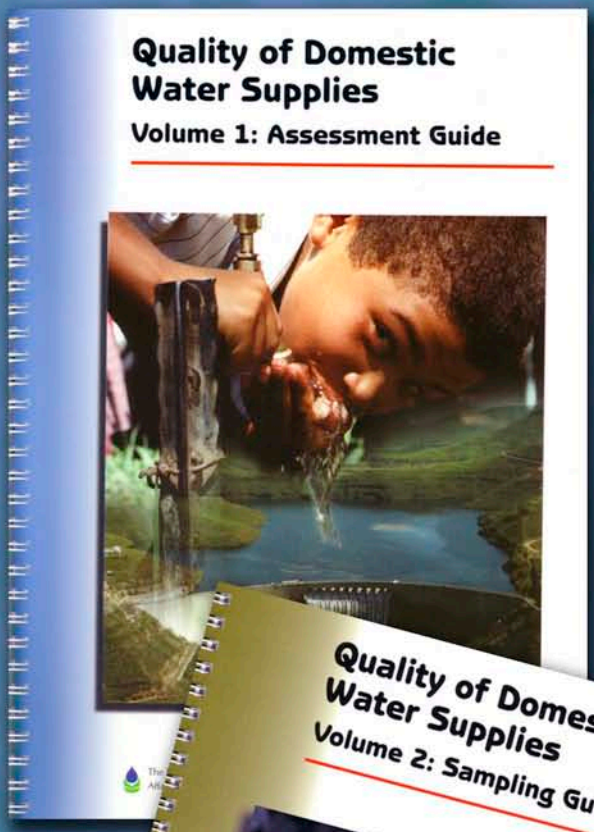
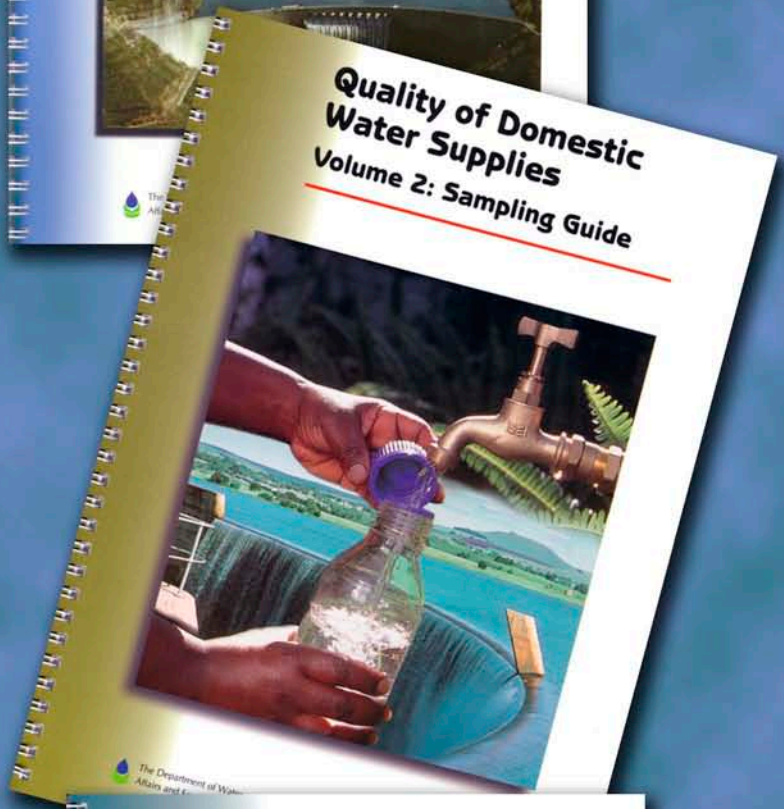
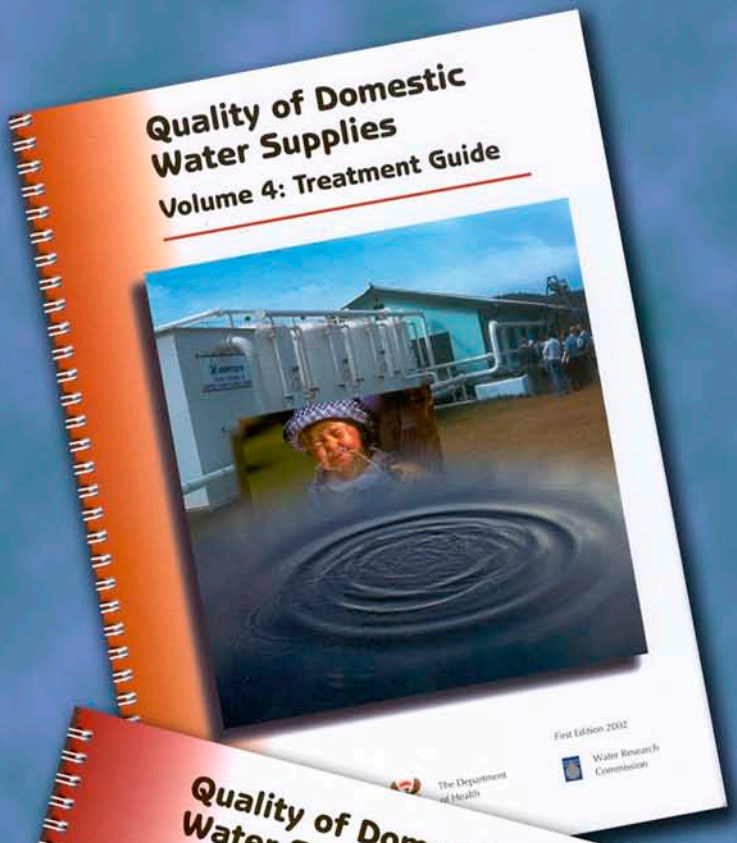
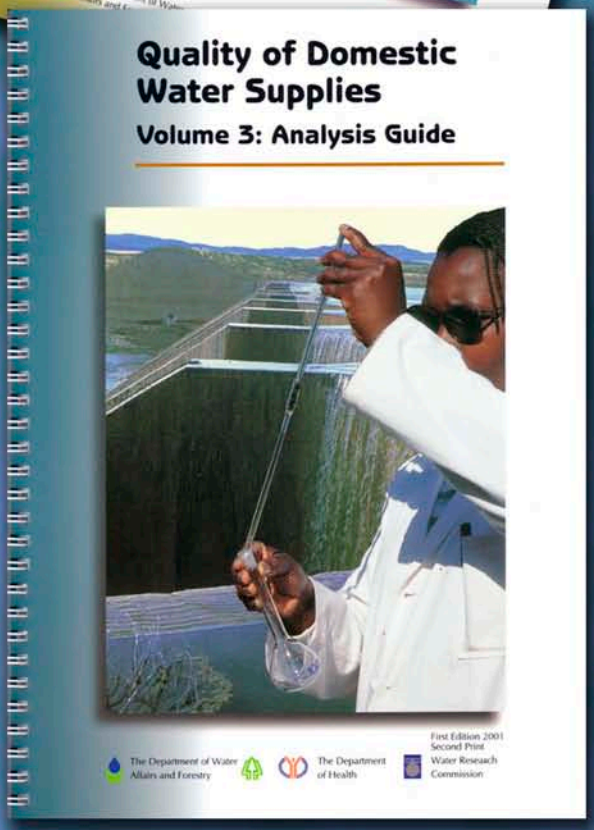
Domestic Water Quality Research Impact Assessment

