution for the integrity of the resource will be concluded in the assessment process and used as input.

**NOTE:**

The GRDM training manual (WRC project 1427), available from the Departments RDM office, provides additional details on setting the Reserve and Resource Quality Objectives.

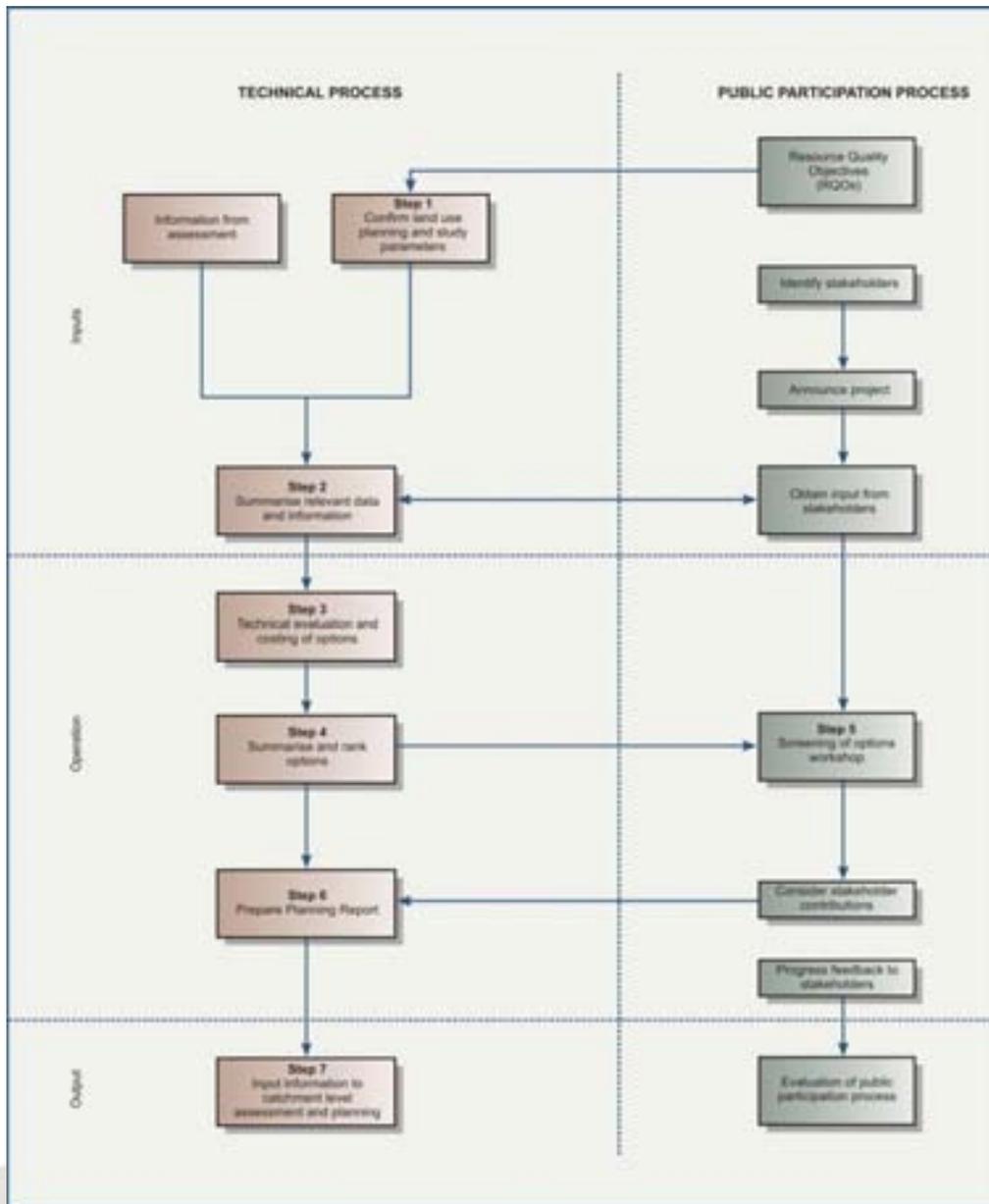


Figure 2.6: Process for national (reconnaissance) level planning

**Step 1: Confirm land use planning and study parameters**

In general, information on land use planning and the study parameters will be determined during the assessment phase. During this step, confirm:

- Land use planning for the study area, particularly in and around the target aquifer
- Requirements for water, including :
  - Likely geographic location for the requirements
  - Quantity of water required (m<sup>3</sup> per month)
  - Specifications on the quality of the water required, or any water quality constraints to be included in the planning process, and
  - The required assurance of use (i.e. the percentage of time in any given month that the water is required)
- Proposed water use options.

**Step 2: Summarise relevant data and information**

Summarise all available data and information on the water development options, as obtained during the assessment process, including:

- All existing Departmental and external reports and databases pertaining to the water use options
- Information from the national level assessment, and
- Details of the conceptual layout for the various water use options.

**Step 3: Technical evaluation and costing of options**

Evaluate the water use options at a preliminary level, including a desk-top assessment of the technical feasibility of the options, preliminary costs and potential fatal flaws. Only limited verification and field work should be required. This evaluation will thus be at a low level of accuracy and will include conceptual-level design input to address the following issues:

- Can the target aquifer meet water requirements on a sustainable basis (technical feasibility)?
- Technical details of each option and are these broadly acceptable
- Cost analysis of the various options
- Comparison of options, and
- Elimination of options with fatal flaws.

**Step 4: Summarise and rank options**

Summarise and rank the water use options in a format that can easily be presented to the stakeholders such that the stakeholders can make informed decisions.

**Step 5: Screening of options workshop**

Present the proposed water use options to stakeholders at a national and regional level to obtain information on fatal flaws and/or consensus on the perceived feasibility of the various options. This will take the form of workshops and focussed discussions. The relevant stakeholders will have been identified as part of the public participation process (refer to Section 0).

**Step 6: Prepare Planning Report**

Summarise the relevant information from the technical and public participation process into one report. This report will provide recommendations on which options can be taken forward to the catchment level (pre-feasibility) planning study.

**NOTE:**

*A generic Table of Contents for the Planning Report is included in Appendix D.2.*

**Step 7: Input information to catchment level assessment and planning**

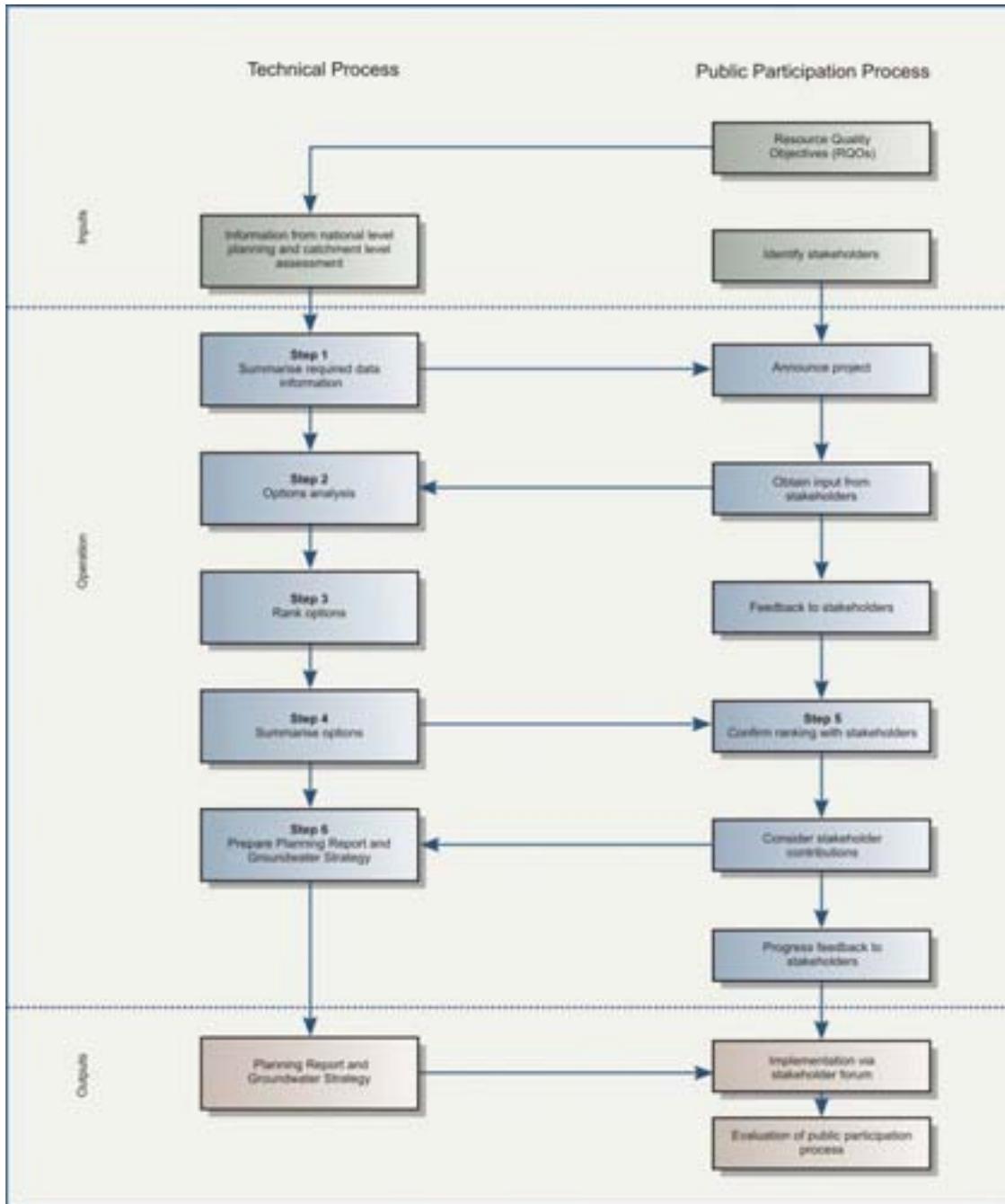
The information gathered during the national level planning process should feed into the catchment level assessment and planning processes. This will form the most basic information necessary to feed into a Catchment Management Strategy for the area.

**2.5.5 Catchment Level Planning: Methodology and Details**

Catchment level planning is undertaken to a pre-feasibility level and is a precursor to the feasibility level study. The pre-feasibility planning study will require a level of field work that secures accurate information and data, and often requires considerable verification of aspects such as sustainable development, potential impacts, the technical feasibility and cost. This study is thus preceded by catchment level assessment and national level planning to obtain the necessary information to minimise the options to be evaluated at a pre-feasibility level.

A risk assessment of likely impacts of any proposed development will form part of the planning process.

Figure 2.7 summarises the steps involved in a catchment (pre-feasibility) level planning study. The steps are described in more detail in the following sections. The input into the process comprises the information from the national level planning process and the catchment level assessment.



*Figure 2.7: Process for catchment (pre-feasibility) level planning*

**Step 1: Summarise required data/information**

Obtain the information and recommendations from the national level planning and catchment level assessment processes that are required for planning, design and costing purposes in the catchment level planning process.

**Step 2: Options analysis**

Undertake sufficient pre-feasibility level design and costing to be in a position to assess the various water use options. Each option should be assessed on the basis of: a) social considerations, b) potential environmental impact, c) economic and financial viability, d) technical feasibility, e) long-term land use, and f) regulatory considerations.

**Step 3: Rank options**

Rank the water use options using the results of the assessment from Step 2. Figure 2.8 and Figure 2.9 provide examples of an evaluation tool that can be used to rank the options at a pre-feasibility level.

							Consequence of success						
		1	2	3	4	5		Social	Environmental	Economic	Technical	Long-term land -use	Regulatory
1	1	1	2	3	4	5	1	No benefit to local community	Very high environmental impact	Very high cost	Not sustainable	No beneficial impact on land-use	Very difficult passage through regulatory requirements
2	2	2	4	6	8	10	2	Limited benefit to local community	High environmental impact	High cost	Limited sustainability	Limited beneficial impact on land-use	Difficult passage through regulatory requirements
3	3	3	6	9	12	15	3	Some benefit to local community	Medium environmental impact	Average cost	Short-term sustainable	Some beneficial impact on land-use	Some difficulties with regulatory requirements
4	4	4	8	12	16	20	4	Large benefit to local community	Low environmental impact	Low cost	Medium-term sustainable	Large beneficial impact on land-use	Easy passage through regulatory requirements
5	5	5	10	15	20	25	5	Significant benefit to local community	Very low environmental impact	Very low cost	Long-term sustainable	Significant beneficial effect on land-use	Very easy passage through regulatory requirements
<b>Probability of success</b>		Very Low	Low	Medium	High	Very High							

**STRATEGIC ASSESSMENT MATRIX**

**KEY**

	Highly undesirable
	Medium desirability
	Highly desirable

*Figure 2.8: Strategic assessment matrix for water use options*

<b>Assessment of short-listed water supply options</b>																	
OPTION	Weighting	1		2		3		4		5		6		7		8	
		Water supply Option #1		Water supply Option #2		Water supply Option #3		Water supply Option #4		Water supply Option #5		Water supply Option #6		Water supply Option #7		Water supply Option #8	
Evaluation criteria		Consequence	Probability														
Social	1	2	2	2	2	2	2	4	4	4	4	3	2	5	4	2	2
Environmental	1	2	2	2	2	2	2	4	4	4	4	3	2	5	4	2	2
Economic	1	2	2	2	2	2	2	4	4	4	4	3	2	5	4	2	2
Technical	1	2	2	2	2	2	2	4	4	4	4	3	2	5	4	2	2
Long-term land use	1	2	2	2	2	2	2	4	4	4	4	3	2	5	4	2	2
Regulatory	1	2	3	3	3	2	3	4	4	4	4	4	4	4	4	2	4

EVALUATION OF OPTIONS	Water supply Option #1	Water supply Option #2	Water supply Option #3	Water supply Option #4	Water supply Option #5	Water supply Option #6	Water supply Option #7	Water supply Option #8
	Social	4	4	4	16	16	6	20
Environmental	4	20	4	12	16	20	16	16
Economic	6	6	6	12	6	12	9	9
Technical	4	16	20	12	12	16	16	8
Long-term land use	4	6	4	9	16	6	6	9
Regulatory	6	9	7.3	16	16	16	16	8
<b>Average</b>	4.7	10.2	7.3	12.8	13.7	12.7	13.8	9.0
Highly undesirable	1 to 3							
Medium desirability	4 to 11							
Highly desirable	12 to 25							
<b>Ranking</b>	8	5	7	3	2	4	1	6
<b>Fatal flaw assessment</b>	acceptable							

*Figure 2.9: Pre-feasibility level screening of options*

**Step 4: Summarise options**

Summarise the water use options in terms of technical feasibility, economic and financial viability and potential environmental impact. The summary of water use options should be presented in a manner that enables the stakeholders to make informed decisions.

**Step 5: Confirm ranking with stakeholders**

Arrange interaction meetings and presentations with stakeholders at which the results of the ranking process and the pre-feasibility level designs and cost estimates can be discussed with the stakeholders and consensus reached on the options that should be pursued.

**Step 6: Prepare Planning Report and Aquifer Strategy**

Use the results of the previous steps to recommend the water use options to be taken to the feasibility level stage and prepare the Planning Report. This information will typically feed into the Catchment Management Strategy for an area.

**NOTE:**

*A generic Table of Contents for the Planning Report is included in Appendix D.2.*

**2.5.6 Site-specific planning: Methodology and details**

Site-specific planning is undertaken at a feasibility level. The feasibility level planning study is an intensive investigation and optimisation of the most beneficial layout of the scheme under investigation, resulting in the best layout of the scheme and its major dimensions and final specifications. This study will provide sufficient information to enable detailed design of the preferred scheme.

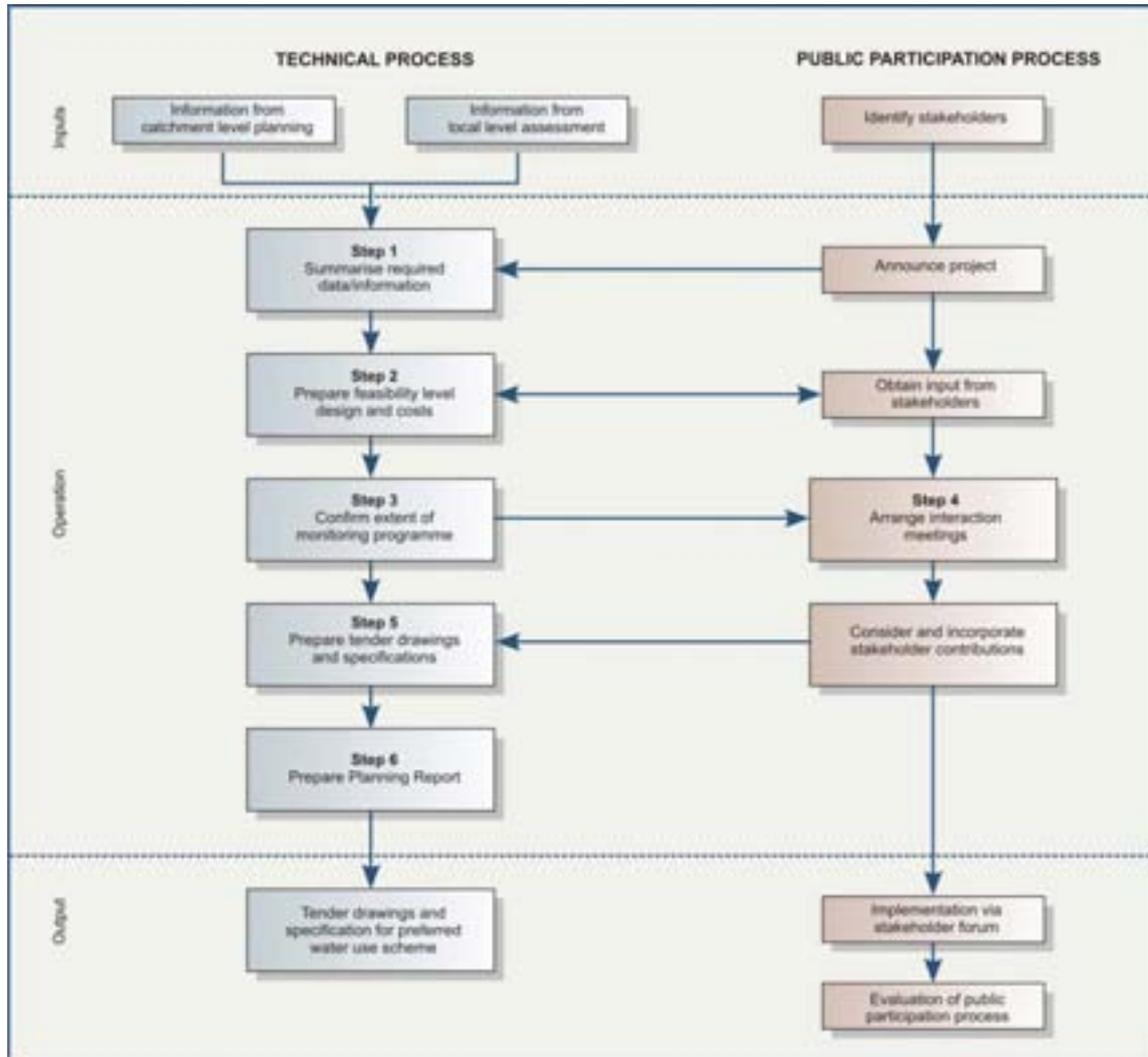
The feasibility level planning study is preceded by a detailed assessment of the feasible options at the site-specific level. The assessment will include siting, drilling and testing of boreholes, and then using this information to derive a conceptual hydrogeological and, if necessary and applicable, a numerical model of the aquifer.

The requirements of the Environment Conservation Act (Act No. 73 of 1989) in respect to Environmental Impact Assessments (EIA) must be understood and adhered to as necessary. The National Environmental Management Act (NEMA) (Act No. 107 of 1998) contains details specifying which proposed activities require an EIA, and to what level this should be undertaken. This is in addition to any licence application that may be required for the proposed use from the Department of Water Affairs and Forestry or the CMA.

Figure 2.10 summarises the steps involved in a pre-feasibility level planning study. The input to the process includes the information from the catchment level planning and site-specific assessment processes. The steps in the site-specific planning process are described in more detail in the following sections.

**NOTE:**

*Additional information is available in the DWAF/NORAD, 2004 document, Section 7.2: Introductory guide to appropriate solutions for water and sanitation and Section 7.3: Decision-making framework for Municipalities.*



*Figure 2.10: Process for site specific (feasibility) level planning*

**Step 1: Summarise required data/information**

Obtain the information and recommendations from the national level planning and catchment level assessment processes that are required for planning and design purposes in the site-specific level planning process.

The EIA requirements applicable to the proposed project must be confirmed and EIA approval must be obtained from the relevant provincial environmental office, where required. It is important to note that obtaining a Record of Decision may take several months for a large development project, and sufficient time must therefore be allowed for this process.

**NOTE:**

*Further information concerning the EIA process and requirements can be found in Environment Conservation Act (Act No. 73 of 1989)*

**Step 2: Prepare feasibility level design and costs**

The design team will prepare the feasibility level drawings and specifications, and the associated costs, for the preferred water use options. The team will submit these drawings, specifications and costs to the Water Manager for approval.

The feasibility level design will include an optimisation of the various elements of the preferred water use option, including:

- Configuration and design of water use/monitoring boreholes
- Layout and routes for the water collection and distribution system
- Design of water use pipelines (diameter, wall thickness, etc)
- Material specifications for pipelines storage systems etc, and
- Detailed assessment of the likely impact of implementing the preferred water use scheme, waste dump and/or other land use option on the integrity of the aquifer (quantity and quality).

**NOTE:**

*The production boreholes required for the feasibility level design will be positioned following a risk assessment.*

**Step 3: Confirm extent of the monitoring programme**

The monitoring programme and plan will be prepared during the planning process, incorporating:

- Objectives to be met in the monitoring programme
- Location of the monitoring points, and
- Frequency of monitoring that should occur and constituents to be analysed.

Confirm the extent of this monitoring programme with the relevant role-players.

**Step 4: Arrange interaction meetings**

Arrange interaction meetings and presentations with stakeholders to present and discuss the design details and costs associated. Incorporate comments and suggestions from the stakeholders in the final reporting.

If at this stage, the preferred option under investigation has a fatal flaw or is too costly, the process stops and another option is investigated.

**Step 5: Prepare tender drawings and specifications**

The design team will prepare the tender drawings and specifications for the preferred water use option. This will include the following details:

- Final design, positioning and drilling of the water use boreholes
- Pumping tests of the boreholes to confirm yields
- Drilling plan for monitoring boreholes
- Construction plans for water collection and distribution pipelines
- Construction plans for water storage systems, if applicable
- Details of construction cost estimates
- Proposed construction programmes, including milestone and target date(s) to completion
- Budget for the preferred scheme, and
- Implementation Plan for the preferred scheme.

The team will submit these drawings, specifications and costs to the Water Manager for approval. Examples of generic technical specifications and drawings are included in Appendix D. These can be used by:

- The Water Manager as a guide for inclusion in tender documents for the specific work, and
- The field Hydrogeologist to ensure adherence and compliance by the contractor.

**NOTE:**

*Additional information is available in the relevant Water Service Development Plans (WSDPs), Integrated Development Plans (IDPs) for the area and Provincial Spatial Development Frameworks.*

**Step 6: Prepare Planning Report**

Prepare the Planning Report. This will include a recommendation for the preferred option for implementation.

**NOTE:**

*A generic Table of Contents for the Planning Report is included in Appendix D.2.*

**2.6 Management****2.6.1 What is meant by Management?**

Management of groundwater resources relates to the sustainable use and development of these resources. It focuses on the sustainable development of the groundwater resources without compromising resource integrity (quantity and quality). Management thus involves monitoring quantity and quality over a long-term period and the use of this information to determine compliance against set goals and to assess whether the strategic goals of the Department are being met.

Management is generally an iterative process that has two components:

- Setting management objectives, including strategic objectives set at a national level, the catchment management strategy (CMS) and management plans set at catchment and site-specific levels, and
- Monitoring and reporting against these objectives, as well as updating the strategies and management plans on an ongoing basis.

Monitoring and reporting will provide information to assess the operations against the strategic goals and objectives (compliance assessment). The results of the compliance auditing will be used to devise action plans and update the strategic goals, if required.

**2.6.2 Why is Management Important?**

The management function is important because it provides:

- A continuous record of the response of the aquifer to various inputs and outputs, including recharge, base flow, impacts, evapotranspiration, etc
- A tool to confirm the continued suitability of the aquifer for the specific water use purposes. Monitoring measures groundwater information continuously and can detect reduced yields and the induced inflow of poorer quality water
- Information for the characterisation of the aquifer on a regional scale

- Information for use by the Water Manager in the integrated management of the water resource to ensure sustainability, including the need for and scoping of intervention strategies
- Information for future decision-making and planning, and
- Feedback to the planning and assessment processes.

### 2.6.3 National Level Management: Methodology and Details

National level management entails setting strategic goals, developing policies and strategies for implementation at regional level, reviewing catchment level performance against set management goals and giving support to CMAs in preparing/updating management plans to ensure ongoing compliance with the strategic goals.

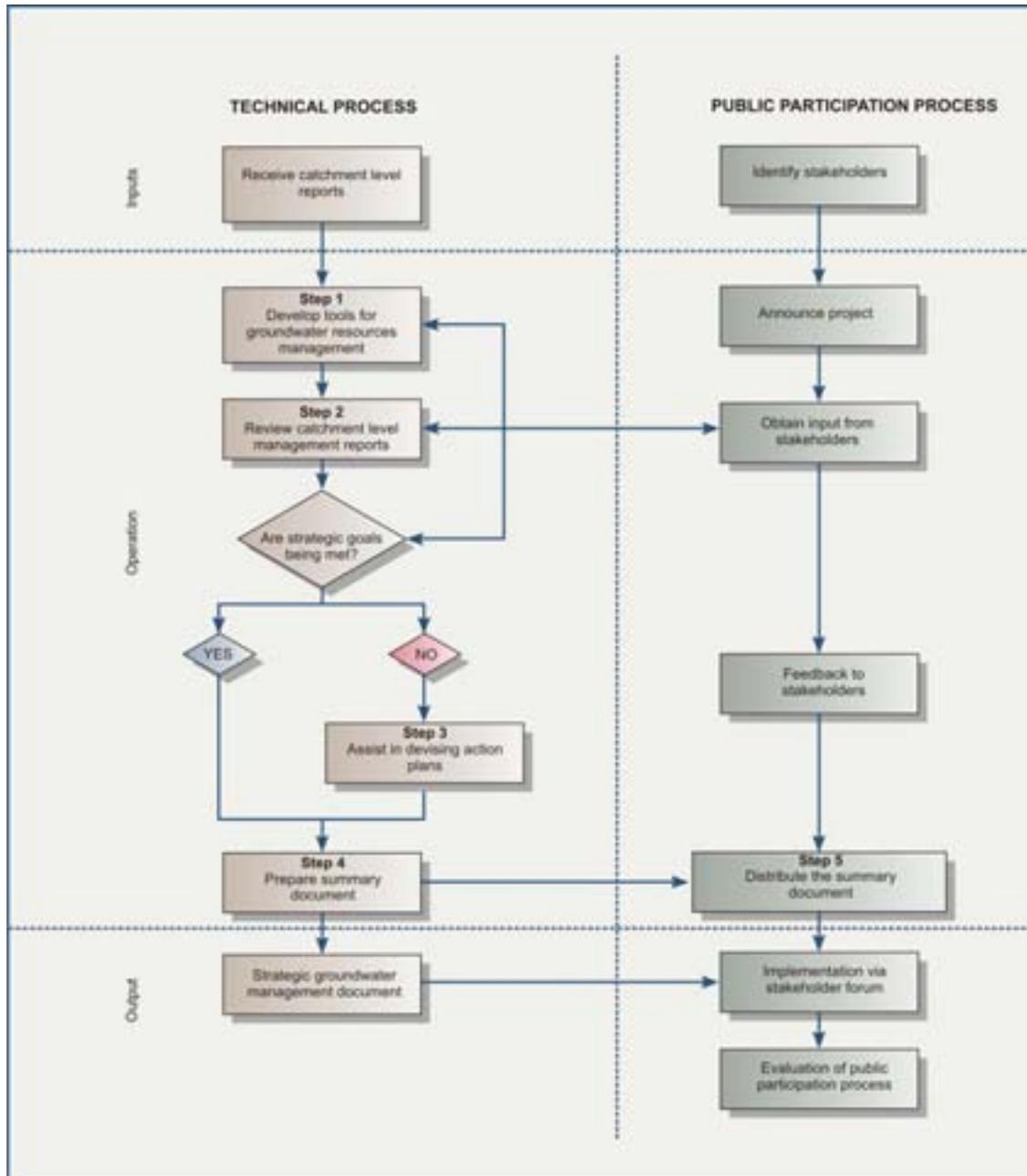
National level management includes the following aspects:

- Auditing performance against NWRS objectives
- Overview of the national water quantity and quality monitoring system through monitoring ambient trends, including surface and groundwater data
- Preparing particular strategies for the management of water resources, for example:
  - Utilisation of the storage of the resource during drought periods. This would involve drawing the water at levels below the normal management level in order to use the storage. This would then be rapidly recharged during subsequent periods of high rainfall, in a manner akin to a surface water dam
  - Setting operational rules for the sustainable utilisation and management of the aquifers (e.g. maximum discharge volumes, normal operation base water level, drought operation base water level), and
  - Establishing guidelines for artificial recharge where this may be feasible (i.e. when a suitable source of surplus water exists). Such a strategy will require a thorough assessment of the aquifer and of the quality of the source water before implementation
- Water Conservation/Water Demand Management and optimising the system potential
- Preparing strategies for land use management (e.g. in relation to urban and industrial development and positioning of waste disposal facilities), and
- Management of strategic issues such as inter-catchment resources and international obligations.

