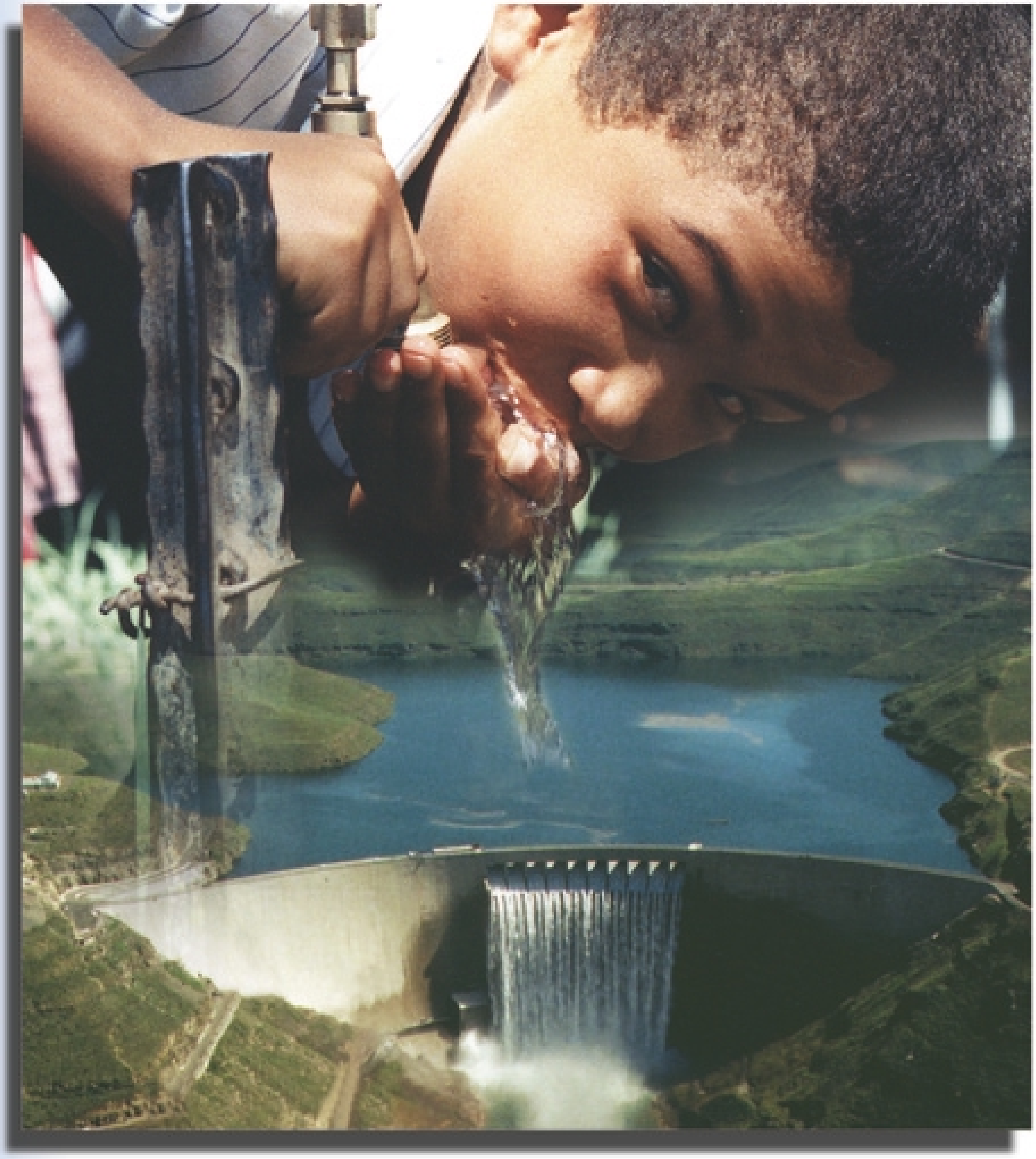
Quality of Domestic Water Supplies

Volume 1: Assessment Guide



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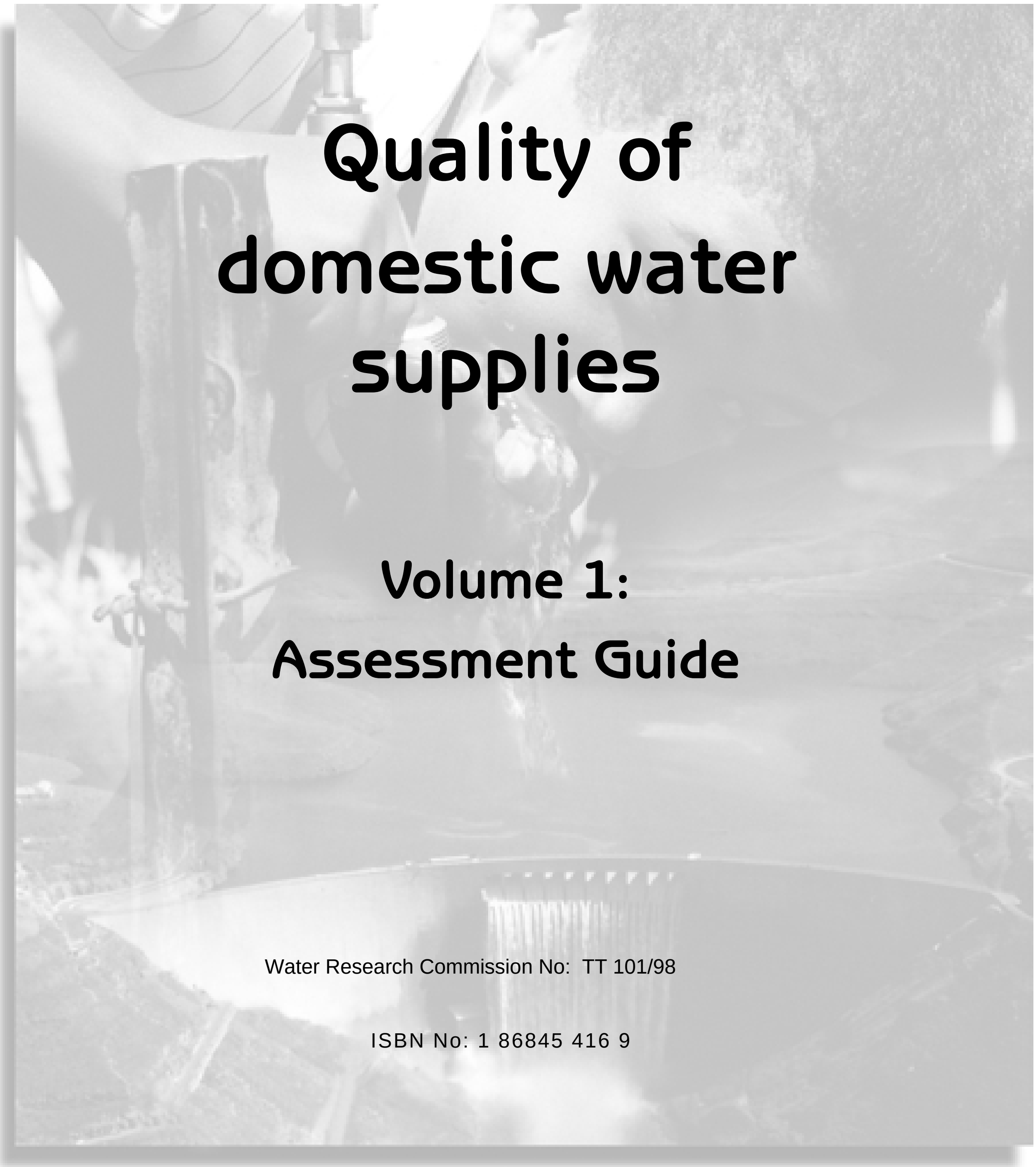

Quality of domestic water supplies

Volume 1:
Assessment Guide

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OTHER REPORTS IN THIS SERIES

This Guide forms part of a series which is intended to provide water supply agencies, water resource managers, workers in health related fields, as well as communities throughout South Africa, with the information they need to sample, analyse, assess and interpret the quality of domestic water supplies. An additional Guide – which will provide further information on the management of domestic water supplies – is also planned.

The following documents form the series:

Quality of domestic water supplies –
Vol: I ***Assessment Guide***

Quality of domestic water supplies –
Vol: II ***Sampling Guide***[1]

Quality of domestic water supplies –
Vol: III ***Analysis Guide***[1]

Quality of domestic water supplies –
Vol: IV ***Treatment Guide***[1]

Quality of domestic water supplies –
Vol: V ***Management Guide***

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[1] Still under preparation

FOREWORD

Without water we cannot survive. Worldwide, tremendous pressures are being placed on water resources due to increasing volumes of domestic, industrial and agricultural wastes as well as other ecological disturbances. The result is pollution of water sources, which in turn may contribute to a rise in water-related diseases. In fact, the World Health Organisation rates poor water quality, together with inadequate sanitation, as the leading causes of death in poorer communities. The quality of water used for domestic purposes and the protection of water resources, particularly in a water scarce country such as South Africa, are everyone's concern.

The provision of an adequate and safe water supply to all people is one of the goals of the South African Government. To ensure the safety of water supplies, a need for a user-friendly Guide to facilitate evaluation of the health-related quality of water supplies was identified as a priority by both the Departments of Health and Water Affairs and Forestry. 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. The document presented a simplified classification system which was widely successful, and has seen extensive use within the country, and has also attracted international interest.

Since the first edition of the Guide was published as a consultative document, it was decided to revise and expand the document into a new edition to accommodate the numerous constructive comments and input received from individuals and organisations that have found the Guide useful. We are thankful for and appreciate these valuable contributions. As a result, the Department of Water Affairs and Forestry and the Department of Health in partnership with the Water Research Commission, have taken the next step along the road towards building capacity to assess the quality of South Africa's domestic water supplies by producing this document.

Particular attention has been paid to ensure a user-friendly Guide. It is aimed at water service developers and suppliers, workers in the health-related fields, and at the communities themselves. As such, the Guide is intended to provide a basis for the planning of water supply schemes in the assessment of the quality of the water supplied, as well as a tool to create an understanding of the concepts behind water quality.

We hope that this Guide will contribute to achieving the goal of providing safe water to all South Africans.

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What is the purpose of this Guide ?

The purpose of this Guide is to answer the questions:

- *Is the water suitable for domestic use?* ***and***
- *If not, what can be done to make it suitable for use?*

This Guide allows the quality of water supplied for domestic use to be assessed by using a simple, colour-coded classification system. The system shows the nature of the effects of water quality on the domestic user for a range of concentration values for those substances commonly encountered in water. The information is presented in a simplified format so that a wide spectrum of users of the Guide will be able to understand the underlying concepts of water quality as it affects the domestic user.

Who should use this Guide ?

The Guide is intended for use by:

- ***Environmental Health Officers*** *– to assess if the water supplied to users is safe and clean.*
- ***Water Supply Agencies*** *– to determine if the water they supply is safe and clean, or if their treatment process needs to be adjusted.*
- ***Water Resource Developers*** *– to assess whether a water source is safe for supply, and if not, whether it could be viably treated to make it safe.*
- ***Educators*** *– to build an understanding of the importance of water quality, and of how to assess water quality.*
- ***The Public*** *– to provide the information they need to decide if the water they are supplied with is of acceptable quality.*

NOTES

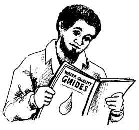
1. The information in the Guide is based on the 2nd edition of the *South African Water Quality Guidelines* (DWAF, 1996) and *Health Guidelines: Drinking Water Quality* (Department of Health, 1995). Please refer to these documents for more information.
2. This Guide is not intended to provide information on the design of water treatment facilities, but is intended only to help make an initial assessment of whether water can be viably treated.

STRUCTURE OF THIS GUIDE

The Guide is divided into two parts. Part 1 describes a procedure to assess and interpret domestic water quality. Part 2 includes water quality guidelines presented in the form of a simple, colour-coded classification system.

Part 1 – Procedure to assess and interpret domestic water quality

Part 1 is divided into five sections. The pages of each section are marked in the top right hand corner with the icon corresponding to that section.