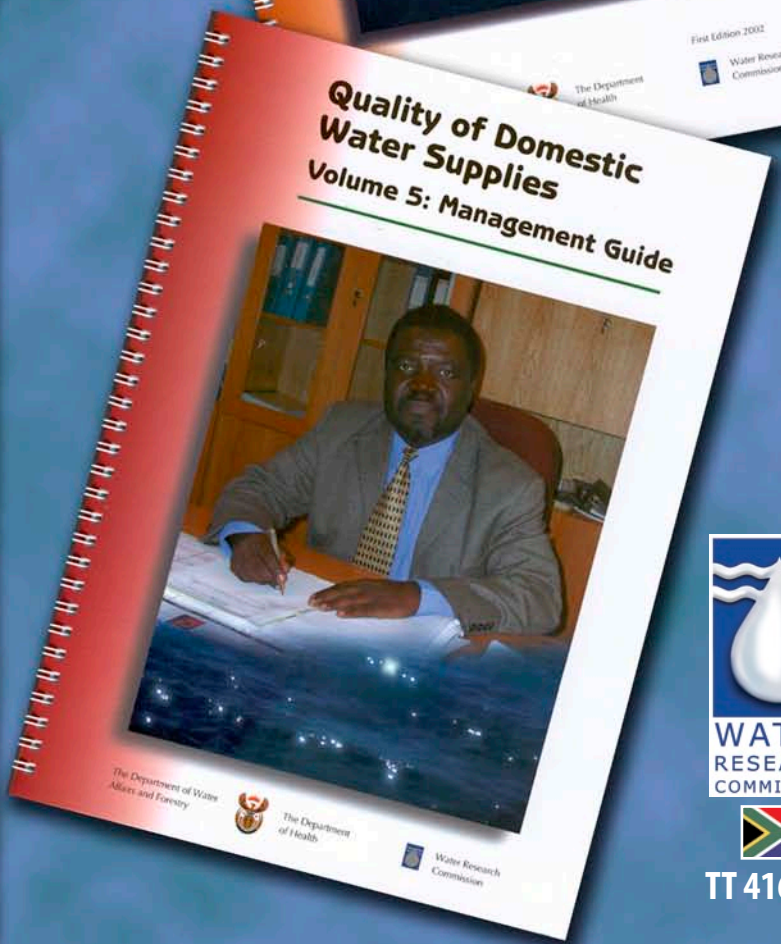
S Shiri & D Winter











WATER RESEARCH COMMISSION

TT 416/09

DOMESTIC WATER QUALITY RESEARCH IMPACT ASSESSMENT

S Shiri & D Winter

Report to the
Water Research Commission

by

Frost & Sullivan

WRC Report No. TT 416/09

March 2010

Obtainable from

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1. Introduction

South Africa is a water scarce country. There is a need to utilise available water resources efficiently to ensure its availability for all South Africans at an acceptable quality and quantity. Metropolitan areas are experiencing increasing levels of urbanisation and South Africa's population is growing, which places significant pressure on existing sources of water. Currently there are approximately 6 million people in South Africa without access to safe drinking water, which has significant health implications for these communities.

South Africa has subscribed to the United Nations Millennium Development Goals (UNMDG) regarding access to water and sanitation. Some of these goals, which need to be met by 2015, focus on access to potable water but without innovative management solutions, it is unlikely that they will be met. The South African National Standards for drinking water (SANS 241-2001) prescribe standards for the numerous physical, microbiological and chemical parameters of water suitable for drinking purposes.

Small water service providers do not have sufficient resources to carry out the various stages involved in the analysis of water quality and therefore the Water Research Commission (hereafter referred to as WRC) has conducted numerous research projects on the subject of domestic water quality. In 1998, it released the first of five user-friendly Quality of Domestic Water Supplies guidelines, hereafter referred to as "the guidelines". These guidelines focus on the management of water quality in the domestic environment.

In an effort to retain and strengthen its position as a "value for money" institution delivering research and innovations that contribute to socio-cultural, economic, political, technical and environmental aspects in South Africa, the WRC has embarked upon a number of studies to assess and portray the impact of its research programmes and resulting products and their benefits to the country.

The WRC has limited capacity to conduct such evaluations, hence it has commissioned international growth consulting company Frost & Sullivan to support it on a review of selected research products / programmes, one of which is within the area of domestic water quality related research.

1.1 Project Aim and Objectives

Project Aim

The aim of this project is to provide the WRC and its stakeholders with a concise assessment of the impact (to date and future potential impact) of the WRC *Quality of Domestic Water Supplies* guidelines research investments and products on socio-cultural, economic, political, technical and environmental aspects of South African society.

Project Objectives

- **To map the full extent of domestic water quality research funded by the WRC since 1971.**
- **To outline the application (to date and expected future application) of the research and products in South Africa (and internationally if relevant).**
- **To determine the impact of the research and products (as per the project aim above).**
- **To relate the outcomes / impact of the developed products to a common measure such as "Rand value of research product impact".**

1.2 Project Scope

This section outlines the geographic and technical scope of this project.

Geographic Scope

This project considers the impact of WRC domestic water quality research projects in all regions within South Africa. However, where international applications of WRC research and sales of funded products were apparent, these were also incorporated in the analysis.

Technical Scope

This project considers and evaluates all research projects and products (defined as: reports, guidelines, publications, techniques, methodologies, software, hardware, equipment, plant and registered patents) developed by the WRC since 1971 which relate to domestic water quality.

1.3 Consulting Approach and Methodology

For consulting projects, Frost & Sullivan utilises tried and tested marketing techniques to provide structure to the research and its results, which allows the effective analysis, review and comparison against industry benchmarks.

The project was carried out using primary research (telephone or face-to-face interviews) and secondary (published and online material) research as the principle methods of data gathering.

Frost & Sullivan interacted with the following respondent groups and stakeholders:

Organisation Type	Target Designations	Type of Information
Water Research Commission	Research Managers and Programme leaders	Research projects conducted Products developed Application of products
Research Institutes (Universities / Consultants)	Project Leaders, Researchers and Lecturers	Water research provided Water related products developed
Government Departments	Policy Directors, Communicable Disease Director, Environmental Health Director, DWAF	Alignment of WRC projects and policy development Impact of research on water management
NGOs	Programme Managers, Environmental Activists	Awareness of WRC research Importance of WRC research to national and local water management
Associations / Other	Industry Specialists, Consultants, Associations	Perceived impact of WRC products Supporting information to substantiate findings

The focus of the interviews predominantly included the respondent groups outlined below.

Primary Participants *	Other Respondent Groups *
Interviews with primary participants ▪ **Local authorities and water boards (15)** ▪ **Tertiary institutions (5)** ▪ **Water consulting firms (4)**	**Interviews with other participants involved:** ▪ **Researchers (4)** ▪ **Non-governmental organisations (1)** ▪ **Government departments (3)**

Total interviews: 32

* Most respondents were contacted on more than one occasion to verify specific information.

1.4 Overview of WRC

The WRC is a statutory organisation established in 1971 by an Act of Parliament. The organisation represents a dynamic hub for water-centred knowledge, innovation and intellectual capital. The WRC provides leadership for water-related research and development through the support of knowledge creation, transfer and application. The WRC engages stakeholders and partners in solving a wide variety of water-related problems, which are critical to South Africa's sustainable development and economic growth.

Funding its projects through levies on national water sales, the WRC faces many challenges including: the creation of appropriate and relevant new water-centred knowledge, the dissemination and application of research, network creation and knowledge building capacity.

1.5 Background to the Quality of Domestic Water Supplies Guidelines

Since 1986, the WRC has undertaken research projects aimed at the analysis, treatment and management of water for domestic use. Figure 1 below provides an overview of some of the domestic water quality related reports that have been produced by the WRC between 1986 and 2008. Please note that the figure below should be read in conjunction with Appendix 1.

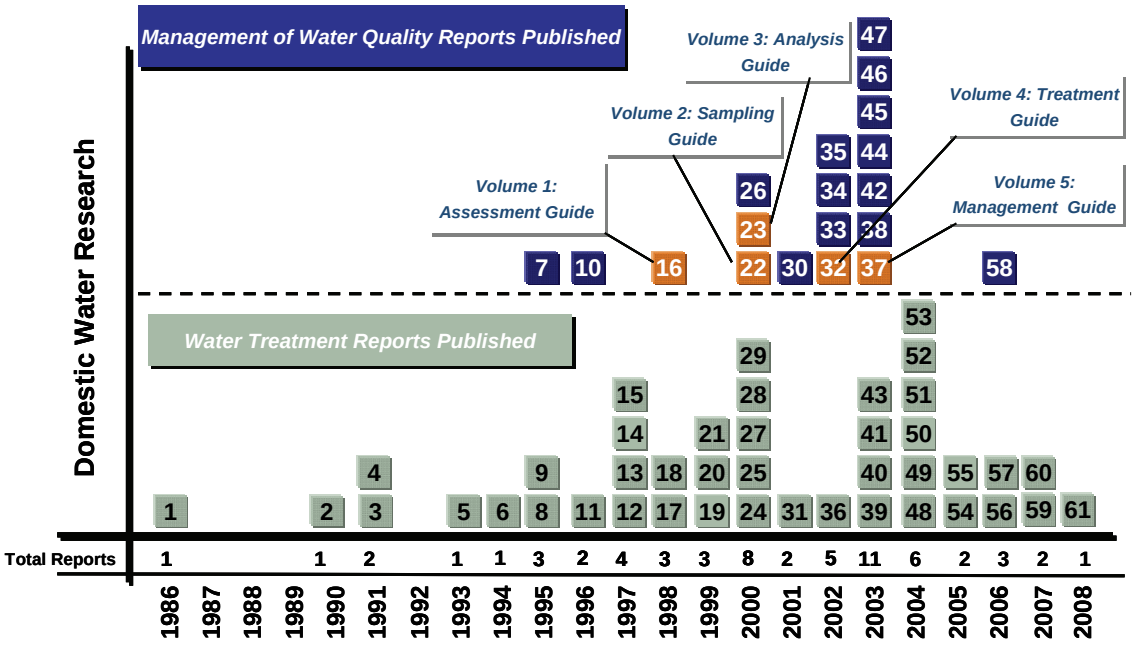


Figure 1: ***Summary of WRC water research projects***

One of the government's goals is to provide an adequate and safe water supply to all citizens. To achieve this goal, the Department of Water Affairs and Forestry (DWAF) realised that there was a