The Policy & Regulation Branch in the Department's National Office will be responsible for the national level management process.

Figure 2.11 summarises the steps involved in national level management. The inputs to national level management include the strategic management objectives and management reports from catchment level.

The steps in national level management are described in more detail in the following sections.



*Figure 2.11: Process for national level management*

**Step 1: Develop tools for groundwater resources management**

The groundwater resources control mechanisms for water use in a catchment will include:

- Guidelines for water use and allocation
- Guidelines for water use authorisations
- Waste discharge charges and water pricing, and
- The Groundwater Strategy.

**NOTE:**

*Further information concerning water use authorisations is available from the Department: Water Affairs and Forestry website: [www.dwaf.gov.za](http://www.dwaf.gov.za).*

**Step 2: Review catchment level management reports**

Review the information received in management reports against the catchment level RQOs and strategic goals. This assessment will review whether or not the strategic goals of the Department are being met.

**Step 3: Assist in devising actions plans**

In the event that the Department's strategic goals for management of the groundwater resources are not being met, the Department's National Office personnel will advise and assist Water Managers in devising action plans to be implemented at catchment level. These action plans should ensure that future actions are aimed at meeting these goals.

**Step 4: Prepare summary document**

Prepare a strategic management and review document summarising:

- Performance during the previous reporting period against the strategic goals
- Areas where performance goals have been achieved
- Areas where performance improvements are required
- Performance goals for the next reporting period, and
- Strategies and action plans to achieve future performance goals.

**Step 5: Distribute the summary document**

Distribute the strategic summary document to all relevant managerial role-players in the Department for comment and sign-off. The Department may also wish to publish these documents for wider use and comment.

**NOTE:**

*Further information concerning water quality components is available in the Water Quality Management Series published by DWAF in March 2003, Sub-Series No. MS 8.1, MS 8.2 and MS 8.3, Edition 1.*

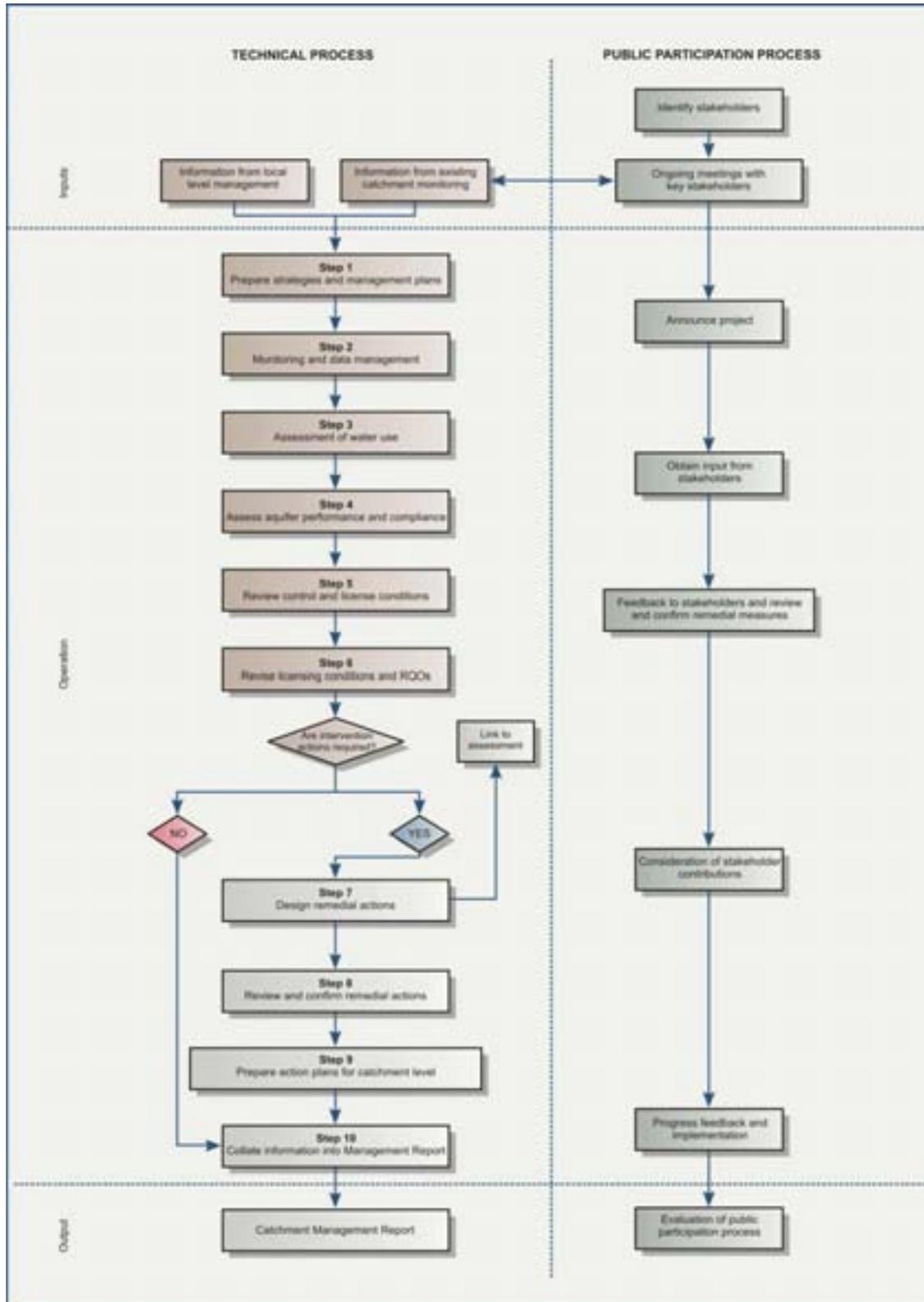
**2.6.4 Catchment level Management: Methodology and Details**

Catchment level management includes, among other functions, the following components:

- Monitoring cumulative impacts on aquifer systems and data management
- Refining the control mechanisms for the management of water use, including operational rules for aquifer utilisation and procedures for combating over-exploitation of the dolomitic aquifer resources, and
- Assessment of the aquifer behaviour as result of impacts imposed against the RQOs
- Auditing the compliance of water use against licensing conditions
- Reporting to both the national and site-specific levels, and
- Feedback to the water users.

The Water Manager will be responsible for the catchment level management function.

Figure 2.12 summarises the steps involved in catchment level management. The inputs to the process include the details from the site-specific management function. The steps in catchment level management are described in more detail in the following sections.



*Figure 2.12: Process for catchment level management*

**Step 1: Prepare strategies and management plans**

Prepare and/or update the Integrated Water Resources Management (IWRM) plan for use by the Water Manager and CMA personnel in the management of the catchment. This will provide the strategic direction and performance targets for the operational personnel for the next reporting period.

**NOTE:**

*A generic Table of Contents for the IWRM Plan is included in Appendix D.3.*

**NOTE:**

*Further information is available in Integrated Water Resources Development Plans, Training Manual and Operational Guide (CIDA) and Water Quality Catchment Assessment study and Catchment Management Strategy Guidelines.*

**Step 2: Monitoring and data management**

Correct data management forms the basis for sustainable water management and is thus an essential component of the overall monitoring and management programme for the groundwater resources of dolomitic aquifers.

Further details on monitoring and data management are provided in site-specific management (**Section 2.0**).

**Step 3: Assessment of water use**

Assess the report received from the site-specific management process against the licensing conditions. Record water management performance within the catchment and any occurrences of non-compliance.

**Step 4: Assess aquifer performance and compliance**

Assess the monitoring data from catchment level monitoring networks against RQOs. Assess the water abstraction, water level response and water quality trends for the monitoring period. Determine aquifer behaviour against management objectives and assess aquifer performance.

On the basis of the monitoring data, determine the compliance and need for the implementation of any remedial actions.

#### **Step 5: Review the control and license conditions**

The groundwater resources control mechanisms for water use in a catchment are developed during the national level management process, and include guidelines for water use and allocation, guidelines for water use authorisations and waste discharge charges and water pricing. Licensing conditions are based on these control mechanisms and the RQOs set for the catchment. The control mechanisms and licensing conditions should be reviewed at a catchment level, based on:

- The catchment level strategies and management plans set in Step 1
- The information provided from the existing catchment monitoring
- The aquifer performance, and
- Water use compliance.

#### **Step 6: Revise licensing conditions and RQOs**

Revise the existing license conditions and RQOs for the catchment, based on the review undertaken in Step 5.

*NOTE:*

*Further information is available in  
Parsons, R, Wentzel, J.(2006) GRDM  
Manual. WRC Project 1427.*

#### **Step 7: Design remedial actions**

Together with the Hydrogeologist and design team, the Water Manager will either notify the water user of the required remedial measures, or will design these measures for implementation by the water user. The Water Manager should ensure that these measures are correctly implemented.

#### **Step 8: Review and confirm remedial actions**

Present the proposed remedial actions to the relevant role-players, obtain input and update the remedial actions accordingly.

**Step 9: Prepare actions plans for catchment level management**

Prepare detailed action plans for use by the Water Manager and CMA personnel for the implementation of the remedial actions. This will include monitoring frequency, well-field and borehole operational procedures and land use management.

**Step 10: Collate information into Management Report**

Collate all information collected and reviewed at the catchment level into a Management Report for use by the Policy and Regulation Branch of the Department's Head Office in the national level management process.

**2.6.5 Site-specific Management: Methodology and Details**

Site-specific management includes the following tasks:

- Collection, collation, storage and assessment of monitoring data within, and surrounding the water use(s)
- Implementation of water development options identified as part of the planning process
- Supervision, or implementation, of the remedial measures identified as part of the monitoring and management function
- Operation and maintenance
- Control of specific water uses, and
- Reporting.

**NOTE:**

*Information on site-specific groundwater management is available in the NORAD toolkit, as follows:*

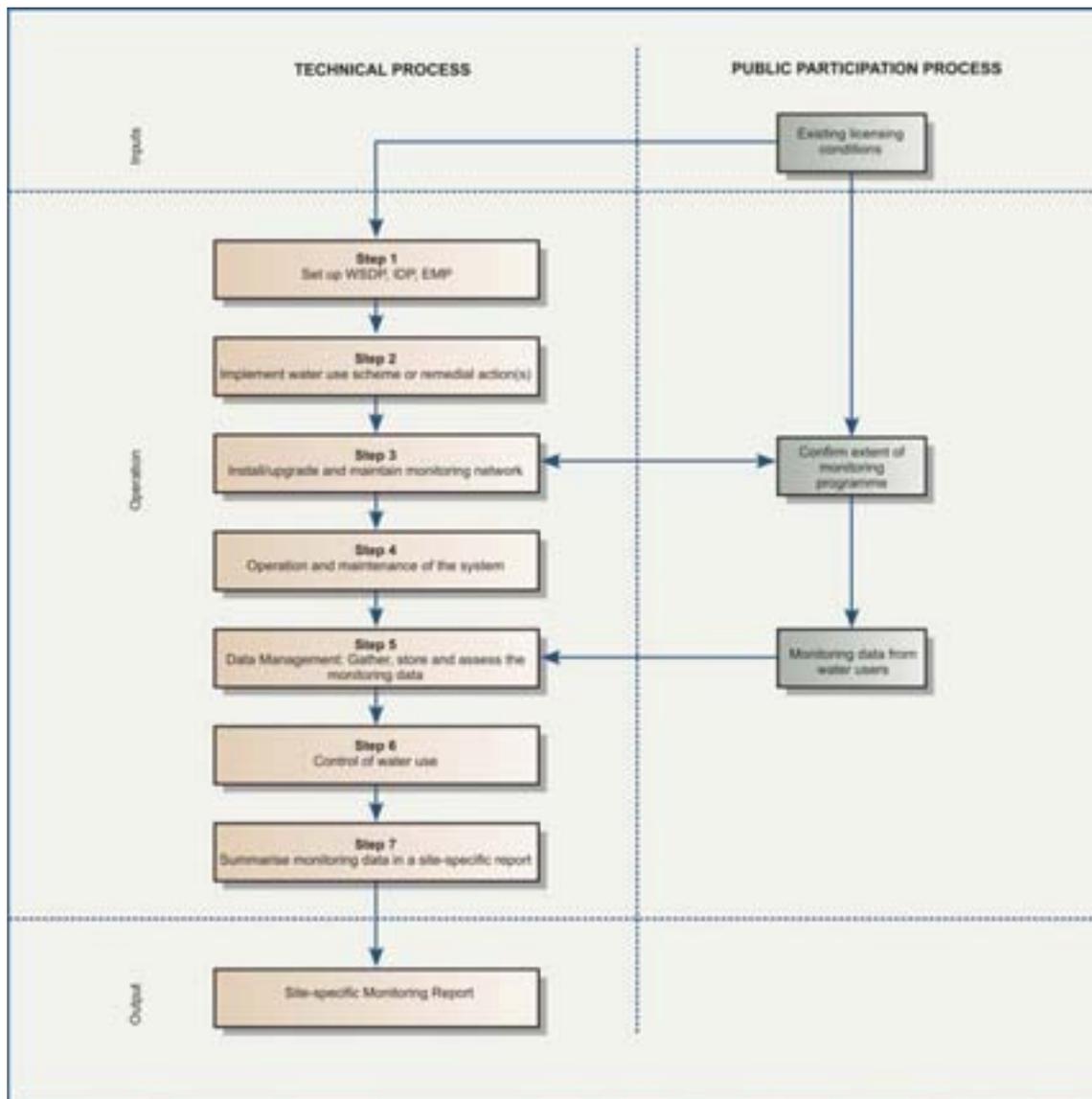
*Section 1.1: A framework for groundwater management of community water supply*

*Section 1.2: Implementing a rural groundwater management system*

*Section 7.1: Sustainability Best Practices, Guidelines for rural services.*

The water user (e.g. Local/District Municipality, WUA, mine, industry or delegated personnel) will be responsible for site-specific management.

Figure 2.13 summarises the steps involved in site-specific management. They are described in more detail in the following sections.



*Figure 2.13: Process for site-specific management*

**Step 1: Set up WSDP, IDP, EMP**

The Water Manager/Hydrogeologist will, together with the relevant personnel from the local municipalities, develop/update the groundwater aspects of the local WSDP and IDP as well as the Environmental Management Plan (EMP) for any new water use. This will take into consideration any information available from the catchment planning phase.

**Step 2: Implement water use scheme or remedial action(s)**

Implement approved site-specific schemes and actions, including:

- The preferred water use schemes as identified during the planning process and specified in the Planning Report, and
- Any remedial measures that have been recommended from the catchment level management function.

**NOTE:**

*Additional information is available in “Minimum Standards and Guidelines for Groundwater Resource Development for the Community Water Supply and Sanitation Programme”.*

**Step 3: Install/update and maintain monitoring network**

Ensure that the monitoring network installed during the implementation phase is sufficient to provide effective coverage and accurate measurements for management purposes. This includes abstraction well-fields and their monitoring boreholes, local and regional monitoring network, monitoring boreholes around individual facilities, such as sewage works, waste dumps, etc, and springs.

The monitoring network should include:

- Weather station within the study area
- In-line flow meters for monitoring water abstraction from boreholes
- Piezometer tubes to measure water levels in pumping holes at the end of a non-pumping cycle; alternatively, install continuous water level monitoring equipment, and
- Borehole sampling to monitor quality of groundwater
- Spring flow measurements, and
- Sampling of spring flow to monitor water quality

The monitoring network must be regularly maintained.

#### **Step 4: Operation and maintenance of the system**

The Water Manager, Hydrogeologist and other relevant personnel will ensure that the well-field for water use and the monitoring system is correctly operated and regularly maintained.

#### **Step 5: Data Management: Gather, store and assess the monitoring data**

Correct data management forms the basis for sustainable water management and is thus an essential component of the overall monitoring and management programme for the groundwater resources of dolomitic aquifers. Data management involves correct data collection, recording, handling, archiving and reporting according to an agreed data management system.

Data collection should be managed as part of a value chain. This value chain includes (a) *data* acquired from the monitoring system (b) *information* generated, based on this monitoring data (c) *knowledge* and insight to resolve questions (d) *strategic* and/or *operational decisions*, and (e) the organisation's *mission and objectives*. The mission and objectives of an organisation clearly provide a long-term focus, while data collection has a short-term focus.

**NOTE:**

*Further details on Good Data Management can be obtained from "Good Data Management Practices" (2006), E. Bertram, DWAF report, unpublished.*

When monitoring data is being collected, the various aspects described in the following sections should be considered.

#### Monitoring frequency

Borehole water level and abstraction monitoring should be undertaken on a routine basis, with the frequency of monitoring generally being set at monthly intervals.

In order to obtain information to guide preventative or remediation measures (if required), borehole monitoring will also be required on an incident-related basis.

**NOTE:**

*The installation of continuous real-time monitoring equipment in key selected boreholes is highly recommended.*

### Water sample collection and frequency

Ensure that a representative groundwater borehole sample is obtained on a routine basis. Samples will generally be collected at six-monthly or yearly intervals. More frequent sampling may be specified where, for example, pollution of the groundwater resource is suspected.

Issues to consider during borehole sampling are:

- Purging the borehole
- Minimum container size
- Filtering
- Preservation method and sterilisation, and
- Use of an accredited laboratory.

**NOTE:**

*Details of sampling protocol are available in: Weaver JMC, Cavé L and Talma AS (2007). Groundwater Sampling (second edition) WRC Project No. TT 303/07, Pretoria.*

*Details are also available in the Field Manual and Desk Manual published by the Winconsin Department of Natural Resources, PUBL-DG-037 96, September 1996.*

**NOTE:**

*Water Service Authorities can obtain additional information on monitoring water levels and flow in the DWAF/NORAD, 2006 document, Section 6.1: Groundwater monitoring for Pump Operators.*

### Reporting format

All data collected must be captured and should include:

- Hydrocensus data
- Drilling data
- Testing data, and
- Analytical data.

Data should be captured on standard forms and submitted to the Water Manager, the CMA personnel or the Department's regional office. Examples of standard forms are included in Appendix B.

#### Data handling and submission

Handling and submission details for the various required datasets are:

- Abstraction data:
  - Recorded by end user, and
  - Reported monthly or according to water use authorisation conditions.
  
- Water level data:
  - Recorded by end user
  - Reported monthly or according to water use authorisation conditions
  - Submitted to the Department, and
  - Automatic recorders installed in key monitoring boreholes by the Department/CMA.
  
- Water quality data:
  - Sample collected by end user and submitted to laboratory according to water use authorisation conditions/detailed constituents
  - Recorded on the catchment level monitoring database, and
  - Submitted for inclusion on the national groundwater archive (NGA), through the Catchment Management Report.

The Water Manager (or the CMA) must arrange for the inspection of measuring devices (e.g. flow meters).

Submit all groundwater monitoring data for storage on the national groundwater database (NGDB) and/or the NGA.

Present the monitoring data in a suitable format for assessment. This is likely to be a graphical representation which will allow the assessment of short-term and long-term trends in water level and quality. The monitoring data are also used:

- To provide insight into aquifer behaviour
- To support licensing decisions and for future water use allocations
- To calibrate the existing models
- To measure the performance of the aquifer / system against licensing conditions, and
- As a basis for intervention actions.

**NOTE:**

*Aquimon, detailed in the DWAF/NORAD, 2006 document, is a tool specifically designed to assist groundwater managers with organising and interpreting data. Aquifer Management System (AMS) is available on [www.usersupport.co.za](http://www.usersupport.co.za). This tool focuses on the spatial and temporal management of aquifer systems based on monitoring data.*

**NOTE:**

*Additional information is available in the WRC report 861/1/02a: Guidelines for the monitoring and management of groundwater resources in rural water supply schemes.*

**Step 6: Control of water use**

The monitoring data and generated information will be used to control water use within the site-specific environment.

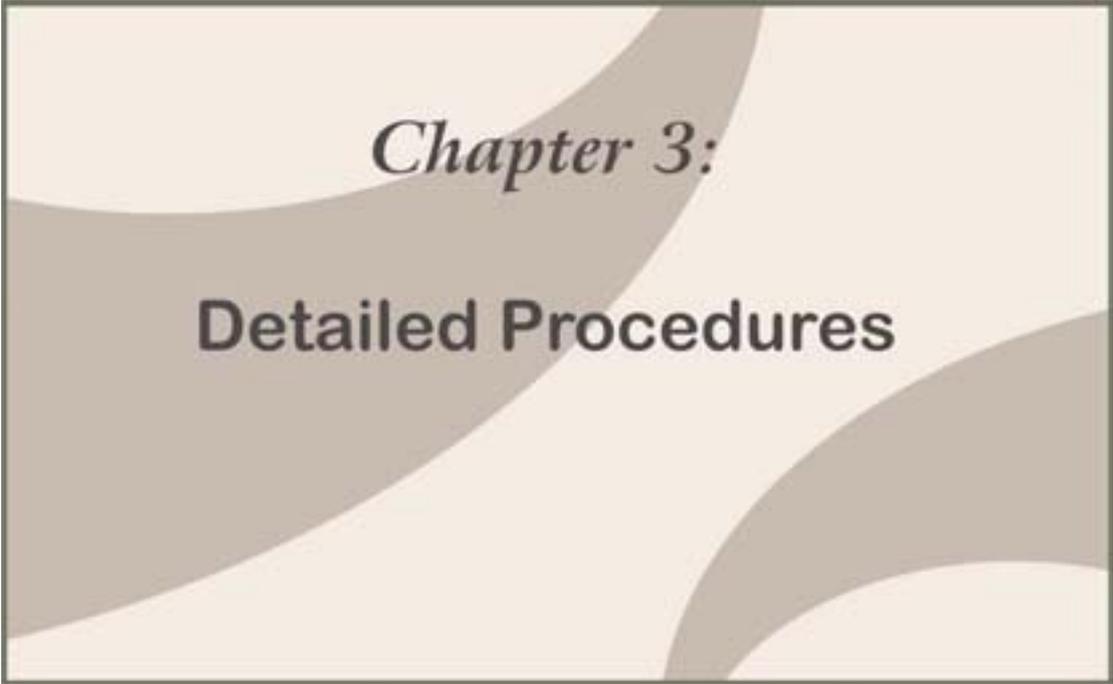
**Step 7: Summarise monitoring data in a site-specific report**

Collate all site-specific monitoring data for the aquifer catchment into a monthly report, for use in the catchment management function. A report that audits the monitoring information should be prepared on:

- Status of the water use
- Performance of use against licensing condition
- Trends in monitoring information, and
- Suspected / planned change in use in the near future.