Section A1

General information on the concepts of water quality

Section B1

Collect and process the data

Section C1

Classify the water in terms of suitability for domestic use

Section D1

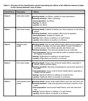
Consider treatment options available to improve water quality

Section E1

Interpret water quality information

Part 2 – Water quality guidelines

Part 2 is divided into three sections. It contains 21 water quality guidelines that deal with the substances most relevant to the assessment of domestic water quality. The guidelines are structured to provide information on:



Section A2

Introduction

Section B2

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PART 1:

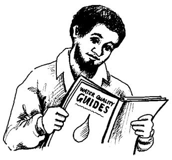
Procedure to assess and interpret domestic water quality

SECTION A1

General information on the concepts of water quality

ROAD-MAP

Section A1
General information on the concepts of water quality



Section B1
Collect and process the data

Section C1
Classify the water in terms of suitability for domestic use

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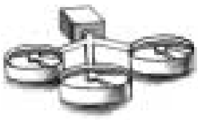
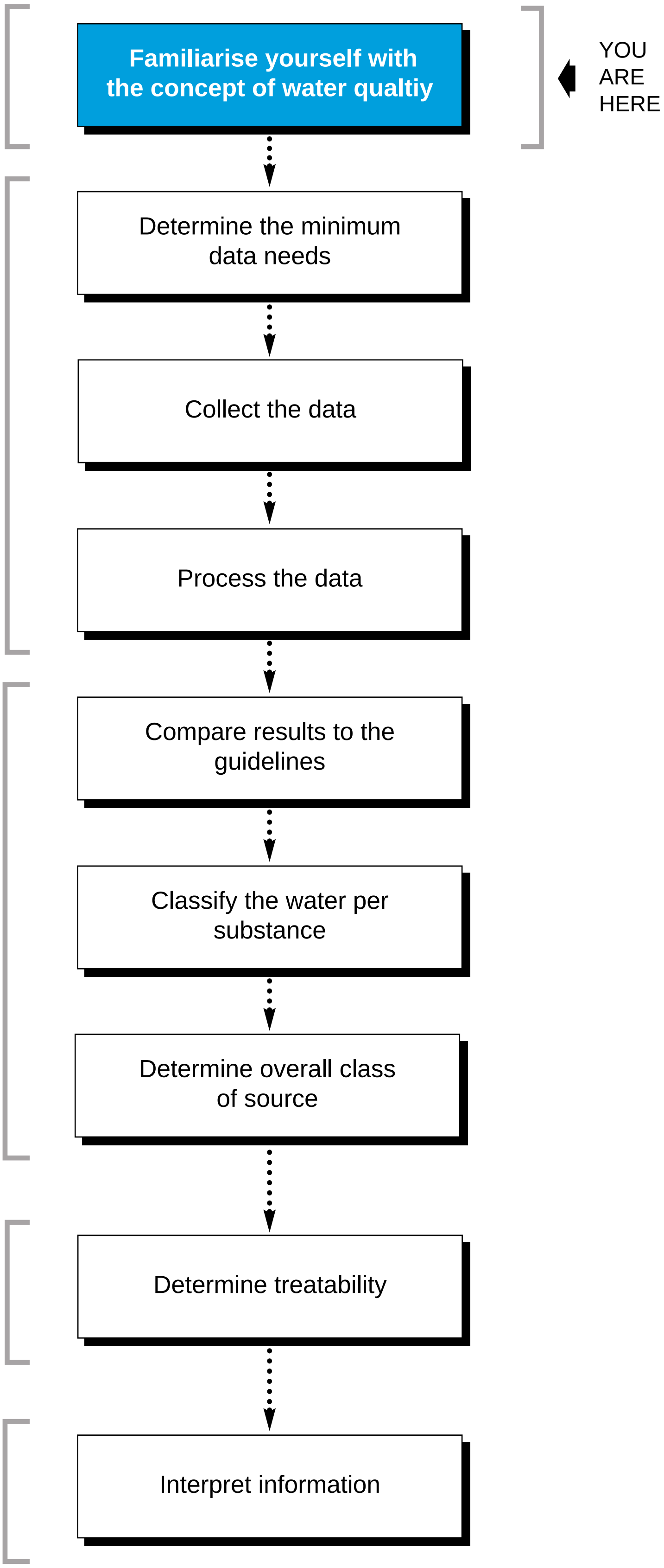
Consider treatment options available to improve water quality



Section E1
Interpret water quality information



Familiarise yourself with the concept of water quality

In order to assess and interpret water quality it is important to understand concepts such as:

- Where does water come from?
- What is water quality?
- What is water pollution?
- Who uses water?
- What is the domestic use of water?
- How does water affect the domestic user?

(a) Where does water come from ?

The fresh water we use for drinking, washing, and for preparing food comes from rainwater, surface water sources (such as rivers or dams), or groundwater sources (such as boreholes and springs). The amount of fresh water is limited and it continuously repeats its journey through the water cycle.

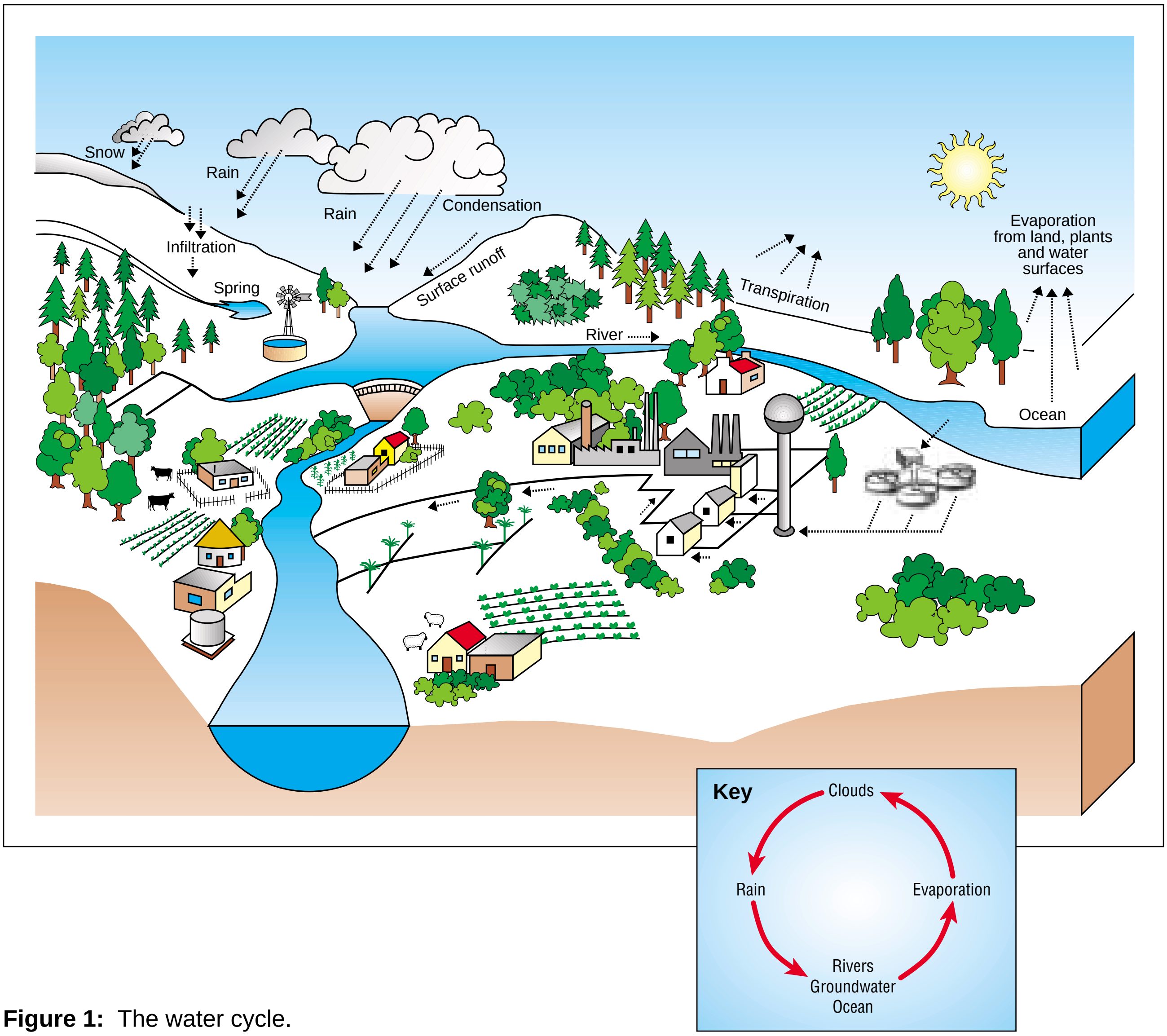


Figure 1: The water cycle.

(b) What is water quality ?

The term "water quality" is used to describe the microbiological, physical and chemical properties of water that determine its fitness for use. Many of these properties are controlled or influenced by substances which are either dissolved or suspended in the water.

In nature, water rarely occurs in its pure form and it normally contains a variety of substances. People generally have their own feeling for what "good" or "bad" quality water is, without giving it much thought. If water looks clean, and the taste and smell are not unpleasant, then people usually think it is good. If water does not look clean, or it has an unpleasant taste or smell, people think it is bad. However, water that is murky, or has a colour or an unpleasant smell, is not necessarily unsafe to drink. On the other hand, clear water, without any smell, is not always safe to drink as it may contain dissolved substances or disease-causing organisms that are harmful to health. This means that good quality water sources are sometimes rejected while bad quality sources are accepted.

NOTE

• **Microbiological quality:**	Refers to the presence of organisms that cannot be seen by the naked eye, such as protozoa, bacteria and viruses. Many of these microbes are associated with the transmission of infectious waterborne diseases such as gastro-enteritis and cholera. Since it is difficult and costly to detect these microbes (pathogens), it is common practice to use microbiological indicators as an indication of recent faecal pollution and the potential risk of infectious diseases from the water. Faecal and total coliforms are commonly used as indicators to determine the microbiological quality of domestic water supplies.
• **Physical quality:**	Refers to water quality properties that may be determined by physical methods such as conductivity, pH and turbidity measurement. The physical quality mainly affects the aesthetic quality (taste, odour and appearance) of water.
• **Chemical quality:**	Refers to the nature and concentration of dissolved substances such as salts, metals and organic chemicals. Many chemical substances in water are essential as part of the daily intake required, but at high concentrations they make water unpalatable and cause illnesses.

- **See guidelines Part 2 (p41-96)**

(c) What is water pollution?

Water pollution occurs when water is rendered less fit for use as a result of human activities.

Where human activity occurs, wastes may get into the water source. These wastes can pose serious risks for domestic water users. Human activities that typically cause problems for domestic water quality are:

- intensive irrigation,
- mining activities,
- industries, and
- dense human settlements (particularly if these settlements have poor sanitation facilities).

Domestic water quality is affected by nearby human activities which may pollute the water, as well as by natural geological conditions in the area.

(d) Who uses water ?

Water users can be divided into four main categories:

- *domestic users (e.g., drinking, food preparation, washing clothes, bathing and gardening),*
- *recreational users (e.g., swimming, fishing),*
- *industrial users (e.g., power generation, process water), and*
- *agricultural users (e.g., watering of crops, water for animals).*

The environment also requires water if it is to survive. This includes water for animals and fish living in the water, as well as for plants growing in rivers or streams, or next to them. The aquatic environment is part of the resource.

There are a great many ways in which water may be used by humans and animals and every user has different water quality requirements. For example, muddy water is less of a problem to someone canoeing down a river than it is for people who must drink it or cook with it.

NOTE

This Guide considers only domestic use of water. Information on the water quality requirements for the other uses is available in the *South African Water Quality Guidelines.*

(e) What is domestic use of water ?

Domestic water is used for a number of purposes in and around the home. These are:

- *for survival – drinking and food preparation,*
- *for personal hygiene – washing clothes, bathing and sewage removal, and*
- *for gardening – watering a vegetable patch or beautifying the surroundings.*

NOTE

The suitability of water for gardening depends on a number of other factors, such as climate and soil quality. This makes the classification of water quality for gardening difficult, and it is not included in this Guide. However, as a general rule, if water is fit for drinking, it can also be used for gardening. If there is any doubt, or if gardening forms an important part of the use of the water concerned, please refer to Volume 4 of the *South African Water Quality Guidelines.*

Water supplied to domestic users can be used in any number of ways, each with different quality requirements. In this Guide, the following five different aspects (or uses) of domestic water quality are considered, and are represented by the following drawings:

Drinking water

Health effects

Aesthetic quality

The health and aesthetic effects of using the water for bathing

The health and aesthetic effects of using the water for food preparation

The health and aesthetic effects of using the water for laundry

NOTE

Water consumed by the domestic user (for drinking and in food preparation) usually represents only a small portion (about 2 to 5 litres(ℓ) per person per day) of the water used in and around the home. However, it is the most important aspect when considering the quality of water for domestic purposes as it directly affects the health of the consumer. It is also important to note that water that is unfit for consumption (drinking and food preparation) may still be safe for other domestic uses such as for personal hygiene (bathing) or laundry.