need to compile a user-friendly guide to facilitate the evaluation of health-related water supply quality issues, after the drilling of boreholes and supplying communities with access to water. This resulted in the production of the first edition of "A Guide for the Health Related Assessment of the Quality of Water Supplies" in 1996. This document presented a simplified classification system which has since been extensively and successfully used in South Africa.

Since the first edition of this guide was published as a consultative document, it was decided to revise and expand the document into a new more user-friendly edition to accommodate the constructive ideas and input from various stakeholders who found the guideline useful. As a result, the WRC took the initiative in partnership with DWAF and the Department of Health and produced the five-series guide on the Quality of Domestic Water Supplies.

Figure 2 depicts the time frame during which the five guidelines were published by the WRC

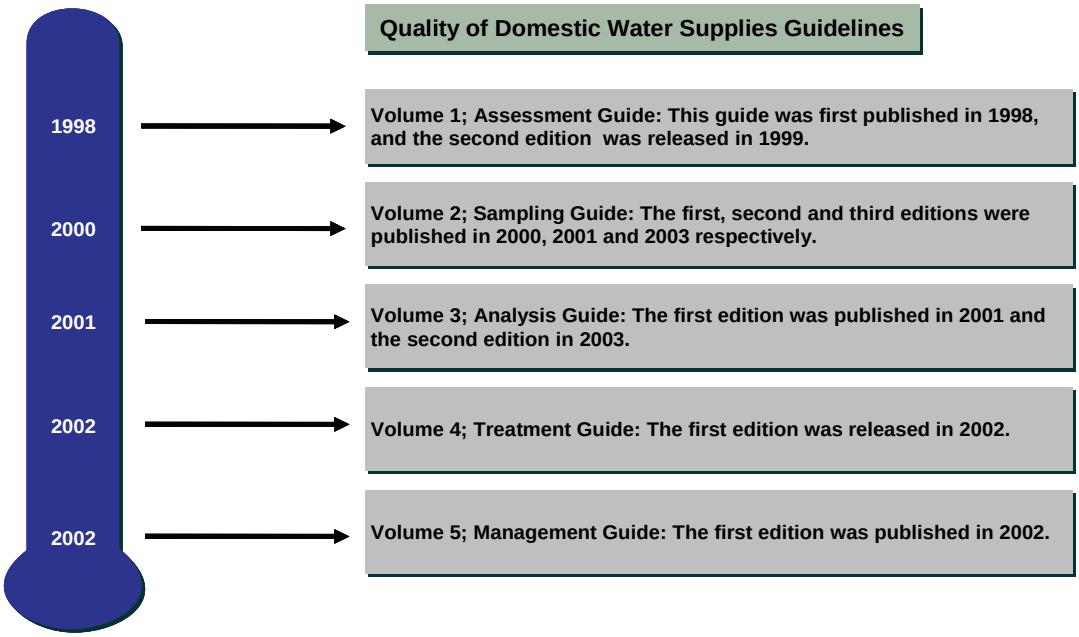
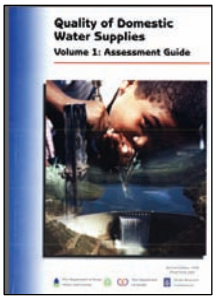


Figure 2: ***Guidelines publication dates***

1.6 Overview of the Quality of Domestic Water Supplies Guidelines

Volume 1: Assessment Guide

Part 1
Procedure to Assess and Interpret Domestic Water Quality
Part 2
Water Quality Guidelines

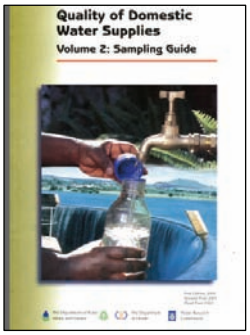


The **Assessment Guide** looks at the overall state of domestic water. It takes into account issues such as the composition of water in terms of the microbiological, physical and inorganic chemical properties, how to take samples of water and how to treat water to an acceptable quality level for domestic use.

This guide allows the quality of water supplied for domestic use to be assessed by using a simple, colour-coded classification system. The manual shows the nature of the effects of water quality on the domestic user for a range of concentration values for those substances commonly found in water.

Volume 2: Sampling Guide

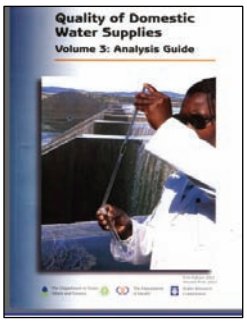
Part 1
General information on the objectives and concepts of domestic water quality sampling
Part 2
Planning of the sampling programme
Part 3
Preparing for the sampling exercise
Part 4
Sample collection



The purpose of the **Sampling Guide** is to provide information on the correct procedures that must be followed to collect a representative water quality sample from a water supply intended for domestic use.

Volume 3: Analysis Guide

Part 1
General Information on Water Quality Analysis
Part 2
Planning, Preparing for and Performing the Analysis
Part 3
Quality Assurance Considerations

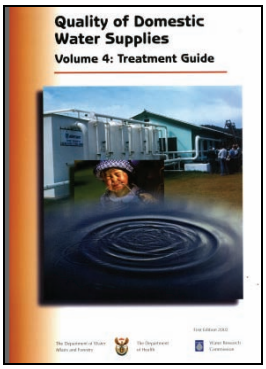


The purpose of the **Analysis Guide** is to provide general information on water quality analysis with specific reference to the following:

- General overview of analytical methods for the analysis of water for domestic use
- The suitability and limitations of different methods of analysis
- Characteristics of substances of concern in domestic water and units in which they are expressed
- The concept of uncertainty associated with water quality analysis
- Quality assurance in water quality analysis

Volume 4: Treatment Guide

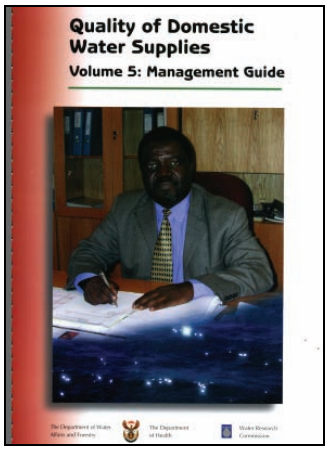
Part 1
General Aspects of Water Treatment
Part 2
Conventional Water Treatment Processes
Part 3
Point-of-Use Treatment Processes
Part 4
Package Water Treatment Plants
Part 5
Advanced / Specialised Treatment Processes
Part 6
Specific issues in Water Treatment: Management, Treatment Problem, Safety, Fluoridation and Waste Disposal



The purpose of the **Treatment Guide** is to provide general information on the treatment of water for domestic use. The main objective of this guide is to empower people to make informed decisions about the selection of treatment processes and the management of treatment plants under their control in order to ensure the sustainability of their water supplies.

Volume 5: Management Guide

Part 1
General Information on the Concepts of Domestic Water Supply
Part 2
Institutional Responsibilities – Who Does What?
Part 3
Water Supply Infrastructure
Part 4
Something Has Gone Wrong – What Now?
Part 5
Decision-Making Hierarchy
Part 6
Management Concepts
Part 7
Capacity Building



The purpose of the **Management Guide** is to provide guidance on domestic water issues with regards to the planning of new domestic water supply scheme operations and the management of a domestic water supply. The guideline also highlights actions that should be taken in the event that something goes wrong at selected points in the domestic water supply system.