**NOTE:**

*Water Service Authorities can obtain additional information in the DWAF/NORAD, 2006 document, Section 5.1: Sustainability Index Tool (SuSIT) for auditing of water supply schemes.*

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*Chapter 3:*

**Detailed Procedures**

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## CHAPTER 3. DETAILED PROCEDURES

### 3.1 Assessment

#### 3.1.1 Step 1: Undertake Desk Study and Remote Sensing

Stage	Activity	Chapter 2 reference	Done
<i>Input</i>	Collect data relevant to the aquifers and the scale of the assessment. Sources include:	2.4.3	
	▪ Directorate: Information Management		✓
	▪ Directorate: Hydrological Services - Sub-Directorate: Groundwater Resources, Assessment and Management		✓
	▪ Directorate: Water Resources Planning Systems - Sub-Directorate: Integrated Hydrological Planning		✓
	▪ Regional DWAF Office, CMA Office		✓
	▪ Others		✓
	Information types include:		
	▪ ISP document(s), WSDP, IDP		✓
	▪ Hydrogeological reports, borehole logs, test data		✓
	▪ Published geological maps		✓
	▪ Published hydrogeological maps and memoirs		✓
	▪ Monitoring data from national, catchment or site-specific monitoring network (temporal water level data and water quality data)		✓
	▪ Information on water use/abstraction (concentrating on major abstractors), registered water users, WARMS data, licences issued and conditions		✓
	▪ Maps and orthophotographs		✓
▪ Satellite imagery and stereo pair air photography		✓	
<i>Methodology</i>	Collate information		✓
	Review and interpret existing data		✓
	Prepare (preliminary) GIS maps at an appropriate scale indicating: <ul style="list-style-type: none"> <li>▪ Aquifer extent</li> <li>▪ Position of springs</li> <li>▪ Water course and boreholes</li> <li>▪ Piezometric levels (water levels)</li> <li>▪ Groundwater flow directions</li> <li>▪ Boundaries</li> <li>▪ Groundwater quality, and</li> <li>▪ Impacted or potentially impacted areas</li> </ul>		✓
	Prepare assessment of water availability and water demand in areas that could be serviced by groundwater		✓
	Compile data into and/or update database		✓
<i>Output</i>	Desk study report, according to Table of Contents from Appendix D, to include:		

<i>Stage</i>	<b>Activity</b>	<b>Chapter 2 reference</b>	<b>Done</b>
	▪ Discussion of available data		✓
	▪ Water balance and water availability		✓
	▪ GIS maps and database		✓
	▪ Water demand assessment for areas that could be supplied by groundwater resources		✓
	▪ Delineation of potential groundwater resources that could supply the required water demand		✓
	▪ Identification of groundwater resources where further studies are required to confirm resource availability/viability		✓
	▪ Identification of target aquifers that could satisfy project requirement (bulk water supply, compulsory licensing, etc)		✓
	▪ Discussion of alternatives (e.g. expanding a surface water scheme or conjunctive surface/groundwater use)		

**3.1.2 Step 2: Identify Areas for Additional Work**

<i>Stage</i>	<b>Activity</b>	<b>Chapter 2 reference</b>	<b>Done</b>
<i>Input</i>	Desk study report and supporting information	2.4.3	✓
<i>Methodology</i>	Review the desk study report:		
	▪ Determine distribution of groundwater availability in the aquifers		✓
	▪ Determine current use of groundwater		✓
	▪ Undertake discussions/workshops with national, regional and local DWAF offices/CMA		✓
	▪ Undertake gap analysis		✓
<i>Output</i>	Confirmation of knowledge gaps		✓
	Identification of areas requiring further work and prepare work plan as required		✓

### 3.1.3 Step 3: Undertake Hydrocensus

<i>Stage</i>	<b>Activity</b>	<b>Chapter 2 reference</b>	<b>Done</b>
<i>Input</i>	Desk study report/gap analysis	2.4.3	✓
	Available data concerning distribution of water boreholes		✓
	Hydrogeological map(s) of aquifers within the catchment		✓
<i>Methodology</i>	Select key areas within the groundwater resource to undertake the hydrocensus to ensure a more-or-less even distribution of data points compatible with objectives and scale of study		✓
	Liaise with land owners, obtain permission to visit boreholes, wells or springs		✓
	Locate selected boreholes, wells or springs. Collect details of:		✓
	▪ Coordinates (using GPS)		✓
	▪ Existing equipment		✓
	▪ Current use		✓
	▪ Owner		✓
	▪ Water level		✓
	▪ Reported or measured depth (if borehole or well)		✓
	▪ Reported or measured yield (flow if spring)		✓
	▪ Any available information (e.g. borehole log). (Details on private boreholes are sometimes available from the drilling contractor's invoice)		✓
	▪ Field measurement of pH and EC.		✓
	Collect sample for full analysis from key selected boreholes/wells/springs to obtain broad overview of groundwater quality. Analyse for at least: pH, TDS, EC, Ca, Mg, Na, K, HCO <sub>3</sub> , SO <sub>4</sub> , Cl, NO <sub>3</sub> , F, Fe, Mn		✓
	Identify potential pollution sources (e.g. waste dumps, mining activities, waste water treatment works, intensive rural settlement, feed lots, irrigation areas)		✓
	Verify existing groundwater use		✓
Record all data on standard hydrocensus forms		✓	
Submit data to relevant department		✓	
<i>Output</i>	Collate all data		✓
	Prepare/update piezometric (water level) maps of the groundwater resource		✓
	Make recommendations on way forward. These could include:		✓
	▪ Recommendations for infilling studies		✓
	▪ Exploratory drilling and testing programme within the identified groundwater resource		✓
	▪ Implementation of, or upgrading of existing, catchment level monitoring network of groundwater resource		✓

### 3.1.4 Step 4: Siting of Monitoring/Exploration Boreholes

<i>Stage</i>	<b>Activity</b>	<b>Chapter 2 reference</b>	<b>Done</b>
<i>Input</i>	Updated desk study report	2.4.3	✓
	Identify areas requiring additional data/information		✓
<i>Methodology</i>	Appoint Hydrogeologist, as required		✓
	Assess need for and number of monitoring/exploratory boreholes		✓
	Obtain and interpret remote sensing data: <ul style="list-style-type: none"> <li>▪ Landsat imagery</li> <li>▪ Stereo pair black and white air photography</li> </ul>		✓
	Identify features (dykes contact zones, faults, weathering), important for groundwater occurrence		✓
	Undertake geological appraisal		✓
	Obtain permission from landowner(s) for access to undertake survey, and to drill and test subsequent boreholes		✓
	Undertake geophysical survey as necessary to select positions for monitoring/exploratory boreholes. Geophysical survey must comprise a minimum of two techniques such as: <ul style="list-style-type: none"> <li>▪ Magnetic</li> <li>▪ Gravity (gravity is a particularly useful technique for detailed siting and aquifer assessment)</li> <li>▪ Electro-magnetic</li> <li>▪ Electrical resistivity</li> <li>▪ Resistivity</li> <li>▪ Seismic</li> <li>▪ Electro-seismic</li> <li>▪ Ground penetrating radar</li> </ul>		✓
	Combine desk study, geological and geophysical data to confirm number of monitoring/exploratory boreholes required		✓
<i>Output</i>	Siting report detailing: <ul style="list-style-type: none"> <li>▪ Hydrocensus result</li> <li>▪ Area surveyed</li> <li>▪ Techniques employed</li> <li>▪ Location and number of monitoring/exploration boreholes</li> <li>▪ Recommendations for the drilling and testing programme</li> </ul>		✓

### 3.1.5 Step 5: Drilling and Testing of Monitoring/Existing Boreholes

<i>Stage</i>	<b>Activity</b>	<b>Chapter 2 reference</b>	<b>Done</b>
<i>Input</i>	Siting report detailing number and location of monitoring/exploration boreholes	2.4.3	✓
	Technical specifications for drilling and testing	Appendix A1 and A2	✓
<i>Methodology</i>	Appoint specialist drilling and testing contractor		✓
	Appoint Hydrogeologist to plan and supervise the work		✓
	Drill the boreholes according to the technical specifications		✓
	Measure water strikes and blowing yields; prepare logs		✓
	Record water levels		✓
	Undertake testing of the boreholes as required according to the technical specifications		✓
	Collect water samples from key selected boreholes, wells and springs. Submit to a laboratory for analysis for macro-determinands, as a minimum: pH, TDS, EC, Ca, Mg, Na, K, HCO <sub>3</sub> , SO <sub>4</sub> , Cl, NO <sub>3</sub> , F, Fe, Mn		✓
<i>Output</i>	Geological and hydrogeological field report containing, as a minimum:		✓
	<ul style="list-style-type: none"> <li>▪ A geological and construction log of each borehole drilled</li> </ul>		✓
	<ul style="list-style-type: none"> <li>▪ A hydrogeological log describing features of importance to the groundwater resources (e.g. cavities, fissures, water strike depths, blowing yield)</li> </ul>		✓
	<ul style="list-style-type: none"> <li>▪ Test results</li> </ul>		✓
	<ul style="list-style-type: none"> <li>▪ Water levels</li> </ul>		✓
	<ul style="list-style-type: none"> <li>▪ Water quality</li> </ul>		✓
	Data files for input into database		✓

**3.1.6 Step 6: Prepare Conceptual Groundwater Model**

<i>Stage</i>	<b>Activity</b>	<b>Chapter 2 reference</b>	<b>Done</b>
<i>Input</i>	Desk study report	2.4.3	✓
	Field reports / information		✓
<i>Methodology</i>	Update desk study report with collated data and information from the previous steps		✓
	Describe the groundwater resource in terms of:		✓
	▪ Aquifer boundaries		✓
	▪ Lithological composition (e.g. distribution of formations) which has a bearing on groundwater occurrence		✓
	▪ Compartments		✓
	▪ Presence of features of importance to groundwater occurrence and movement (e.g. fractures, cavities, faults)		✓
	▪ Piezometric levels		✓
	▪ Distribution of springs, seepage zones and wetlands		✓
	▪ Recharge potential		✓
	Identify areas of existing abstraction		✓
	Distribution of land use (e.g. irrigation, mining, waste dumps, urban areas)		✓
Identification of impacts (e.g. dewatered or polluted areas)		✓	
<i>Output</i>	Report presenting the conceptual model of the aquifer to be used as planning and management document		✓

**3.1.7 Step 7: Risk Assessment**

<i>Stage</i>	<b>Activity</b>	<b>Chapter 2 reference</b>	<b>Done</b>
<i>Input</i>	South African Groundwater Decision Tool	2.3.4	✓
<i>Methodology</i>	Identify risks		✓
	For each risk, identify probability of occurrence and consequence of occurrence		✓
	Rank risks in terms of probability and consequence		✓
	Identify mitigation measures		✓
	Prepare a Risk Management and Mitigation Plan		✓
<i>Output</i>	Risk Management and Mitigation Plan		✓

**3.1.8 Step 8: Spring Capture and Surface/Groundwater Interaction**

<i>Stage</i>	<b>Activity</b>	<b>Chapter 2 reference</b>	<b>Done</b>
<i>Input</i>	Desk study report	2.4.3	✓
	Hydrocensus report		✓
	Water use information and water demand assessment		✓
	Reserve determination (as available)		✓
	Water Quality Objectives (WQO) (as available)		✓
<i>Methodology</i>	Assess spring status, including:		✓
	▪ Location, type, flow, size		✓
	▪ Existing infrastructure at the spring, weirs, canals, protection, etc		✓
	Map areas of wetlands		✓
	Map areas of seepage from groundwater into surface drainage and pans		✓
	Assess water quality		✓
	Assess vulnerability		✓
<i>Output</i>	Identification of springs with potential for capture		✓
	Identification of springs requiring protection (e.g. providing base flow into wetlands where capture could be detrimental)		✓
	Spring capture design		✓
	Recommendations for further studies		✓

**3.1.9 Step 9: Present to Stakeholders and obtain Input**

<i>Stage</i>	<b>Activity</b>	<b>Chapter 2 reference</b>	<b>Done</b>
<i>Input</i>	Results of assessment of water availability and water requirements	2.4.3	✓
<i>Methodology</i>	Identify stakeholders		✓
	Set up focus group meetings and discuss recommendations and options		✓
<i>Output</i>	Prepare issues report		✓
	Recommendations on options		✓

**3.1.10 Step 10: Prepare Numerical/Analytical/Risk-based Groundwater Model**

<i>Stage</i>	<b>Activity</b>	<b>Chapter 2 reference</b>	<b>Done</b>
<i>Input</i>	Desk study report	2.4.3	✓
	Hydrocensus report		✓
	Field data, field report		✓
	Conceptual model		✓
	Objectives of the modelling process (e.g. regional/ catchment or site-specific resource assessment, land use assessment, water quality trends)		✓
<i>Methodology</i>	Select appropriate modelling technique		✓
	▪ Analytical (e.g. spread sheet, arithmetic, statistical)		✓
	▪ Risk based (e.g. Risk Based Corrective Action (RBCA), The South African Groundwater Decision Tool (SAGDT))		✓
	▪ Numerical – 2D or 3D modelling package (e.g. Modflow or Feflow)		✓
	Develop, refine and test model		✓
<i>Output</i>	Modelling predictions		✓
	Gap analysis		✓
	Report dealing with the modelling process and results		✓

## 3.1.11 Step 11: Prepare Assessment Report

<i>Stage</i>	<b>Activity</b>	<b>Chapter 2 reference</b>	<b>Done</b>
<i>Input</i>	Desk study and/or conceptual model report	2.4.3	✓
	Field data, results and interpretations		✓
	Output from stakeholder consultations		✓
<i>Methodology</i>	Review and integrate data collected		✓
<i>Output</i>	Update assessment report according to generic Table of Contents	Appendix D1	✓
	Assessment report incorporating all work undertaken in the completed steps, describing the groundwater resources. The report will include:		✓
	Hydrogeological maps		✓
	Borehole logs		✓
	Test pumping data		✓
	Distribution of aquifer zones		✓
	Delineation of aquifers within study area		✓
	An assessment of the available groundwater resources		✓
	An assessment of the groundwater quality		✓
	Delineation of target areas suitable for future development		✓
	Delineation of areas of heavy or over-exploitation		✓
	Discussion of current impacts from existing abstraction or land use (e.g. irrigation, mining)		✓
	Discussion of surface and groundwater interaction		✓
	Recommendations for planning and sustainable management of the groundwater resource		✓
	Recommendations for upgrading of existing, or implementation of new, monitoring programme		✓
	Identification of issues. These could include:		✓
	Over-exploitation <ul style="list-style-type: none"> <li>▪ Areas impacted by mining dewatering</li> <li>▪ Areas suffering from water shortages</li> <li>▪ Threats to water quality</li> <li>▪ Cross-boundary issues (catchment, WMA, international)</li> <li>▪ Management and monitoring issues</li> </ul>		✓

### 3.1.12 Specialist Studies

<i>Stage</i>	<b>Activity</b>	<b>Chapter 2 reference</b>	<b>Done</b>
<i>Input</i>	Definition of specialist study. Examples are:	2.4.4	
	▪ Surface/groundwater interaction		✓
	▪ Contribution of groundwater to stream, rivers and wetlands		✓
	▪ Identification of groundwater-dependant ecosystems		✓
	▪ Direct, indirect and/or unique/keystone ecosystems		✓
	▪ Determine sensitivity of landscape to fluctuations in water levels – e.g. subsidence		✓
	▪ Assess existing or planned infrastructure that may be affected		✓
	All available data from previous studies		✓
<i>Methodology</i>	Define specialist study objectives		✓
	Appoint specialist service provider		✓
	Desk study		✓
	Design field study programme (the details of the study will depend upon the specialist study)		✓
	Undertake the field programme (i.e. data collection, drilling, testing, water sampling, monitoring, modelling, etc)		✓
<i>Output</i>	Specialist study report		✓

## 3.2 Planning

### 3.2.1 National Level Planning

#### Step 1: Confirm Land Use Planning and Study Parameters

<i>Stage</i>	<b>Activity</b>	<b>Chapter 2 reference</b>	<b>Done</b>
<i>Input</i>	Recommendations from relevant level of the assessment study	2.5.3	✓
	Resource Quality Objectives for the selected catchment(s)		✓
	Land use planning details		✓
<i>Methodology</i>	Define and confirm the parameters for the study, including:		✓
	▪ Likely geographic location		✓
	▪ Quantity of water required, as well as the assurance of supply (percentage of time that the water is required)		✓
	▪ Water quality constraints / requirements		✓
	▪ Proposed water use options		✓
<i>Output</i>	Confirmation of land use planning		✓
	Confirmation of study parameters		✓

**Step 2: Summarise Relevant Data and Information**

<i>Stage</i>	<b>Activity</b>	<b>Chapter 2 reference</b>	<b>Done</b>
<i>Input</i>	Information from National Level Planning: Step 1	2.5.4	✓
<i>Methodology</i>	Prepare design criteria report		✓
	Prepare data summary report containing all relevant information as appendices		✓
<i>Output</i>	Design criteria report		✓
	Data summary report		✓
	Conceptual layouts of the water use options		✓
	Preliminary cost analyses of the options		✓

**Step 3: Technical Evaluation and Costing of Options**

<i>Stage</i>	<b>Activity</b>	<b>Chapter 2 reference</b>	<b>Done</b>
<i>Input</i>	Confirmation of land use planning	2.5.4	✓
	Design criteria report		✓
	Data summary report		✓
<i>Methodology</i>	Prepare conceptual layout drawings of water use options		✓
	Assess technical feasibility of water use options, including:		✓
	▪ Sustainable yield of the source		✓
	▪ Pump and pipeline requirements		✓
	▪ Distribution network		✓
	Determine conceptual level costs for each water use option, from the conceptual layout plans		✓
	Compare technical and financial aspects for each water use option		✓
	Prepare conceptual level report		✓
<i>Output</i>	Report on conceptual level comparison of water use options		✓

**Step 4: Summarise and Rank Options**

<i>Stage</i>	<b>Activity</b>	<b>Chapter 2 reference</b>	<b>Done</b>
<i>Input</i>	Report on conceptual level comparison of water use options	2.5.4	✓
	Design criteria report		✓
	Data summary report		✓
<i>Methodology</i>	Prepare a summary of the water use options		✓
	Rank the water use options in a user-friendly format		✓
<i>Output</i>	Summary report on water use options, with rankings, for presentation to the stakeholders		✓

**Step 5: Screening of Options Workshop**

<i>Stage</i>	<b>Activity</b>	<b>Chapter 2 reference</b>	<b>Done</b>
<i>Input</i>	Report on conceptual level comparison of water use options	2.5.4	✓
	Records of discussions during assessment phase		✓
	Summary report on water use options, with rankings		✓
<i>Methodology</i>	Identify and/or confirm stakeholders		✓
	Set up workshops and focus group meetings and discuss water use options		✓
	Prepare issues and comments report		✓
<i>Output</i>	Issues and comments report		✓
	Recommendations from the workshops on the preferred options/screening of options		✓

**Step 6: Prepare Planning Report**

<i>Stage</i>	<b>Activity</b>	<b>Chapter 2 reference</b>	<b>Done</b>
<i>Input</i>	Report on conceptual level comparison of water use options	2.5.4	✓
	Summary report on water use options		✓
	Issues and comments report		✓
	Recommendations from the workshops on the preferred options		✓
<i>Methodology</i>	Collate information and prepare national level planning report		✓
	Review national level planning report:		✓
	▪ Within the Department (internal review)		✓
	▪ With stakeholders (external review and comment)		✓
	Prepare review and summary report		✓
	Sign-off national level planning report		✓
<i>Output</i>	National level planning report		✓
	Comments documents from review		✓

**Step 7: Input Information to Catchment Level  
Assessment and Planning**

<i>Stage</i>	<b>Activity</b>	<b>Chapter 2 reference</b>	<b>Done</b>
<i>Input</i>	National level planning report	2.5.4	✓
	Comments documents from review		✓
<i>Methodology</i>	Liaise with the Directorate: Water Resource Planning Systems, Sub-Directorate: Integrated Hydrological Planning, the Directorate: Information Management; Sub-Directorate: Groundwater Resources, Assessment and Monitoring and the relevant Regional Offices		✓
	Provide relevant data for input into NGS, including:		✓
	▪ Location and layout of potential water use options		✓
	▪ Technical and financial feasibility		✓
<i>Output</i>	Updated NGS		✓

### 3.2.2 Catchment Level Planning

#### Step 1: Summarise required data/ information

<i>Stage</i>	<b>Activity</b>	<b>Chapter 2 reference</b>	<b>Done</b>
<i>Input</i>	National level planning report	2.5.5	✓
	Catchment level assessment report		✓
<i>Methodology</i>	Prepare updated design criteria report		✓
	Prepare data summary report containing all relevant information as appendices		✓
<i>Output</i>	Design criteria report		✓
	Data summary report		✓

**Step 2: Options analysis**

<i>Stage</i>	<b>Activity</b>	<b>Chapter 2 reference</b>	<b>Done</b>
<i>Input</i>	National level planning report	2.5.5	✓
	Catchment level assessment report		✓
	Design criteria report		✓
	Data summary report		✓
	Conceptual and/or numerical groundwater model		✓
	Catchment-based resource evaluation models (water resource planning model, water resource yield model, WRSM 2005)		✓
	Other relevant information within the Department's data management system		✓
<i>Methodology</i>	Using the conceptual level groundwater model and the resources models, undertake pre-feasibility level design for each water use option, including an assessment of:		✓
	▪ Social considerations		✓
	▪ Potential environmental impact		✓
	▪ Economic and financial viability		✓
	▪ Technical feasibility		✓
	▪ Long-term land-use		✓
	▪ Regulatory considerations		✓
	Prepare pre-feasibility level drawings of water use options		✓
Prepare summary bill of quantity and pre-feasibility level costs for each water use option (25% accuracy)		✓	
<i>Output</i>	Pre-feasibility design report, including costs		✓
	Pre-feasibility level drawings		✓

**Step 3: Rank options**

<i>Stage</i>	<b>Activity</b>	<b>Chapter 2 reference</b>	<b>Done</b>
<i>Input</i>	Pre-feasibility design report, including costs	2.5.5	✓
	Pre-feasibility level drawings		✓
	National level planning report		✓
	Catchment level assessment report		✓
<i>Methodology</i>	Rank the water use options being assessed, in order of preference, using one or more of the following methods:		✓
	▪ Discounted Cash Flow (DCF)		✓
	▪ Multi-criteria assessment		✓
	▪ Internal consultation within the Department (qualitative assessment)		✓
<i>Output</i>	Report on ranking of water use options		✓
	Recommendations on options to take to feasibility level design		✓

**Step 4: Summarise options**

<i>Stage</i>	<b>Activity</b>	<b>Chapter 2 reference</b>	<b>Done</b>
<i>Input</i>	Report on ranking of water use options	2.5.5	✓
	Recommendations on options to take to feasibility level design		✓
<i>Methodology</i>	Prepare a summary of the water use options		✓
	Rank the water use options in a user-friendly format		✓
<i>Output</i>	Summary report on water use options, with rankings, for presentation to the stakeholders		✓

**Step 5: Confirm ranking with stakeholders**

<i>Stage</i>	<b>Activity</b>	<b>Chapter 2 reference</b>	<b>Done</b>
<i>Input</i>	Report on ranking of water use options	2.5.5	✓
	Summary report		✓
<i>Methodology</i>	Set up workshops and focus group meetings with stakeholders		✓
	Discuss water use options, noting comments and issues raised		✓
	Prepare proceedings of workshops and meetings		✓
	Prepare comments and issues report		✓
<i>Output</i>	Proceedings reports		✓
	Comments and issues report		✓
	Summary of impact of the discussions on the ranking and design of the water use options		✓

**Step 6: Prepare planning report and aquifer strategy**

<i>Stage</i>	<b>Activity</b>	<b>Chapter 2 reference</b>	<b>Done</b>
<i>Input</i>	Report on ranking of water use options	2.5.5	✓
	Summary report		✓
	Comments and issues report		✓
	Summary of impact of the discussions on the ranking and design of the water use options		✓
	Summary report giving recommendations		✓
<i>Methodology</i>	Collate information and prepare Catchment Level Planning Report, including aquifer management strategy		✓
	Review catchment level planning report		✓
	Prepare review and summary report		✓
	Sign-off catchment level planning report		✓
<i>Output</i>	Catchment level planning report		✓
	Comments documents from review		✓

### 3.2.3 Site-Specific Planning

#### Step 1: Summarise required data/information

<i>Stage</i>	<b>Activity</b>	<b>Chapter 2 reference</b>	<b>Done</b>
<i>Input</i>	Catchment level planning report	2.5.6	✓
	Summary report		✓
	Catchment level and site-specific assessment report		✓
<i>Methodology</i>	Prepare/update design criteria report		✓
	Prepare data summary report containing all relevant information as appendices		✓
<i>Output</i>	Updated design criteria report		✓
	Data summary report		✓

**Step 2: Prepare feasibility level design and costs**

<i>Stage</i>	<b>Activity</b>	<b>Chapter 2 reference</b>	<b>Done</b>
<i>Input</i>	Report on ranking of water use options	2.5.6	✓
	Summary report		✓
	Conceptual and/or numerical groundwater model		✓
<i>Methodology</i>	Undertake feasibility level design, including details on:		✓
	▪ Borehole configuration and layout		✓
	▪ Water collection and distribution piping		✓
	▪ Water storage and pumping network		✓
	Prepare feasibility level drawings		✓
	Update bill of quantities and prepare feasibility level costs (to 10% accuracy)		✓
<i>Output</i>	Summary feasibility level design report, including:		✓
	▪ Design criteria and details		✓
	▪ Feasibility level drawings		✓
	▪ Cost estimates		✓

**Step 3: Confirm extent of monitoring programme**

<i>Stage</i>	<b>Activity</b>	<b>Chapter 2 reference</b>	<b>Done</b>
<i>Input</i>	Report on ranking of water use options	2.5.6	✓
	Summary report		✓
	Feasibility level design report		✓
<i>Methodology</i>	Prepare monitoring programme, including details on:		✓
	▪ Objectives to be met in the monitoring programme		✓
	▪ Location of the monitoring points		✓
	▪ Frequency of monitoring and constituents to monitor		✓
<i>Output</i>	Monitoring programme		✓

**Step 4: Arrange interaction meetings**

<i>Stage</i>	<b>Activity</b>	<b>Chapter 2 reference</b>	<b>Done</b>
<i>Input</i>	Detailed design report	2.5.6	✓
	Tender document		✓
<i>Methodology</i>	Set up workshops and focus group meetings with stake-holders		✓
	Discuss water use options, noting comments and issues raised		✓
	Prepare proceedings of workshops and meetings		✓
	Prepare comments and issues report		✓
	Finalise plan		✓
<i>Output</i>	Final water use plan		✓

**Step 5: Prepare tender drawings and specifications**

<i>Stage</i>	<b>Activity</b>	<b>Chapter 2 reference</b>	<b>Done</b>
<i>Input</i>	Catchment level and site-specific assessment report	2.5.6	✓
	Detailed design report		✓
<i>Methodology</i>	Prepare drawings to issue to contractors for pricing		✓
	Prepare detailed Bill of Quantities		✓
	Prepare construction specifications		✓
<i>Output</i>	Tender package, including:		✓
	▪ Tender drawings		✓
	▪ Tender specifications		✓
	▪ Bill of Quantities		✓

**Step 6: Prepare planning report**

<i>Stage</i>	<b>Activity</b>	<b>Chapter 2 reference</b>	<b>Done</b>
<i>Input</i>	Detailed design report	2.5.6	✓
	Comments and issues report		✓
	Summary of impact of the discussions on the design of the final water use option		✓
	Summary report giving recommendations		✓
<i>Methodology</i>	Collate information and prepare Site-specific level Planning report, including aquifer management strategy		✓
	Review planning report		✓
	Prepare review and summary report		✓
	Sign-off planning report		✓
<i>Output</i>	Final planning report		✓

### 3.3 National Level Management

#### 3.3.1 Step 1: Develop Tools for Groundwater Resources Management

<i>Stage</i>	<b>Activity</b>	<b>Chapter 2 reference</b>	<b>Done</b>
<i>Input</i>	Monitoring reports	2.6.3	✓
	Stakeholder issues and concerns		✓
<i>Methodology</i>	Consider management options to ensure sustainable use of the groundwater resources		✓
	Compare/review monitoring reports against desired management objectives		✓
	Set guidelines for sustainable use of the groundwater resources		✓
<i>Output</i>	Management document detailing desired management objectives, recommendations for intervention		✓
	Management objectives for water use authorisations and licensing		✓
	Recommendations for water pricing		✓
	Recommendations for waste water discharge pricing		✓

### 3.3.2 Step 2: Review Catchment Level Management Reports

<i>Stage</i>	<b>Activity</b>	<b>Chapter 2 reference</b>	<b>Done</b>
<i>Input</i>	Catchment monitoring reports	2.6.3	✓
	National groundwater resource management objectives		✓
<i>Methodology</i>	Compare monitoring data and aquifer behaviour response with aquifer management objectives and strategic goals		✓
	Determine level of compliance		✓
	Establish whether intervention is required		✓
	Identify geographic area where intervention is needed		✓
<i>Output</i>	Geographic delineation of areas of compliance		✓
	Geographic delineation of non-compliant areas		✓

**3.3.3 Step 3: Assist in devising Action Plans**

<i>Stage</i>	<b>Activity</b>	<b>Chapter 2 reference</b>	<b>Done</b>
<i>Input</i>	Compliance audit from step 3 above	2.6.3	✓
	National groundwater management objectives		✓
	National aquifer strategic goals		✓
<i>Methodology</i>	Assist in preparing intervention plans for non-compliant areas. These could include: <ul style="list-style-type: none"> <li>▪ Adjustment of licensing conditions</li> <li>▪ Cancellation of licences</li> <li>▪ Introduction of compulsory licences for impacted areas</li> <li>▪ Direct instructions to reduce groundwater abstraction where licences are not in place</li> <li>▪ Expansion of protection zones for springs, wetlands and recharge areas</li> <li>▪ Requirement for tightening/upgrading EMPs for impacting industry or mines</li> <li>▪ Upgrading of EIAs</li> <li>▪ Increased level of monitoring</li> <li>▪ Revision/review of land use planning authorisations</li> </ul>		✓
<i>Output</i>	Intervention recommendations		✓

**3.3.4 Step 4: Prepare Summary Document**

<i>Stage</i>	<b>Activity</b>	<b>Chapter 2 reference</b>	<b>Done</b>
<i>Input</i>	Monitoring reports	2.6.3	✓
	Management objectives		✓
	Intervention recommendations from Step 4		✓
<i>Methodology</i>	Compare performance against RQOs		✓
	Identify areas of compliance		✓
	Identify areas of non-compliance		✓
	Set performance goals for next reporting period		✓
	Determine strategies for long-term aquifer management		✓
<i>Output</i>	Strategic management report		✓
	Strategy for long-term sustainable use of the groundwater resources		✓
	Recommendations for intervention as per output from Step 4		✓
	Input to the assessment process		✓