(f) How does water quality affect the domestic user ?

Water quality affects the domestic user in terms of:

- *health,*
- *aesthetics (the appearance of the water or the effects it has on clothes and household fixtures such as baths), and*
- *economics (replacement of pipes, hot water geysers, etc.).*

The health effects of water quality on the user can be divided into two types:

1. Acute effects: Effects that can be seen after a very short time.

2. Chronic effects: Effects that show only after the water has been used for a long time.

The effects themselves could be serious and long-lasting, or they may be insignificant and only temporary. For example, a high magnesium concentration may result in an upset stomach for a few days. However, a low concentration of arsenic will slowly accumulate in the body until severe effects appear after a number of years. Aesthetic effects can also be immediate, such as the staining of laundry by manganese, or long-term, such as the staining of baths.

In some cases, it is not the water quality alone that affects the users' health, but a combination of circumstances. For example, water with a low pH level may corrode galvanised or copper pipes inside homes. This may lead to increased zinc, cadmium or copper concentrations in the water, and these in turn may cause health or aesthetic problems. Similarly, water taken directly from a borehole may contain few disease-causing organisms, but poor sanitation practices in the home may result in the water being contaminated before it is used.

NOTE

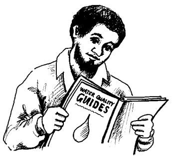
In this Guide mainly health and aesthetic effects are considered. Information on economic effects is limited, and the effects vary greatly from situation to situation. This makes it difficult to include a detailed description of these effects in a Guide such as this.

SECTION B1

Collect and process the data

ROAD-MAP

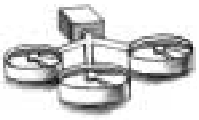
Section A1
General information on the concepts of water quality



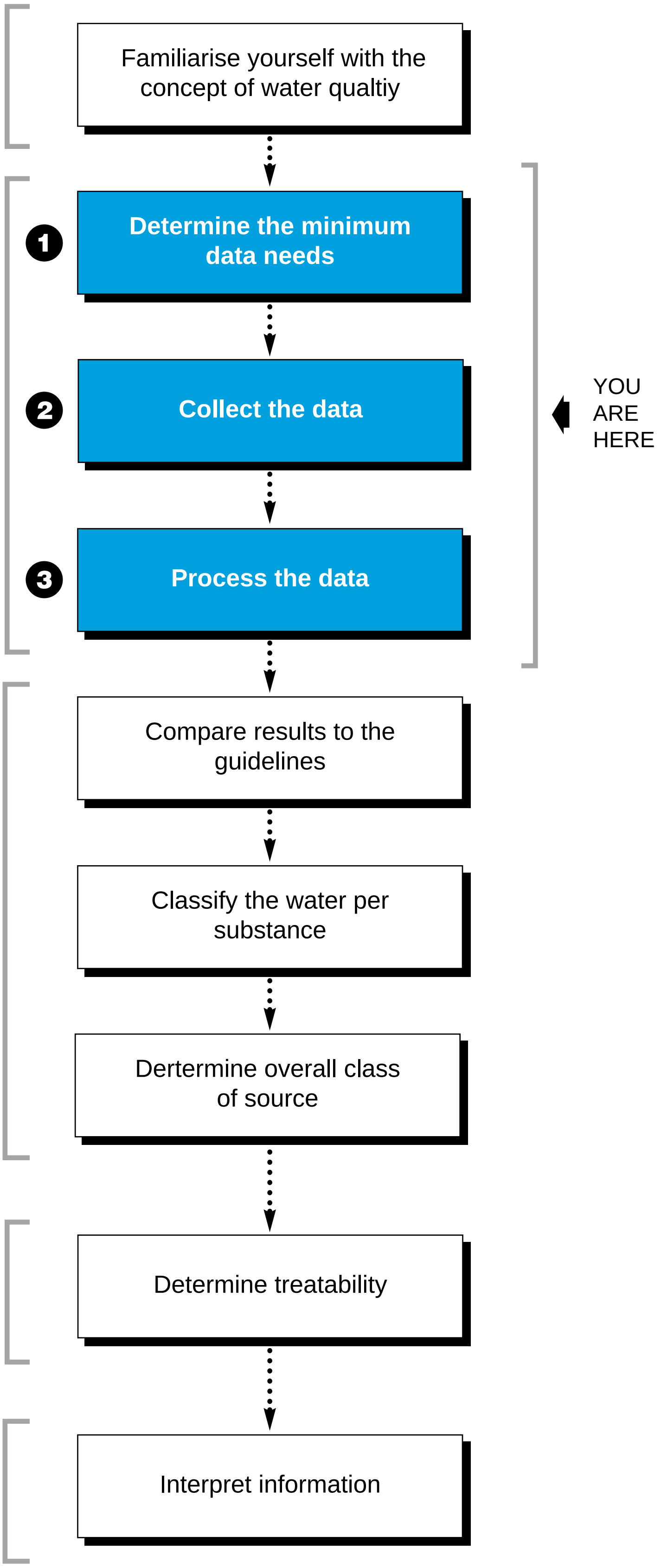
Section B1
Collect and process the data

Section C1
Classify the water in terms of suitability for domestic use

Section D1
Consider treatment options available to improve water quality



Section E1
Interpret water quality information

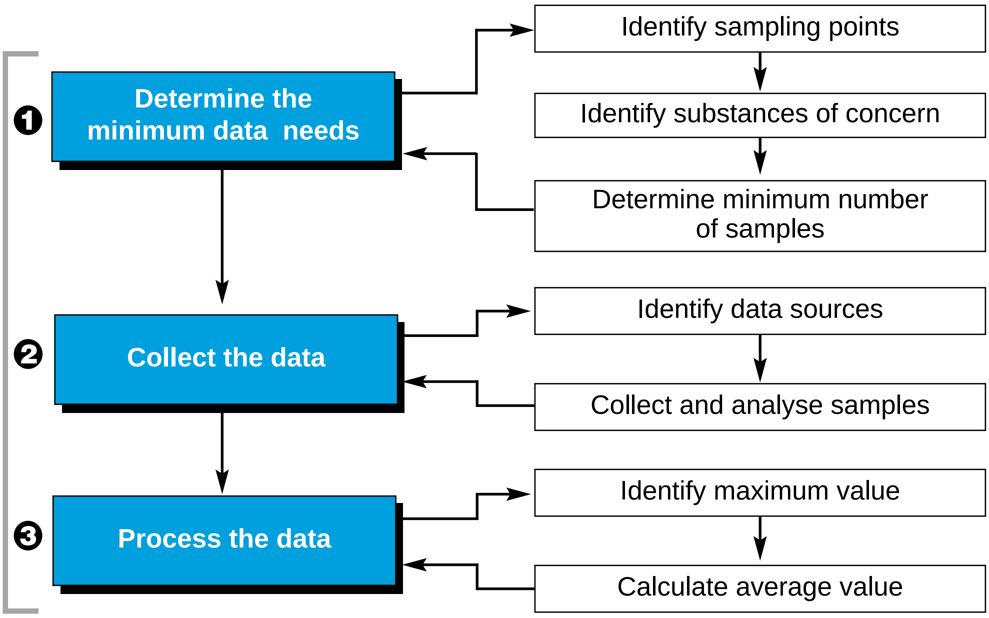


The previous section provided a background to the concept of water quality and its effects on domestic users.

This section provides guidance on:

- where water quality should be assessed in the water supply system (point of use, source),
- which substances are important,
- how much data is required, or how many samples,
- how or where to acquire the data, and
- which calculations must be done.

A step-by-step procedure for collecting and processing the data



1. **DETERMINE THE MINIMUM DATA NEEDS**
   (a) Identify sampling point. (Figure 2)
   (b) Determine which substances are important. (Table 1, p 12-14)
   (c) Determine which substances must be included. (Table 2, p 15))
   (d) Determine minimum data required. (Table 3, p 16)

2. **COLLECT DATA**
   Collect samples and analyse, or consult existing databases. (See other sources of data, Appendix A)

3. **PROCESS THE DATA**
   Process the data for each substance:
   (a) Identify the maximum value.
   (b) Calculate the average value. (See Case study, p 18)

1. Determine the minimum data needs

(a) Where should the quality of domestic water supply be assessed ?

It is important to assess the quality of the water supplied at all points in the water supply system. The water supply system consists of the water source, the water treatment works and the distribution system up to the point of use.

At the minimum, samples should be taken from:

- *the source of the water,*
- *the outflow from the treatment works (if the water is treated), and*
- *at the point of use.*

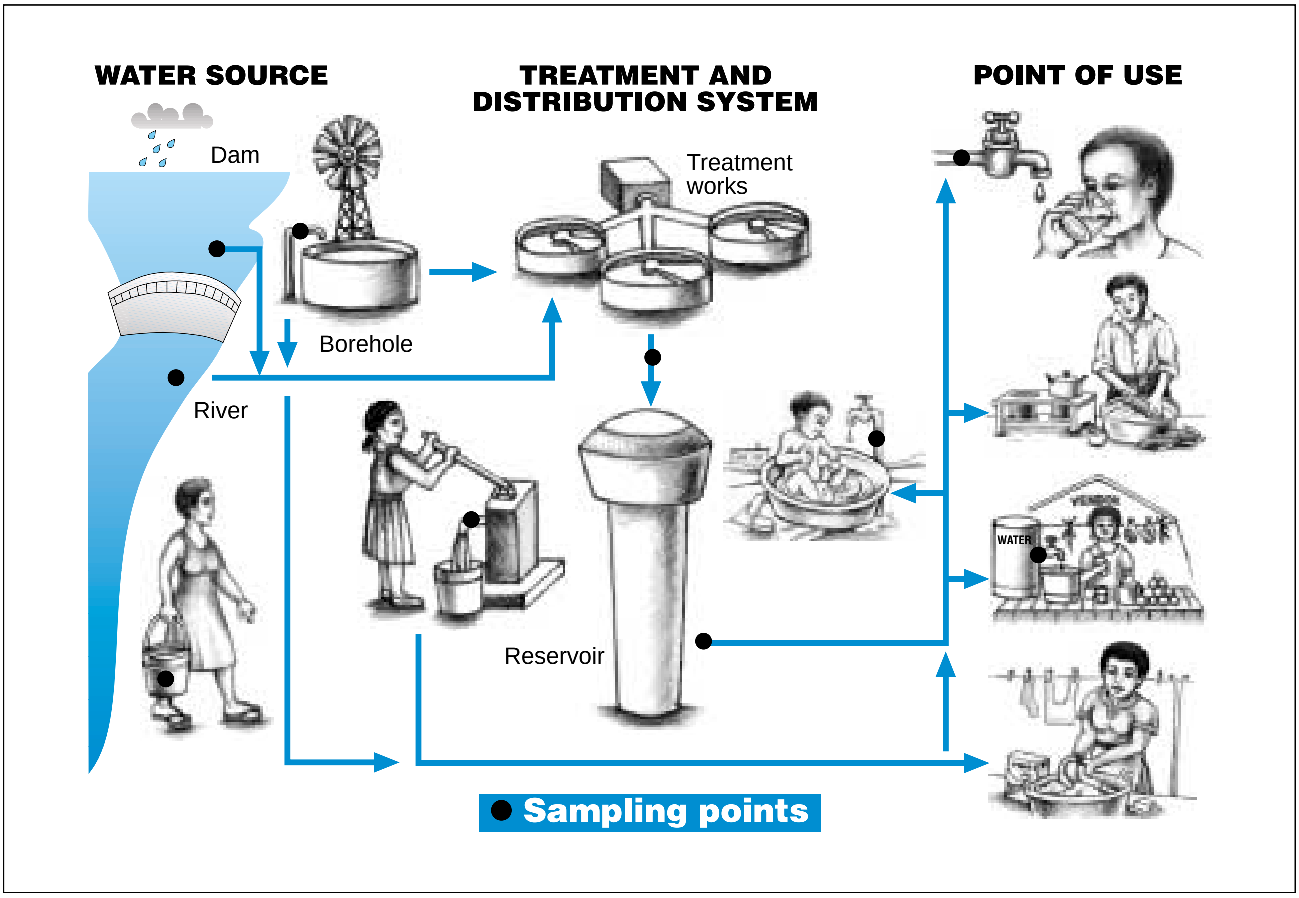


Figure 2: The water supply system showing the points that should be sampled to assess domestic water quality.