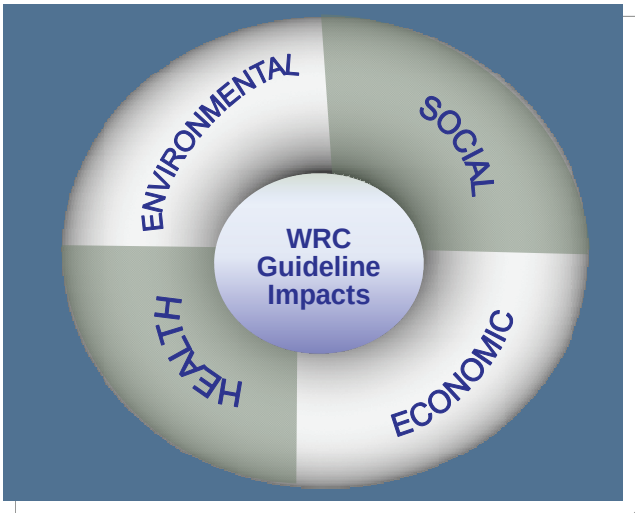
2. Impact of Quality of Domestic Water Supplies Guidelines

2.1 Impacts

The WRC guidelines have had both qualitative and quantitative impacts on South African society. Since the first guideline was published in 1998, tertiary institutions, water research consultants, local authorities and other water services providers have been using these guidelines in different water-related applications.

Certain impacts are simply defined, assessed and quantified. There are particular instances, however, where the assessment and quantification of impacts is more difficult. In cases where a perceived impact is not easily quantified, a qualitative assessment is provided.

The impacts can be classified according to economic, social, environmental and health aspects of society, depending on how and in what context the guidelines were utilised.



Water Quality Standards:

One cannot attribute all the improvements in water quality solely to the use of the WRC guidelines. Water services providers also use other water quality management tools and standards such as the South African National Standards (SANS 241) and the World Health Organisation (WHO) “Guidelines for Drinking-water Quality”.

However, unlike SANS 241, water services providers are not mandated to use the WRC guidelines. As a result, many local authorities are aware of the guidelines but have never put

them to proper use because they are not obliged to use them.

	WRC "Quality of Domestic Water Supplies" guidelines	SANS 241 Water Quality Standards	World Health Organisation, "Guidelines for Drinking-water quality"
Overview	WRC guidelines that focus on the assessment, sampling, analysis, treatment and overall management of domestic water supplies in South Africa.	SABS drinking water quality standards that focus on microbiological, physical, organoleptic and chemical water parameters at the point of delivery in South Africa.	A global tool used as basis for regulation and standard setting for drinking water. Focused on microbial safety and guideline values for chemical hazards. Later editions have included improved risk assessment and management tools.
Target audience	Water Supply Organisations, Environmental Health Officers, Educational Institutions, Water Resource Developers, Domestic Water Users, Treatment Plant Operators.	Water supply organisations, Environmental Health Officers, Education institutions, Water Resource Developers, Treatment Plant Operators.	Policy Makers, Water Supply Organisations, Water Resource Developers, Treatment Plant Operators.

Figure 3: Comparison of WRC Guidelines to other Water Treatment Tools

2.1.1 Assumptions

It should be noted that the impact of the WRC guidelines has been assessed as defined in the project scope. These guidelines can only be used in the assessment and treatment of domestic water and not for any other purposes. The diagram below indicates the portion of the water supply chain where the guidelines can be utilised.

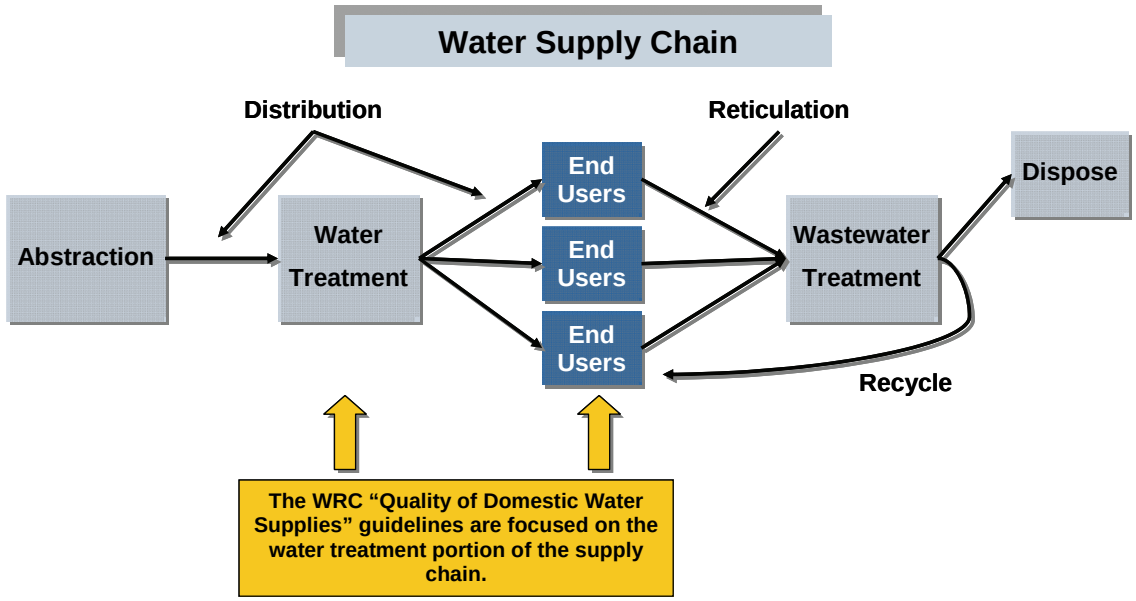


Figure 4: Water Supply Chain

Environmental Impacts:

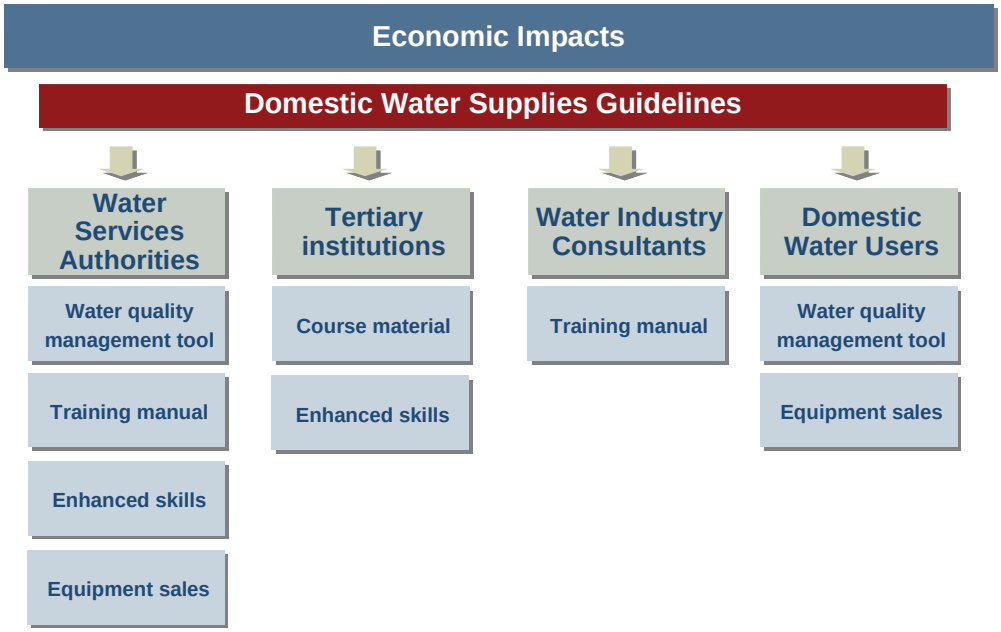
Environmental impacts have not been included in the scope of this research project. This is because domestic water is typically treated to levels that are acceptable for drinking standards and there are no documented cases where poor quality of domestic water has resulted in land contamination or any other environmental costs. For this reason, the impact of the WRC guidelines on the environment was not considered in this report.

2.2 Economic Impacts

2.2.1 Introduction

The South African water sector is challenged by inefficiencies, which are exacerbated by chronic shortages of trained personnel. Key development areas that government must focus on to alleviate this problem are skills development and capacity building.