**3.3.5 Step 5: Distribute the Summary Document**

<i>Stage</i>	<b>Activity</b>	<b>Chapter 2 reference</b>	<b>Done</b>
<i>Input</i>	Strategic assessment report	2.6.3	✓
	List of recipients		✓
<i>Methodology</i>	Confirm distribution lists		✓
	Advertise availability of report		✓
	Send to Minister		✓
	Distribute to CMA water managers		✓
	Distribute to stakeholders		✓
<i>Output</i>	Strategic aquifer management document which will include process and management procedures for sustainable management of groundwater resources		✓
	Updated monitoring report as part of the long-term sustainable national aquifer management programme		✓

### 3.4 Catchment Level Management

#### 3.4.1 Step 1: Prepare Strategies and Management Plans

<i>Stage</i>	<b>Activity</b>	<b>Chapter 2 reference</b>	<b>Done</b>
<i>Input</i>	Site-specific monitoring reports	2.6.4	✓
	Updated control mechanisms		✓
<i>Methodology</i>	Prepare/review/update aquifer strategic management plans. This will include: <ul style="list-style-type: none"> <li>▪ Water use authorising</li> <li>▪ Licensing</li> <li>▪ Comparison of use against availability</li> <li>▪ Resources identification/delineation of protection zones (springs, wetlands and recharge areas)</li> <li>▪ Setting monitoring frequency guidelines/targets</li> </ul>		✓
<i>Output</i>	Updated/revised aquifer management strategy		✓

### 3.4.2 Step 2: Monitoring and Data Management

<i>Stage</i>	<b>Activity</b>	<b>Chapter 2 reference</b>	<b>Done</b>
<i>Input</i>	Monitoring Programme from Catchment level planning report	2.6.4	✓
<i>Methodology</i>	Establish monitoring objectives		✓
	Establish monitoring frequency		✓
	Establish data to be collected: <ul style="list-style-type: none"> <li>▪ Water levels</li> <li>▪ Water abstraction</li> <li>▪ Water quality</li> <li>▪ Spring flow</li> <li>▪ Rainfall and climatic data</li> </ul>		✓
	Confirm protocols for recording data		✓
	Collect water level and abstraction data on standard data sheets		✓
	Confirm water quality parameters to be analysed; will be dependent upon sampling objectives: <ul style="list-style-type: none"> <li>▪ Potability</li> <li>▪ Pollution control</li> <li>▪ Ecological, etc</li> </ul>		✓
<i>Output</i>	Data sheets		✓
	Water quality analyses		✓

### 3.4.3 Step 3: Assessment of Water Use

<i>Stage</i>	<b>Activity</b>	<b>Chapter 2 reference</b>	<b>Done</b>
<i>Input</i>	Site-specific monitoring reports	2.6.4	✓
	Updated/revised aquifer management strategy		✓
<i>Methodology</i>	Compare site-specific monitoring data with site-specific and catchment level licensing conditions.		✓
	Identify areas of non-compliance with licensing conditions		✓
	Identify unlicensed water abstractors/water users		✓
<i>Output</i>	Identification of areas of compliance with aquifer management strategy		✓
	Identification of areas of non-compliance		✓
	Establishment of need for intervention		✓

**3.4.4 Step 4: Assess Aquifer Performance and Compliance**

<i>Stage</i>	<b>Activity</b>	<b>Chapter 2 reference</b>	<b>Done</b>
<i>Input</i>	Site-specific monitoring reports	2.6.4	✓
	Updated/revised aquifer management strategy		✓
<i>Methodology</i>	Compare site-specific monitoring data with site-specific and catchment level RQOs		✓
	Assess water abstraction, water level response and water quality trends		✓
	Determine aquifer behaviour		✓
<i>Output</i>	Aquifer behaviour		✓
	Establishment of need for intervention		✓

### 3.4.5 Step 5: Review Control and License Conditions

<i>Stage</i>	<b>Activity</b>	<b>Chapter 2 reference</b>	<b>Done</b>
<i>Input</i>	Site-specific monitoring reports	2.6.4	✓
	Identification of areas of compliance with aquifer management strategy		✓
	Identification of areas of non-compliance		✓
	Establishment of need for intervention		✓
<i>Methodology</i>	Review reports and assessment		✓
	Review control mechanisms and license conditions		✓
<i>Output</i>	Review report of control mechanisms and license conditions		✓

**3.4.6 Step 6: Revise Licensing Conditions and RQOs**

<i>Stage</i>	<b>Activity</b>	<b>Chapter 2 reference</b>	<b>Done</b>
<i>Input</i>	Review report of control mechanisms and license conditions	2.6.4	✓
	Aquifer behaviour		✓
	Establishment of need for intervention		✓
<i>Methodology</i>	Revise control mechanisms, based on the recommendations in the review report		✓
	Revise license conditions, based on the recommendations in the review report		✓
<i>Output</i>	Revised control mechanisms and licensing conditions		✓

### 3.4.7 Step 7: Design Remedial Actions

<i>Stage</i>	<b>Activity</b>	<b>Chapter 2 reference</b>	<b>Done</b>
<i>Input</i>	Identification of areas of non-compliance	2.6.4	✓
	Establishment of need for intervention		✓
<i>Methodology</i>	Assess cause of non-compliance in identified areas, for example: <ul style="list-style-type: none"> <li>▪ Declining water levels due to over-abstraction, unlicensed water use, drought</li> <li>▪ Deterioration of water quality due to poor management practices of waste dumps, tailings dams, land use</li> </ul>		✓
	Design intervention to deal with areas identified as non-compliant; these could include: <ul style="list-style-type: none"> <li>▪ Adjustment of licensing conditions</li> <li>▪ Cancellation of licences</li> <li>▪ Introduction of compulsory licences for impacted areas</li> <li>▪ Direct instructions to reduce groundwater abstraction where licences are not in place</li> <li>▪ Expansion of protection zones for springs, wetlands and recharge areas</li> <li>▪ Requirement for tightening/upgrading EMPs for impacting industry or mines</li> <li>▪ Upgrading of EIAs</li> <li>▪ Increased level of monitoring</li> <li>▪ Revision/review of land use planning authorisations</li> </ul>		✓
<i>Output</i>	Areas satisfying management strategies and goals. These may be identified as suitable for additional use		✓
	Intervention plans for remedial action in non-compliant areas		✓

**3.4.8 Step 8: Review and Confirm Remedial Actions**

<i>Stage</i>	<b>Activity</b>	<b>Chapter 2 reference</b>	<b>Done</b>
<i>Input</i>	Intervention plans for remedial action in non-compliant areas	2.6.4	✓
	Details of stakeholders		✓
<i>Methodology</i>	Convene focus group meetings/ workshops		✓
	Discuss monitoring reports and intervention recommendations		✓
	Obtain consensus on intervention		✓
	Prepare issues and comments report		✓
<i>Output</i>	Confirm recommendations of Step 3, updated as necessary to take into account views and response of stakeholders		✓
	Updated strategic management plan		✓

### 3.4.9 Step 9: Prepare Action Plans for Catchment Level Management

<i>Stage</i>	<b>Activity</b>	<b>Chapter 2 reference</b>	<b>Done</b>
<i>Input</i>	Updated strategic management plan developed in Steps 6 - 8	2.6.4	✓
	Confirmation of plan from consultation		✓
<i>Methodology</i>	Prepare detailed action plan for intervention, including:		✓
	▪ Construction methodology		✓
	▪ Key success factors		✓
	▪ Time-frames for implementation		✓
	▪ Monitoring criteria		✓
<i>Output</i>	Detailed actions plans		✓

**3.4.10 Step 10: Collate Information into Management Report**

<i>Stage</i>	<b>Activity</b>	<b>Chapter 2 reference</b>	<b>Done</b>
<i>Input</i>	Site-specific monitoring reports	2.6.4	✓
	Catchment level aquifer management strategy		✓
	Compliance assessments (Step 2)		✓
<i>Methodology</i>	Collate all data from the various monitoring reports		✓
	Prepare overall aquifer management report. This will include: <ul style="list-style-type: none"> <li>▪ Summary of the catchment management strategy and goals</li> <li>▪ Presentation of water level, water use and water quality trends, and comparison against RQOs</li> <li>▪ Details of new licences issued</li> <li>▪ Details/update of monitoring frequency for all users in the catchment</li> <li>▪ Recommendations for adjusting management objectives to ensure sustainability</li> </ul>		✓
<i>Output</i>	Management report for distribution to stakeholders and delivery to National Office.		✓

### 3.5 Site Specific Management

#### 3.5.1 Step 1: Set up WSDP, IDP, EMP

<i>Stage</i>	<b>Activity</b>	<b>Chapter 2 reference</b>	<b>Done</b>
<i>Input</i>	Current versions of the WSDP, IDP and EMP	2.6.5	✓
<i>Methodology</i>	Review the current versions of the WSDP, IDP and EMP		✓
	Update/amend the groundwater aspects of the WSDP, IDP and EMP documents.		✓
<i>Output</i>	Updated WSDP, IDP and EMP		✓

### 3.5.2 Step 2: Implement Water Supply Scheme or Remedial Action(s)

<i>Stage</i>	<b>Activity</b>	<b>Chapter 2 reference</b>	<b>Done</b>
<i>Input</i>	Agreed project plan	2.6.5	✓
	Water supply		✓
	Spring capture		✓
	Site-specific monitoring		✓
	Remediation plan (aquifer overexploitation, groundwater pollution, spring or wetland protection, etc)		✓
<i>Methodology</i>	Undertake required activities. These could include:		✓
	▪ Siting, drilling and testing of water supply boreholes (refer to procedures outlines in 4 & 5 of assessment)		✓
	▪ Position production boreholes away from existing boreholes, potential sources of pollution and area vulnerable to flooding		✓
	▪ Siting, drilling and testing of site-specific monitoring boreholes (refer to procedures outlines in 4 & 5 of assessment)		✓
	▪ Siting, drilling and testing of site-specific pollution control boreholes (refer to procedures outlines in 4 & 5 of assessment)		✓
<i>Output</i>	Project completion report		✓
	Monitoring plan		✓

**3.5.3 Step 3: Install/Update and Maintain Monitoring Network**

<i>Stage</i>	<b>Activity</b>	<b>Chapter 2 reference</b>	<b>Done</b>
<i>Input</i>	Agreed monitoring plan	2.6.5	✓
<i>Methodology</i>	Equipping of boreholes with: <ul style="list-style-type: none"> <li>▪ Production pumps, piezometer tubes and flow meters</li> <li>▪ Piezometer tubes</li> <li>▪ Automatic data loggers</li> </ul>		✓
	Construction of weirs or flow meters at springs		✓
	Prepare monitoring plans and administrative requirements		✓
<i>Output</i>	Ongoing monitoring programme		✓

### 3.5.4 Step 4: Operation and Maintenance of the System

<i>Stage</i>	<b>Activity</b>	<b>Chapter 2 reference</b>	<b>Done</b>
<i>Input</i>	Agreed Monitoring Programme	2.6.5	✓
<i>Methodology</i>	Assess current status of the monitoring network		✓
	Identify areas that require maintenance and upgrade		✓
	Develop annual maintenance plan		✓
<i>Output</i>	Annual maintenance plan		✓

### 3.5.5 Step 5: Data Management: Gather, Store and Assess the Monitoring Data

<i>Stage</i>	<b>Activity</b>	<b>Chapter 2 reference</b>	<b>Done</b>
<i>Input</i>	Monitoring programme	2.6.5	✓
<i>Methodology</i>	Establish monitoring objectives		✓
	Establish monitoring frequency		✓
	Establish data to be collected: <ul style="list-style-type: none"> <li>▪ Water levels</li> <li>▪ Water abstraction</li> <li>▪ Water quality</li> <li>▪ Spring flow</li> <li>▪ Rainfall and climatic data</li> </ul>		✓
	Confirm protocols for recording data		✓
	Collect water level and abstraction data on standard data sheets		✓
	Confirm water quality parameters to be analysed; will be dependent upon sampling objectives: <ul style="list-style-type: none"> <li>▪ Potability</li> <li>▪ Pollution control</li> <li>▪ Ecological, etc</li> </ul>		✓
<i>Output</i>	Data sheets		✓
	Water quality analyses		✓

**3.5.6 Step 6: Control of Water Use**

<i>Stage</i>	<b>Activity</b>	<b>Chapter 2 reference</b>	<b>Done</b>
<i>Input</i>	Agreed monitoring plan	2.6.5	✓
	Information on compliance assessment		✓
<i>Methodology</i>	Assess level of compliance of water use		✓
	Develop/revise control mechanisms for water use		✓
<i>Output</i>	Report on compliance assessment and control of water use		✓

**3.5.7 Step 7: Summarise Monitoring Data in a Site-Specific Reporting**

<i>Stage</i>	<b>Activity</b>	<b>Chapter 2 reference</b>	<b>Done</b>
<i>Input</i>	Water level, water abstraction and water quality monitoring data	2.6.5	✓
	Management objectives		✓
<i>Methodology</i>	Prepare monitoring report		✓
	Compare water level trends		✓
	Compare water quality trends		✓
	Assess need for intervention by comparison with management objectives		✓
<i>Output</i>	Monthly monitoring report for submission to CMA		✓

### **3.6 Managing ongoing Stakeholder Relationships**

This section provides detailed procedures to assist the Water Manager in managing ongoing stakeholder relations, particularly after the public participation process has come to an end.

Before considering the details of the procedure to manage ongoing stakeholder relations, it is important to understand the difference between “Company Public Relations” and “Public Participation” (Table 5) (*Greyling T and Pietersen T 2006. Guide to Public Participation in environmental authorisation: Theory and Practice. Golder Associates Africa, Midrand, South Africa*). It is also essential that there is synergy between communication aspects relating to the public participation process for a particular project and communication with external stakeholders by the Public Relations Division of the proponent.

Public participation never promotes the proposed project, but rather presents information relating to the project in an objective way, both negative and positive. Stakeholders will not trust the public participation practitioner to be independent and impartial if they perceive the project to be promoted in any way, nor will they want to share their views. It is essential that Water Managers understand this concept.

It would be fatal for the public participation office to issue a media release encouraging stakeholder comment while, at the same time, the Water Manager’s public relations (PR) division issues a media release boasting about the proposed project as if it were already approved by the authorities.

Experience and the results of public participation process assessments strongly recommend that the company develops, maintains and manages an ongoing stakeholder relationship programme. This will require dedicated staff to provide the wider audience in the project area with information on progress on a regular basis. This communication process will rely heavily on the application of public relations techniques.

However, it remains essential that the synergy is reinforced between communication aspects relating to the public participation process for the project and communication with external stakeholders by the Public Relations Division of the proponent.

The public participation and public relations practitioners should therefore coordinate their activities and act in mutual support of each other. Regular meetings of the project team and the client should take place throughout the duration of the project.

*Table 3.1: Differences between external company communication and public participation*

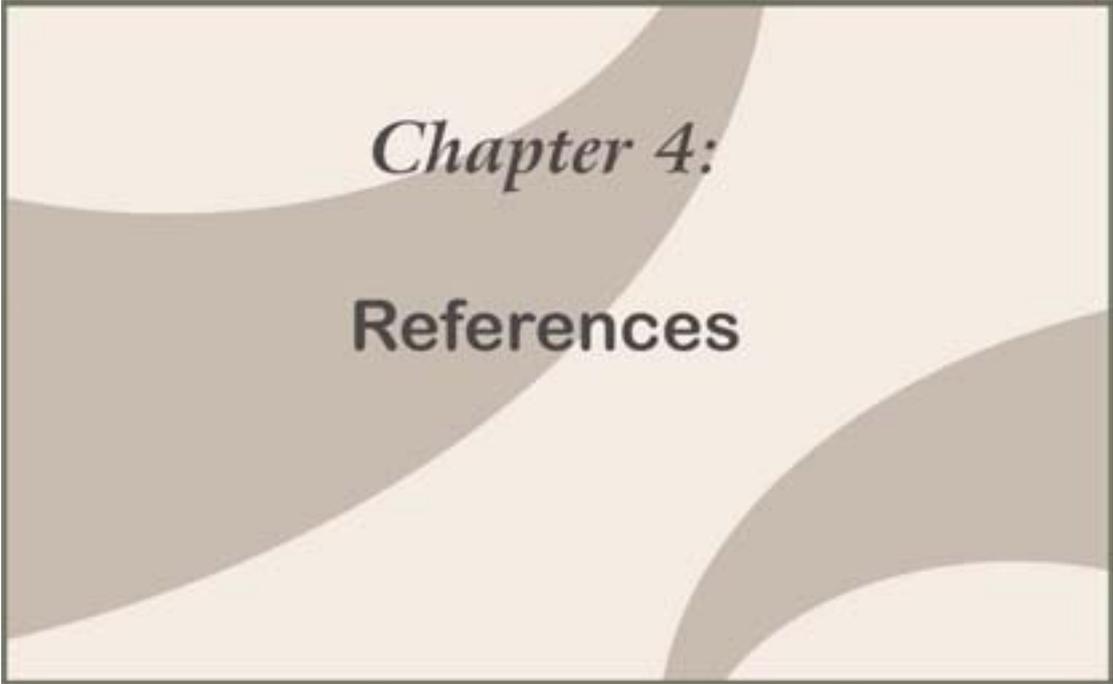
Company Communication (PR)	Public Participation
Conducted by company itself	Conducted by independent agency
Ongoing, for the life of the company	Finite with clear start and finish dates, usually around 6-12 months, depending on the project
All aspects of the company	Focussing on a particular project
Usually about existing activities/projects	Usually about a proposed project
Mainly promotional in nature, and awareness creation	Under no circumstances promotional, always by independent agencies (by law)
Aimed at information transfer and distribution of information	Aimed at receiving contributions
Aimed at changing attitudes and mindsets	Aimed at enabling contributions
Promotional material with corporate identity usually in colour, fairly costly to produce	Discussion documents with project identity, seldom in colour, photocopied

Table 3.2 provides detailed procedures to assist the Water Manager in managing ongoing stakeholder relations, particularly after the public participation process has come to an end.

*Table 3.2: Procedures to assist Water Managers in managing ongoing stakeholder relations*

Stage	Activity	Chapter 2 reference	Done
<i>Input</i>	Evaluation and Monitoring Report of the Public Participation Process	2.6	✓
	Compilation of a communication strategy to provide stakeholders with ongoing feedback on progress using the above report as main reference document		✓
<i>Methodology</i>	Assess the need for appointing a senior Public Relations Officer (PRO). If the company already has a PRO, it will not be necessary to appoint one		✓
	The PRO should evaluate the outcome of the Evaluation and Monitoring Report of the Public Participation Process		✓
	Prepare a situational analysis. Provide a brief outline of the current situation pertaining to communication needs, including key issues, challenges and sensitivities that will require communication		✓
	Develop a communication strategy that is aligned with the company's overarching communication protocols and existing policies and frameworks. Such a strategy should have the following components:		✓
	<ul style="list-style-type: none"> <li>▪ <b>Objectives:</b> The setting of broad objectives of the communication strategy, flowing from the situational analysis</li> </ul>		✓

<i>Stage</i>	<b>Activity</b>	<b>Chapter 2 reference</b>	<b>Done</b>
	<ul style="list-style-type: none"> <li>▪ <b>Target audiences:</b> Identify and list various target audiences, with specific objectives for communication with each target audience, including an internal (within the company) target audience. Information about the target audiences can be obtained from the public participation report</li> </ul>		✓
	<ul style="list-style-type: none"> <li>▪ <b>Key messages:</b> A short list of overarching messages should be developed to be conveyed to all target audiences, and where necessary, specific messages for specific target audiences</li> </ul>		✓
	<ul style="list-style-type: none"> <li>▪ <b>Channels/methods:</b> Establish communication channels (e.g. media (radio and newspapers), brochures, meetings, complaints register, hotline, information desk, etc) to reach different target audiences</li> </ul>		✓
	<ul style="list-style-type: none"> <li>▪ <b>Action plan:</b> Compile a broad outline of an action plan indicating who communicates what to which target audiences, how often and how.</li> </ul>		✓
	<ul style="list-style-type: none"> <li>▪ <b>Crisis communication plan:</b> A broad outline of a crisis communication plan should form part of the communication strategy (e.g. what should be done if sinkholes form in an active urban area)</li> </ul>		✓
	<ul style="list-style-type: none"> <li>▪ <b>Record-keeping, monitoring and evaluation:</b> Broad recommendations for record-keeping, monitoring and evaluation of the effectiveness of the communication strategy should be developed as part of the communication strategy</li> </ul>		✓
	<ul style="list-style-type: none"> <li>▪ <b>Budget:</b> The Communication Strategy should provide for budget estimates in broad terms for the first two years of plan implementation. This will assist water managers with overall planning and management</li> </ul>		✓
	When the Communication Plan is in place, the methods of communicating with the target audience for a specific area will fall into place. Similar techniques as those listed in Volume II, Section 2 can be used		✓
	Communication with the target audience should take place regularly, preferably once every two to three months, and can be linked to initiatives by the company (e.g. National Water Week; World Environment Day, etc)		✓
<i>Output</i>	Action plan of regular communication activities complete with actions, person(s) responsible and deadlines		✓
	Improved stakeholder relations		✓
	Trust and credibility for the company involved		✓



*Chapter 4:*

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*Appendix A1:*

**Model Technical  
Specifications for the  
Drilling of Boreholes**

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## APPENDIX A1. MODEL TECHNICAL SPECIFICATIONS FOR THE DRILLING OF BOREHOLES

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### **A1.1 Documents**

This Specification shall be read in conjunction with the Invitation of Tender, Conditions of Contract, the Bill of Estimated Quantities and Rates, and other relevant documents and the whole be deemed to constitute one document.

### **A1.2 Drawings**

The following drawings accompanying and referred to in these specifications shall consist of:

- (i) Locality Map (Fig. ....)
- (iii) Construction of boreholes - Open hole hard rock design (Drawing No. ....)
- (iii) Construction of boreholes - Slotted casing hard rock design (Drawing No. ....)
- (iv) Jetting tool (Drawing No. ....)
- (v) Typical slotted casing (Drawing No. ....)

### **A1.3 Locality**

The works are required in situated as illustrated on Locality Map (Fig. ....)

### **A1.4 Scope of Contract**

The Works comprise the construction of XX boreholes. The actual number of boreholes will be decided by the Client but no guarantee is given as to the actual number finally ordered. Additional boreholes could be required under the specifications contained herein, and if so will be paid at the rates tendered.

### **A1.5 Geological and Hydrogeological Data**

Hydrogeological data may be inspected at the offices of the Catchment Management Agency. The Contractor shall form his own assessment of the anticipated drilling conditions from the available data and no claims for misinterpretation will be entertained.

No claims for extra payment for such variations will be entertained nor do such variations relieve the Contractor from any responsibility hereunder nor from fulfilling any or all of the terms and requirements of this Contract.

**A1.6 Nature of Contract**

The specifications are for a Schedule of Quantities and Rates Contract for the drilling, construction and development of boreholes.

The Contractor shall provide all labour, transport, plant, tools, materials and appurtenances, and shall perform all work necessary to satisfactorily construct and complete the boreholes in accordance with this Specification. The borehole depths will be dependent on results and the strata intersected.

The Contractor shall employ only competent workmen for the execution of his/her work, and all work shall be performed under direct supervision of an experienced water well driller.

**A1.7 Contractor's Plant**

The Contractor shall specify in the Schedule of Plant and Equipment the type of plant to be used and the method of operation. Its capacity shall be sufficient to cope with the work within the contract time. It shall be kept at all times in full working order and good repair.

No extra payment shall be made for Contractor's plant, labour or equipment to complete the work specified, nor for any incidentals thereto, the cost being deemed to be included in the Contractor's prices.

It is noted that drilling rig(s) equipped for air percussion, including foam, is (are) required on site.

**A1.8 Assignment**

The Contractor may not assign this Contract not sub-let any part of this Contract or any of its obligations hereunder without the prior written consent of the Client.

**A1.9 Time Schedule**

The contractor shall position and start operation on site within 7 calendar days after written communication to proceed with the Works have been received from the Client.

**A1.10 Safety Standards**

The Contractor shall adhere to applicable safety regulations at all times.

**A1.11 Drilling Positions and Access**

The drilling positions will be marked on the ground and pointed out to the Contractor by the Client or his representative. Should access to site prove to be difficult the onus is on the Contractor to make a genuine attempt in reaching the site.

**A1.12 Material**

The used materials shall be new and undamaged. The materials used shall be paid for at the rates tendered by the Contractor in the Schedule of Quantities and Rates.

**A1.13 Casing****A1.13.1 Steel Casing - Plain**

The plain casing will be of an approved standard and shall be as specified in the Schedule of Estimated Quantities and Rates. All casing will have a minimum wall thickness of 4mm and shall be bevel edged with lugs or threaded to accomplish positive mechanical interlocking.

**A1.13.2 Steel or PVC Casing - Slotted**

Where collapsing conditions are present at the water bearing horizon, slotted steel or PVC casing shall be installed over the affected zone. The manner in which the slots are to be cut is shown in Drawing No: ..... The width of the slots shall be 3mm minimum and 4mm maximum. Wall thickness shall be 4mm minimum. The slots shall be of uniform width with no resultant protrusions and shall be clear of debris.

**A1.14 Equipment and Chemicals**

It will be the responsibility of the contractor to bring on site with all equipment and chemicals required to complete the Work without interruption.

**A1.15 Other Materials**

Casing clamps and all other such items as are required in the construction of the boreholes shall be constructed in accordance with normal groundwater engineering practice.

**A1.16 Formation Stabiliser**

Gravel pack material shall be well rounded, uniform and clean quartzitic gravel with a grain size varying between 6 and 10 mm. Sieved and washed river gravel can also be accepted. Samples of the gravel pack must be submitted to the Client approval before placement.

**A1.17 Borehole Construction****A1.17.1 Design and Depth**

Two separate designs, one requiring the installation of plain casings and the second requiring the installation of both plain and slotted casing and formation stabiliser may be used. Borehole designs are shown schematically on drawing Nos. ....and .....

The anticipated depth is unlikely to exceed .....m.

#### **A1.17.2 Diameter**

Drilling diameters may vary from 165mm to 420mm. Anticipated drilling diameters are those indicated on Drawing Nos. .... and .....

#### **A1.17.3 Drilling Technique(s)**

The drilling technique will be air percussion. Provision must be made for the use of foam, as required. A stabiliser of a minimum length of 6m must be used to ensure the straightness and verticality of the borehole. The stabiliser forms the first drilling rod and is attached immediately above the hammer.

#### **A1.17.4 Drilling Media**

The Contractor may not use drilling media which may cause hole erosion or involve the use of clay, oil, salt or any lost circulation agent, sawdust, cement, or any form of plugging that could affect the production capacity of the water bearing strata intersected or contaminate groundwater. The use of foam may be required. It will be the responsibility of the driller to use a foam mix compatible with and suitable for the geological conditions being experienced.

#### **A1.17.5 Sanitary Seal**

Each borehole shall be completed with 3m of cement grout extending from ground level to the top of the gravel pack.

The sanitary seal shall be mixed in the following ratio, 30 litres of water to 50kg cement.  
Concrete Slab

Each borehole shall, be completed with a concrete slab of dimensions 1m x 1m x 0,5m, sunk into the ground for 0,3m. The slab will be made of aggregate, river sand and cement in the ratio 3:2:1. The strength must be 20KPA minimum after 28 days.

#### **A1.17.6 Sampling**

Representative samples of the strata intersected shall be collected every one metre and at geological contacts. The Contractor will take every possible precaution to guard against sample contamination due to poor circulation, hole erosion, or caving.

**A1.18 Drilling and Construction of Boreholes**

The drilling shall be carried out with the least possible delay in order to run the casing as required, and to remove any drilling fluid from the borehole in the shortest possible time.

All boreholes shall be presented for testing free of all bridging and obstructions to bottom. Any time spent in conditioning holes or removing obstructions shall be at the contractor's expense.

**A1.19 Straightness and Verticality**

All boreholes shall be drilled and cased straight and vertical and all casings liners shall be set round, plumb and true to line. The Client shall have the right to reject any or all casing which fails to meet the requirements of this Specification, and the casing rejected will be replaced at the Contractor's expense.