(b) What substances are important for domestic water users ?

A great many substances can be found in water. However, only a few of these commonly occur in concentrations high enough to be of concern to domestic water users. The most important substances to measure are those that often occur in concentrations high enough to cause health, aesthetic or other problems.

The substances that are of main concern to the domestic user are presented in order of priority in Tables *1A to 1D.*

Table 1A: Substances which are general indicators of water quality

GROUP A	
Electrical conductivity (total dissolved salts)	Conductivity is an indicator of total dissolved salts (TDS), and also establishes if the water is drinkable and capable of slaking thirst.
Faecal coliforms	This is an indicator of the possible presence of disease-causing organisms. It establishes if water is polluted with faecal matter.
pH value	This has a marked effect on the taste of the water and also indicates possible corrosion problems and potential copper, zinc and cadmium problems.
Turbidity	This affects the appearance, and thus the aesthetic acceptability, of the water. Turbidity is commonly high in surface waters.
Free available chlorine (Residual chlorine)	This is a measure of the effectiveness of the disinfection of the water. Residual chlorine is the chlorine concentration remaining at least 30 minutes after disinfection. There should be residual chlorine in the water, but if concentrations are too high it may impart an unpleasant taste and smell to the water.
Group A substances are indicators of potential problems and should be frequently tested at all points in the water supply system, irrespective of the source of the water. (Free available (or residual) chlorine has to be measured only if the water has been treated with chlorine-based disinfectants.)	

Table 1B: Substances which are commonly present at concentrations which may lead to health problems

GROUP B	
Nitrate & nitrite	These are common in groundwater (borehole) samples, particularly in areas of intensive agricultural activity, or where pit latrines are used. Severe toxic effects are possible in infants.
Fluoride	This is often elevated in groundwater in hot, arid areas. Can cause damage to the skeleton and the marking of teeth.
Sulphate	This is particularly common in mining areas. Causes diarrhoea, particularly in users not accustomed to drinking water with high sulphate concentrations.
Chloride	This is often elevated in hot, arid areas, and on the western and southern Cape coasts (particularly in groundwater). May cause nausea and vomiting at very high concentrations.
Arsenic	This may be present in groundwater, particularly in mining areas. Can lead to arsenic poisoning.
Total coliforms	This provides an additional indicator of disease-causing organisms, and the effectiveness of disinfection.
The presence/concentration of Group B substances should be determined before the water is supplied. The frequency of testing depends on the source and the treatment applied. Note that substances of concern due to pollution sources in the area, may have to be added to Group B (see note on page 14).	

Table 1C: Substances which occur less frequently at concentrations of real concern to health

GROUP C	
Cadmium	This usually occurs along with zinc in acidic waters where it may have been dissolved from appliances.
Copper	This affects the colour of the water and can cause upset stomachs. Normally occurs only when copper piping is used to carry water with a low pH value.
Group C substances should be tested for at point of use only in areas of the country where soft water of a low pH value is used.	

Table 1D: Substances which may commonly be present at concentrations of aesthetic or economic concern in domestic water sources

GROUP D	
Manganese	This is common reason for brown or black discolouration of fixtures and for stains in laundry. Can be common in bottom waters of dams, or in mining areas.
Zinc	This affects the taste of water. Usual cause is acidic water dissolving zinc from galvanised pipes or from appliances.
Iron	This affects the taste of the water and may also cause a reddish brown discolouration. Can be common in bottom waters of dams, or in mining areas. Can cause growth of slimes of iron reducing bacteria that ultimately appear as black flecks in the water.
Potassium	This affects the taste of the water and is bitter at elevated concentrations.
Sodium	This affects the taste of the water. Often elevated in hot, arid areas and on the western and southern Cape coasts (particularly in groundwater).
Calcium	This can cause scaling and can reduce the lathering of soap.
Magnesium	This affects the taste of the water. It is bitter at high concentrations. Common in some areas it adds to the effect of calcium.
Hardness, Total	This is a combination of calcium and magnesium. It is associated with scaling and inhibition of soap lathering.
The presence of Group D substances should be determined at least when assessing the water for the first time. Thereafter they can be included when there is reason to believe that their concentrations may have changed.	

NOTES

1. The importance of substances in Groups B, C and D varies according to:
   - where the water comes from (the source),
   - what pollution may occur in the area, and
   - problems with similar sources in the area.

   The frequency at which substances in these groups needs to be sampled varies according to the source, or the point in the water supply system sampled.

2. Other substances that may also be important depend on sources of pollution that occur nearby. Activities which may cause problems are:
   - intensive malaria control (possible pesticide pollution of water supplies),
   - intensive agriculture (possible pesticide and herbicide pollution of water supplies),
   - extensive mining (possible pollution by trace metals), and
   - industrial activities (possible pollution by trace metals and organic compounds).

   Expert advice on what substances should be monitored is necessary if these activities may be polluting the water supply.

(c) Which substances must be included in the assessment?

A number of factors influence the choice of substances (also called variables or constituents) which should be included in the assessment. These are:

- *where are you assessing the water? (i.e., at the source, the treatment works, or at the point of use),*
- *what is the source of the water? (i.e., river, stream, well, borehole, dam or rainwater tank),*
- *what pollution problems may occur in the area? , and*
- *what problems have been experienced with similar sources in the vicinity?*

Table 2: The substances which must be included when assessing domestic water quality at different points in the supply system, and from different sources

SUBSTANCE	SOURCE			TREAT. WORKS	POINT OF USE
	River, well, stream	Dam	Borehole		
Group A Electrical conductivity (EC) Faecal coliforms pH Turbidity Free available chlorine[1]	■■■■ ■■■■ ■■■■ ■■■■ NA	■■■■ ■■■■ ■■■■ ■■■■ NA	■■■■ ■■■■ ■■■■ ■■■■ NA	■■■■ ■■■■ ■■■■ ■■■■ ■■■■	■■■■ ■■■■ ■■■■ ■■■■ ■■■■
Group B Nitrate/nitrite[2] as N Fluoride[2] Sulphate[3] Chloride[3] Arsenic Total coliforms	■ ■ ■■ ■■ ■■ ■■	■ ■ ■■ ■■ ■■ ■■	■■■■ ■■■■ ■■ ■■ ■■ ■■	■■ ■■■■ ■■ ■■ ■■ ■■	■■ ■■■■ ■■ ■■ ■■ ■■
Group C[4] Cadmium Copper	■ ■	■ ■	■ ■	■■ ■■	■■ ■■
Group D Manganese Zinc Iron Potassium Sodium[3] Magnesium Calcium Hardness, Total	■ ■ ■ ■ ■ ■ ■ ■	■■ ■ ■■ ■ ■ ■ ■ ■	■■ ■ ■■ ■ ■ ■■ ■■ ■■	■ ■■ ■ ■ ■ ■ ■ ■	■ ■■ ■ ■ ■ ■ ■ ■

■■■■ = Critical, must always be included in the assessment.
■■ = Important, should be included in the assessment, particularly in certain areas (see footnotes).
■ = Useful, often provides more information about the quality of the water.
NA = Should not be included for this source.

Footnotes

[1] Free available (or residual) chlorine has to be measured only if the water has been treated with chlorine-based disinfectants.

[2] Nitrate/nitrite and flouride rarely occur at concentrations of concern to human health in surface water.

[3] More important in mining areas, and in many hot, arid areas.

[4] Group C substances are more important where the pH of the water supplied is lower than 6.

(d) How frequently should the substances be measured ?

The concentrations of the substances in water are never constant. In general, the more often a substance is measured, the more reliable the assessment of the water quality will be.

The rate at which water quality changes depends on the source of the water, and this determines how often samples should be collected. When assessing the average quality, it is recommended that data collected over one year should be used. For this, a minimum number of samples, spread evenly over time, should be collected. Substances in Group A should be tested as frequently as possible. The following table provides a basis for deciding on how much data is needed to assess the quality of domestic water supplies where samples are drawn from different sources, and at different points in the supply system.

Table 3: The minimum and recommended numbers of samples and sampling frequencies for different points in the water supply system

SAMPLING POINT		MINIMUM		RECOMMENDED	
		Number of samples/year	Sampling frequency	Number of samples/year	Sampling frequency
SOURCE	River/stream/spring/well	4	3 - monthly	26	2 - weekly
	Dam	2	6 - monthly	12	2 - monthly
	Borehole	1	–	2	6 - monthly
Treatment works		4	3 - monthly	12/52/365[1]	monthly/weekly/daily[1]
Point of use		4	3 - monthly	12/52/365[1]	monthly/weekly/daily[1]

Footnote

[1] Depends on size of treatment works, the variability in the water quality and the number of people supplied with water.

NOTE

Changes in land use in the catchment can also affect the concentrations of substances over the longer term. It is therefore recommended that only the most recent year's data be used. Data that is more than three years old should be used as an indication only, and the quality should be confirmed by collecting a sample as soon as possible.

2. Collect the data

How is data obtained?

The collection and analysis of samples is possibly one of the most important steps in the process of assessing the quality of domestic water supplies. This should be done in the correct way to ensure reliable water quality data.

(a) Collection of samples

It is important to collect samples in both the wet and dry seasons to ensure that the full range of possible conditions is assessed.

(b) Analysis of samples

It is important to use a reliable laboratory to analyse the samples.

NOTES:

1. Sampling and analytical procedures are complex and are, therefore, not addressed in detail here. Refer to the Sampling Guide and the Analysis Guide for further information.
2. Some authorities, such as the Department of Water Affairs and Forestry and certain water boards, operate monitoring programmes that can be valuable sources of data. It is wise to contact these organisations before embarking on a costly monitoring exercise. Details of these organisations can be found in Appendix A.

3. Process the data

How must water quality data be processed?

The water quality data is processed by:

- *taking the maximum (highest) concentration to determine acute effects,and*
- *calculating the average concentration to determine chronic effects.*

The data processing procedure is presented in the flow diagram below.

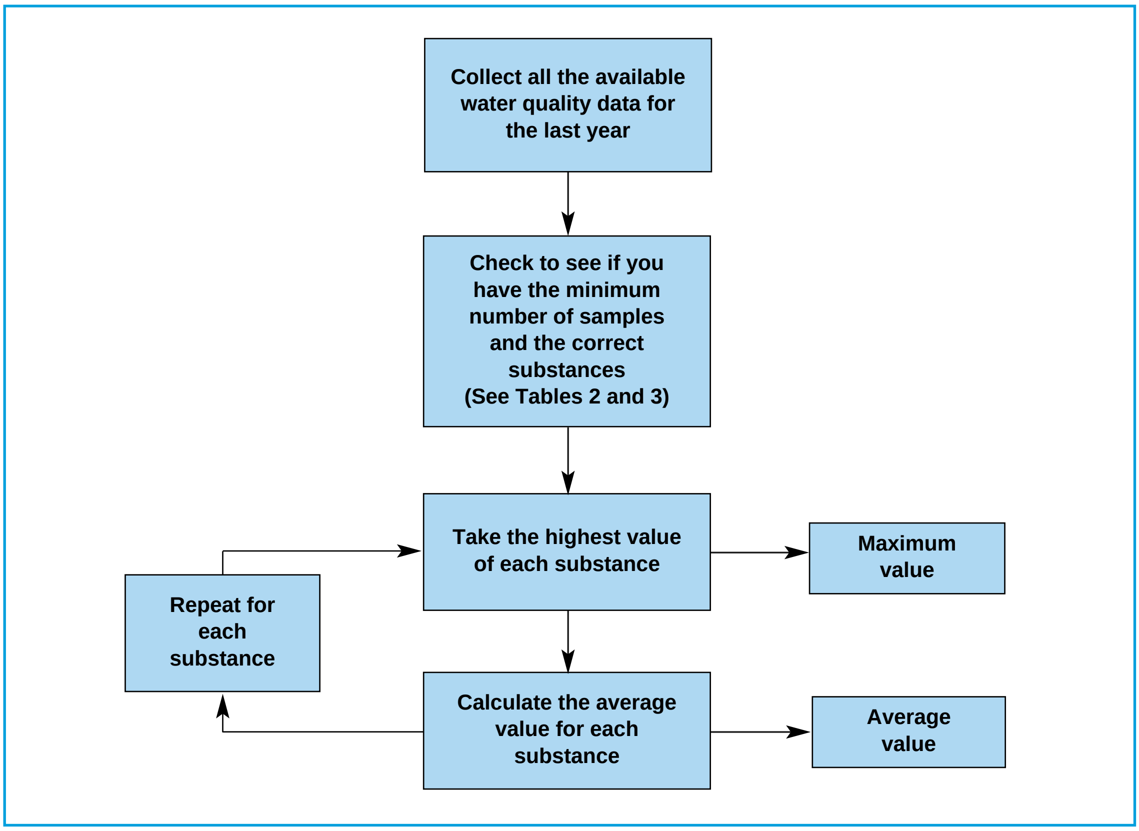


Figure 3: The processing of the water quality data for the assessment.