The WRC guidelines have had a broad array of economic impacts ranging from their use as training material to the enhancement of skills within the South African water sector. The following are some of the economic benefits that have resulted:



2.2.2 Impact Assessment

A core focus of this project was to assess the current and potential economic impact of the WRC guidelines on South African society and efforts have been made to quantify the impact that they have had on the local economy. The guidelines are being used in different water-related applications and many stakeholders have derived economic benefits from them.

Enhanced Skills

Water services providers have been using the guidelines to train their plant operators and water quality managers. For local authorities that have used the guideline information, it has helped to alleviate the skills shortage that has been affecting the water treatment sector.

Course Material

Tertiary institutions have been utilising the guidelines as course material for students who are completing water-related courses. This has helped to bridge the gap between the inexperienced graduates that tertiary institutions have been producing and the skilled personnel required in the water industry. The use of the guidelines has helped to equip students with the necessary skills required and most graduates have easily found work. This has helped to reduce the shortage of skilled personnel that has been hampering the water services sector.

About 8,000 copies of the Assessment Guide (Volume 1) were sent to high schools. The guidelines are being used in schools as reference material for their water quality assessment projects and the WRC has been receiving regular requests from parents regarding information on water quality to assist children in their learning.

Water Quality Management Tool

Water service providers are mandated to supply water of a particular standard to domestic users. This is achieved through the use of water quality standards that have been set by government. SANS 241 are the South African domestic water quality standards that were established to ensure that the water supplied to the public is of an acceptable quality.

These SANS standards prescribe exactly what the quality of domestic water should be, but do not stipulate how these standards can be achieved. This is where the scope of the WRC guidelines falls. The guideline documents outline how water should be assessed, sampled, analysed, treated and managed with a view of achieving SANS 241 standards, as the guidelines complement these standards. Therefore, if used correctly, they can be an effective water quality management tool.

Training

Water service providers and water consulting firms have been using the guideline information for training. Most of the training has been done to equip plant operators and water quality managers with the necessary skills required in the water treatment industry. In addition, local authorities and water boards have also been using the information as an internal training manual and in some instances it has been used for induction training.

The diagram below outlines some of the water service providers that are using the guidelines. However, it should be noted that some of the local authorities are not directly responsible for providing water services. This is typically the case in areas where domestic water is supplied by water boards.

Table 1. Examples of water service providers that are using the guidelines

Water Service Authorities	Application
Scientific Services (City of Capetown)	• **Water quality management** • **Internal training manual**
Moses Kotane Municipality	• **Water quality management**
Ndlambe Municipality	• **Training manual for plant operators**
Adjunk Municipality	• **Water quality management**
Midvaal Water Laboratory	• **Water quality management**
Kungwini Municipality	• **Water quality management** • **Reference manual for students on industrial attachment**
Umgeni Water	• **Water quality management**
Sedibeng Water	• **Training material for community based organisations (CBOs)** • **Training manual for students on industrial attachment**
***Mvula Trust**	• **Training of CBOs and members of the community** • **Policy formulation**
Hessequa Municipality	• **Water quality management**
Ladysmith Municipality	• **Water quality management**
Durban Metro	• **Water quality management** • **Induction training** • **Training manual for students on industrial attachment**

**Mvula Trust is a non-governmental organisation that deals with water and sanitation issues*

Water industry consultants have been using the WRC guidelines to train members of the public, municipalities and other relevant stakeholders who deal with water-related issues. Further, a number of seminars / workshops have been held by private consultants to train water quality managers and plant operators. The guideline information has been used as the primary reference material.

For example, Chris Swartz Engineers, a water consulting firm, has been using the information as a training manual for municipal water managers. Between April 2007 and March 2008, the company held training workshops with all municipalities in the Western Cape Province utilising the guidelines as the primary course material. DWAF also utilise the information for training purposes with water service providers.

Courses on domestic water quality that were based on the guidelines have been presented on two occasions outside South Africa. In 2007, the South African government decided to extend help to the countries that had been affected by the Tsunami disaster and these included Sri Lanka, Somalia and the Maldives Islands. As part of this initiative, a training workshop on Water

Resource Management was conducted in the Maldives Islands. This was done against the background that there are no roads and rivers in the Maldives, groundwater is the only source of water and is vulnerable to contamination. Nineteen people participated in the training workshops. The Assessment Guide was used as the main reference material and upon course completion each participant received a copy of this report.

In 2004, BKS Consulting Engineers conducted a training workshop on Water Supply and Sanitation to the Ugandan Ministry of Water and Environment. The workshop targeted personnel from the laboratory at Entebbe where water samples are analysed and the quality assessed. The Assessment Guide was used as the main reference material for this one-day course and each of the 20 participants got a copy of the guideline on completion of the workshop. A full set of guidelines was given to the Director.

In addition, the WRC has received requests for the Assessment and Sampling guides from farmers and other owners of small-scale water treatment plants.

Water Treatment Equipment Sales

The use of the guideline reports in some municipalities has contributed to water treatment equipment sales. For municipalities that have been experiencing water problems, the use of the guidelines has, to a large extent, contributed to the setting up of water treatment plants in those areas. Such municipalities include Ndlambe in the Eastern Cape and Ladysmith in the Western Cape.

In some communities where water shortages have been prevalent, members of the community have resorted to setting up their own water treatment plants. These communities are able to operate their small-scale plants through the use of the guideline documents. For example, communities in Ndlambe in the Eastern Cape Province have set up small-scale water treatment plants and are using the guideline information to monitor and manage their domestic water quality.

Observed Failure to Use The Guidelines:

Certain stakeholders are not using the guidelines for the following reasons:

- Some municipalities have never received the guidelines and are not aware of their existence.
- Other municipalities have received the guidelines but have not put them to proper use.
- Some municipalities have also indicated that the guidelines were not designed for bulk water treatment plants; they find the guidelines are too simple for their operations.

2.2.3 Case Study

Introduction

This case study outlines the use of the guidelines at the Ndlambe municipality.

Ndlambe is a small municipality located on the south-eastern coast of the Eastern Cape Province. It incorporates the formerly independent towns of Bathurst, Alexandria, Boknes, Bathurst, Bushmansrivermouth and Kenton-on-Sea. Agriculture and tourism are the most dominant economic activities in this area.

Study Site

Background and Overview

The Ndlambe municipality has faced chronic water challenges in the past decade, as the water in this area is highly saline. This has negatively affected agricultural and other economic activities. Because of these water problems, companies such as Clover, which were operating in the area, have relocated and the number of tourists visiting this area has also been declining.

Utilisation of the Guidelines

Training Manual

The municipality has been using the guidelines as a training manual for their plant operators as well as for their daily plant operations. This has helped them to maintain and upgrade the skills required for operating the municipality's water treatment plant.

Water Quality Management Tool

Plant operators have been using the guideline information to assess and monitor the quality of water supplied to domestic users. This has helped them realise that their water is below the standards required for drinking water purposes, and have been looking at ways to solve this problem. The guideline series has also been used to assess the feasibility of using other advanced water treatment technologies that can produce better water quality.

Water Treatment Plant

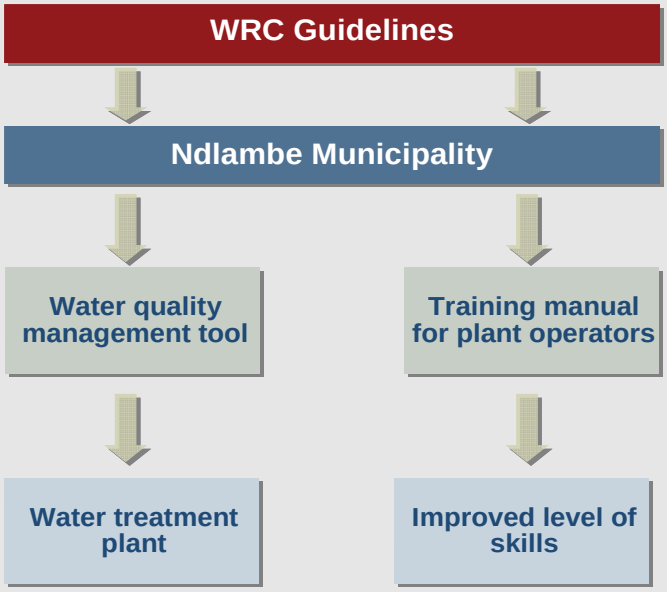
The municipality has been using the WRC guidelines extensively as a water quality management tool and this has contributed to the municipality's decision to build a new water treatment plant. The municipality has recently commissioned VWS Envig, a water treatment equipment company,

to supply them with a desalination plant. The plant will employ reverse osmosis technology and will supply water to the communities of Boknes and Cannon Rocks. The project is expected to be completed by May 2009.