Any delays encountered in running casing considered to be due to poor hole alignment, shall be at the Contractor's expense.

To demonstrate the compliance of his work with this requirement the Contractor, when called upon to do so, shall furnish all labour, tools and equipment and shall make the tests described herein in the manner prescribed by, and to the satisfaction of the Client. Tests for plumbness and alignment will be made after the complete construction of the borehole before its acceptance.

Plumbness and alignment shall be tested by lowering into the borehole to a depth as directed by the Client, a section of pipe 12m long. The outer diameter of the plumb shall not be greater than 15mm smaller than the diameter of the cased/screened hole to be tested. Should the plumb fail to move freely throughout the length of the casing to the required depth, or should the well vary from the vertical in excess of two-thirds of the smallest inside diameter of that part of the borehole being tested per 30m of depth, or beyond limitations of this test, the plumbness and diameter of the well shall be corrected by the contractor at his own expense. Should the contractor fail to correct such faulty straightness or plumbness, the Client may refuse to accept the borehole and no payment of the work and materials shall be made.

**A1.20 Protection**

During the contract period when work is not in progress, the boreholes shall be kept capped in such a manner as to prevent the entrance of foreign material. The Contractor shall remove any foreign matter at his own expense. On completion of each borehole, the Contractor shall supply and fit an approved permanent cap as per drawing No. ....

**A1.21 Expertise**

The Contractor under this Contract is considered to be an expert water well driller and is expected to organise and carry out the work specified hereunder in an expert manner. Drilling problems encountered will be overcome entirely within the framework of this Specification and Schedule of Estimated Quantities and rates, and no claim for extra payments will be entertained for problems foreshadowed in the Specification or due to limitations placed by this Specification.

**A1.22 Abandonment**

The Client shall have the right at any time during the progress of the work to order the abandonment of the borehole. The Contractor thereupon shall remove the plant, withdraw the casing, if applicable, and salvage or attempt to salvage all such materials as the Client shall direct and/or up until the Client revokes such direction, and shall fill or leave the borehole to the satisfaction of the Client.

Payment shall be made for such abandoned borehole at the appropriate rates as detailed in the Schedule Estimated Quantities and Rates.

**A1.23 Lost Borehole**

Should accident to the plant, behaviour of the ground, jamming of the tools or casing, or any other cause, prevent the satisfactory completion of the works, the borehole shall be deemed to be lost and no payment shall be made for the drilling costs nor for any materials not recovered in good order therefrom, nor for any time.

In the event of a lost borehole, the Contractor shall construct a new borehole adjacent to the lost borehole, on a site indicated by the Client. The option of declaring any borehole lost shall rest with the Contractor, subject to directions from the Client.

**A1.24 Development**

On completion the borehole shall be developed to a maximum yield of water, free of suspended materials. Development will be carried out using air lift pumping, jetting and block surging, or such other standard techniques as may be directed by the Client. The standard jetting tool is shown on Drawing No. ....

Development will be continued for the period directed by the Client.

**A1.25 Disinfection**

On completion of development the screen area will be disinfected by pumping a solution of 5 kg of HTH in 200 litres of water through the jetting tool.

**A1.26 Reports**

At the end of the Works, the Contractor shall provide all information necessary to complete the data form.

## **A1.27 Allowable Payment**

### **A1.27.1 Establishment and Subsequent Removal Thereof**

This is payment to cover the establishment of all the required drilling equipment, personnel, camping and general equipment necessary to carry out and complete the Works described in this specification and any extensions, and to cover the removal of all plant, equipment and personnel permanently from the project and the restoration of the sites to a level and reasonably tidy stage. This rate can be either a lump sum or a Km rate.

### **A1.27.2 Drilling**

The rates for drilling are based on diameter and are to cover all the costs involved in drilling, including mud and foam mixing, injection mixers, bit sharpening, conditioning of the drilling mud for logging, tripping in and out of hole and all other such works as are associated with the drilling, and are not covered under other allowable payments.

### **A1.27.3 Supply and Delivery of Materials on Site**

The rates for materials are to cover purchase cost, transport and safe storage on site of all materials required for drilling, construction, development and use in the boreholes, ref. to letter of invitation. Payment will be made only for materials used and shall be calculated for each completed hole. No claim for extra payment will be entertained by reason of remoteness, wharfage, insurance etc. or by reason of omission in calculating the quoted rate. No payment will be made for those materials which may be provided by the Client.

### **A1.27.4 Standby Time**

This time rate, which is provisional and estimated in the Bill of Quantities, is to cover only those items when the rig and crew are idle waiting for decisions by the Client, where those decisions or whose presence is required before further work is possible. Under no circumstances will standby be payable for any other delays or hold ups other than those incurred by the Client's decision.

### **A1.27.5 Development Time**

The borehole development time rate is to cover all the time effectively spent on borehole development, except where included under other time rates. Contractors will note that time rates do not allow for building standard development tools on site.

### **A1.27.6 Work Time**

The work time rate which is provisional and estimated in the Bill of Quantities, is to cover time spent where the rig is held up waiting for on site manufacture of special non-standard tools as requested, or any other directive by the Client for non-standard work which requires the use of

the rig and is not included in the Specification or covered under any other rate. It does not include mud mixing time or fishing time.

#### **A1.27.7 Casing Installation**

This rate covers the installation of permanent casing into production or abandoned boreholes and the pulling of temporary casing and casing from abandoned boreholes. It does not cover the running and pulling of casing in boreholes declared lost or in which the casing cannot be set in position due to misalignment or other operational problems.

#### **A1.27.8 Moving between Borehole Sites**

This item is to cover the movement of the rig and ancillary equipment from one borehole site to the next. Payment may be claimed per site move after the initial site establishment to the first borehole.

#### **A1.27.9 Payments**

All payments will be made on the basis of measured quantities only.

#### **A1.28 Supervision of Works**

The Contractor shall have a senior tool pusher on site at all times to manage and organise the contract and to liaise with the Client.

#### **A1.29 Site Clearing**

The Contractor is responsible to clean and restore the site as far as possible to the natural state by:-levelling drilling cuttings; cleaning up rubbish, waste materials, debris and oil spills.

*Appendix A2:*

**Model Technical  
Specifications for the  
Pumping Tests of Boreholes**

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## APPENDIX A2. MODEL TECHNICAL SPECIFICATIONS FOR THE PUMPING TESTS OF BOREHOLES

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### ***A2.1 Documents***

This Specification shall be read in conjunction with the Invitation of Tender, Conditions of Contract, Bill of Quantities and Rates, and other relevant documents and the whole be deemed to constitute one document.

### ***A2.2 Drawings***

The following drawings accompanying and referred to in these Specifications shall consist of:

- (i) General Locality Map. (Fig. ....).

### ***A2.3 Locality***

The works are required in ....., situated ..... as illustrated on the Locality Map (Fig. ....).

### ***A2.4 Nature of Contract***

The Contractor shall provide all labour, transport, plant, tools, materials and appurtenances, and shall perform all work necessary to satisfactorily pump test the boreholes in accordance with this Specification and shall employ only competent workmen for the execution of his work.

### ***A2.5 Contractor's Plant***

The Contractor shall specify in the Schedule of Plant and Equipment and type of plant to be used and the method of operation. Its capacity shall be sufficient to cope with the work within the Contract time. It shall be kept at all times in full working order and good repair.

### ***A2.6 Assignment***

The Contractor may not assign this Contract nor sub-let any part of this Contract or any of its obligations hereunder without the prior written consent of the Client.

**A2.7 Access**

Should access to site prove to be difficult the onus is on the Contractor to make a genuine attempt in reaching the site. In the event that after the attempted access is not forthcoming, the Contractor will have the right to charge standby time.

**A2.8 Expertise**

The Contractor under this Contract is considered to be an expert pumping test contractor and is expected to organise and carry out the work specified hereunder in an expert manner. Testing problems encountered will be overcome entirely within the framework of this specification and Bill of Quantities and Rates, and no claim for extra payments will be entertained for problems foreshadowed in the Specification or due to limitations placed by this Specification.

**A2.9 Cessation of Testing Activities**

The termination, at any stage, of testing operations on a particular borehole shall rest with the Client.

**A2.10 Supervision of Works**

The Contractor shall have a senior pumping test technician on site at all times to manage and organise the Contract and to liaise with the Client or his representative.

**A2.11 Safety Standards**

The Contractor shall adhere to applicable laws and regulations relating to safety at all times.

**A2.12 Pumping Tests**

The services to be rendered are the execution of:  
Step drawdown test(s), followed by  
Constant discharge test(s).

It is expected that (state duration) constant discharge tests and step tests will be required on approximately *X* boreholes to be tested. However, should additional hours be required, or additional boreholes be required to be tested, the Contractor will undertake to do this at the rate quoted in the Bill of Quantities and Rates.

### **A2.13 Equipment Required**

The Contractor shall provide all labour, plant, tools and materials and shall perform all work to carry out the pumping tests referred to in Clause 12 above. An arc welding machine and oxy-acetylene torch must be available on site at all times.

#### **A2.13.1 Pump Equipment**

The pumps shall be positive displacement pumps capable of producing variable yields between X l/s to XX l/s at a XXm head. Power will be provided to the pump head via a motor fitted with a gearbox and clutch that can be throttled back without over loading. .... (Insert number) pump units are required on site. The pump units must be able to maintain a constant discharge throughout the test period. Under no circumstances shall electrical submersible, air lift or bailing techniques be acceptable.

#### **A2.13.2 Depth of Pump Installation**

This is likely to be between .....m and .....m.

##### **Discharge Rate Control**

Control of the discharge will be provided by direct measurement into a tank of known capacity, supplied by the Contractor and shall form part of his standard equipment under this Contract. The discharge rates are to be quantified using the appropriate table as detailed in the operational guidelines.

### **A2.14 Discharge Outlet**

The discharge pipeline shall release water at least 100m from the borehole in a down gradient direction. The precise distance will be determined by the Client.

### **A2.15 Measurement of Water Level**

These will be carried out by the Contractor at regular intervals as per the model data sheets.

Measurement of the water level drawdown will be taken using an electrical dip meter inserted inside a 20mm diameter stilling piezometer tube. The piezometer tube will be inserted with the pump test to a similar depth as the pump inlet. The conduit shall be plugged at the bottom and shall have 10mm slots cut every 25mm over the bottom 3m.

The Contractor shall provide at least 2 water level measuring devices capable of measurements to  $\pm 10$ mm accuracy and in proper working order. These water measuring devices shall be electrically operated. Air line measuring devices will not be permitted.

### **A2.16 Step Drawdown Test**

This test will be carried out on each borehole prior to the commencement of the constant discharge test.

The test shall comprise a minimum of four discharge rates, with each rate being greater than the previous rate. Each discharge shall be pumped for 60 minutes or as directed by the Client, and the increased rate will be commenced immediately after the previous discharge has been pumped for the specified time.

The discharge rates will be based on blowing yield and are likely to be between X l/s and XX l/s. Water drawdown measurements during the test shall be taken on the borehole. When these tests are completed, a minimum period of 2 hours will elapse before the start of the constant discharge test to allow recovery of the water level.

The test shall be continuous, and the Contractor will be responsible for labour, for maintaining each discharge rate constant, for increasing the discharge rate at the specified time, and for recording drawdown levels in the borehole. Interruptions exceeding 5% of the total pumping time will not be allowed. Should interruptions exceed the above limit, the test will be restarted, after allowing for water level recovery, at the expense of the Contractor.

### **A2.17 Constant Discharge Test**

The constant discharge test will follow the step drawdown test.

T

he pumping tests shall have a continuous and constant yield and the Contractor shall be responsible for providing labour for maintaining the yield constant and recording drawdown levels in the pumping borehole and any observation boreholes. Interruptions exceeding 5% of the total pumping time will not be allowed. Should the interruptions exceed the above limit the test will be restarted, after allowing for water level recovery, at the expense of the Contractor.

The test(s) will last for a period of .....hours to .....hours, unless pump suction is reached, followed by a minimum of ..... hours of recovery. In the event that the water level is drawn down to pump suction, the pump will be stopped and recovery will commence immediately.

### **A2.18 Disinfection of Boreholes**

On completion of the test and after removal of the pumping test equipment the borehole shall be disinfected with a solution of 0.5 kg of **HTH** mixed into 200 litres of clean water and this shall be poured into the borehole.

## **A2.19 Allowable Payments**

### **A2.19.1 Site Establishment**

This is a payment to cover the establishment of all the required pump testing equipment, personnel, camping and general equipment necessary to carry out and complete the Works described in this specification and any extensions, and to cover the removal of all plant, equipment and personnel permanently from the project and the restoration of the sites to a reasonably tidy state. This rate can be either a lumpsum or a Km rate.

### **A2.19.2 Movement between Borehole Sites**

This is charged as a lump sum or rate per kilometre to cover movement from the one borehole to the next.

### **A2.19.3 Installation and Removal of Pumping Test Unit**

This payment shall cover the installation and removal of the pump testing equipment per borehole tested. The installation depths are likely to be between XX and XXm.

### **A2.19.4 Pumping Tests**

The tendered rate shall be deemed to compensate all the time spent on pumping (measurements of drawdown) and PAYMENT WILL BE MADE ONLY FOR THE DURATION OF A COMPLETE AND UNINTERRUPTED PUMPING PHASE, PLUS ANY UNINTERRUPTED STEP DRAWDOWN TEST.

Any time spent on a test which is interrupted through break down or other operational problems will be at the Contractor's expense.

### **A2.19.5 Recovery of Measurements**

The recovery measurement time shall cover all time spent by the Contractor measuring borehole recovery while the pump is still in the borehole as well as from adjacent monitoring/observation boreholes, if present.

### **A2.19.6 Standby Time**

*This rate, which is provisional, is to cover only those items when the Contractor's crew are waiting for decisions by the Client, where those decisions or whose presence is required before the commencement of testing operations or for the continuation of the Work. Under no*

*circumstances will Standby Time be payable for any other delays other than those incurred by the Client's decisions.*

### **A2.20 Water Samples**

A two litre or a volume water sample specified by the Client for full chemical analyses shall be collected at the end of the constant discharge test. The samples will be collected with the correct equipment and stored in a suitable container.

### **A2.21 Capping of Boreholes**

After completion of the pumping test operations, the boreholes are to be closed with a welded plate 4mm thick or a cap secured with a bolt and double lock nuts.

### **A2.22 Finishing and Cleaning up of Site**

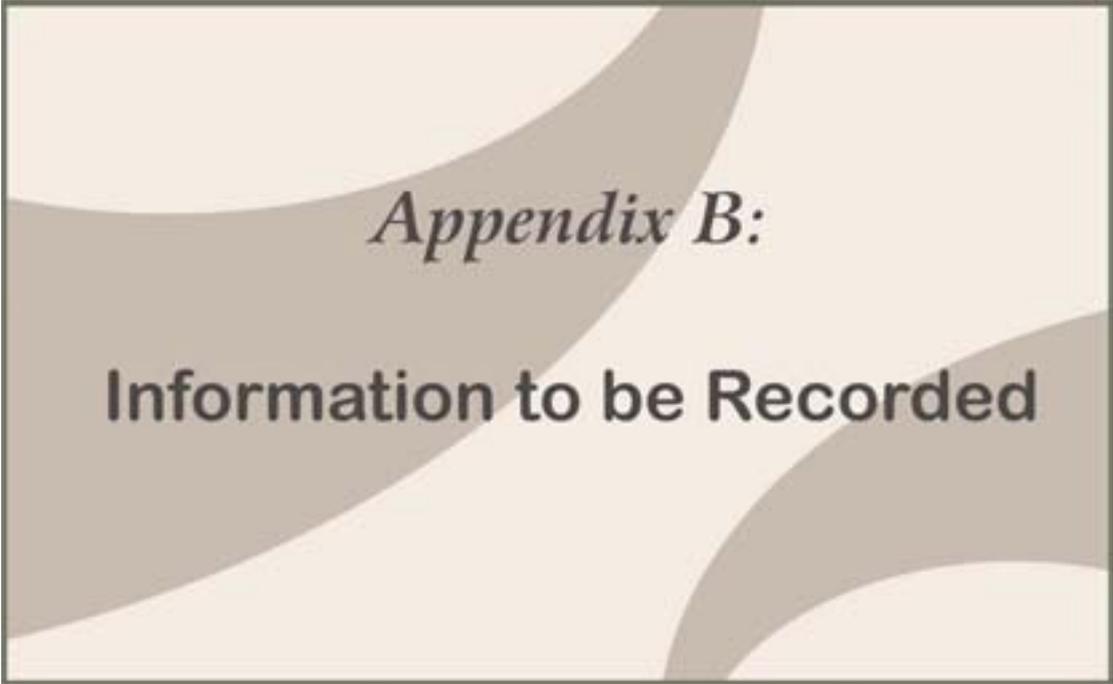
On completion of the pumping test all the debris of construction, such as unsuitable or rejected materials, spillage and cuttings shall be removed. The site of the work shall be cleaned of all rubbish, excess materials, false works, temporary structural installations and abandoned equipment. All resulting construction scars from these Works shall be treated to blend with the contour and vegetation of the surroundings.

### **A2.23 Forms**

At the end of the Works, the Contractor shall provide all information necessary to complete the required data forms.

**EXAMPLE OF SCHEDULE OF ESTIMATED QUANTITIES AND RATES FOR THE DRILLING OF BOREHOLES**

ITEM	DESCRIPTION	UNIT	QTY	RATE	TOTAL
	NOTE: All materials specified here to be purchased by the contractor. The estimated quantities refer to the construction of X boreholes.				
1.	Establishment to and removal from site of all plant (one drilling machine equipped air Percussion drilling) and ancillary equipment.	LUMP	SUM		
2.	Moving from site to site	No			
3.	Drilling Air Percussion Drilling include drilling foam				
3.1.	Drilling of 420mm diameter				
3.2.	Drilling of 355mm diameter				
3.3.	Drilling of 254mm diameter	m			
3.4.	Drilling of 203mm diameter	m			
3.5.	Drilling of 165mm diameter	m			
4.	Casing Supply and delivery of plain threaded/ bevel ended steel casing wall thickness minimum 4mm				
4.1	355mm ID				
4.2	254mm ID				
4.3	203mm ID	m			
4.4.	165mm ID	m			
	Supply and delivery of slotted threaded/ bevel ended steel casing wall thickness minimum 4mm				
4.5	355mm ID				
4.6	254mm ID				
4.7	203mm ID				
4.8	165mm ID				
5.	Installation				
5.1.	Installation of ..... m ID casing.	m			
5.2.	Installation of ..... m ID casing Materials and Services	m			
6	Supply and insertion of gravel pack	m			
7.	Sanitary seal	m			
8.	Cap and concrete block	No.			
9.	Disinfection	No.			
10.	Work Time	hr	Prov.		
11.	Standby Time	hr	Prov.		
12.	Development Time	hr			
	AMOUNT CARRIED FORWARD TO FORM OF TENDER				R

The title is centered within a rectangular frame. The background of the frame consists of several overlapping, curved shapes in two shades of beige and tan, creating a layered, abstract effect.

*Appendix B:*

**Information to be Recorded**

# CONTENTS

APPENDIX B. INFORMATION TO BE RECORDED \_\_\_\_\_ 1

## APPENDIX B. INFORMATION TO BE RECORDED

### NGA GROUNDWATER HYDROCENSUS FORM

All colored fields are mandatory.

\* Notes and/or Tips are indicated with an asterisk (\*).

Owner Information	
1	Ownership Date (ccyy-mm-dd)
2	Owner Surname
3	Owner Initials
<b>Home Address</b>	
4	Address Location <input type="checkbox"/> Home
5	Address Type <input type="checkbox"/> Postal <input type="checkbox"/> Physical
6	Address Text
7	Suburb
8	Town/City
9	Postal Code
<b>Business Address</b>	
10	Address Location <input type="checkbox"/> Business
11	Address Type <input type="checkbox"/> Postal <input type="checkbox"/> Physical
12	Building Name
13	Office Number
14	Street Name and Number
15	Suburb
16	Town/City
17	Postal Code
18	Telephone Number Location <input type="checkbox"/> Business <input type="checkbox"/> Home
19	Telephone Number Type <input type="checkbox"/> Switchboard <input type="checkbox"/> Fax <input type="checkbox"/> Cellular <input type="checkbox"/> Land Line
20	Dialling code
21	Telephone Number
22	Extension

Geosite		
1	Geohydrology Office	<input type="checkbox"/> Geo, Water Affairs - Eastern Cape <input type="checkbox"/> Geo, Water Affairs - Free State <input type="checkbox"/> Geo, Water Affairs - Gauteng <input type="checkbox"/> Geo, Water Affairs - Kwazulu Natal <input type="checkbox"/> Geo, Water Affairs - Limpopo <input type="checkbox"/> Geo, Water Affairs - Mpumalanga <input type="checkbox"/> Geo, Water Affairs - Northern Cape <input type="checkbox"/> Geo, Water Affairs - North West <input type="checkbox"/> Geo, Water Affairs - Pretoria <input type="checkbox"/> Geo, Water Affairs - Western Cape
2	Identifier	
3	Reporting Institution	
4	Geosite Type	<input type="checkbox"/> Borehole <input type="checkbox"/> Drain <input type="checkbox"/> Dug Well <input type="checkbox"/> Lateral / Radial Arm Collector <input type="checkbox"/> Mine <input type="checkbox"/> Prospective Borehole Site <input type="checkbox"/> Seepage Pond <input type="checkbox"/> Sinkhole <input type="checkbox"/> Spring <input type="checkbox"/> Tunnel <input type="checkbox"/> Well Point
5	Geosite Status	<input type="checkbox"/> Abandoned <input type="checkbox"/> Destroyed <input type="checkbox"/> Dry <input type="checkbox"/> In Use <input type="checkbox"/> Inaccessible <input type="checkbox"/> Not Drilled <input type="checkbox"/> Standby (Production)
6	Date when Status Observed (ccyy-mm-dd)	
7	Map Number	
8	Reference Datum	<input type="checkbox"/> Cape Datum <input type="checkbox"/> Hartbeeshoek Datum (WGS 84)
9	Latitude (DDMMSS / DD.ddddd )	
10	Longitude (DDMMSS / DD.ddddd )	
11	Coordinate Method	<input type="checkbox"/> Differential GPS with Base Station (GB1) <input type="checkbox"/> Differential GPS without Base Station (GB) <input type="checkbox"/> Global Positioning System (Hand - Held) <input type="checkbox"/> Surveyed
12	Coordinate GPS Accuracy (m) Estimated Position Error (EPE)	
13	Elevation (mamsl)	
14	Elevation Method	<input type="checkbox"/> Altimeter <input type="checkbox"/> Differential GPS with Base Station (GB1) <input type="checkbox"/> Differential GPS without Base Station (GB) <input type="checkbox"/> Global Positioning System (Hand - Held) <input type="checkbox"/> Levelled or Surveyed
15	Elevation GPS Accuracy (m) Estimated Position Error (EPE)	
16	Location Name	
17	Location Number	
18	Province	<input type="checkbox"/> Eastern Cape <input type="checkbox"/> Free State <input type="checkbox"/> Gauteng <input type="checkbox"/> Kwazulu Natal <input type="checkbox"/> Limpopo <input type="checkbox"/> Mpumalanga <input type="checkbox"/> North West <input type="checkbox"/> Northern Cape <input type="checkbox"/> Western Cape
19	Registration District	
20	Quaternary Drainage Region	
21	Water Management Area	<input type="checkbox"/> Berg <input type="checkbox"/> Breede <input type="checkbox"/> Crocodile (West) and Marico <input type="checkbox"/> Fish to Tsitsikamma <input type="checkbox"/> Gouritz <input type="checkbox"/> Inkomati <input type="checkbox"/> Limpopo <input type="checkbox"/> Lower Orange <input type="checkbox"/> Lower Vaal <input type="checkbox"/> Luxubu and Letaba <input type="checkbox"/> Middle Vaal <input type="checkbox"/> Mvoti to Umzimkulu <input type="checkbox"/> Mzimvubu to Keiskamma <input type="checkbox"/> Olifants <input type="checkbox"/> Olifants / Doorn <input type="checkbox"/> Thukela <input type="checkbox"/> Upper Orange <input type="checkbox"/> Upper Vaal <input type="checkbox"/> Usutu to Mhlatuze
22	Geomorphology	<input type="checkbox"/> Alluvial Fan <input type="checkbox"/> Flat / Gently Undulating Surface <input type="checkbox"/> Hill / Mountain Top <input type="checkbox"/> Low Gradient Hill Slope <input type="checkbox"/> Near Sinkhole <input type="checkbox"/> Raised Terrace <input type="checkbox"/> Riparian Zone <input type="checkbox"/> Steep Mountain Slope <input type="checkbox"/> Unvegetated Shifting Dunes <input type="checkbox"/> Valley Floor <input type="checkbox"/> Vegetated Dunes <input type="checkbox"/> Water Body (Wetlands, Pan, River, Spring)
23	Land cover	<input type="checkbox"/> Barren Rock <input type="checkbox"/> Cultivated: Commercial Dryland <input type="checkbox"/> Cultivated: Permanent - Commercial Irrigated <input type="checkbox"/> Cultivated: Permanent - Commercial Sugarcane <input type="checkbox"/> Cultivated: Temporary - Commercial Irrigated <input type="checkbox"/> Cultivated: Temporary - Commercial Dryland <input type="checkbox"/> Cultivated: Temporary Semi-Commercial / Subsistence Dryland <input type="checkbox"/> Degraded: Forest and Woodland <input type="checkbox"/> Degraded: Grassland <input type="checkbox"/> Degraded: Hermland <input type="checkbox"/> Degraded: Shrubland and Low Fynbos <input type="checkbox"/> Degraded: Thicket and Bushland (etc.) <input type="checkbox"/> Dongas and Sheet Erosion Scars <input type="checkbox"/> Forest plantations (Indicate Eucalyptus) <input type="checkbox"/> Forest plantations (Indicate Pine) <input type="checkbox"/> Forest plantations (Indicate Wattle) <input type="checkbox"/> Grassland <input type="checkbox"/> Hermland <input type="checkbox"/> Mines and Quarries <input type="checkbox"/> Natural Forest <input type="checkbox"/> Natural Forest and Woodland <input type="checkbox"/> Shrubland and Low Fynbos <input type="checkbox"/> Thicket and Bushland (etc.) <input type="checkbox"/> Urban / Built-Up Land: Industrial / Transport <input type="checkbox"/> Urban / Built-Up Land: Residential <input type="checkbox"/> Urban / Built-Up Land: Residential (Small Holdings: Bushland) <input type="checkbox"/> Urban / Built-Up Land: Residential (Small Holdings: Grassland) <input type="checkbox"/> Urban / Built-Up Land: Residential (Small Holdings: Shrubland) <input type="checkbox"/> Urban / Built-Up Land: Residential (Small Holdings: Woodland) <input type="checkbox"/> Urban / Built-Up: Commercial
24	Taste of Water	<input type="checkbox"/> Brack <input type="checkbox"/> Fresh <input type="checkbox"/> Salty
25	DWAF Geosite Purpose	<input type="checkbox"/> Dewatering <input type="checkbox"/> Drainage <input type="checkbox"/> Exploration <input type="checkbox"/> Observation <input type="checkbox"/> Production <input type="checkbox"/> Recharge <input type="checkbox"/> Standby <input type="checkbox"/> Waste Disposal
26	Observed / Actual Water Use	<input type="checkbox"/> Agriculture <input type="checkbox"/> Bulk Water Supply <input type="checkbox"/> Commercial <input type="checkbox"/> Domestic <input type="checkbox"/> Gardening <input type="checkbox"/> Industrial <input type="checkbox"/> Irrigation <input type="checkbox"/> Mining <input type="checkbox"/> Nature Conservation <input type="checkbox"/> Power Generation <input type="checkbox"/> Public <input type="checkbox"/> Stock Watering