NOTE

It is possible to do a more complex statistical analysis of the data and this may provide greater confidence in the assessment. Expert advice should be sought in this regard.

An example of how to process data is provided below. For the purpose of this Guide, only one case study is used.

Case study

Sample data set – processing of the data

Description of the source and data

The following data set represents a sample taken from a borehole in the Northern Province. The borehole was equipped to supply a community with domestic water. Water was being collected from the borehole in buckets and used without any treatment. Samples were taken approximately once a month during most of 1997. While the data does not cover a full wet and dry season, the fact that it was a borehole being sampled means that the amount of data is more than is required.

With the exception of free available chlorine, all the substances in Group A were analysed. It was not necessary to analyse free available chlorine as the water was untreated. Most of the other substances considered important in groundwater were analysed, although a manganese analysis should be requested in future. As the water is not treated, the point of use (buckets in homes) should also be sampled (see Figure 2,page 11 Section B1). All units are the same as in the guidelines.

It is possible to provide a reasonably reliable assessment of the quality of the water supplied using this data.

Processing the data

The data is processed by calculating the average concentration for each substance. This is done by adding all the concentrations for any substance together and dividing the total by the number of times data was available. The following table presents the data for this sampling point.

See the blank worksheet, which may be copied for use in Appendix B.

Table B1: A sample data set for a borehole water source

DATE RECEIVED: 12/11/97

Analytical results

SUBSTANCE	DATE				CALCULATED	
	01/04/97	07/07/97	10/08/97	05/10/97	Maximum	Average
pH (pH units)	8,2	8,2	8,0	8,0	8,2	8,0 (USE MINIMUM)
Conductivity in mS/m at 25 °C	170	102	94,0	68	170	109
Nitrate as N mg/ℓ	40	25	20	30	40	29
Chloride mg/ℓ	112	42	44	17	112	54
Sulphate mg/ℓ	104	46	30	18	104	50
Fluoride mg/ℓ	0,72	0,47	0,59	1,1	1,1	0,72
Sodium mg/ℓ	145	121	75	58	145	100
Magnesium mg/ℓ	91	54	39	27	91	53
Iron mg/ℓ				76	76	–
Faecal coliforms (No./100 mℓ)	3	5	20	3	20	Not used
Arsenic mg/ℓ	<0,005	<0,005	<0,005	<0,005	–	–
Turbidity (NTU)	3	5	4	2	5	3,5
Free available chlorine mg/ℓ	NA	NA	NA	NA	NA	NA

NOTES:

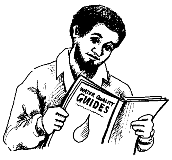
1. For pH, the minimum and maximum values are used.
2. For faecal coliforms, only the maximum value is used.
3. <0,005 = Below detection limit, leave these values out.
4. NA = Not applicable for this source.
5. The average is calculated by adding all the concentrations of the samples taken for each substance together and dividing by the number of data points available (in this example 4 samples). The exception is for iron as only one sample was tested for iron.

SECTION C1

Classify the water

ROAD-MAP

Section A1
General information on the concepts of water quality



Familiarise yourself with the concept of water qualtiy

Section B1
Collect and process the data

Determine the minimum data needs

Collect the data

Process the data

Section C1
Classify the water in terms of suitability for domestic use

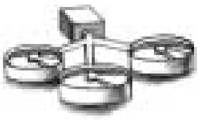
❶ **Compare results to the guidelines**

❷ **Classify the water per substance**

❸ **Determine overall class of source**

◀ YOU ARE HERE

Section D1
Consider treatment options available to improve water quality



Determine treatability

Section E1
Interpret water quality information

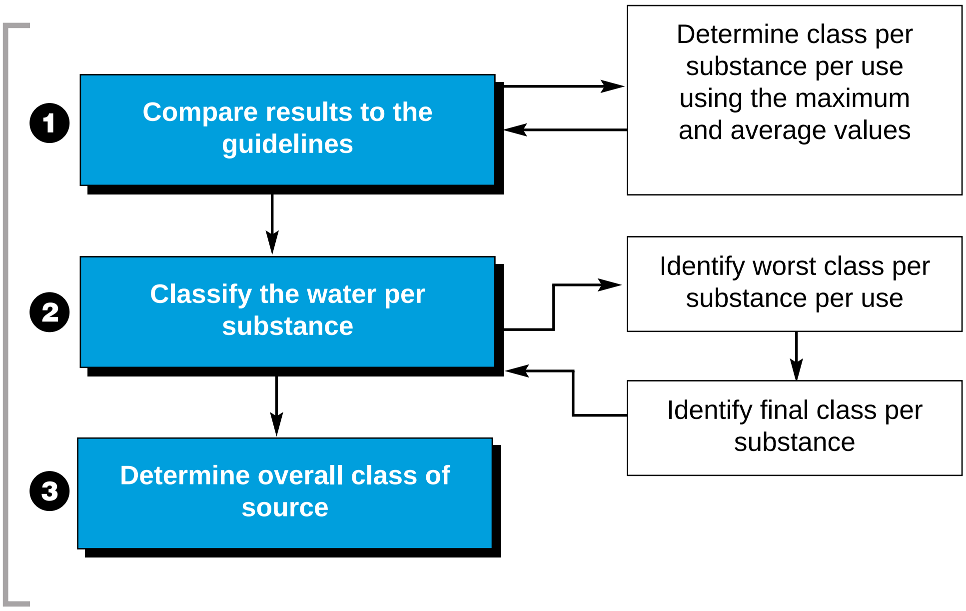
Interpret information

The previous section described how to obtain data and explained how the data should be processed. This section describes how to classify the water in terms of its suitability for domestic water use

This section sets out to answer the questions:

- Why classify water?
- How does the classification work?
- When is water safe for use?
- How is water classified?

A step-by-step procedure for classifying water is explained in the flow diagram below



1. **COMPARE RESULTS TO GUIDELINES**
   (a) Select first substance.
   (b) Compare maximum value to guideline for each use. (See guidelines in Part 2.)
   (c) Note class, e.g., blue, green, yellow, red or purple.
   (d) Compare average value (if available and applicable) to guideline for each use.
   (e) Note class, e.g., blue, green, yellow, red or purple.

2. **CLASSIFY WATER PER SUBSTANCE**
   (a) Identify the worst class for each substance for both the maximum and the average values .
   (b) Classify the water per substance according to **Table 5**, p 25

3. **DETERMINE THE OVERALL CLASS OF WATER SOURCE**
   The worst class determines the overall class. (See case study, p 26)

Footnote

[1] (Blank worksheets are provided in Appendices C and D)

Classify the water

(a) Why classify water ?

Water is classified to:

- *establish how suitable it is for the various domestic uses, namely drinking, food preparation, bathing and for washing clothes,*
- *make it easy to communicate water quality information to the public and other role players, and*
- *to aid in decision-making regarding the management of the quality of domestic water supplies.*

Water quality does not suddenly change from good to bad when a given concentration or value is exceeded. There is generally a gradual change from water which is of ideal quality, and which will not have negative effects on any users, to water which is dangerous to all users – even if used only once. Between these two values, there is an area where the risk of using the water gradually increases. The classification system used in this Guide allows for this gradual change.

In a community different people react differently to the same water. For example, babies and people with heart or kidney disease may be affected at much lower concentrations than healthy adults. In hot, dry climates people drink more water and this increases the risks of accumulating substances in the body, which can cause chronic effects.

The guidelines in Part 2 are presented in terms of a simple colour-coded classification system for the substances outlined in the previous section as important for domestic users. The classification is based on increasing concentrations of these substances, and allows for classifying the:

- health effects of water used for drinking, as well as aesthetic effects of water used for drinking,
- health and aesthetic effects of water used for food preparation,
- health and aesthetic effects of water used for bathing, and
- the health and aesthetic effects of water used for washing clothes.

NOTE

Water used for drinking is the most important aspect when considering the quality of water for domestic purposes as it directly affects the health of the consumer. For this reason the classification system distinguishes between the health and aesthetic effects of substances in water used for drinking purposes (see Table 4).

(b) How does the classification system work ?

The classification system describes the effects of increasing concentrations of each of the substances considered important for domestic use. The system uses a simple colour and number code ranging from ideal to totally unacceptable water quality.

Table 4: Structure of the classification system describing the effects of the different classes of water on the various domestic uses of water

CLASS/COLOUR	DESCRIPTION	EFFECTS
Class 0 B	Ideal water quality	***Drinking Health:*** No effects, suitable for many generations. ***Drinking Aesthetic:*** Water is pleasing. ***Food preparation:*** No effects. ***Bathing:*** No effects. ***Laundry:*** No effects.
Class 1 G	Good water quality	***Drinking Health**:* Suitable for lifetime use. Rare instances of sub-clinical effects. ***Drinking Aesthetic:*** Some aesthetic effects may be apparent. ***Food preparation:*** Suitable for lifetime use. ***Bathing:*** Minor effects on bathing or on bath fixtures. ***Laundry:*** Minor effects on laundry or on fixtures.
Class 2 Y	Marginal water quality	***Drinking Health**:* May be used without health effects by the majority of individuals of all ages, but may cause effects in some individuals in sensitive groups. Some effects possible after lifetime use. ***Drinking Aesthetic:*** Poor taste and appearance are noticeable. ***Food preparation:*** May be used without health or aesthetic effects by the majority of individuals. ***Bathing:*** Slight effects on bathing or on bath fixtures. ***Laundry:*** Slight effects on laundry or on fixtures.
Class 3 R	Poor water quality	***Drinking Health**:* Poses a risk of chronic health effects, especially in babies, children and the elderly. ***Drinking Aesthetic:*** Bad taste and appearance may lead to rejection of the water. ***Food preparation:*** Poses a risk of chronic health effects, especially in children and the elderly. ***Bathing:*** Significant effects on bathing or on bath fixtures. ***Laundry:*** Significant effects on laundry or on fixtures.
Class 4 P	Unacceptable water quality	***Drinking Health:*** Severe acute health effects, even with short-term use. ***Drinking Aesthetic:*** Taste and appearance will lead to rejection of the water. ***Food preparation:*** Severe acute health effects, even with short-term use. ***Bathing:*** Serious effects on bathing or on bath fixtures. ***Laundry:*** Serious effects on laundry or on fixtures.

B = Blue
G = Green
Y = Yellow
R = Red
P = Purple

(c) When is water safe for use?

According to the classification system:

- *Water in the Blue and Green classes is safe for lifetime use.*
- *Water in the Yellow class may be safe for use under certain conditions, but should be used with caution:*
  - *It is most important to sample and assess the quality of water in the Yellow class regularly.*
  - *Expert advice should be called upon to determine the real threat to sensitive users.*
  - *Sensitive groups should also be informed when water falls into the Yellow class.*
- *Water falling into the Red class should be considered unsafe for use and should be treated. Water in the Red class may be used for short-term emergency supply, but only where no alternative supplies are available.*
- *Water falling into the Purple class should be considered unsafe for use and should be treated. Water in the Purple class is unsafe even for short-term emergency use.*

(d) What are sensitive groups?

Sensitive groups include people who may have particular medical conditions which make them more susceptible to poor water quality. Babies, young children and the elderly may also be more sensitive to some substances.

People differ widely in their responses to water quality. What is safe for one person is not necessarily safe for another. Even in the Blue (ideal) class, there may be a few individuals who show some negative response. Where a few individuals may experience negative effects, these individuals have been identified as “sensitive groups”.

Babies are generally more susceptible to poor water quality, and are identified as “sensitive” for most substances. But it is important to note that not all babies will show negative effects, and that normal, healthy babies will not necessarily be affected.

(e) How is water classified ?