Plant operators at Ndlambe Municipality use the guidelines as an internal training manual and for assessing and monitoring the quality of water.

Currently the water is highly saline and the municipality has realised a need to commission a desalination plant.

The use of the guidelines as a water quality management tool has contributed to the municipality's decision to set up a desalination plant.



Project Details	
Estimated cost	R2.7 million
Capacity	700 kl/day
Expected completion date	May 2009
Source of water	Seawater
Technology	Reverse Osmosis

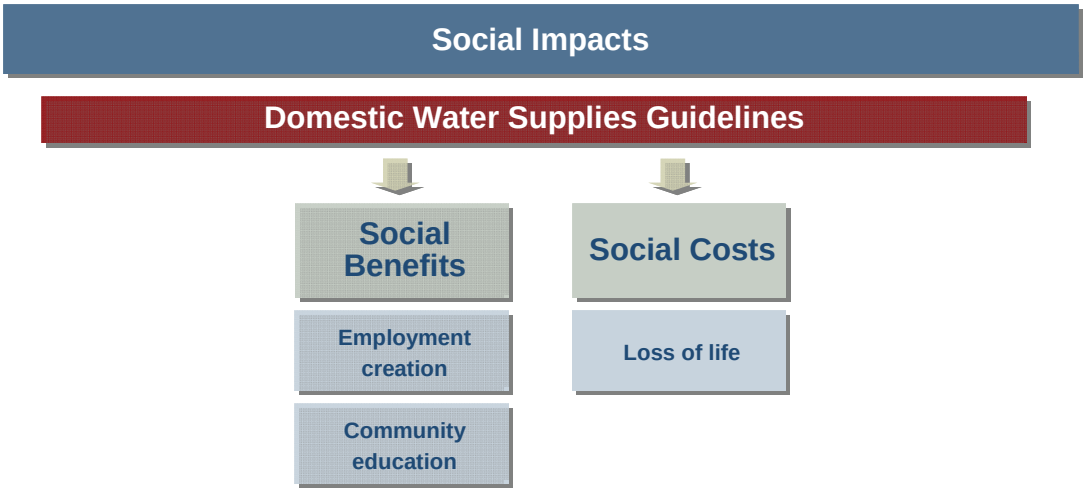
In addition, residents of this community have resorted to setting up their own small-scale water treatment systems. Water treatment equipment such as UV and ultra-filtration is being used to treat domestic water at household level. Members of this community are using the guideline information as the main reference material in the operation of these small-scale treatment plants.

2.3 Social impacts

2.3.1 Introduction

Water quality and access to potable water is central to South African society. The Constitution clearly states that everyone has the right to safe water. Historically, access to potable water within South African communities has been limited and increasingly, with skill shortages within the water sector, water providers are faced with water supply challenges.

The WRC guidelines have impacted South African society from a social perspective and there are also examples where failure to use the guideline information has resulted in social costs.



Social benefits have arisen from the use of the guideline documents through access to better water quality, employment creation, enhanced skill levels and hence improved living standards. However, in instances where authorities have not been using this information, there have been outbreaks of water-borne diseases which have resulted in the loss of lives.

Regarding microbiological water qualities, the WRC has developed another five-series guideline addressing specific issues on microbial pollution and microbial water quality management. The first four volumes of these guidelines are already available for use at water treatment plants and volume 5 is expected to be available by the end of 2009 and will be specifically target domestic end-users.

2.3.2 Impact Assessment

Loss of Life

Poor water quality, together with inadequate sanitation, has been the main cause of deaths in impoverished communities. The quality of water is described by the levels of microbiological, physical and chemical properties which determine its fitness for use. Excess levels of chemicals and microbial organisms in drinking water may be harmful to people's health.

Water service providers use the WRC guidelines to assess the quality of water and to determine its suitability for domestic use. However, failure to use this information in some cases has resulted in authorities being unable to detect the presence of disease-causing organisms in drinking water. Babies, children, the elderly and people who are living with HIV/AIDS are the most vulnerable groups when it comes to high levels of metal content in drinking water.

High levels of total coliforms in drinking water cause diarrhoea, which is a life threatening disease to infants. In a recent case, approximately 78 infants were reported to have lost their lives from diarrhoea as a result of poor domestic water quality. This occurred between January and April 2008 in the Ukhahlamba District in the Eastern Cape Province. Details of this case are given in later sections of this report.

Community Education

Non-governmental organisations focusing on water, sanitation and environmental issues use the guidelines to train community-based organisations and members of the community on how to manage domestic water quality. Mvula Trust and Sedibeng Water are some of the organisations that have been using the guideline information for community-based training and capacity building.

> *'I find the guidelines very easy to understand, the colour coding makes it easier to demonstrate to communities the acceptable levels of water quality required,'* **Dr. Goldie, Water Consultant**

A further example occurred in June 2008 when the Durban Metro received complaints from members of the community that their domestic water was discoloured. It was discovered that the water colour was turning brown because of the rising level of manganese. The local authority used the guideline series to explain to members of the community what this meant and how it was going to affect them. The guideline documents helped solve the problem quickly and effectively.

Employment Creation

Tertiary institutions in South Africa are utilising the guideline series as course material. Civil engineering, bio-technology and other related water-subject students are being equipped with the necessary skills required by the water treatment industry. This has contributed to alleviating skill shortages and the practical nature of the guidelines is a welcome addition to typically theory-focused curriculums.

Water service providers (Durban Metro, Sedibeng Water and Kungwini Municipalities) utilise the guideline information as a training manual for students who are completing internships. The students are from universities such as the Durban University of Technology, Mangosuthu University of Technology, Tshwane University of Technology and other technical universities across the country. The information is being used for induction training as well for reference material during the students' internship periods.

'Since we started using the guidelines, I do not know of any student who has struggled for a long time to get a job. And I believe that in the next 2 years, our students will get jobs even before they finish their degrees because there is so much demand for them out there...,' **Mr. Sieg Schwartzer, Tshwane University of Technology.**

'The guidelines are colourful and easy to understand. The colour coding helps students understand when they are doing their practical lessons. The students also receive a copy of each guideline so that when they are in the field and start working, they are still be able to use the guidelines,' **Mr. Kobus du Plessis, Stellenbosch University.**

2.3.3 Case Study

Introduction

The South African water treatment industry is faced with a shortage of skilled staff with the necessary technical expertise to operate and manage water treatment plants. Qualified and experienced personnel are moving to the private sector or leaving the country to secure employment in more developed economies. This has negatively affected municipal operations.

The rate at which qualified graduates are entering the water treatment industry is far below the required level to curtail current skills shortages. Most of the graduates also lack the expertise and experience required to operate advanced water treatment technologies.

Background and Overview




The use of the guideline documents in tertiary institutions has helped equip graduates with the required knowledge and skills required by the water treatment industry. Stellenbosch University, Tshwane University of Technology and Cape Peninsula University of Technology are examples of tertiary institutions that are utilising the guideline information as part of their course material.

Figure 5 below depicts some of the tertiary institutions that have included the guideline content in their course material. The indicated number of students who have graduated refers to students who were studying civil engineering and other water-related courses.

Figure 5: Tertiary institutions using the WRC Guidelines as course material.