Other Number Information				
1	Other Number Type, Number and Assignor	Other Number Type	Number	Assignor
		<input type="checkbox"/> Aquabase Number		
		<input type="checkbox"/> Borehole Number (* BHNO)		
		<input type="checkbox"/> Boring Branch Number (* BBNO)		
		<input type="checkbox"/> DWAF Number		
		<input type="checkbox"/> G Number		
		<input type="checkbox"/> Hydrocom Number (* HYDR)		
		<input type="checkbox"/> Hydrological Station Number (* HSTA)		
		<input type="checkbox"/> Monitoring Feature ID (* MFID)		
		<input type="checkbox"/> Old Hydrological Station Number (* OHST)		
		<input type="checkbox"/> Open-NGDB Number (* SITE ID)		
		<input type="checkbox"/> Regional Borehole Number (* RBHN)		
		<input type="checkbox"/> T Number		
		<input type="checkbox"/> W Number		
		<input type="checkbox"/> Water Level Monitoring Point (* WLMP)		
		<input type="checkbox"/> ZQC QUAL Number		
		<input type="checkbox"/> ZQM QUAL Number		

Reference Information	
1	Reference Type <input type="checkbox"/> NGA Groundwater Hydrocensus Form <input type="checkbox"/> Consultants Report
2	Report Number
2	Report Date
3	Report Name
4	Location <input type="checkbox"/> Geo, Water Affairs - Eastern Cape <input type="checkbox"/> Geo, Water Affairs - Mpumalanga <input type="checkbox"/> Geo, Water Affairs - Free State <input type="checkbox"/> Geo, Water Affairs - Northern Cape <input type="checkbox"/> Geo, Water Affairs - Gauteng <input type="checkbox"/> Geo, Water Affairs - North West <input type="checkbox"/> Geo, Water Affairs - Kwazulu Natal <input type="checkbox"/> Geo, Water Affairs - Pretoria <input type="checkbox"/> Geo, Water Affairs - Limpopo <input type="checkbox"/> Geo, Water Affairs - Western Cape

Drilling Completion and Relevant Information	
1	Construction Cost (Rand)
2	Drilling Method <input type="checkbox"/> Cable-Tool <input type="checkbox"/> Hand Dug <input type="checkbox"/> Core Drilling <input type="checkbox"/> Hydraulic Rotary <input type="checkbox"/> Direct Circulation (Mud Rotary) <input type="checkbox"/> Jetting: Percussion Drilling <input type="checkbox"/> Driven Well <input type="checkbox"/> Jetting: Well Point <input type="checkbox"/> Earth Augers: Bucket <input type="checkbox"/> Reverse Circulation (Mud Rotary) <input type="checkbox"/> Earth Augers: Hollow-Stem <input type="checkbox"/> Rotary Air Percussion <input type="checkbox"/> Earth Augers: Solid Stem <input type="checkbox"/> Tube Well
3	Drilling Company
4	Drilling Contractor
5	Drilling Fluid <input type="checkbox"/> Air <input type="checkbox"/> Water <input type="checkbox"/> Air With Additives <input type="checkbox"/> Water With Additives
6	Water Additives <input type="checkbox"/> Clay <input type="checkbox"/> Polymers
7	Air Additives <input type="checkbox"/> Clay <input type="checkbox"/> Surfactant <input type="checkbox"/> Polymers <input type="checkbox"/> Water
8	Additional Additives
9	Drilling Completion Date (ccyy-mm-dd)

Geosite Depth and Diameter Information					
		1	2	3	4
1	Date Measured (ccyy-mm-dd / ccyy-mm / ccyy)				
2	Depth to Bottom (m)				
3	Depth Qualifier	<input type="checkbox"/> Blocked <input type="checkbox"/> Collapsed <input type="checkbox"/> Construction		<input type="checkbox"/> Deepened <input type="checkbox"/> Measured <input type="checkbox"/> Reamed	
4	Diameter (mm)	<input type="checkbox"/> 127 ( 5" ) <input type="checkbox"/> 140 ( 5.5" )	<input type="checkbox"/> 152 ( 6" ) <input type="checkbox"/> 165 ( 6.5" )	<input type="checkbox"/> 203 ( 8" ) <input type="checkbox"/> 216 ( 8.5" )	<input type="checkbox"/> 254 ( 10" ) <input type="checkbox"/> 305 ( 12" ) <input type="checkbox"/> 445 ( 17.5" )
5	Data Source	<input type="checkbox"/> Downhole Geophysical Logging <input type="checkbox"/> Driller's Log <input type="checkbox"/> Check by Reporting Institution <input type="checkbox"/> Geo Specialist's Record		<input type="checkbox"/> Memory (* Owner, Driller, Operator) <input type="checkbox"/> Owner's Record <input type="checkbox"/> Pump Operator's Record <input type="checkbox"/> Report / File	
6	Penetration Information Available	<input type="checkbox"/> Yes			

Casing	
1	Casing Column Number (1 - 9)
2	Casing Height (m)
3	Observed Casing Details <input type="checkbox"/> Yes
4	Inner Diameter (mm)
5	Outer Diameter (mm)
6	Casing Wall Thickness (mm)
7	Casing Material
8	Other Material

Discharge Rate					
		1	2	3	4
1	Date Measured (ccyy-mm-dd)				
2	Time Measured (hh:mm)				
3	Discharge Rate (l/s)				
4	Determining Method	<input type="checkbox"/> Estimated <input type="checkbox"/> Flow Meter <input type="checkbox"/> Flume <input type="checkbox"/> Submerged Orifice <input type="checkbox"/> Totalling Meter		<input type="checkbox"/> Venturi Meter <input type="checkbox"/> V-Notches <input type="checkbox"/> Volumetric Measurement	
5	Type of Discharge	<input type="checkbox"/> Airlift <input type="checkbox"/> Bailer		<input type="checkbox"/> Pump <input type="checkbox"/>	
6	Data Source	<input type="checkbox"/> Driller's Log <input type="checkbox"/> Check by Reporting Institution <input type="checkbox"/> Geo Specialist's Record <input type="checkbox"/> Memory (owner, driller, operator)		<input type="checkbox"/> Owner's Record <input type="checkbox"/> Pump Operator's Record <input type="checkbox"/> Report / File	

Water Level Information				
1	Casing Column Number (1 - 9)			
2	Piezometer Number			
3	Method of Measuring	<input type="checkbox"/> Airline <input type="checkbox"/> Capacity Probe <input type="checkbox"/> Data Logger <input type="checkbox"/> Dip Meter <input type="checkbox"/> Estimated	<input type="checkbox"/> Pressure Gauge <input type="checkbox"/> Recorder <input type="checkbox"/> Reported <input type="checkbox"/> Steel Tape	
4	Water Level Status	<input type="checkbox"/> Affected By Nearby Pump <input type="checkbox"/> Artesian <input type="checkbox"/> Dry	<input type="checkbox"/> Obstructed <input type="checkbox"/> Static <input type="checkbox"/> Suspect Data	
5	Data Source	<input type="checkbox"/> Driller's Log <input type="checkbox"/> Check by Reporting Institution <input type="checkbox"/> Geo Specialist's Record <input type="checkbox"/> Memory (* Owner, Driller, Operator)	<input type="checkbox"/> Owner's record <input type="checkbox"/> Pump Operator's Record <input type="checkbox"/> Report / File	
6	Date Measured (ccyy-mm-dd)	1	2	3
7	Time (hh:mm)			
8	Water Level (m)			

Visitor Information	
1	Visit Date (ccyy-mm-dd)
2	Reason for Visit
3	Visitor Surname
4	Visitor Initials
<b>Home Address</b>	
5	Address Location <input type="checkbox"/> Home
6	Address Type <input type="checkbox"/> Postal <input type="checkbox"/> Physical
7	Address Text
8	Suburb
9	Town/City
10	Postal Code
<b>Business Address</b>	
11	Address Location <input type="checkbox"/> Business
12	Address Type <input type="checkbox"/> Postal <input type="checkbox"/> Physical
13	Building Name
14	Office Number
15	Street Name and Number
16	Suburb
17	Town/City
18	Postal Code
19	Telephone Number Location <input type="checkbox"/> Business <input type="checkbox"/> Home
20	Telephone Number Type <input type="checkbox"/> Switchboard <input type="checkbox"/> Cellular <input type="checkbox"/> Fax <input type="checkbox"/> Land Line
21	Dialling code
22	Telephone Number
23	Extension

STRATEGY AND GUIDELINE DEVELOPMENT

APPENDIX B

Equipment Installed													
1	<table border="0"> <tr> <td>Type of Monitoring</td> <td> <input type="checkbox"/> Abstraction Monitoring                             <input type="checkbox"/> Water Level Monitoring                         </td> </tr> <tr> <td></td> <td> <input type="checkbox"/> Rainfall Monitoring                         </td> </tr> </table>	Type of Monitoring	<input type="checkbox"/> Abstraction Monitoring <input type="checkbox"/> Water Level Monitoring		<input type="checkbox"/> Rainfall Monitoring								
Type of Monitoring	<input type="checkbox"/> Abstraction Monitoring <input type="checkbox"/> Water Level Monitoring												
	<input type="checkbox"/> Rainfall Monitoring												
<b>Water Level Monitoring</b>													
2	Date Installed (ccyy-mm-dd)												
3	<table border="0"> <tr> <td>Data Source</td> <td> <input type="checkbox"/> Check by Reporting Institution                             <input type="checkbox"/> Owner's Record                         </td> </tr> <tr> <td></td> <td> <input type="checkbox"/> Geo Specialist's Record                             <input type="checkbox"/> Pump Operator's Record                         </td> </tr> <tr> <td></td> <td> <input type="checkbox"/> Memory (*Owner, Driller, Operator)                             <input type="checkbox"/> Report / File                         </td> </tr> </table>	Data Source	<input type="checkbox"/> Check by Reporting Institution <input type="checkbox"/> Owner's Record		<input type="checkbox"/> Geo Specialist's Record <input type="checkbox"/> Pump Operator's Record		<input type="checkbox"/> Memory (*Owner, Driller, Operator) <input type="checkbox"/> Report / File						
Data Source	<input type="checkbox"/> Check by Reporting Institution <input type="checkbox"/> Owner's Record												
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	<input type="checkbox"/> Memory (*Owner, Driller, Operator) <input type="checkbox"/> Report / File												
4	<table border="0"> <tr> <td>Water Level Monitoring Equipment</td> <td> <input type="checkbox"/> Electronic Data Logger                             <input type="checkbox"/> No Equipment                             <input type="checkbox"/> Recorder                         </td> </tr> </table>	Water Level Monitoring Equipment	<input type="checkbox"/> Electronic Data Logger <input type="checkbox"/> No Equipment <input type="checkbox"/> Recorder										
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5	<table border="0"> <tr> <td>Data Logger Manufacturer</td> <td> <input type="checkbox"/> Eijkelkamp                             <input type="checkbox"/> OTT                         </td> </tr> </table>	Data Logger Manufacturer	<input type="checkbox"/> Eijkelkamp <input type="checkbox"/> OTT										
Data Logger Manufacturer	<input type="checkbox"/> Eijkelkamp <input type="checkbox"/> OTT												
6	Serial Number [Data Logger]												
7	<table border="0"> <tr> <td>Data Logger Measurement Method</td> <td> <input type="checkbox"/> Bubble Pot                             <input type="checkbox"/> Water Pressure                         </td> </tr> <tr> <td></td> <td> <input type="checkbox"/> Counter Weight                         </td> </tr> </table>	Data Logger Measurement Method	<input type="checkbox"/> Bubble Pot <input type="checkbox"/> Water Pressure		<input type="checkbox"/> Counter Weight								
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	<input type="checkbox"/> Counter Weight												
<b>Rainfall Monitoring</b>													
1	Date Installed (ccyy-mm-dd)												
2	<table border="0"> <tr> <td>Data Source</td> <td> <input type="checkbox"/> Check by Reporting Institution                             <input type="checkbox"/> Owner's Record                         </td> </tr> <tr> <td></td> <td> <input type="checkbox"/> Geo Specialist's Record                             <input type="checkbox"/> Pump Operator's Record                         </td> </tr> <tr> <td></td> <td> <input type="checkbox"/> Memory (* Owner, Driller, Operator)                             <input type="checkbox"/> Report / File                         </td> </tr> </table>	Data Source	<input type="checkbox"/> Check by Reporting Institution <input type="checkbox"/> Owner's Record		<input type="checkbox"/> Geo Specialist's Record <input type="checkbox"/> Pump Operator's Record		<input type="checkbox"/> Memory (* Owner, Driller, Operator) <input type="checkbox"/> Report / File						
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3	<table border="0"> <tr> <td>Rainfall Monitoring Equipment</td> <td> <input type="checkbox"/> Electronic Data Logger                             <input type="checkbox"/> Recorder                             <input type="checkbox"/> Volumetric Meter                         </td> </tr> </table>	Rainfall Monitoring Equipment	<input type="checkbox"/> Electronic Data Logger <input type="checkbox"/> Recorder <input type="checkbox"/> Volumetric Meter										
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	<input type="checkbox"/> Counter Weight												
<b>Abstraction Monitoring Pump</b>													
1	Date Installed (ccyy-mm-dd)												
2	<table border="0"> <tr> <td>Data Source</td> <td> <input type="checkbox"/> Check by Reporting Institution                             <input type="checkbox"/> Owner's Record                         </td> </tr> <tr> <td></td> <td> <input type="checkbox"/> Geo Specialist's Record                             <input type="checkbox"/> Pump Operator's Record                         </td> </tr> <tr> <td></td> <td> <input type="checkbox"/> Memory (* Owner, Driller, Operator)                             <input type="checkbox"/> Report / File                         </td> </tr> </table>	Data Source	<input type="checkbox"/> Check by Reporting Institution <input type="checkbox"/> Owner's Record		<input type="checkbox"/> Geo Specialist's Record <input type="checkbox"/> Pump Operator's Record		<input type="checkbox"/> Memory (* Owner, Driller, Operator) <input type="checkbox"/> Report / File						
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	<input type="checkbox"/> Memory (* Owner, Driller, Operator) <input type="checkbox"/> Report / File												
3	<table border="0"> <tr> <td>Pump Type</td> <td> <input type="checkbox"/> Centrifugal Pump (* For Spring only)                             <input type="checkbox"/> Positive Displacement                         </td> </tr> <tr> <td></td> <td> <input type="checkbox"/> Jet                             <input type="checkbox"/> Submersible Pump                         </td> </tr> <tr> <td></td> <td> <input type="checkbox"/> Mono Type Pump                             <input type="checkbox"/> Turbine                         </td> </tr> </table>	Pump Type	<input type="checkbox"/> Centrifugal Pump (* For Spring only) <input type="checkbox"/> Positive Displacement		<input type="checkbox"/> Jet <input type="checkbox"/> Submersible Pump		<input type="checkbox"/> Mono Type Pump <input type="checkbox"/> Turbine						
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	<input type="checkbox"/> Mono Type Pump <input type="checkbox"/> Turbine												
4	Depth to Pump Intake (m below surface)												
5	<table border="0"> <tr> <td>Pump Power Source</td> <td> <input type="checkbox"/> Compressed Air                             <input type="checkbox"/> Hand                         </td> </tr> <tr> <td></td> <td> <input type="checkbox"/> Electricity                             <input type="checkbox"/> Sun                         </td> </tr> <tr> <td></td> <td> <input type="checkbox"/> Fuel                             <input type="checkbox"/> Wind                         </td> </tr> </table>	Pump Power Source	<input type="checkbox"/> Compressed Air <input type="checkbox"/> Hand		<input type="checkbox"/> Electricity <input type="checkbox"/> Sun		<input type="checkbox"/> Fuel <input type="checkbox"/> Wind						
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	<input type="checkbox"/> Electricity <input type="checkbox"/> Sun												
	<input type="checkbox"/> Fuel <input type="checkbox"/> Wind												
6	Power Rating (kW)												
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	<input type="checkbox"/> uPVC												
10	Riser Nominal Diameter												
11	<table border="0"> <tr> <td>Linked to a Bulk Meter</td> <td> <input type="checkbox"/> Yes                         </td> </tr> </table>	Linked to a Bulk Meter	<input type="checkbox"/> Yes										
Linked to a Bulk Meter	<input type="checkbox"/> Yes												
<b>Abstraction Monitoring Meter</b>													
1	Date Installed (ccyy-mm-dd)												
2	<table border="0"> <tr> <td>Meter Type</td> <td> <input type="checkbox"/> Hour Meter (* h )                             <input type="checkbox"/> Power Meter (* kWh)                             <input type="checkbox"/> Water Meter (* m<sup>3</sup>)                         </td> </tr> </table>	Meter Type	<input type="checkbox"/> Hour Meter (* h ) <input type="checkbox"/> Power Meter (* kWh) <input type="checkbox"/> Water Meter (* m <sup>3</sup> )										
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3	Meter Serial Number												
4	Supplying Company												
5	Supplying Contractor												

Field Measurement Information				
Sampling point	<input type="checkbox"/> NON - STATION		<input type="checkbox"/> STATION	
	1	2	3	4
Sample #				
1 Date Measured (ccyy-mm-dd)				
2 Time Measured (hh:mm)				
3 Electrical Conductivity (EC) (mS/m)				
OR				
4 pH Class 1 (values between 6-9)				
OR				
5 pH Class 2 (values between 4-6 and 9-11)				
OR				
6 pH Class 3 (values <4 and >11)				
OR				
7 Temperature (°C)				
OR				
8 Bicarbonate (HCO <sub>3</sub> ) (mg/l)				
9 Piezometer Number				
10 Depth of Measurement (m)				
11 Data Source	<input type="checkbox"/> Check by Reporting Institution <input type="checkbox"/> Geo Specialist's Record <input type="checkbox"/> Owner's Record		<input type="checkbox"/> Pump Operator's Record <input type="checkbox"/> Report / File <input type="checkbox"/>	
Water Sample For Chemical Analysis				
1 Sampling Type	<input type="checkbox"/> Groundwater <input type="checkbox"/> Surface water		<input type="checkbox"/> Rainfall water	
2 Sampling Method	<input type="checkbox"/> Irregular Interval GRAB <input type="checkbox"/> Pumped		<input type="checkbox"/> Flowing	
3 Analyse for	<input type="checkbox"/> Macro (Normal) <input type="checkbox"/> Micro (Cl < 5 mg/l) <input type="checkbox"/> Macro + Boron (B) <input type="checkbox"/> Macro + Turb <input type="checkbox"/> Al + Fe <input type="checkbox"/> Total Organic Carbon (TOC)		<input type="checkbox"/> Macro + KN +TP <input type="checkbox"/> Macro + B + KN +TP <input type="checkbox"/> Toxicity <input type="checkbox"/> Hg <input type="checkbox"/> Trace Elements <input type="checkbox"/> Li	
	<input type="checkbox"/> Carbon <sup>14</sup> C (radioactive) <input type="checkbox"/> Tritium (Hydrogen <sup>3</sup> H (radioactive)) <input type="checkbox"/> Chlorine <sup>36</sup> Cl (radioactive)		<input type="checkbox"/> Strontium <sup>87</sup> Sr <input type="checkbox"/> Radon <sup>222</sup> Rn (radioactive)	
	<input type="checkbox"/> Deuterium (Hydrogen <sup>2</sup> H) <input type="checkbox"/> Oxygen <sup>16</sup> O, <sup>17</sup> O, <sup>18</sup> O <input type="checkbox"/> Nitrogen <sup>14</sup> N <sup>15</sup> N		<input type="checkbox"/> Carbon <sup>12</sup> C, <sup>13</sup> C <input type="checkbox"/> Sulphur <sup>32</sup> S, <sup>34</sup> S <input type="checkbox"/> Hydrogen <sup>1</sup> H	
4 Preserve Type	<input type="checkbox"/> Unpreserved <input type="checkbox"/> Hg Cl <sub>2</sub> <input type="checkbox"/> HNO <sub>3</sub>		<input type="checkbox"/> H <sub>2</sub> SO <sub>4</sub> <input type="checkbox"/> Na OH <input type="checkbox"/> Cooling	
5 Sampler Name & Initials				
6 FOR OFFICE USE ONLY	Sample number	<input type="text"/>	<input type="text"/>	<input type="text"/>

**Step Test Information**

<b>All colored fields are mandatory.</b>	
Identification number	
Duration (minutes)	
Step test start date (ccyy-mm-dd)	
Static water level (DDDD.dd)	
Step test start time (hh:mm)	
Water Level status	<input type="checkbox"/> Drawdown <input type="checkbox"/> Recovery
Abstraction measurement type	<input type="checkbox"/> Abstraction readings (l/s) <input type="checkbox"/> Abstraction quantities (m <sup>3</sup> )

Step test start time (hh:mm)	Elapsed Time (hh:mm)	Water level measurement type		Abstraction measurement
		wl difference	wl actual	
Step No 1	0:01			
	0:02			
	0:03			
	0:05			
	0:07			
	0:10			
	0:15			
	0:20			
	0:25			
	0:30			
	0:35			
	0:40			
	0:50			
	1:00			
	1:15			
1:30				
Step No 2	0:01			
	0:02			
	0:03			
	0:05			
	0:07			
	0:10			
	0:15			
	0:20			
	0:25			
	0:30			
	0:35			
	0:40			
	0:50			
	1:00			
	1:15			
1:30				
Step No 3	0:01			
	0:02			
	0:03			
	0:05			
	0:07			
	0:10			
	0:15			
	0:20			
	0:25			
	0:30			
	0:35			
	0:40			
	0:50			
	1:00			
	1:15			
1:30				

**Multi-rate Test Information**

Identification number	
Duration (minutes)	
Multi-rate test start date (ccyy-mm-dd)	
Static water level (DDDD.dd)	
Multi-rate test start time (hh:mm)	
Water Level status	<input type="checkbox"/> Drawdown <input type="checkbox"/> Recovery
Abstraction measurement type	<input type="checkbox"/> Abstraction readings (l/s) <input type="checkbox"/> Abstraction quantities (m <sup>3</sup> )

Multi-rate test start time (hh:mm)	Elapsed Time (hh:mm)	Water level measurement type		Abstraction measurement
		wl difference	wl actual	
Step No 1	0:01			
	0:02			
	0:03			
	0:05			
	0:07			
	0:10			
	0:15			
	0:20			
	0:25			
	0:30			
	0:35			
	0:40			
	0:50			
	1:00			
1:15				
1:30				
Step No 2	0:01			
	0:02			
	0:03			
	0:05			
	0:07			
	0:10			
	0:15			
	0:20			
	0:25			
	0:30			
	0:35			
	0:40			
	0:50			
	1:00			
1:15				
1:30				
Step No 3	0:01			
	0:02			
	0:03			
	0:05			
	0:07			
	0:10			
	0:15			
	0:20			
	0:25			
	0:30			
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	0:40			
	0:50			
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1:30				

### Constant Yield Test Information

Identification number	
Duration (minutes)	
Constant yield test start date (ccyy-mm-dd)	
Static water level (DDDD.dd)	
Constant yield test start time (hh:mm)	
Abstraction measurement type	<input type="checkbox"/> Abstraction readings (l/s) <input type="checkbox"/> Abstraction quantities (m <sup>3</sup> )

DRAWDOWN				
Constant yield test start time (hh:mm)	Elapsed Time (hh:mm)	Water level measurement type		Abstraction measurement
		wl difference	wl actual	
	0:01			
	0:02			
	0:03			
	0:05			
	0:07			
	0:10			
	0:15			
	0:20			
	0:25			
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	12:00			
	14:00			
	16:00			
	18:30			
	21:00			
	24:00			

Form 3a

2-MAP CODE

DW 71

23 UNCONSOLIDATED; 24 CONSOLIDATED NATIONAL GROUND WATER DATA BASE

112-Customer Name	Street Address
Postal Address	Plot/Erf No. 113-Borehole No.
	Farm Name

Fill in for ALL boreholes				CONS. ONLY Feature 5	UNCONSOLIDATED FORMATIONS ONLY 6.Feature					
Depth	1.Lithology code	Colour 2P 3S			4.Texture	P	S	TA	RS	9R
1.00										
2.00										
3.00										
4.00										
5.00										
6.00										
7.00										
8.00										
9.00										
10.00										
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43.00										
44.00										
45.00										
46.00										
47.00										
48.00										
49.00										
50.00										

Circle one of the following:

FOR DEPTH	1 - 50m
OR DEPTH	101 - 150m

1 LITHOLOGY CODE

Overburden	OBON
Clay	CLAY
Clay and sand	CLSD
Coal	COAL
Boulders	BLDR
Boulderclay	BLCL
Alluvium	ALVM
Chert	CHRT
Calcrete	CLCR
Conglomerat	CLGM
Dabase	DDBS
Dolerite	DDET
Dolomite	DLMT
Granite	GRNT
Gravel	GRVL
Lava	LAVA
Quartzite	QRZT
Sand	SAND
Shale	SHLE
Sandstone	SNDS

2 PRIMARY COLOURS

Black	S
Blue	B
Brown	C
Green	G
Grey	H
Purple	N
Orange	O
Pink	P
Red	R
White	W
Yellow	Y
No information	

3 SECONDARY COLOURS

Bluish	B
Brownish	C
Dark	D
Greenish	G
Greyish	H
Light	L
Purple	M
Orange	O
Pinkish	P
Redish	R
Olive	V
Yellowish	Y
No information	

4 TEXTURE

Crypto	CR
Very fine	VF
Fine	FN
Fine/medium	FM
Medium	MD
Medium/Coarse	MC
Very coarse	VC

5 FEATURE (Consolidated only)

Consolidated	CE
Consolidated	CS
Fractured	FC
Hard	D
Soft	SF
Unconsolid	UC
Weathered	WT

*Appendix C:*

**Technical Guidelines and  
Procedures for the Drilling,  
Testing and Sampling of  
Boreholes**

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## APPENDIX C. TECHNICAL GUIDELINES AND PROCEDURES FOR THE DRILLING, TESTING AND SAMPLING OF BOREHOLES

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### ***C.1 Introduction***

This section details the technical considerations the Water Manager needs to apply when designing and implementing assessment, planning and management programmes for groundwater resources. This section covers the siting, drilling testing and sampling procedures that need to be followed to ensure the implementation of a successful programme.

For further information concerning these aspects refer to the Toolkit for Water Services developed by DWAF and NORAD in 2004.

### ***C.2 Final design of boreholes***

Boreholes provide a means of exploring, quantifying, accessing and tapping groundwater resources. They are used for many purposes including:

- Exploration (assessment),
- Water supply,
- Monitoring,
- Dewatering, and
- Artificial recharge.

Boreholes serve as a means of obtaining invaluable subsurface geological and hydrogeological data. Information that can be obtained from drilling includes:

- Geology (granite, dolomite, chert, dolerite, etc),
- Weathering profile,
- Position of water bearing and non-water bearing zones,
- Position of (potential) aquifer(s) within the profile,
- Water strike(s),
- Blowing yield, (from air percussion drilling),
- Hydraulic parameters, etc.

It is therefore important that boreholes are sited and drilled, pump-tested and equipped according to the set of minimum requirements as set out in this guideline. Application of these minimum

requirements to boreholes drilled for whatever purpose during the assessment phase will ensure the preservation of the natural quality of the groundwater resource being investigated by preventing contaminated water from entering the resource.

### **C.2.1 Borehole Design**

The Hydrogeologist will undertake the final design of each individual borehole while on site during the drilling process. Upfront planning and preparation by the Hydrogeologist is however required to ensure that sufficient and correct materials are available on site to allow the completion of each borehole immediately following the drilling of the hole.

### **C.2.2 Technical Specifications**

The Hydrogeologist and Drilling Contractor should ensure that drilling is undertaken according to the technical specifications forming part of the drilling tender. A generic technical specification suitable for drilling of boreholes is included in Appendix A.1.