The classification of water quality to determine its suitability for domestic use is a two step process. Step 1 involves determining the class per substance for each of the domestic uses, namely drinking, food preparation, bathing and laundry. Step 2 involves determining the overall class of the water supply.

Step 1:

Determine the class ***per substance*** *for each of the domestic uses*:

(i) Check to see if the data is shown in the same units as used in the Guidelines (see part 2). In most cases the concentrations in the tables are in milligrams per litre (mg/ℓ). If the data is not in milligrams per litre (if relevant), the laboratory which analysed the samples will be able to provide advice on how to convert the data.

(ii) Compare the maximum and average concentrations of each substance to the concentration ranges in the left hand column of the Guidelines. The colour class of the **substance** is then read off in the columns for each use of domestic water in the right hand column.

(iii) For some substances (those which have acute effects only) only the maximum value is needed. For pH and for free available chlorine, both the maximum and minimum values should be used. An example of how to do this is shown in the case study.

Case study continued (see p 18)

Sample data set – comparison to the guidelines

The average and maximum concentrations for each substance (as previously calculated) are compared to the guidelines in Part 2 of this Guide. This is done for each of the uses of domestic water. The following table demonstrates this process.

Table C1: Comparing the average and maximum concentrations to the guidelines for each use

(a) MAXIMUM CONCENTRATIONS

SUBSTANCE	**COLOUR CLASS**						
	Maximum	**Drinking Health**	**Drinking Aesth.**	**Food Prep.**	**Bathing**	**Laundry**	**Worst substance class**
pH (Units)	8,2	Blue	Blue	Blue	Blue	Blue	Blue
Conductivity mS/m	170	Yellow	Yellow	Yellow	Blue	Green	Yellow
Nitrate as N mg/ℓ	40	Red	Blue	Red	Yellow	Blue	Red
Chloride as Cl mg/ℓ	112	Green	Green	Green	Blue	Green	Green
Sulphate as SO_4 mg/ℓ	104	Blue	Blue	Blue	Blue	Blue	Blue
Fluoride as F mg/ℓ	1,1	Yellow	Blue	Yellow	Blue	Blue	Yellow
Sodium as Na mg/ℓ	145	Green	Green	Green	Blue	Blue	Green
Magnesium as Mg mg/ℓ	91	Green	Yellow	Green	Yellow	Yellow	Yellow
Iron as Fe mg/ℓ	76	Purple	Purple	Purple	Yellow	Purple	Purple
Faecal coliforms no/100mℓ	20	Red	Blue	Red	Yellow	Yellow	Red
Arsenic as As mg/ℓ	ND	Blue	Blue	Blue	Blue	Blue	Blue
Turbidity (NTU)	5	Yellow	Yellow	Yellow	Yellow	Green	Yellow
Free available chlorine mg/ℓ^2	NOT NECESSARY FOR THIS ASSESSMENT						

(b) AVERAGE CONCENTRATIONS

SUBSTANCE	**COLOUR CLASS**						
	Average	**Drinking Health**	**Drinking Aesth.**	**Food Prep.**	**Bathing**	**Laundry**	**Worst Substance class**
pH (Units)^1	8.0(min)	Blue	Blue	Blue	Blue	Blue	Blue
Conductivity mS/m	109	Green	Green	Green	Blue	Blue	Green
Nitrate as N mg/ℓ	29	Red	Blue	Red	Yellow	Blue	Red
Chloride as Cl mg/ℓ	54	Blue	Blue	Blue	Blue	Blue	Blue
Sulphate as SO_4 mg/ℓ	50	Blue	Blue	Blue	Blue	Blue	Blue
Fluoride as F mg/ℓ	0,72	Green	Blue	Green	Blue	Blue	Green
Sodium as Na mg/ℓ	100	Green	Green	Green	Blue	Blue	Green
Magnesium as Mg mg/ℓ	53	Blue	Green	Blue	Green	Green	Green
Iron as Fe mg/ℓ	NA	NOT USED, AS ONLY ONE SAMPLE TAKEN					
Faecal coliforms no/100mℓ		AVERAGE IS NOT USED IN THE ASSESSMENT					
Arsenic as As mg/ℓ	ND	Blue	Blue	Blue	Blue	Blue	Blue
Turbidity (NTU)	3,5	Yellow	Yellow	Yellow	Yellow	Green	Yellow
Free available chlorine mg/ℓ^2	NOT NECESSARY FOR THIS ASSESSMENT^2						

Note: 1. For pH, the minimum value is used.
2. Water is not treated.

NOTE If there is only one value, accept this as the maximum and classify the water accordingly.

Step 2:

Determine the overall class of the water supply:

(i) After comparing all the data to the guidelines, the worst class for a use (drinking, cooking or laundry and other uses) is used to determine the substance class as shown in Table 5. The worst substance class will then determine the overall class of water supply. An example of how to do this is shown in **Table D1** (p 26).

Table 5: Classification of substances

SUBSTANCE	WORST CLASS PER USE		SUBSTANCE CLASS
	Maximum* value	**Average** value**	
1 Faecal coliforms Total coliforms (cause acute effects – use maximum value only)	Blue	not used***	Blue
	Green	not used***	Green
	Yellow	not used***	Yellow
	Red	not used***	Red
	Purple	not used***	Purple
2 Electrical conductivity, turbidity, nitrate/nitrite, fluoride, sulphate, chloride, arsenic, zinc, cadmium, copper, iron, potassium, sodium, magnesium, calcium, hardness	Blue	Blue	Blue
	Green	Blue/Green	Green
	Yellow	Blue	Green
	Yellow	Green/Yellow	Yellow
	Red	Blue/Green	Yellow
	Red	Yellow/Red	Red
	Purple	Blue/Green	Purple
	Purple	Red/Yellow/Purple	Purple
3 Free available chlorine, pH	As for 1, but use minimum value instead of maximum when pH values are below 7, or chlorine is below 0,3 mg/ℓ		

* Maximum value determines whether acute effects occur or not.

** Average value determines whether chronic effects occur or not.

*** To provide additional information for the assessment of the treatment process, the geometric mean may be used.

Case study continued (see p 18)

Sample data set – classifyng the water

Determining the final class for each use

The final colour class of the water is determined using the process outlined below, using Table 5, with transfer of data to worksheet given in Appendix D.

Table D1

SUBSTANCE	WORST SUBSTANCE CLASS		SUBSTANCE CLASS
	Maximum	Average	
Arsenic (mg/ℓ As)	Blue	Blue	Blue
Cadmium (mg/ℓ Cd)	✻[1]	✻[1]	–
Calcium (mg/ℓ Ca)	✻[1]	✻[1]	–
Chloride (mg/ℓ Cl)	Green	Blue	Green
Conductivity in mS/m at 25˚C	Yellow	Green	Yellow
Copper (mg/ℓ Cu)	✻[1]	✻[1]	–
Faecal coliforms (No./100mℓ)	Red	–	Red
Fluoride (mg/ℓ F)	Yellow	Green	Yellow
Free available chlorine mg/ℓ	✻[2]	✻[2]	–
Hardness (mg/ℓ $CaCO_3$)	✻[1]	✻[1]	–
Iron (mg/ℓ Fe)	Purple	–	Purple
Magnesium (mg/ℓ Mg)	Yellow	Green	Yellow
Manganese (mg/ℓ Mn)	✻[1]	✻[1]	–
Nitrate (mg/ℓ N)	Red	Red	Red
pH (Units)	Blue	Blue	Blue
Potassium (mg/ℓ K)	✻[1]	✻[1]	–
Sodium (mg/ℓ Na)	Green	Green	Green
Sulphate (mg/ℓ SO_4)	Blue	Blue	Blue
Turbidity (NTU)	Yellow	Yellow	Yellow
Zinc (mg/ℓ Zn)	✻[1]	✻[1]	–

OVERALL WATER CLASS Purple

Footnotes

✻[1] Not analysed in case study

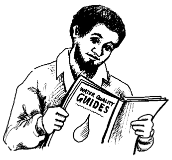
✻[2] Not applicable in unchlorinated water

SECTION D1

Determine treatability

ROAD-MAP

Section A1
General information on the concepts of water quality



Familiarise yourself with the concept of water quality

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Section B1
Collect the data

Determine the minimum data needs

↓

Collect the data

↓

Process the data

↓

Section C1
Classify the water in terms of suitability for domestic use

Compare results to the guidelines

↓

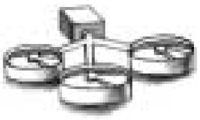
Classify the water per substance

↓

Determine the overall class of source

↓

Section D1
Consider treatment options available to improve water quality



Determine treatability

YOU
ARE
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Section E1
Interpret water quality information

Interpret information

The previous section described how to classify the water in terms of suitability for use. After classifying the water, and at the same time identifying problems, it is necessary to determine whether or not the water can be treated to overcome these problems.

NOTE

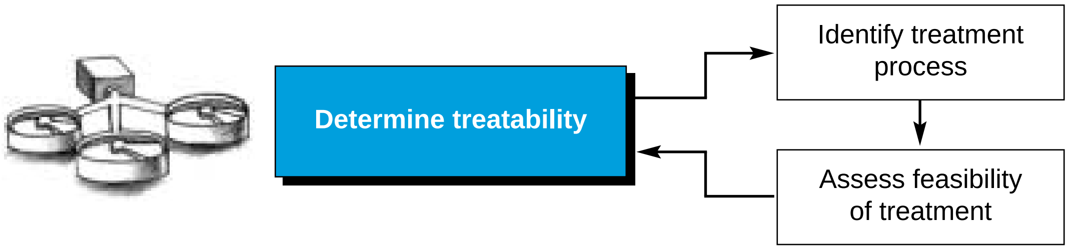
This section does not provide the information necessary to design water treatment works. It is intended only to:

- indicate what type of treatment options are available to remove problem substances, using either home, community, conventional or advanced treatment, and
- provide a tool for the rapid comparison of the treatability of two potential water sources so as to facilitate water supply planning decisions.

This section sets out to answer the questions:

- Can the water be treated to remove problem substances?
- What is the purpose of treatment?
- What treatment is required?
- How effective should treatment be?
- What treatment is available?
- What other methods can be used to improve water quality?

A step-by-step procedure to determine the treatability of the water.



1. DETERMINE TREATABILITY

(a) Identify the first substance of concern (Yellow, Red or Purple class).

(b) Identify possible treatment from Table 7.

(c) Determine if treatment is economically and technically feasible with respect to the user.

(d) Identify next substance of concern and repeat steps b to c until all substances have been accounted for.

Determine the availability of treatment

(a) Can the water be treated to remove problem substances ?

Water can be treated (at a cost) to remove any substance which may make it unsuitable for domestic use – but it may be easy to remove some substances from water and difficult to remove others. Similarly, treatment may be cheap or expensive.

Sources of water falling into the Red (Class 3), or Purple (Class 4), classes should not be immediately rejected. Many of the substances which cause problems can be easily removed by treating the water before it is used. The costs and ease of treating the water depend on the substance causing the problem.

While any water could be treated to reach the Blue class, the costs of treatment may be very high. However, some substances can be removed from water using chemicals, materials or processes which are both **cheap** and **readily available** in most communities. (For example, the use of bleach or boiling to disinfect water.) Other substances can be removed only by using advanced techniques and special materials which may be **expensive** and not necessarily readily available to the community.

Treatment of water to remove problem substances may also be **difficult**, requiring trained people and a high level of expertise, or it may be **easy** to apply – even in the home and with only simple instructions.

Table 6: The classification of treatment options

CHEAP	***Easy***	Treatment does not require trained people to administer. Chemicals or materials to treat the water are easy to obtain in the community or the home.
	Difficult	Treatment requires trained people to supervise. Chemicals or materials to treat the water are usually readily available in the community or the home and are cheap.
EXPENSIVE	***Easy***	Treatment does not require trained people to administer (easy to administer). Chemicals or materials to treat the water are expensive.
	Difficult	Treatment requires trained people to supervise. Chemicals or materials to treat the water are expensive.

The treatment of the water can be done in several ways:

- **Home treatment**:
  This can be done in the home, using materials which are common in most households or which are readily availabe.
- **Basic treatment**:
  This can be done by the community, using materials which are common in most communities, or which can be easily bought. The treatment is done by the community at common watering points. Working together to use basic treatment may save costs.
- **Conventional treatment**:
  This is done in a treatment plant constructed for the purpose. Conventional treatment includes: Coagulation, flocculation, filtration, and disinfection (usually by chlorine). Conventional treatment requires trained people to run the plant.