Institution	Number of students graduated between 1999 and 2008	Workshops / Seminars held
*Stellenbosch University	200	5
*University of Pretoria	60	-
Tshwane University of Technology	300	-
Cape Peninsula University of Technology	300	-
Total	860	5

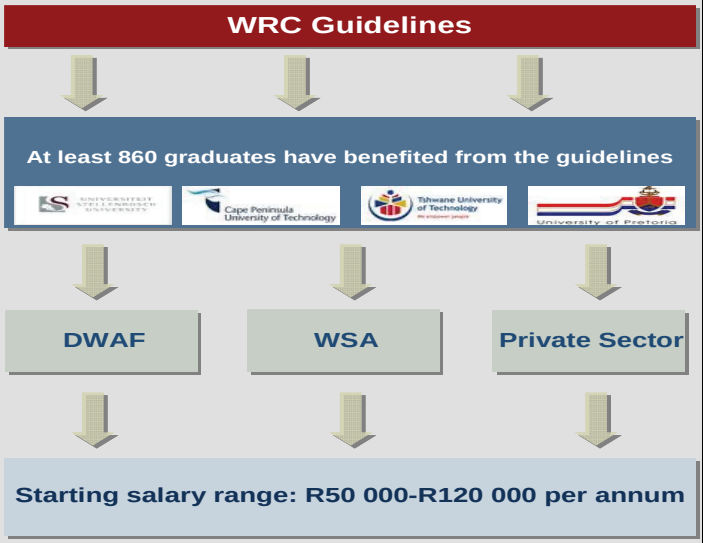
**Stellenbosch University and University of Pretoria started using the guidelines in 2005 and 2006 respectively*

Impact Assessment

Tertiary institutions use the guidelines as course material for students who are studying civil engineering and water related courses. The four universities are examples of institutions that are using the guidelines.

Since the guidelines were published in 1999, the four universities have produced approximately 860 graduates and a significant portion of them are now employed at DWAF, water service authorities and in the private sector.

Salaries differ depending on the sector; the private sector normally offers higher rates than the public sector. Graduate students entering the water sector that are able to demonstrate marketable skills, as derived from the guidelines, will be able to secure employment.



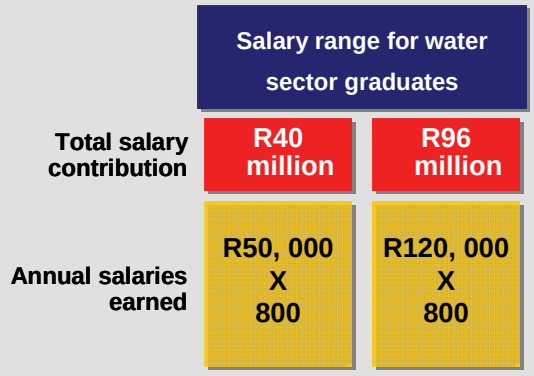


Figure 6: Earning impact potential within water sector

Starting salary ranges from R50 000 to R120 000 per annum and collectively of the 800 graduates who have utilised the guidelines the total salary contribution could range from R40 000 000 to R96 000 000 per annum. These salary contributions could have significant social knock-on benefits for the individual as well as their families.

Tshwane University of Technology

Tshwane University of Technology has included the guideline content in lectures for students who are enrolled in the National Diploma in Water Care. The university has been using this information since 1998 when the Assessment Guide was first published. Before this only the SANS 241 standards were available. The lecturers have indicated that since they started using this information their workload has reduced because they are simpler to understand and students find them to be user-friendly. The students use the guidelines mostly in their practical lessons.

On completion of their diplomas, the students are given a copy of each guideline so that they may use them when working in the water sector. To date, at least 300 students have graduated and many of them have found employment at water treatment plants, laboratories and also at DWAF.

Stellenbosch University

Stellenbosch University uses the guideline information in the Civil Engineering Department for students who are completing courses on water and wastewater treatment. They have also used them when conducting training courses.

For example, the University of Stellenbosch organised a training course on Water and Wastewater Treatment. The workshop was conducted from the 3rd to the 6th of November 2008 in the Western Cape and the aim of the workshop was to train engineers and water treatment managers on the advanced methods that are currently being used in the water industry.

70 participants attended the workshop which included civil, electrical and chemical engineers as well as students. Municipalities, Water Boards and other private stakeholders were also represented. Professionals in the water treatment industry and other water consultant firms presented on different water-related topics. Thirty copies of each guideline document were distributed during the workshop, apart from those that were distributed electronically.

Cape Peninsula University of Technology

The university uses the guideline content for students who are studying courses on water quality and bio-technology (purification and reclamation of water).

Apart from the lectures, the students also use the guideline information when undertaking research projects on measuring the effectiveness of different water technologies. The university has been utilising the guideline documents since 1998, and 300 students have graduated to date.

University of Pretoria

The University of Pretoria has been including the guideline information in their course material for students who are undertaking water treatment and environmental management studies. Of the five guidelines, they have found the Treatment and Assessment Guides to be the most useful. Although the guidelines are only used as reference material, they have been found to be very useful for practical lessons and practical applications after the students have graduated.

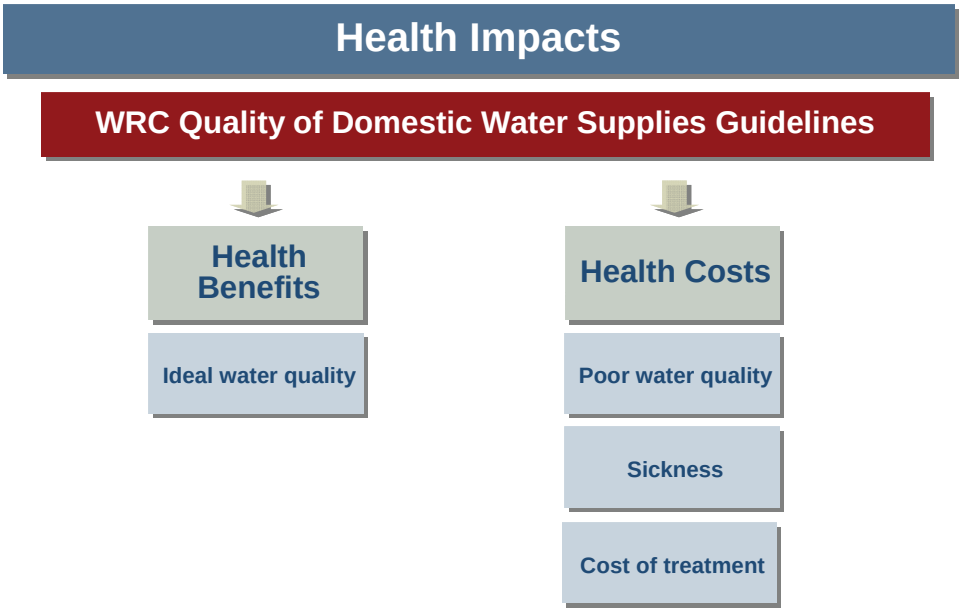
To date, the university has produced approximately 60 students since they started utilising the guideline information about four years ago.

2.4 Health Impacts

2.4.1 Introduction

There is a strong link between access to potable water supplies and the overall health levels of a population. Communities that have access to safe drinking water face lower levels of risk with regard to water-borne diseases. This reduces both the health and opportunity costs for these communities.

Below are some of the health benefits that have been derived from utilisation of the guideline series. However, in some instances where water authorities have failed to use the information contained in the guideline series, poor water quality has impacted negatively on human health.



2.4.2 Impact Assessment

High Water Quality

The effective use of the WRC guidelines has led to improved water quality being supplied to domestic users. The guideline information has been used to interpret water quality information to determine its suitability for domestic use. In instances where domestic water quality was discovered to be poor, the information has been used to assess other water treatment options available to improve water quality. The supply of acceptable water quality to communities has also led to a reduction in the outbreaks of water-borne diseases.

Poor Water Quality and Sickness

Failure to use the guideline information has, in some instances, led to the supply of poor water quality to the public. Poor water quality is described by high levels of microbiological, physical and

chemical properties. High levels of chemicals and organisms in water can render it unfit for domestic use. The guideline documents have been used to determine the levels of chemical substances and organisms that are acceptable for domestic water which may lead to acute or chronic health problems.

Cost of Treatment

In instances where people have fallen sick as a result of poor water quality they have had to spend a lot of money seeking medical treatment. This can also be quantified in terms of the opportunity cost of not being able to work.

2.4.3 Case Study:

Introduction

The case study below depicts how poor water quality led to an outbreak of diarrhoea in the Ukhahlamba District.

Background and Overview

Between January and April 2008, 78 babies were reported to have died of diarrhoea in Ukhahlamba District and the surrounding towns of Sterkspruit and Barkly East. Health authorities also reported that 27 babies from Chris Hani District Municipality and Makhana DM had also died of diarrhoea in the first quarter of 2008. Poor water quality was established to be the main cause of the deaths.

Impact Assessment:

Poor Water Quality

Although the investigating team could not get laboratory results from the stool samples that could shed some light on the possible causes of the diarrhoea, it was evident from the epidemiological investigation that the water quality could be a major contributing factor considering that the water quality results recorded from the monthly sampling programme showed the presence of the bacteria causing diarrhoea (*E. coli and Coliform)* between October 2007 and March 2008.