### **C.2.3 Drilling Diameters**

The diameter of boreholes that are drilled and completed must be compatible with the expected condition of the groundwater resource (formation, weathering, fracturing etc.), anticipated final borehole depth, and type of borehole (exploration, monitoring, production).

Starting diameters will be between 8" to 15" (200mm to 380mm) or more, depending upon the anticipated drilling depth and final diameter.

Completed diameters vary between 6" to 10" (152 mm to 254 mm) depending on use, anticipated yield and size of the production pump.

### **C.2.4 Reaming**

Reaming involves enlarging the initial drill hole to a larger diameter through unstable material, including the overburden and any collapsing formation encountered at depth, to allow insertion of casing.

### **C.2.5 Casing**

Casing (or borehole lining) is required to ensure the long term stability of the borehole. The function of the casing is to support unstable material from collapsing into the borehole during and after drilling.

Where casing is required below the water strike level to prevent unstable water bearing zones from collapsing, the casing must be slotted to allow inflow of the water intersected. All steel casing should have a minimum wall thickness of 4mm and should be approximately 60mm less in diameter than the drilled hole.

Steel casing with a minimum wall thickness of 4mm should be used in unstable conditions. Plastic or uPVC casings are not suitable since casings made from these materials cannot be pushed past collapsing horizons.

### **C.2.6 Formation Stabiliser**

Formation stabiliser (sometimes referred to as gravel pack) is placed in the annular space between the slotted casing and the borehole sidewall to provide a permeable zone between the geological formation and the casing, while at the same time protecting the slotted casing from clogging due to the collapse of the formation.

The formation stabiliser must comprise well sorted, sub-rounded quartzite or similar rock. The smallest grain size must be larger than the casing perforations/slots.

The formation stabiliser should extend a minimum of 10m above the top of the uppermost perforated/slotted section of casing before the borehole is developed. Drilling cuttings removed from the borehole must not be used as a formation stabiliser substitute, but can be used as backfill above the formation stabiliser.

### **C.2.7 Sanitary Seal**

The sanitary seal comprises a cement or cement-bentonite mix grout and extends to a depth of 3 - 6m below ground surface. A sanitary seal is installed to:

- Prevent the inflow of potentially polluting surface water into the borehole via the annular space between the borehole sidewall and the outside of the casing, and
- Provide surface stability to the casing.

Every borehole must be completed with a sanitary seal, irrespective of its use, .i.e, monitoring, exploratory, production, dewatering, etc., unless backfilled and sealed with a concrete plug.

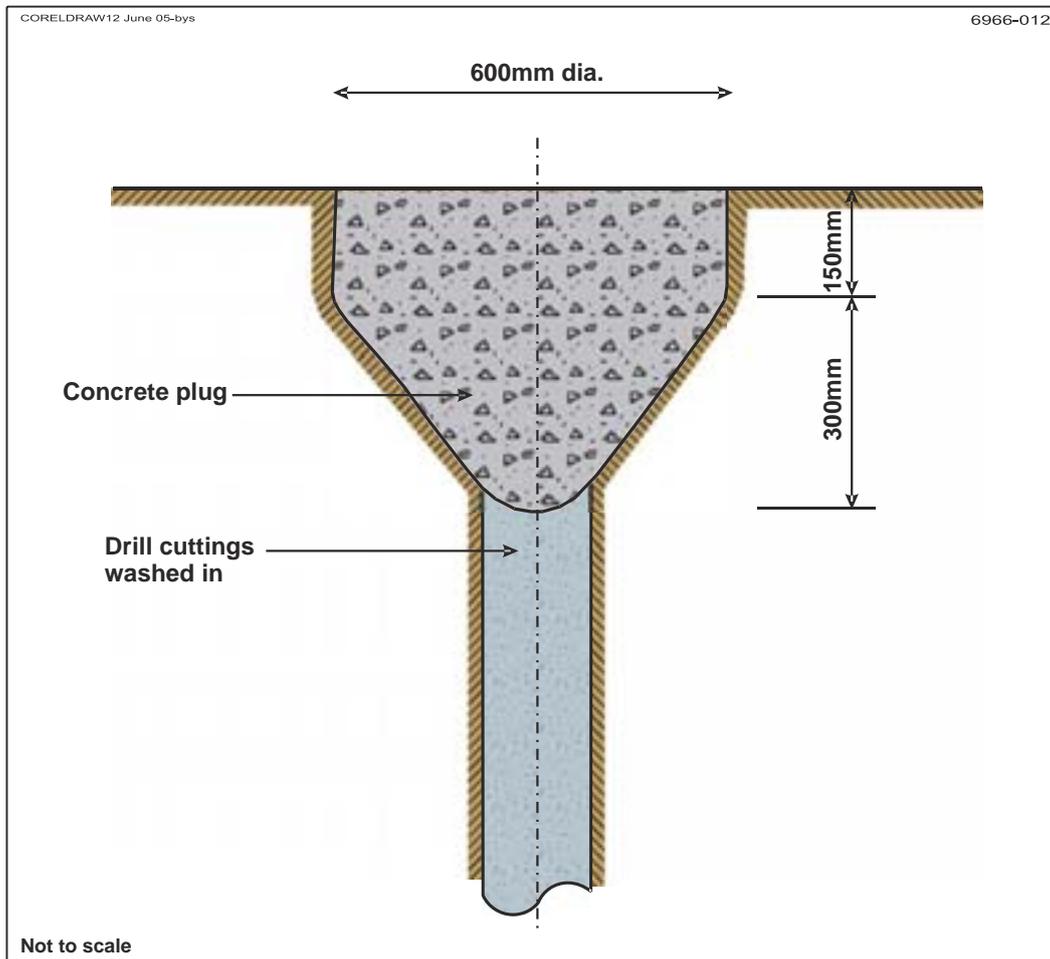
### **C.2.8 Borehole Verticality and Straightness**

It is important that boreholes are both vertical and straight to allow for trouble free installation and operation of the production pump. The technical specifications in Appendix A.1 detail the tests that the Drilling Contractor may be requested to carry out to confirm the borehole verticality and straightness. The Hydrogeologist should confirm these tests on site.

### **C.2.9 Unsuccessful Boreholes**

Unsuccessful, abandoned or lost boreholes must be correctly plugged for safety and to protect the aquifer against pollution. Such boreholes must be backfilled to the surface with the drilling

cuttings, compacted and sealed with a concrete plug to a depth of 450mm, as illustrated in Figure C.1.



*Figure C.1: Sealing of boreholes*

### C.2.10 Drilling Techniques

Two drilling methods are commonly employed in South Africa, namely air percussion and mud rotary drilling. A third method, namely cable tool (Jumper) drilling is only rarely available. Each method involves different equipment and one method may be more applicable than another to overcome geological/hydrogeological conditions. The various methods are described in the sections below.

#### Down-the-Hole Air percussion drilling

This technique involves using compressed air to operate a pneumatic hammer and button bit to break up the formation as drilling advances. Air percussion drilling is suitable for the weathered and hard rock and is the most commonly used technique. Difficult drilling conditions encountered through collapsing ground, and other unstable or cavernous formations can be overcome by using the Oversize Diameter (ODEX) method.

#### Mud rotary drilling

This technique involves the continuous circulation of a viscous biodegradable drilling fluid within the borehole, which prevents caving of the borehole, removes drill cuttings and cleans the tricone bit. This technique can also be used for the drilling of unconsolidated or highly weathered formations but is not suitable for cavernous formations and very hard layers.

#### Cable tool percussion drilling

This technique involves the repeated lifting and dropping of a heavy string of drilling tools suspended at the end of a continuous cable. It is suitable for drilling in unconsolidated weathered and cavernous formations. Progress will be extremely slow in hard consolidated layers and its use has thus been superseded by the down-the-hole air percussion method. Cable tool rigs are currently normally utilised for the cleaning and rehabilitating of existing boreholes.

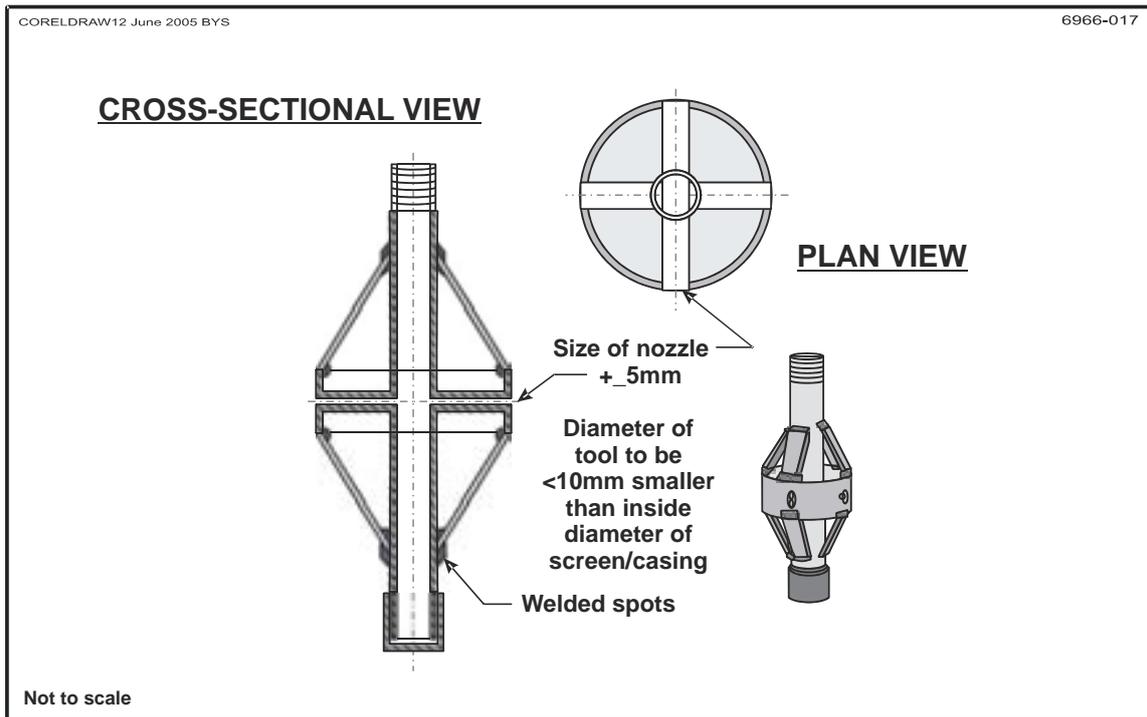
### **C.2.11 Develop boreholes**

Borehole development is undertaken on completion of the drilling and insertion of casing and formation stabiliser to maximise the yield. Development involves the removal of all fine and clogging material, including drilling cuttings, clay, silt, etc., from the borehole after completion of the drilling. Some applicable borehole development techniques are described below.

#### Mechanical methods

*Air lifting:* Air is injected into the borehole to lift the water to the surface. This is achieved by positioning the base of the drill string, with or without the hammer, to a depth between 0.5 and 3m above the bottom of the borehole and introducing air. At first, as the water reaches the surface, the air supply is cut off and the borehole allowed to recover. During the subsequent cycles the air is opened for progressively longer periods, until the water blown out becomes sediment free. The turbulence and inflow introduced into the borehole dislodges fine particles from the formation and washes the sidewalls.

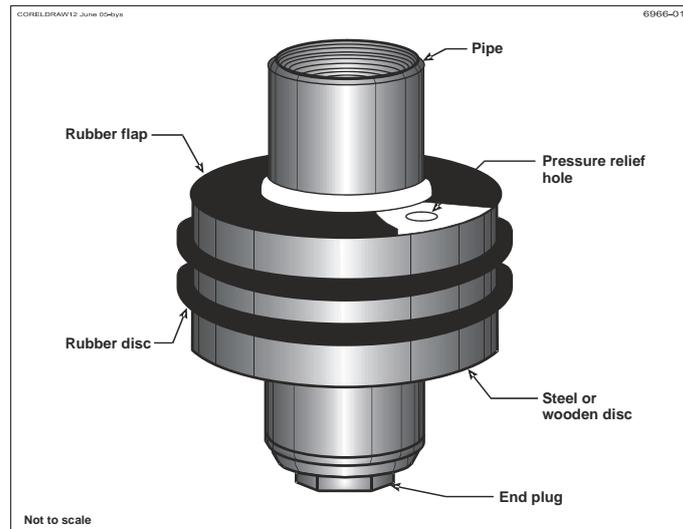
*Air jetting:* This method is commonly used in slotted boreholes. The jetting tool is attached to the drill stem and lowered to the bottom of the required slotted section to be developed and then moved slowly up and down and rotated while high pressure air is pumped into the formation out of the jetting tool. Once the required section has been completely developed and sand and silt free water obtained, a drill rod is removed and the procedure repeated until the entire section to be developed has been jetted. A diagram of a typical jetting tool is given in Figure C.2.



*Figure C.2: Typical jetting tool*

**Water jetting:** This method employs the same principles as air jetting. Water is pumped at high pressure through the jetting tool into the borehole instead of air.

**Block surging:** This technique involves the repeated lifting and lowering of a surge block below the water level and within the cased section of the borehole. The surge block comprises a plunger which fits snugly inside the casing thus forming a tight seal. Water is drawn into and forced out of the borehole through the formation stabiliser and weathered and fractured formation with each up and down stroke. The suction created draws fine clogging material into the borehole. Block surging is a particularly effective development technique. Air lifting or jetting will subsequently remove the material freed by the surging. A typical surging block is shown in Figure C.3.



*Figure C.3: Typical surging block*

### Chemical methods

*Polyphosphate:* Adding polyphosphate (calgon) before and during development helps to remove clay and wad that can occur naturally in the aquifer by dispersing clay particles. These are later removed by air lifting.

*Acidification:* This development technique involves the introduction of an acid into the borehole. The acid dissolves some of the formation thus improving permeability around the borehole. The borehole is subsequently air lifted for cleaning.

Air lifting and air jetting are the most commonly used and recommended techniques in South Africa. Development is completed when the water removed is clean and free of any visible sand, silt and/or clay.

### **C.2.12 Disinfect boreholes**

The purpose of disinfection is to cleanse the borehole of any bacteria, in particular coliform bacteria, introduced during the drilling, rehabilitation or testing operations. Disinfection can be accomplished by injecting chlorine (or chlorine-yielding compounds) into the borehole. The recommended quantities to inject are shown in Table C.1.

*Table C.1: Recommended injection quantities for borehole disinfection*

Nominal diameter of borehole	Volume of water (l) per metre of borehole	Volume/weight of sterilant to be used for disinfection per unit volume of water below groundwater test level		
		Sodium Hypochlorite	Calcium Hypochlorite	Chlorinated lime
152 mm	18l	500 ml (2 cups)	26 g (¼ cup)	90g (1 cup)
165 mm	21l	600 ml (2½ cups)	30 g (½ cup)	105g (1 cup)
203 mm	33l	940 ml (4 cups)	47g (½ cup)	165g (1½ cups)
254 mm	51l	1500 ml (6 cups)	73g (¾ cup)	255g (2½ cups)

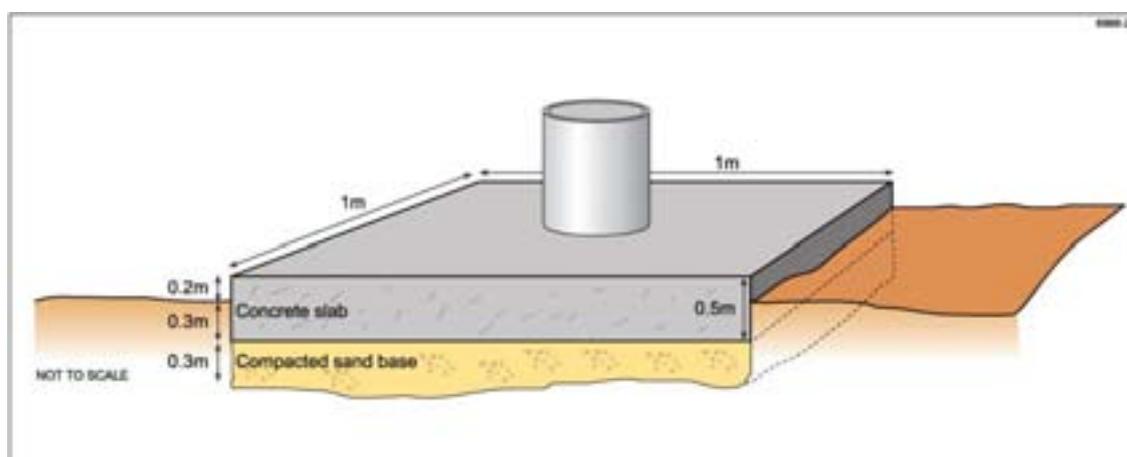
NOTES:

- No distinction is made between open and cased portions of a borehole since these differences are considered to have a negligible impact on calculated unit volumes.
- The trade percentage of chlorine in the listed sterilants is taken to be:  
3.5 percent by volume (35ml/l) for sodium hypochlorite  
70 percent by weight (700g/kg) for calcium hypochlorite  
20 percent by weight (200g/kg) for chlorinated lime.

### C.2.13 Borehole surface works

#### Concrete Slab

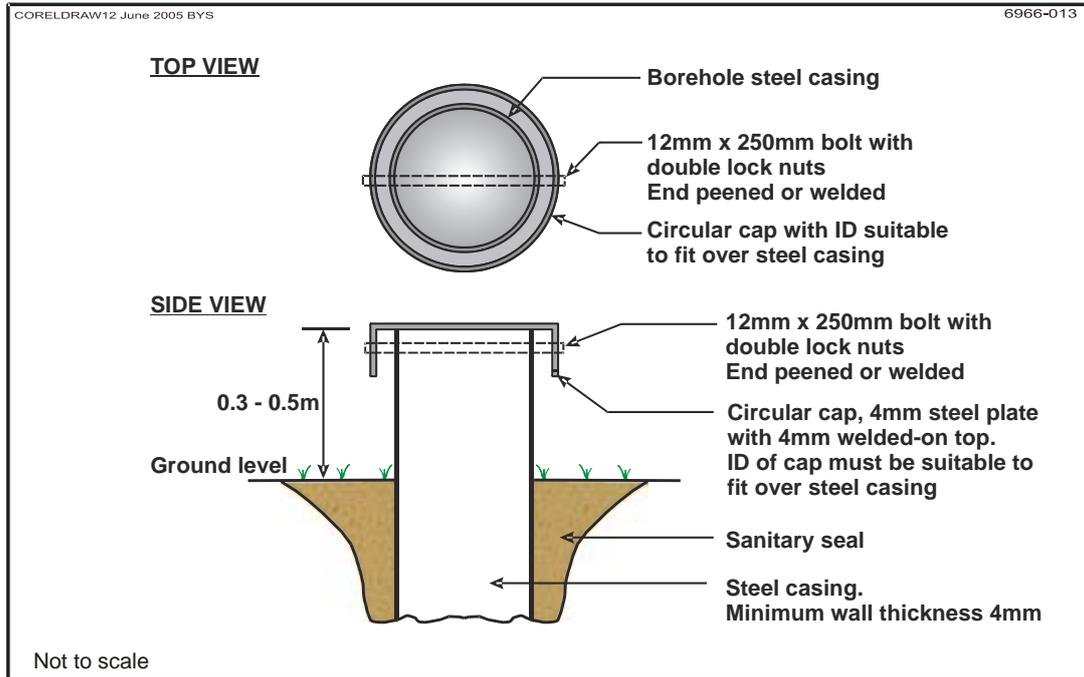
Unless a particular headwork construction is adopted, boreholes must be completed with a concrete slab, with minimum dimensions shown in Figure C.4. The purpose of the concrete slab is to protect the sanitary seal and prevent surface erosion and thus ponding of water around the borehole head.



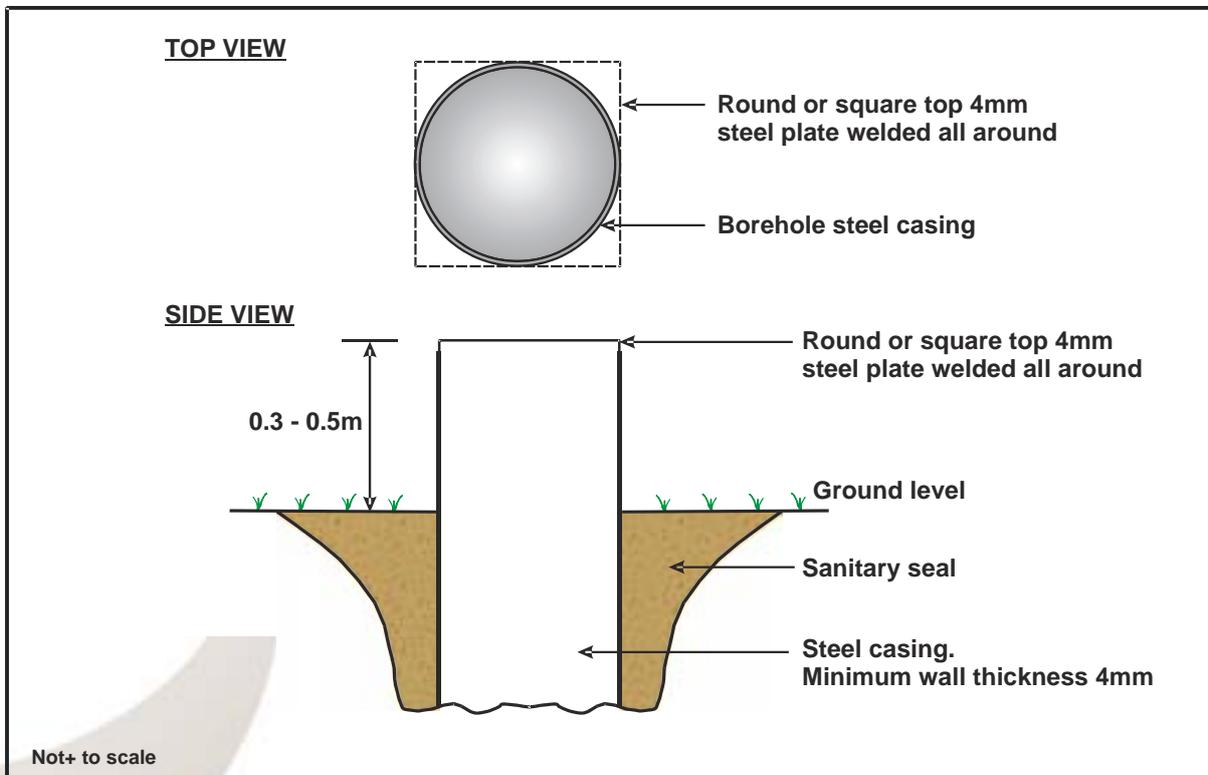
*Figure C.4: Typical concrete slab detail*

#### Caps or Seals

Capping or sealing of the borehole is required to prevent introduction of foreign material. This is achieved either by the fitting of a cap and double locking nuts or Allen key bolt to the borehole casing (Figure C.5) or by the welding of a 4 mm thick steel plate (lid) onto the borehole casing (Figure C.6).



*Figure C.5: Cap and double locking nut system*



*Figure C.6: Welding of steel plate*

#### C.2.14 Borehole identification

Each borehole must be allocated a unique number according to the system approved by the DWAF. No hydrogeological consultant, drilling number or owner should use an independent numbering system. Borehole numbers are issued by the regional DWAF offices.

Each borehole should be marked in the field with its unique number, depth and drilling date. This information should be stencilled or welded:

- Onto the casing itself; or
- Onto a metal plaque set into the concrete slab; or
- On a marker pole and plate concreted into the ground close to the borehole.

#### C.2.15 Site cleaning

Upon completion of the drilling the site must be restored as far as possible to the natural state to minimise the environmental impact of the drilling operations.

#### C.2.16 Further Information

The reader is referred to the following document should further details of drilling techniques, borehole construction, suitable materials, development techniques, etc. be required:

*Driscoll, Fletcher. G., 1986 **Groundwater and Wells**. Second Edition. Published by Johnson Filtration Systems Inc. St. Paul, Minnesota 55112 ISBN 0-9616456-0-1*

### C.3 Pumping Tests

Pumping tests are an integral part of any groundwater assessment or development programme. Pumping tests are carried out to determine the hydraulic parameters of the aquifer (transmissivity, storativity, specific capacity, etc.), from which the long term yield of the tested borehole and the correct size and type of pump to be installed are determined. Data from properly conducted pumping tests are essential for groundwater assessments and aquifer management.

Pumping tests involve measuring the water level decline in the pumped borehole and in any observation/monitoring boreholes with time.

Three types of pumping test can be carried out. These are:

- Step drawdown test,
- Constant discharge rate test, and
- Recovery test.

Standard data recording sheets (No's A, B and C) for the three types of pumping tests are included in Appendix B.

Table C.2 summarises the type of test recommended for various sectoral uses as well as the minimum test durations.

*Table C.2: Pumping tests and durations for various sectors (after SABS 1996)*

Identification of use	Type of test	Pumping duration
Stock or domestic	Step Drawdown	4 x 1 hour
Irrigation Low cost consequence if failure occurs	Step Drawdown	4 x 1 hour
	Constant Discharge	24 hours
Irrigation High cost consequence if failure occurs	Step Drawdown	4 x 1 hour
	Constant Discharge	48 hours or more
Engine driven pump for rural village supply	Step Drawdown	4 x 1 hour
	Constant Discharge	48 hours
Town water supply	Step Drawdown	4 x 1 hour
	Constant Discharge	72 hours or more
Industry/Mining (Water supply not critical to production)	Step Drawdown	4 x 1 hour
	Constant Discharge	48 hours
Industry/Mining Water supply critical to production	Step Drawdown	4 x 1 hour
	Constant Discharge	100 hours or more
Power Station and similar water user	Step Drawdown	4 x 1 hour
	Constant Discharge	100 hours to 30 days

Pump testing must be carried out by a suitably experienced and equipped contractor familiar with these guidelines and in accordance with minimum technical specifications to ensure the collection of reliable data. A model technical specification for test pumping is included in Appendix A.2.

### **C.3.1 Step Drawdown Test**

The step drawdown test generally comprises four different discharge rates, usually of 1 hour duration each. During each hour the discharge rate is maintained at a constant level, and increased at the beginning of each subsequent step. Measurements of both the discharge and the drawdown are taken at specified intervals during the test.

### **C.3.2 Constant Discharge Test**

The constant discharge test follows the step drawdown test.

During the constant discharge test the borehole is tested by pumping at a constant yield for the required duration. The test yield is selected from the results of the step test. During the test it is important to check the yield frequently to ensure the yield remains constant. Readings of the water level drawdown are recorded at specified intervals. An example of a data recording sheet is included in Appendix B.

The water level drawdown data obtained are used to:

- Determine the hydraulic parameters of the aquifer, and
- Assist in assessing the long term sustainable production yield of the tested borehole.

### C.3.3 Recovery Test

The recovery test involves recording the recovery of the water level in the pumped and any observation boreholes on completion of the constant rate test. Readings of the water level recovery commence immediately the pumping phase described in Section 2.3.2 is completed. Water level readings are recorded at specified intervals. An example of a data recording sheet is included in Appendix B.

The water level recovery data obtained (often termed residual drawdown) are used to determine the hydraulic parameters of the aquifer and to assist in assessing the long term sustainable yield of the tested borehole.

### C.3.4 Measurement Guidelines

#### Discharge

The discharge from a borehole may not vary by more than 5 % and may be measured using the following methods:-

*Volumetric method:* This method involves determining the time required to fill a container of a known volume. Table C.3 provides guidelines regarding the container's size per borehole yield range. All time readings must be made using a stopwatch. The volumetric method is especially recommended for low discharges in boreholes.

*Table C.3: Guidelines on container size per borehole yield range*

Borehole Yield Range (l/s)	Container Size (l)
Less than 2	20
2 to 56	50
5 to 20	200
Greater than 20	Other suitable methods (Orifice weir or flow meter)

*V-notch Weir.* This is a rectangular weir of known dimensions installed in a horizontal position at the end of the discharge point of the borehole. The outlet of the weir is a rectangular plate with a 90° constriction (notch) over which the water will flow. The dimensions of the V-notch weir are shown in Figure C.7. The height of the water flowing over the notch is related to a particular discharge. Table C.4 indicates the various discharges calibrated for the dimensions of the V-notch. The height of the water flowing over the notch must be read/measured to within 5mm accuracy.