- **Advanced treatment**:
  This requires specialised treatment such as activated carbon filtration, reverse osmosis and ion exchange. These technologies are not commonly used in conventional treatment plants.

(b) What is the purpose of treatment ?

Water is treated to make it suitable for domestic use. Treatment requires sufficient removal of substances which cause water quality problems so as to make the water safe and acceptable.

Water sources may not always be fit for domestic users – indeed, most surface water sources require some form of treatment, even if this consists only of disinfection (removal of microbiological organisms). However, any treatment process involves a cost.

In some cases treatment is not aimed at rectifying a problem, but rather at maintaining a desirable condition. For example, groundwater (from deep boreholes) is generally clear and free of bacteria, and can be used without any treatment. But, water may be contaminated during distribution or in the home. In this case disinfection is aimed at reducing the risks associated with contamination during transport and storage.

(c) What treatment is required?

The treatment required depends on:

- *the substances in the water before treatment,*
- *the desired quality at the point of use, and*
- *the cost of treatment.*

It is important to refer back to the substances which are causing the problem (see Table 5, p 25 Section C). Most consumers desire water of an ideal quality (Blue or Class 0 water), but are usually prepared to accept Class 1 (Green) or even Class 2 (Yellow) water if the cost of treatment becomes too high. Community consultation is therefore important before deciding on water quality goals and a treatment process.

In some cases, treatment for one problem will also solve another. Conventional treatment to remove sediment will also remove a substantial proportion of dissolved metals such as iron and manganese. On the other hand, much of the chlorine added to water with high concentrations of iron and manganese may be consumed in the oxidation of these substances. In such cases, excess chlorine may be required to yield the desired free available chlorine concentrations at the point of use, and the water should be stored in a reservoir to allow the precipitated substances to settle.

Lastly, while it is possible to remove all substances from water, water without any dissolved substances in it can also be unhealthy. The human body requires certain substances in small amounts to remain healthy and these substances can often be supplied in water.

NOTE

Treatment of a problem should never be considered as an alternative to protecting the source against pollution.

(d) How effective should treatment be?

The aim of treatment is to achieve the best water quality possible (Blue or Green). Often conditions make it difficult to achieve this goal. In these cases, at least Yellow water quality should be supplied.

(e) What treatment is available?

There is a wide range of treatment methods available, each suited to different circumstances.

Table 7, p 32-34 offers some guidance on available treatment options to improve the microbiological, physical and chemical quality of water.

(f) What other methods can be used to improve water quality?

In some cases, treatment is not the only option to overcome water quality problems. Other methods include:

- *Mixing water of good and bad quality to obtain water of acceptable quality.*
- *Selection of time or position of abstraction of water.*

Mixing:

If there is more than one source of water available, such as surface and underground water, it may be possible to mix the water. This can provide water of an acceptable quality, as long as the ratio is chosen correctly. In this way more water can be made available.

Selection:

If the water quality in a source, for instance a stream, is occasionally not fit for use, it is an option to let this water pass until the quality improves. To use this option it is necessary to provide storage outside the stream as an alternative interim water source. Similarly, the depth of the abstraction point in a dam can be set at a point where the water quality is the best .

NOTE

The tables on pages 32-34 are arranged according to the microbiological, physical and chemical quality of water.

Table 7A: Some available treatment options for the improvement of microbiological quality

VARIABLE	TREATMENT			
	Easy and cheap	**Easy and expensive**	**Difficult and cheap**	**Difficult and expensive**
Faecal coliforms & total coliforms	• Boil water • Add household bleach • Expose to sunlight • Slow sand filtration	• Hypochlorites • Ultra violet radiation	• Fast sand filtration	• Ultrafiltration • Ozone • Chlorine dioxide • Chlorine gas • Chlorination
Excess Free available chlorine (residual chlorine)[1]	• Boil water • Allow water to stand in an open container	• Activated carbon filtration	–	–

Footnote:

[1] Residual chlorine is normally controlled through adjustment of the chlorination process.

Table 7B: Some available treatment options for the improvement of physical quality

VARIABLE	TREATMENT			
	Easy and cheap	**Easy and expensive**	**Difficult and cheap**	**Difficult and expensive**
TDS/Conductivity	–	• Ion exchange[2]	–	• Reverse osmosis • Electrolysis
pH[1]	–	• Columns with buffers	• Low pH: Add lime and filter • High pH: Add acid	• Chemical treatment, depending on nature of problem, eg carbon dioxide addition
Turbidity	• Sedimentation and filtration • Slow sand filtration	• Disposable filtration kits	• Conventional flocculation, settling and filtration	–

Footnote:

[1] Merely adjusting the pH is not enough, as this may not create sufficient buffering capacity, especially when treating low pH.

[2] Home treatment devices: Ion exchange is easy, but very expensive when use is made of throw-away cartridges.

Table 7C: Some available treatment options for the improvement of chemical quality

VARIABLE	**TREATMENT**			
	Easy and cheap	**Easy and expensive**	**Difficult and cheap**	**Difficult and expensive**
Arsenic	–	• Ion exchange[2]	• Oxidation together with flocculation, settlement and filtration	• Flocculation with an iron salt ($FeCl_3$), settlement and filtration. Can be done as part of the normal treatment process.
Cadmium	–	• Ion exchange[2]	–	• Chemical precipitation, settlement and filtration.
Calcium	• Boiling of water[4]	• Ion exchange[2]	–	• Precipitation with sodium carbonate, settlement and filtration. This must be done as an additional step to the normal treatment process. • Ion exchange[3]
Chloride	–	• Ion exchange[2]	–	• Reverse osmosis • Electrolysis
Copper	–	• Ion exchange[2]	–	• Chemical precipitation, settlement and filtration
Fluoride	–	• Ion exchange[2] • Adsorption on activated alumina	–	• Reverse osmosis • Re-activated alumina/bone char
Hardness, Total	–	• Ion exchange[2]	–	• Precipitation with sodium carbonate, settlement and filtration. This must be done as an additional step to the normal treatment process. • Ion exchange[3]
Iron	• Oxidation through aeration. Operation is easy, but design requires expertise. • Add bleach and filter after allowing to settle.	• Ion exchange[2]	• Removal as part of normal treatment process. High iron concentrations may require additional chlorine for end-point chlorination.	• Precipitation, sedimentation and filtration. Strong oxidants and/or high lime treatment.

➥

Table 7C: Some available treatment options for the improvement of chemical quality (continued)

VARIABLE	TREATMENT			
	Easy and cheap	**Easy and expensive**	**Difficult and cheap**	**Difficult and expensive**
Magnesium	• Boiling of water	• Ion exchange[2]	–	• Precipitation with sodium carbonate, settlement and filtration. This must be done as an additional step to the normal treatment process. • Ion exchange[3]
Manganese	• Oxidation through aeration chlorine addition. Operation is easy, but design requires expertise. • Add bleach and filter after allowing to settle	• Ion exchange[2]	• Removal as part of normal treatment process. High manganese concentrations may require additional chlorine for end-point chlorination. Allow for precipitation and settlement in reservoir.	• Chemical precipitation with high lime treatment followed by sedimentation and filtration and pH readjustment.
Nitrate/Nitrite	–	• Ion exchange[2]	–	• Denitrification with anaerobic biological reduction. • Reverse osmosis • Ion exchange[3]
Potassium	–	• Ion exchange[2]	–	• Reverse osmosis • Electrolysis
Sodium	–	• Ion exchange[2]	–	• Reverse osmosis • Electrolysis
Sulphate	–	• Ion exchange[2]	–	• Reverse osmosis • Electrolysis
Zinc	–	• Ion exchange[2]	–	• High lime treatment, chemical precipitation, settlement and filtration

Footnotes:

[2] **Home treatment devices:** Ion exchange is easy, but very expensive when use is made of throw-away cartridges.

[3] **Large-scale treatment plants:** Ion exchange is difficult and expensive where the ion exchange resin must be re-generated.

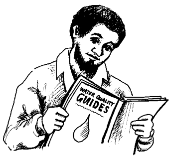
[4] Calcium and magnesium bicarbonates precipitate as scale on boiling.

SECTION E1

Interpretation of water quality information

ROAD-MAP

Section A1
General information on the concepts of water quality



Familiarise yourself with the concept of water qualtiy

Section B1
Collect the data

Determine the minimum data needs

Collect and prepare data

Process the data

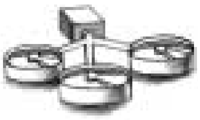
Section C1
Classify the water in terms of suitability for domestic use

Compare results to the guidelines

Classify the water per substance

Determine overall class of source

Section D1
Consider treatment options available to improve water quality



Determine treatability

Section E1
Interpret water quality information

Interpret water quality information

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Guiding decision-making

The previous sections have:

- provided a background into the effects of water quality on the domestic water user,
- indicated how to classify domestic water supplies, and
- indicated some options which may be used to remove harmful substances from the water.

This section provides some guidelines for decision making based on the classification of the water, and outlines:

- typical water quality problems in different parts of South Africa,
- guidelines for deciding if a water source could be developed for water supply, and
- guidelines for deciding if the water supply to the community is safe.

1. Typical water quality problems in South Africa

(a) What water quality problems are common in South Africa ?

The most important water quality problem in surface water in South Africa is most likely to be faecal pollution together with the associated disease-causing organisms. However, elevated salt concentrations (TDS, sodium and chloride) are also common in many parts of the country. In groundwater the most common problems are high nitrate/nitrite and fluoride concentrations.

(i) Problems in surface water

Most of the surface water in South Africa is of good quality and requires only clarification and disinfection. There are, however, a few notable exceptions:

- **Faecal pollution**

  High faecal and total coliform counts (used as indicator organism to indicate recent faecal pollution) occur in most surface water near dense human settlements.

- **Colour and stability**

  The rivers that drain the mountain catchments along the southern coastline have waters that are highly coloured due to organic acids. These waters have characteristically low TDS (Electrical conductivity (EC)) concentrations and a low pH. Colour removal requires precise chemical dosing, and together with the stabilisation of the water, treatment is neither cheap nor easy.

- **Salt concentrations (TDS or EC, sodium, chloride and sulphate)**

  The rivers that drain the dry interior regions carry water that may have a high TDS concentration mostly resulting from high sulphate and chloride concentrations. This means that the water is corrosive and has a distinctly salty taste. Salt removal by means of reverse osmosis or ion exchange is expensive, and most communities accept the water after clarification and disinfection. Care should be taken in areas where the TDS, sulphate or chloride concentrations are in the Red or Purple classes.

  The rivers that drain the northern and eastern parts of South Africa generally carry good quality water, unless it has been contaminated due to human activity. A prime example of this is the Vaal River downstream of the Vaal Dam, which has a high TDS due to effluent from the Witwatersrand area and from the gold mines. Treatment is expensive and the consumers normally accept the high salinity.

- **Eutrophication (high algal concentrations)**

  Some reservoirs in South Africa have high algal concentrations. Water from these water bodies may have taste and odour problems. In many cases, authorities have implemented treatment options such as powdered activated carbon, or processes such as dissolved air flotation instead of the more conventional sedimentation in the clarification process. In some cases algae may produce toxins which are of concern to human health. Generally, however, these toxins are also removed by the above processes.

(ii) Problems in groundwater

The most common problems in groundwater are:

- **Salinity**

  Many groundwaters have high TDS concentrations, especially those in the drier regions of the country where the predominant geological formations are sedimentary rocks of marine origin. The Karoo shales are a prime example of this. Salinity can be removed only at high cost and by means of, for instance, reverse osmosis, electrodialysis or deionisation.

- **Fluoride**

  Fluoride concentrations in groundwater in some areas tend to be high, especially in the central and western parts of the country. In the coal-bearing regions of the country fluoride concentrations tend to be very high. Fluoride removal is expensive.

- **Sulphate and chloride**

  Water with high TDS concentrations tends to have high sulphate concentrations as well. Sulphate removal is expensive (desalination or ion exchange) and normally not considered viable.

- **Calcium and magnesium**

  The groundwater in the dolomitic areas and the northern parts of the country tends to be very hard. This usually has no health implications, except where concentrations are extremely high. It does, however, lead to clogging of pipes and scaling of the elements in hot water appliances. The cost of replacement and maintenance of these appliances may make it cheaper to treat the water. For small communities, or single households, water softening by means of ion exchange is recommended. For larger communities, chemical dosing, settling and filtration will be more economic.