Sickness

For the period under review, municipal water was also visibly dirty, which negatively affected the chemical interaction with the chlorine, counteracting its ability to sanitise the water and to make it safe to drink. An epidemiological investigation was done to establish the cause of the deaths. The babies had been diagnosed with diarrhoea, pneumonia and marasmus, which caused their deaths. According to the records from the local clinic and Cloete Joubert Hospital, 94 patients had been treated with diarrhoea symptoms.

3. Conclusions

The Quality of Domestic Water Supplies guideline series have had an important impact across South African society.

The Assessment and Sampling guidelines were found to be the most useful in the water treatment sector. Specifically, these two documents can be used by the public, whilst the remaining three guidelines were designed more for specialised groups of people. Volumes I, 2 and 3 were amongst the most popular reports distributed during 2008.

The guidelines have been used to develop resource quality objectives (in this case water quality objectives) for river catchment management. These resource quality objectives describe the desired state of the water resource and are therefore measurable management goals. These, in turn, are used to determine the standards with which treated effluent and other waste discharges have to comply. In this way the domestic water quality guidelines form an essential part of the implementation of integrated water resource management.

From an **economic** perspective, equipment sales, training and the enhancement of skills and education purposes are some of the economic benefits that South African society has derived. A significant number of water service authorities are using the guideline information as a training manual which has helped to enhance the level of skills in the water treatment industry, while tertiary institutions are using it as reference material for students.

Employment creation and community education are some of the **social** benefits that have been derived. The guidelines have been found to be user-friendly, even to non-scientific readers, and the colour coding approach has helped people to quickly grasp concepts of water quality assessment and management. Non governmental and environmental organisations have been using the information for training purposes and capacity building workshops with local communities.

From a **health** perspective, an improved level of water quality was identified as a key impact area. In cases where the guideline information has not been used, there have been reported cases of poor water quality that have led to infant deaths and illnesses.

All of the impacts identified during this project indicate that the Quality of Domestic Water Quality guideline series have had a positive impact across economic, social and health aspects of South African society.

4. Appendix 1

Project Number	Year	Code	Research Report Title
1	1986	TT 24/86	Softening and stabilisation of municipal waters
2	1990	337/1/90	Removal of algae from water by ultrafiltration
3	1991	202/1/91	Dissolved air flotation for the pretreatment of eutrophied surface water for potable use
4	1991	244/1/91	Development of a two-stage counter-current powdered activated carbon-dissolved air flotation system for the removal of organic compounds from water
5	1993	321/1/93	Research on bacteriophages as indicators of water quality
6	1994	281/1/94	The influence of water quality on the efficiency of chlorine dioxide as pre-oxidant and algaecide in the production of potable water
7	1995	KV 76/95	The removal of invertebrates by sand filtration and the influence thereof on water Quality
8	1995	449/1/95	Non-conventional disinfection technologies for small water systems
9	1995	469/1/95	Studies on microbiological drinking water quality guidelines
10	1996	380/1/96	Tools for microbial water quality assessment of South African Rivers
11	1996	558/1/96	Algal rupture during abstraction from reservoirs and the consequences for water treatment
12	1997	TT 92/97	Water purification works design
13	1997	354/1/97	Evaluation of direct series filtration for the treatment of South African surface waters
14	1997	488/1/97	Optimisation of Rand Water's distribution system
15	1997	557/1/97	Optimization of combined flotation and filtration at a large water treatment plant
16	**1998**	**TT 101/98**	**Quality of domestic water supplies. Volume 1: Assessment Guide**
17	1998	534/1/98	Guidelines for the treatment of Cape coloured waters
18	1998	615/1/98	Modeling the water quality in impoundments within the Umgeni Water operational area and the consequences for potable water treatment costs
19	1999	KV 117/99	Investigation into total organic halogen formation after disinfection of drinking water by chlorine
20	1999	363/1/99	The use of small-scale equipment for evaluating water treatment plants
21	1999	549/1/99	Algal toxins in drinking water supplies
22	**2000**	**TT 117/00**	**Quality of domestic water supplies, Volume 2: Sampling Guide**
23	**2000**	**TT 129/00**	**Quality of domestic water supplies: Volume 3: Analysis Guide**

24	2000	446/1/00	The use of ozonation in combination with lime and activated sodium silicate in water treatment
25	2000	567/1/00	The occurrence, distribution and removal of algal species and related substances in a full-scale water purification plant
26	2000	611/1/00	Procedures for biodegradability testing of organic chemical compounds
27	2000	832/1/00	The application and efficiency of "mixed oxidants" for the treatment of drinking water
28	2000	834/1/00	Photo catalytic purification of drinking water
29	2000	963/1/00	Trouble shooting guide for domestic consumer
30	2001	741/1/01	Entero-pathogens in water; rapid detection techniques, occurrence in South African waters and the evaluation of epidemic risks (health related)
31	2001	921/1/01	Water quality deterioration in potable water reservoirs relative to chlorine decay
32	**2001**	**TT 162/01**	**Quality of domestic water supplies. Volume 5: Management Guide**
33	**2002**	**TT 181/02**	**Quality of domestic water supplies: Volume 4: Treatment Guide**
34	2002	743/1/02	Executive summary: The health impact of waterborne viruses and methods of control in high risk communities
35	2002	833/1/02	Measurement of COD (organics) in drinking waters and tertiary effluents
36	2002	962/1/02	Water quality management for small communities: Decision-support software and guidelines manual
37	2002	1023/1/02	Inhibition of biofilm regrowth in potable water systems
38	2003	TT 205/03	Elementary handbook of water disinfection
39	2003	TT 206/03	WATREX: Expert system for water treatment plant design user manual - Release 5.0
40	2003	831/1/03	Development and implementation of gas and liquid chromatographic organic water profiles as a management tool
41	2003	919/1/03	Optimisation of an autonomous valve-less gravity filter for the cost effective production of potable water for rural areas
42	2003	924/1/03	Characterisation and chemical removal of organic matter in South African coloured surface waters
43	2003	920/1/03	Evaluation of a filter backwash recovery plant to establish guidelines for design and future operation
44	2003	1030/1/03	The evaluation of alternative disinfection processes for the removal of protozoan ocysts and cyst and other micro organisms, in the treatment of wastewater
45	2003	1031/1/03	The occurrence of emerging viral, bacterial and parasitic pathogens in source and treated water in South Africa
46	2003	1067/1/03	Situation analysis of the health-related water quality problems of the Umtata River
47	2003	TT 175/03	Management of Water-related Microbial Diseases Volume 1 - What is the problem? - Disease Characteristics.

48	2004	821/1/04	A study of viable-but-not-culturable pathogens in water
49	2004	1124/1/04	Evaluation of powered activated carbon (PAC) for the removal of taste and odour causing compounds from water and the relationship between this phenomenon and the physio-chemical properties of the PAC and the role of water quality
50	2004	1164/1/04	Assessment of the risk of infection associated with viruses in South African drinking water supplies
51	2004	1070/1/04	The development of small-scale ultrafiltration systems for potable water production
52	2004	1185/1/04	Guidelines for planning and design of small water treatment plants for rural communities, with specific emphasis on sustainability and community involvement and participation
53	2004	1196/1/04	Removal of organic components and bacteria from water by electrochemical combustion
54	2005	829/1/05	A critical evaluation of sand abstraction systems in Southern Africa (Volume 1).
55	2005	TT 12/82 1387/1/05	The application of advanced control techniques in water treatment and supply systems.
56	2006	TT 263/06	Generic Incident Management Framework for Toxic Blue-Green Algal Blooms, for application by Potable Water Suppliers.
57	2006	TT 265/06	Handbook for Waterworks Operation
58	2006	1276/1/06	Prevalence, survival and growth of bacterial pathogens in biofilms in drinking water distribution systems.
59	2007	TT 297/07	Management of Water-related Microbial Diseases. Volume 2: What causes the Problem? - What to do for Water Suppliers Following Diarrhoea Incidents.
60	2007	TT 298/07	Management of Water-related Microbial Diseases. Volume 4: How Dangerous is the Problem - Communicating the Risk
61	2008	TT 323/08	Condensed Laboratory methods for Monitoring Phytoplankton, Including Cyano-bacteria, in South African Freshwaters.