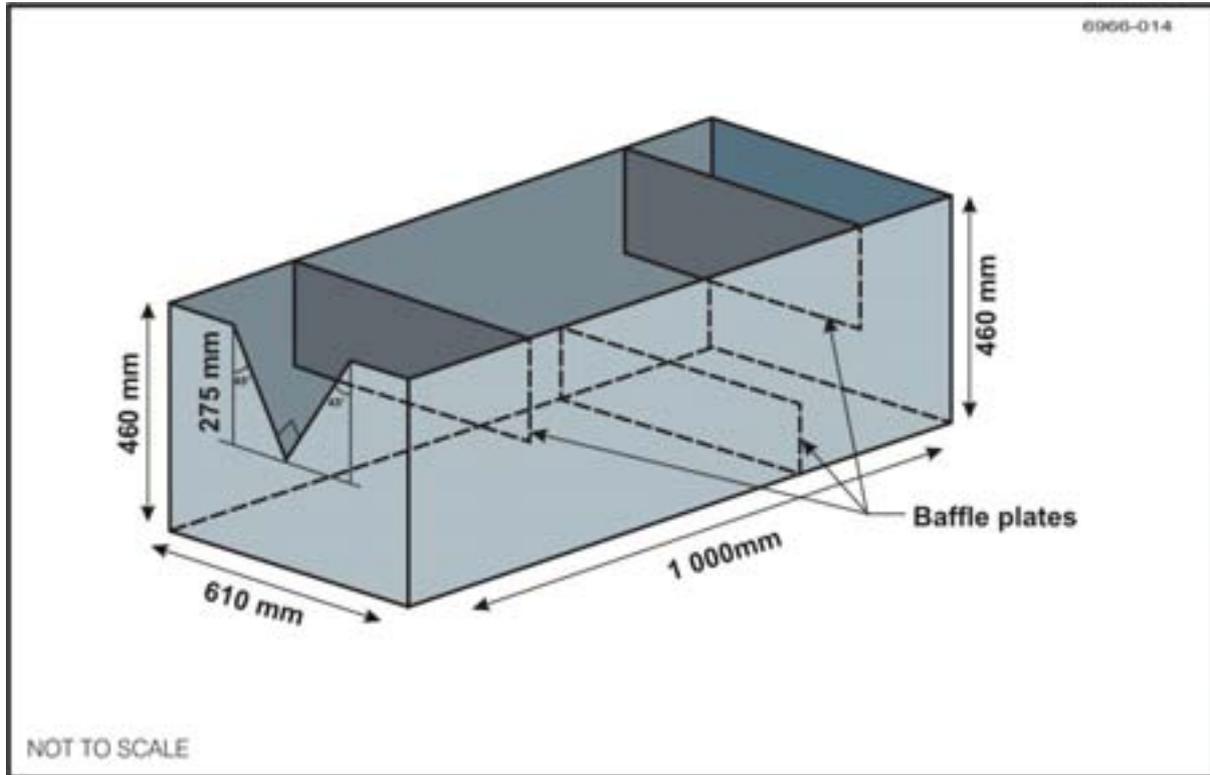


Figure C.7: Typical details of a rectangular V-notch weir

Table C.4: Calibration details for a rectangular V notch weir

Height over Weir (mm)	Flow rate (l/s)	Height over Weir (mm)	Flow rate (l/s)	Height over Weir (mm)	Flow rate (l/s)	Height over Weir (mm)	Flow rate (l/s)	Height over Weir (mm)	Flow rate (l/s)	Height over Weir (mm)	Flow rate (l/s)	Height over Weir (mm)	Flow rate (l/s)
10	0.013	48	0.675	86	2.90	124	7.24	162	14.12	200	23.9	238	36.9
12	0.021	50	0.747	88	3.07	126	7.53	164	14.56	202	24.5	240	37.7
14	0.031	52	0.824	90	3.25	128	7.84	166	15.01	204	25.1	242	38.5
16	0.043	54	0.91	92	3.43	130	8.15	168	15.47	206	25.8	244	39.3
18	0.058	56	0.99	94	3.62	132	8.46	170	15.93	208	26.4	246	40.1
20	0.076	58	1.08	96	3.82	134	8.79	172	16.40	210	27.0	248	41.0
22	0.096	60	1.18	98	4.02	136	9.12	174	16.89	212	27.7	250	41.8
24	0.119	62	1.28	100	4.23	138	9.46	176	17.37	214	28.3	252	42.6
26	0.146	64	1.39	102	4.44	140	9.81	178	17.87	216	29.0	254	43.5
28	0.175	66	1.50	104	4.66	142	10.16	180	18.38	218	29.7	256	44.3
30	0.208	68	1.61	106	4.89	144	10.52	182	18.89	220	30.4	258	45.2
32	0.245	70	1.73	108	5.12	146	10.89	184	19.42	222	31.0	260	46.1
34	0.285	72	1.86	110	5.37	148	11.27	186	19.95	224	31.8	262	47.0
36	0.329	74	1.99	112	5.61	150	11.65	188	20.49	226	32.5	264	47.9
38	0.376	76	2.13	114	5.87	152	12.04	190	21.04	228	33.2	266	48.8
40	0.428	78	2.27	116	6.13	154	12.44	192	21.60	230	33.9	268	49.7
42	0.483	80	2.42	118	6.39	156	12.85	194	22.16	232	34.7	270	50.5
44	0.543	82	2.57	120	6.67	158	13.27	196	22.74	234	35.4	272	51.6
46	0.807	84	2.73	122	6.95	160	13.69	198	23.32	236	36.2	274	52.5

Note: Flow calculated from Barnes Formula:  $Q = 0.01337 \times H^2$  (Vs) (where H is the head of water above apex of notch in cm)

*Orifice Plate with Piezometer (Orifice Weir):* This is installed in a horizontal position at the end of the discharge pipe and comprises a straight length of pipe fitted with an orifice plate at the outlet and a vertical piezometer tube to record the pressure head within the pipe. The orifice plate has calibrated orifice diameters for the piezometer pressure head readings to be converted into discharge measurements. Pressure head readings are to be read to within 2mm accuracy. The minimum discharge that an orifice weir can reliably measure is 3.5 l/s, as shown in Table C.5.

*Table C.5: Flow rates through circular orifice weirs (after Driscoll 1986)*

Head of water (cm)	4" (10.2cm) Pipe		6" (10.2cm) Pipe		4" (10.2cm) Pipe		
	2.5" (6.3cm) Orifice (l/s)	3" (7.6 cm) Orifice (l/s)	3" (7.6 cm) orifice (l/s)	4" (10.2 cm) orifice (l/s)	4" (10.1 cm) orifice (l/s)	5" (12.7 cm) orifice (l/s)	6" (15.2 cm) orifice (l/s)
12.57	3.5	5.7	4.8	9.3	8.5	14.2	22.4
15.2	3.8	6.2	5.3	10.0	9.2	15.3	25.1
17.8	4.1	6.7	5.7	10.8	9.9	16.5	26.8
20.3	4.4	7.1	6.1	11.7	10.5	17.6	28.9
22.9	4.7	7.6	6.6	12.5	11.3	18.9	30.4
25.4	4.9	8.0	6.7	13.0	11.9	19.8	32.0
30.5	5.4	8.7	7.4	14.3	13.1	21.7	35.2
35.6	5.9	9.4	8.0	15.4	14.1	23.3	38.1
40.6	6.3	10.	8.5	16.5	15.0	25.0	40.6
45.7	6.7	10.7	8.8	17.5	15.9	26.6	43.2
50.8	7.0	11.3	9.6	18.4	17.0	28.1	45.4
55.9	7.4	12.1	10.0	19.3	17.7	29.4	47.6
63.6	7.8	12.7	10.7	20.6	18.9	31.4	50.8
76.2	8.6	13.8	11.7	22.3	20.7	34.5	55.6
88.9	9.3	15.0	12.7	24.3	22.4	37.1	60.1
101.6	9.9	16.0	13.4	25.9	23.7	39.6	64.0
114.3	10.5	17.1	14.3	27.5	25.3	42.2	67.8
127.0	11.1	18.0	15.0	29.1	26.6	44.1	71.6
152.4	12.2	19.8	16.6	32.0	29.1	48.6	78.7
177.8	13.1	22.4	18.0	33.6	31.4	51.8	82.0

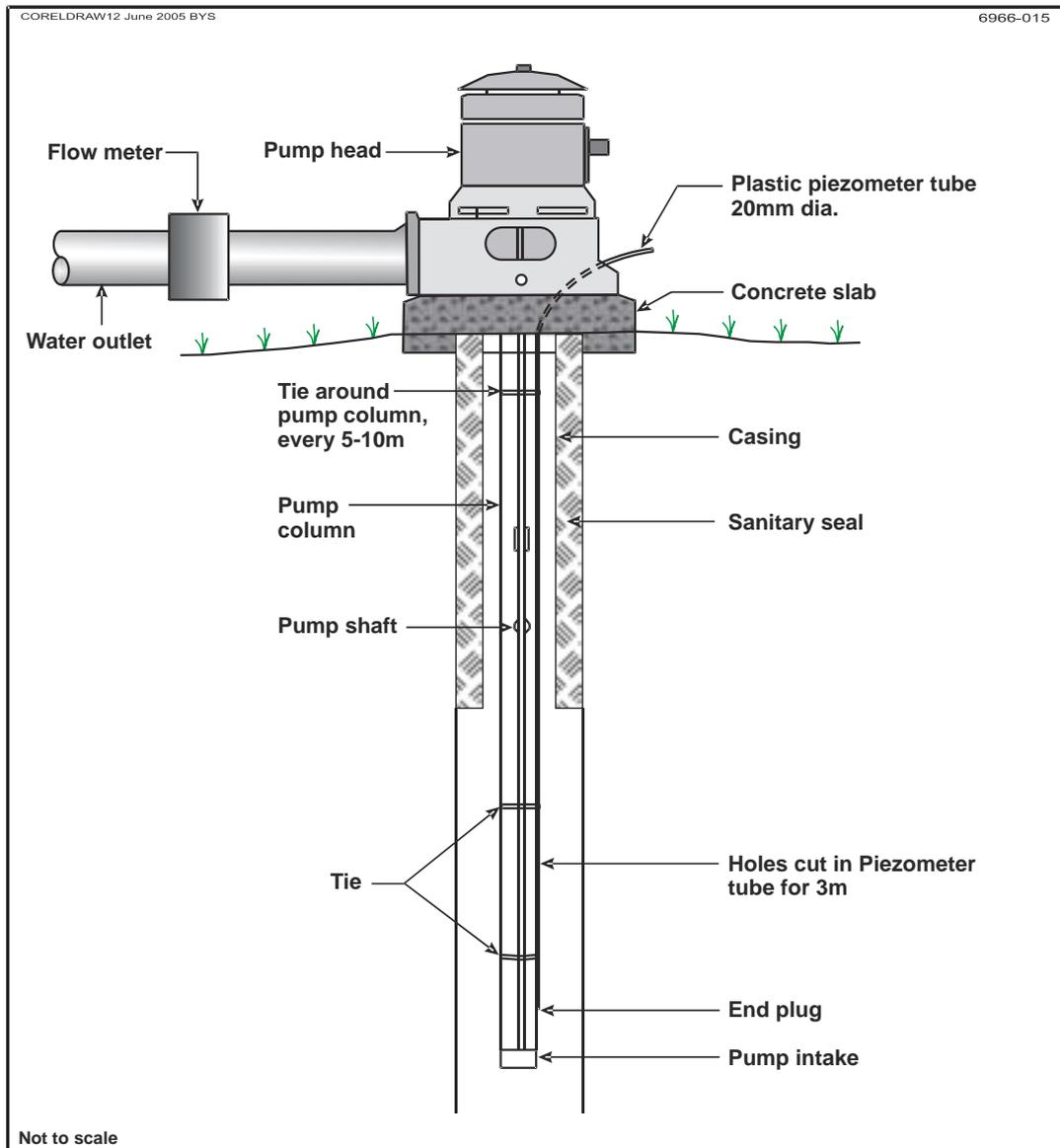
Note: Flow rates indicated below the line are more exact than those above because the head developed in the piezometer tube for particular pipe and orifice diameters is large enough to ensure the accuracy of the results.

*Flow meter:* This must be calibrated and of similar diameter to that of the discharge pipe to which it is installed. The anticipated test yield must be compatible with the measuring range of the flowmeter. An in-line flow meter is the most accurate method of determining the test yield.

#### Water Level Measurements

Water level measurements are taken within a piezometer (measuring) tube. A piezometer made of PVC/polyethylene tubing must be attached to the pump column and installed at the same time as the pump (see Figure C.8). A piezometer made of galvanized pipe can be suspended independently within the borehole.

The piezometer tube acts as a stilling well within the borehole and water level readings are therefore not affected by turbulence and/or cascading caused by pumping. Readings of the water level must be made using an electrical dip meter with an accuracy of  $\pm 10$  mm.



*Figure C.8: Typical details of the installation of a PVC/polyethylene piezometer and flow meter*

### C.3.5 Test Continuity

Pumping tests must be carried out for the minimum duration as specified in Table C.2. In the event of a mechanical breakdown or other reason preventing the test from being completed, the test must be repeated after allowing recovery of the water level to its original level.

### C.3.6 Further Information

The reader is referred to the following documents should further details of testing techniques be required:

*Driscoll, Fletcher. G., 1986 **Groundwater and Wells**. Second Edition. Published by Johnson Filtration Systems Inc. St. Paul, Minnesota 55112 ISBN 0-9616456-0-1*

## C.4 Water sampling and quality

Knowledge of the groundwater chemistry and, where required, bacteriological quality, is essential to:

- Determine the suitability of the groundwater for the intended use, and
- For the overall groundwater resource management.

Measurement of temperature, electrical conductivity and pH should be taken during the constant discharge test, using field kits. These measurements should be taken at the beginning of the test, halfway through the test and a few minutes before the termination of the test. Other constituents can be measured using portable test kits as required.

A water sample should be collected before the end of the pumping test. The sample should be submitted to a reputable (accredited) laboratory to undertake the required testwork.

Each sample must be analyzed for pH, TDS, conductivity, Ca, Mg, Na, K, HCO<sub>3</sub>/CO<sub>2</sub>, SO<sub>4</sub>, Cl, NO<sub>3</sub>, Fe, F, and Mn.

Where groundwater pollution is suspected, it will be necessary to also analyse samples for specific constituents associated with the suspected pollution.

Details of the correct water sampling procedures are given in Water Research Commission Sampling Manual (second edition) by Weaver and Cave 2007.

### **C.5 Rehabilitation of boreholes**

Rehabilitation is necessary when the yield performance of a borehole decreases with time. It is carried out to increase the yield and/or to stabilise the borehole.

Decrease in the hydraulic performance and efficiency of borehole can be caused by:

- Chemical encrustation and/or build up slime due to iron bacteria of the slotted casing section and/or of the water bearing formation thereby reducing permeability,
- The formation and, where installed, the slotted casing, become clogged by fine particles,
- Pumping of wad and silt due to collapse of the sidewalls and/or corrosion of the casing, leading to ingress of overburden or collapsing zones.

Rehabilitation of boreholes is achieved by one or more of the following techniques:

- Chemical rehabilitation including acidification and oxygenation
- Mechanical rehabilitation (cleaning using surging, airlifting, hydrofracturing, etc)
- Replacement of the casings/screens installed in the borehole
- Inserting a smaller diameter casing inside the original casing after the borehole has been cleaned out.

The mechanical and chemical rehabilitation techniques are essentially those used for borehole development.

*Appendix D1:*

**Generic Table of Contents  
for the Assessment Report**

# CONTENTS

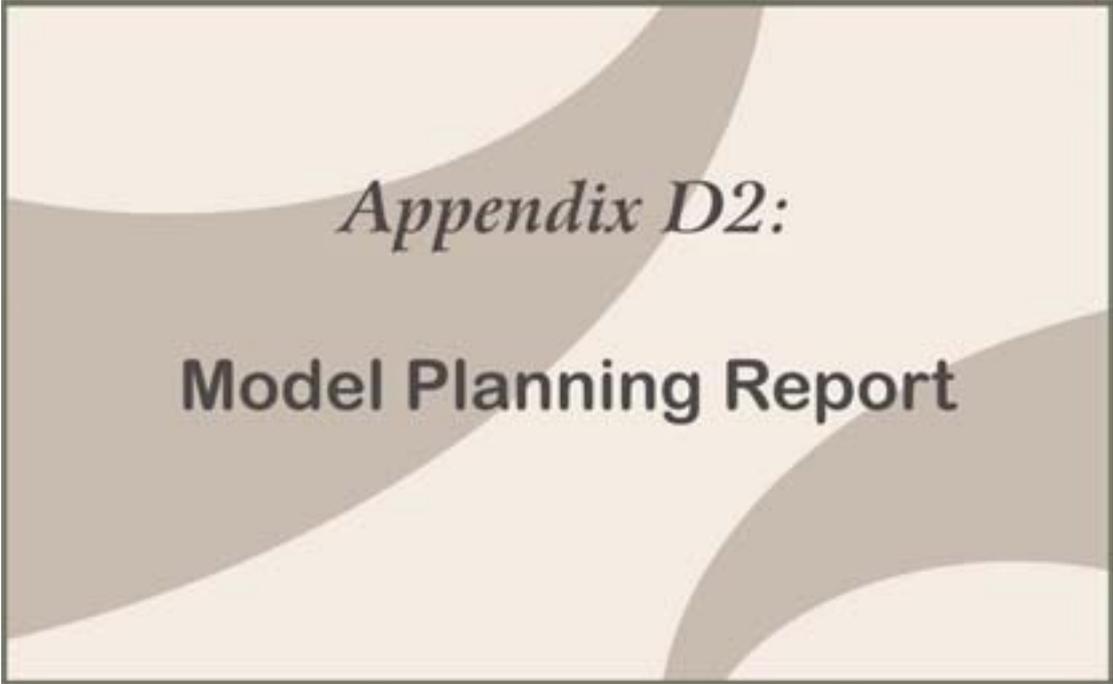
APPENDIX D1. GENERIC TABLE OF CONTENTS \_\_\_\_\_ 1

## APPENDIX D1. GENERIC TABLE OF CONTENTS

---

- Introduction
- Physiography
  - Location
  - Population
  - Climate and Precipitation
  - Topography, geomorphology and drainage
  - Vegetation (& groundwater dependent ecosystems)
- Geology
  - Structural Geology
  - Map all relevant surfaces and subsurface features
  - Drilling records / geology
- Geohydrology
  - Description of aquifer – areal extent, compartmentalisation
  - Groundwater levels
  - Groundwater quality
  - Aquifer Parameters
  - Recharge estimations
  - Springs (including capture zones and groundwater / surface water interaction)
  - Groundwater Flow Regime
  - Groundwater Resource Units
  - Resource Directed Measures
- Water use
  - Define the water users
  - Current demands on the system
  - Socio-economic impacts of water
  - Institutional links
  - Identify critical WARMS information gaps
  - Determine needs of users, including issues and concerns
- Hydrocensus
- Siting, drilling and construction of boreholes
- Conceptual model
- Resource monitoring
  - Evaluate existing relevant monitoring networks according to conceptual model
  - Identify critical information gaps
- Modelling

- This can be various types of models e.g. analytical, numerical, risk-based
- Assessment and Conclusions
  - Compare water availability & requirements
  - Water quantity and quality issues
  - Risk assessment
  - Vulnerability assessment
  - Impacts
  - Groundwater protection zones

The image shows a rectangular cover for a report. The background is a light beige color with several overlapping, curved, darker beige shapes that create a layered, abstract design. The text is centered on the page.

*Appendix D2:*

**Model Planning Report**

# CONTENTS

APPENDIX D2. MODEL PLANNING REPORT \_\_\_\_\_ 1

## APPENDIX D2. MODEL PLANNING REPORT

---

### EXECUTIVE SUMMARY

### LIST OF TABLES

### LIST OF APPENDICES

### ABBREVIATIONS AND ACRONYMS

#### 1. Background and Introduction

- 1.1 The need for a strategy
- 1.2 The geographical area covered by the strategy
- 1.3 Vision and objectives of the strategy
- 1.4 Approach adopted in developing the strategy
- 1.5 The Water Supply System
- 1.6 Introduction to the strategy

#### 2. Water Requirements

- 2.1 Introduction
- 2.2 Sub-themes and key issues
- 2.3 Assumptions underlying recommendations
- 2.4 Recommendations
- 2.5 Responsibilities

#### 3. Water Use Efficiency

- 3.1 Introduction
- 3.2 Urban water use efficiency
- 3.3 Agricultural water use efficiency
- 3.4 Use of treated effluent
- 3.5 Sub-themes and key issues
- 3.6 Recommendations
- 3.7 Responsibilities

#### 4. Water Availability and System Operation

- 4.1 Quantification of water availability
- 4.2 System operations
- 4.3 Sub-themes and key issues
- 4.4 Assumptions underlying recommendations
- 4.5 Recommendations
- 4.6 Responsibilities

#### 5. Comparison of Requirements and Availability

- 5.1 Current and future water balance
- 5.2 Assumptions underlying recommendations
- 5.3 Recommendations
- 5.4 Responsibilities

**6 Selection of Interventions and Decision Making Process**

- 6.1 Introduction
- 6.2 Decision making process for selection
- 6.3 A short-list of interventions for further study
- 6.4 Sub-themes and key issues
- 6.5 Recommendations
- 6.6 Responsibilities

**7 Risk**

- 7.1 Introduction
- 7.2 Sub-themes and key issues
- 7.3 Assumptions underlying recommendations
- 7.4 Recommendations
- 7.5 Responsibilities

**8 Water Resource Protection and Management**

- 8.1 Introduction
- 8.2 Options for future use
- 8.3 Sub-themes and key issues
- 8.4 Recommendations
- 8.5 Responsibilities

**9 Stakeholder Engagement**

- 9.1 Introduction
- 9.2 Sub-themes and key issues
- 9.3 Assumptions underlying recommendations
- 9.4 Recommendations
- 9.5 Responsibilities

**10 Implementation and Performance Monitoring**

- 10.1 Introduction
- 10.2 National Water Act and National Water Strategy
- 10.3 Regional and local frameworks of plan
- 10.4 Relevant water institutions
- 10.5 Other factors that might influence the strategy
- 10.6 Current potential performance monitoring structures
- 10.7 Targets and key performance areas
- 10.8 Sub-themes and key issues
- 10.9 Assumptions underlying recommendations
- 10.10 Recommendations
- 10.11 Responsibilities

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- 1.1 Strategy theme and objectives
- 2.1 WATER REQUIREMENTS: Summarised key issues, issues and approach
- 3.1 Estimates of water wastage and inefficient use
- 3.2 Activities to achieve WC/WDM goals
- 3.3 WATER USE EFFICIENCY: Summarised key issues, issues and approach
- 4.1 Main schemes of the WCWSS
- 4.2 WATER AVAILABILITY AND SYSTEM OPERATION: Summarised key issues, issues and approach
- 5.1 COMPARISON OF REQUIREMENTS AND AVAILABILITY: Summarised key issues, issues and approach
- 6.1 SELECTION OF INTERVENTIONS AND DECISION-MAKING: Summarised key issues, issues and approach
- 6.2 Required actions to support the information needs for the selection of interventions
- 7.1 RISK: Summarised key issues, issues and approach
- 8.1 WATER RESOURCES PROTECTION AND MANAGEMENT: Summarised key issues, issues and approach
- 9.1 STAKEHOLDER ENGAGEMENT: Summarised key issues, issues and approach
- 10.1 IMPLEMENTATION AND PERFORMANCE MONITORING: Summarised key issues, issues and approach

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- 1.1 Geographical area covered by the strategy
- 1.2 WCWSS Reconciliation Strategy deliverables
- 2.1 Historical water use
- 2.2 estimated future and agricultural water requirements
- 4.1 The Water Supply System
- 5.1 Water balance for the Water Supply System
- 6.1 Potential interventions

*Appendix D3:*

**Generic Table of Contents for  
the Integrated Water  
Resources Management Plan  
(IWRMP)**

# CONTENTS

**APPENDIX D3. GENERIC TABLE OF CONTENTS FOR THE  
INTEGRATED WATER RESOURCES MANAGEMENT  
PLAN (IWRMP) \_\_\_\_\_ 1**

## APPENDIX D3. GENERIC TABLE OF CONTENTS FOR THE INTEGRATED WATER RESOURCES MANAGEMENT PLAN (IWRMP)

---

- Summary of existing information
  - Problems, Issues & Concerns
  - Progress in IWRM
- Resource Management Units
  - Define the resource management units according to the technical and socio-economic information supplied
  - Describe the monitoring networks according to the RMUs, including shortcomings
  - Extend groundwater monitoring networks if needed
  - Integrate monitoring networks – link this to a monitoring plan
- Management goals
  - Prioritise management goals
  - Recommendations
- Define Management Instrument
- Analyse various Options / Solutions
  - Options need to be ranked by the technical expertise before presenting it to the stakeholders.
  - At national level this will typically be WMA scale or cross-boundary type of issues.
  - At catchment level looking at which options to develop to address a specific need.
  - At site-specific level mostly 2 or 3 options which needs detail level study and optimising designs.
- STRATEGY TABLES
  - Strategy tables are useful tools to enable implementing the strategies. The ISPs can be used as an example of the strategies that take priority in a WMA and further work can be built on this
  - Management/Development Plan according to the outcome of the strategy phase,
- IWRM in the area
  - A description of the approach that will be followed in managing the area
- Purpose of the plan
- Water resource situation
  - A very brief description of the most relevant information in the area summarised from the situation analysis and strategy

- Set RQOs according to this information
- Management action plan
  - From the actions that were defined in the strategy the following should be developed for implementation.
  - Management Activities
  - Management Responsibilities
  - Management Timeframes & Budget
  - Progress Indicators
- Conclusions
- MANAGEMENT TABLES
  - Populate management tables according to strategy tables, summarising the activities, responsibilities, time frames and budget.
- Summary

It is helpful to summarise the management tables according to the various stakeholders, then one can see upfront what your next task will be in this overall framework.

*Appendix D4:*

**Generic Table of Contents for  
Hydrogeologist Input into  
Environmental Impact  
Assessment (EIA) Processes**

# CONTENTS

<b>APPENDIX D4. GENERIC TABLE OF CONTENTS FOR HYDROGEOLOGIST INPUT INTO ENVIRONMENTAL IMPACT ASSESSMENT (EIA) PROCESSES</b>	<b>1</b>
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## APPENDIX D4. GENERIC TABLE OF CONTENTS FOR HYDROGEOLOGIST INPUT INTO ENVIRONMENTAL IMPACT ASSESSMENT (EIA) PROCESSES

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Adopted from: Saayman, I. 2005. Guideline for involving hydrogeologists in EIA processes: Edition 1. CSIR Report No ENV-S-C 2005 053 D. Republic of South Africa, Provincial Government of the Western Cape, Department of Environmental Affairs & Development Planning, Cape Town.

- **Background information**
  - Relevant project and site related information
  - Information describing the affected environment
  - The legal, policy and planning context
  - Information generated by other specialists in the EIA process
  
- **Specialist input for impact assessment and recommending management actions**
  - Predicting potential impacts
  - Interpreting impact assessment criteria
  - Establishing thresholds of significance
  - Describing the distribution of impacts – beneficiaries and losers
  - Identifying key uncertainties, assumptions and risks
  - Defining confidence levels and constraints to input
  - Recommending Management actions
  - Identifying the best practicable environmental option
  - Communicating the findings of the specialist input
  
- **Specialist input to the monitoring programme**