  It is important to note that water softening by means of ion exchange will add sodium to the water. This could prove problematic if the sodium concentration is already high.

- **Iron and/or manganese**

  Iron and manganese commonly occur in high concentrations in groundwater. Treatment for both of these problems is cheap and easy, consisting of oxidation by means of aeration, or by adding chlorine.

2. Interpret water quality information

One of the main reasons for classifying domestic water supplies is to facilitate decision making with regard to either the safety of the water supplied, or whether a water source can viably be developed for domestic supply. However, the appropriate course of action in each of these cases is not only affected by the class of the water, but also by:

- the purpose of classifying the water,
- what substance(s) is (are) causing the problem,
- the ease of treating the water, and,
- the amount of data used to classify the water.

Deciding on a course of action based on the class of the water is therefore difficult and should be made on a site-specific basis. Decision-making should also not only be based on the overall class of the water, but on the class of the various substances and their effects on the domestic user. It is therefore important to refer back to the guidelines when making decisions regarding the quality of domestic water supplies. The following paragraphs may help in this decision-making process.

Can a water source be developed for supply?

In general terms;

- *water sources falling in the Blue and Green classes can be used with little or no treatment,*
- *water falling in the Yellow class can conditionally be developed as a supply, but may require treatment in the long term, and*
- *water falling in the Red and Purple classes will have to be treated before supply.*

It is unlikely that untreated surface waters in South Africa would fall into the Blue, Green or Yellow classes (with the possible exception of mountain streams). Turbidity in most rivers and dams will place the water at least in the Red or Purple classes. Similarly, most surface waters in South Africa, especially those near human settlements, face some risk of faecal pollution. It is, therefore, recommended that all surface waters for drinking purposes in South Africa be treated at least by filtration and disinfection, irrespective of the class.

When surface water sources fall into the Red or Purple class, decisions with respect to the development of the resource for domestic supply are most likely to be made on the ease of treating the water. Substances which can be easily and cheaply removed from the water should not restrict the development of the water source for domestic use, while substances which are expensive and difficult to remove may warrant investigation of alternate sources. It is also recommended that a treatment expert be consulted when assessing the treatability of water sources falling into the Red and Purple classes.

Some groundwater sources in South Africa may be suitable for use without treatment, but local pollution of the groundwater, even after its development for supply, is also likely to create problems. In this respect it is recommended that both protection of the groundwater source and simple treatment be considered when developing groundwater sources. However, those groundwater sources which fall into Red and Purple classes due to total dissolved salts, fluoride, nitrate/nitrite, sodium or chloride will be difficult to treat. In these cases alternative sources should be investigated.

When is the water safe for domestic use?

In general terms:

- *water in the Blue and Green classes is safe for domestic water use,*
- *water in the Yellow class is safe for use, but may affect certain sensitive groups,*
- *water in the Red class may be used for short-term emergency use where no other supply is available, and*
- *water in the Purple class is unsafe for use without treatment.*

Decision making on the suitability of water for domestic use is largely determined by the health-related drinking class of the water. It is therefore important to assess whether the substance causing the problem has any health effect. The following can then be used to guide decision making:

- Water falling in the Blue or Green class can be used without reservation and should be considered safe for all users.
- Water falling in the Yellow class can generally be regarded as safe, but sensitive users should be identified and warned to take their own precautions.
- Water falling in the Red class may be used for short-term emergency supply (± 7 days) only, where other sources are not available. Where water falls into the Red class it is important to check if the substance causing the problem commonly falls in the Red class. If the water is treated, short infrequent problems are unlikely to be a cause for concern, and are most likely to be associated with temporary problems in the treatment works. In these cases the water treatment authority should be consulted. If the water is not treated it may be necessary to investigate treatment. If the substance is difficult and expensive to treat it may be necessary to investigate alternative water supplies.
- When water falls into the Purple class the public should be warned not to use the water, or to use emergency home treatment where possible. If emergency home treatment is not possible, alternative water supplies should be considered. However, relying on home treatment is not recommended for long periods of time.

Water falling in the Red or Purple class should in any event be re-sampled immediately to confirm the classification. It should also be remembered that water falling into the Red or Purple class for "drinking health" may still be suitable for the other domestic uses. In these cases an alternate supply, for example water tankers, can be used only for drinking water.

Lastly, if water supplies frequently fall into the Red or Purple class, it is recommended that water quality experts be consulted for more detailed advice on treatment (see Appendix A).

NOTE

This guide has, as far as possible, been brought into line with the revised *SA Bureau of Standards Specification for Water for Domestic Supplies* (SABS 241 1998, in preparation). The latter refers to the Blue, Green and Yellow classes for drinking water as the ideal, acceptable and maximum allowable limits respectively.

Case study continued (see p 18)

Interpretation

The water is classed as Purple for all uses except bathing. However, this is due to high iron concentration and the iron classification is based on only one sample. It is important, therefore, that the water be sampled again to confirm the high iron value. High iron concentrations are typical of many groundwaters, but this problem is easily and cheaply solved by aerating the water(Table 7). The population should, therefore, be encouraged to at least let the water stand before use, and to filter the water through a cloth. Basic treatment by letting the water stand in a reservoir is also likely to remove most of the iron.

Given that iron can be easily removed, a further classification can be done without iron.

The water is now classed as Red for Drinking Health, and this is due to high faecal coliform and nitrate concentrations. While the high faecal coliform problem can be easily treated by disinfecting the water (Table 7), high nitrate concentrations are difficult and expensive to remove. The average Nitrate concentration also falls into the Red class. This means that the water typically has high Nitrate concentrations, and should be used only for emergency supply and indicates that alternative sources should be used, especially for the drinking water of infants. Adults will not normally be affected by nitrates in the Red class. The Yellow classification for the other uses also indicates that some aesthetic problems are likely.

PART 2:

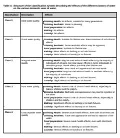
Guidelines for assessing domestic water quality

PART 2

Guidelines

ROAD-MAP

Section A2
Introduction to the structure of the guidelines



INTRODUCTION

– Structure of Part 2
– Substances of concern
– Structure of guidelines
– Additional information

YOU ARE HERE

Section B2
Microbiological quality

MICROBIOLOGICAL WATER QUALITY

– Faecal coliforms
– Free available chlorine (Residual)
– Total coliforms

Section C2
Physical quality

PHYSICAL WATER QUALITY

– Electrical Conductivity
– pH Value
– Turbidity

Section D2
Chemical quality

CHEMICAL WATER QUALITY

– Arsenic
– Cadmium
– Calcium
– Chloride
– Copper
– Fluoride
– Iron
– Hardness (Total)
– Magnesium
– Manganese
– Nitrate/Nitrite as N
– Potassium
– Sodium
– Sulphate
– Zinc

INTRODUCTION

Part 1 of this Guide gives a description of the procedure that has to be followed to assess and interpret the quality of domestic water supplies.

Part 2 of this Guide contains the "tools" to assess the quality of domestic water supply. The tools consists of 21 water quality guidelines for substances that are generally found in water and that are most relevant in the assessment of the quality of domestic water supplies.

Structure of Part 2

Water quality is defined in terms of its microbiological, physical and chemical characteristics (see Part 1, Section A, p4). The guidelines for the 21 key substances are, therefore, subdivided into three categories namely substances that are of relevance for the assessment of:

Section B2

Microbiological water quality

Section C2

Physical water quality

Section D2

Chemical water quality

Substances of concern to the domestic water user

Table 8 gives information on the water quality substances that are most relevant to the domestic user. Information is also given on the order of priority (in terms of a priority group rating) in which the various constituents should be included in the assesment of the quality of domestic water supplies.

The groups have been selected according to the following criteria (see Part 1, Section B1, pp 12-14):

- **Group A** substances are general indicators of water quality and should be frequently tested at all the points in the water supply system.
- **Group B** substances are commonly present at concentrations which may lead to health problems and should always be determined before water is supplied.
- **Group C** substances occur less frequently at concentrations of real concern to health, but should always be tested in areas of the country where soft water of low pH value is used.
- **Group D** substances may commonly be present at concentrations of aesthetic and economic concern in domestic water sources.

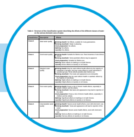


Table 8: Water quality substances of key relevance to the domestic user

KEY SUBSTANCES	RELEVANCE TO DOMESTIC USER	PRIORITY GROUP	PAGE
	Microbiological quality		
Faecal coliforms	Indicates recent faecal pollution, and the potential risk of contracting infectious diseases	A	50-51
Total coliforms	Indicates the general hygienic quality of the water	A	52-53
Free available chlorine (residual)	Indicates the adequacy of disinfection using chlorine	B	54-55
	Physical quality		
Electrical conductivity/ total dissolved salts	Affects the taste and "freshness" of the water	A	58-59
pH	Affects the taste and corrosivity of the water	A	60-61
Turbidity	Indicates the cloudiness of the water and affects the risk of infectious disease transmission	A	62-63
	Chemical quality		
Arsenic	Excessive amounts can make the water poisonous and may also cause cancer	B	66-67
Cadmium	May affect the toxicity of the water	C	68-69
Calcium	Causes scaling in pipes; affects taste of water	D	70-71
Sodium & chloride	May impart a salty taste to the water	D	90/1-72/3
Copper	Affects taste of the water and causes staining	C	74-75
Fluoride	Excessive amounts stain teeth and cause crippling skeletal deformities	B	76-77
Iron & manganese	May discolour water; excessive amounts may be toxic	D	78/9-84/5
Total hardness	Affects the scaling and foaming quality of the water	D	80-81
Magnesium	Excessive amounts make water bitter, and may cause diarrhoea	D	82-83
Nitrate + nitrite	May be toxic to infants	B	86-87
Potassium	Imparts a bitter taste; toxic in large amounts	D	88-89
Sulphate	Excessive amounts cause diarrhoea	B	92-93
Zinc	May affect the taste of the water – Makes water bitter	C	94-95

Please note: *The above list is by no means comprehensive (see Section B for other substances that may also be important when assessing domestic water quality).*

Footnote

[1] See Table 1 p 12-14

Structure of guidelines

The effect of changes in water quality on the domestic water user is described in a water quality guideline for each of the 21 key substances. Each guideline is structured in such a way that it gives information on the following aspects:

(a) Domestic water-use types

Water is used for a number of purposes in and around the house (also see Section A, p7) namely:

- drinking,
- food preparation,
- bathing and personal hygiene, and
- laundry.

(b) Assessment criteria

Water quality affects the various domestic uses in terms of (see Part 1, Section A, p 8):

- health,
- aesthetics, and
- economics.

As the most critical use of domestic water is for drinking purposes and the sustaining of life, the health effects of water that is consumed should always be considered first. Therefore, the health and aesthetic effects of drinking water have been considered separately. For the other three main uses of domestic water, viz., food preparation, bathing and laundry, the use is looked at in totality (the health and aesthetic effects have not been separated).

(c) Colour coded classification system

To facilitate easy interpretation and reporting of water quality information, the water quality guidelines are presented in terms of a simple colour coded classification system (see Part 1, Section C).

The suitability for domestic use of each of the 21 key substances, is expressed in terms of the colour coded classes that can be seen on page 47.

Table 9: Colour coded classification system (Also see Table 4, p 22)

Blue B	**(Class 0)**	**Ideal water quality** – suitable for lifetime use.
Green G	**(Class I)**	**Good water quality** – suitable for use, rare instances of negative effects.
Yellow Y	**(Class II)**	**Marginal water quality** – conditionally acceptable. Negative effects may occur in some sensitive groups.
Red R	**(Class III)**	**Poor water quality** – unsuitable for use without treatment. Chronic effects may occur.
Purple P	**(Class IV)**	**Dangerous water quality** – totally unsuitable for use. Acute effects may occur.

Footnote

Negative effects can be:

Health effects: Illnesses.

Aesthetic effects: Changes in water colour, taste or odour; staining of laundry and household fixtures.

Economic effects: Increased soap consumption and scaling and corrosion of household pipes.

Additional information

Each guideline also gives:

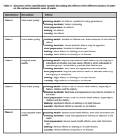
- a short description of the nature of the specific water quality substance and its effects, and
- a brief indication of the type of treatment available.

PART 2

Guidelines

ROAD-MAP

Section A2
Introduction to the structure of the guidelines



INTRODUCTION

- Structure of Part 2
- Substances of concern
- Structure of guidelines
- Additional information

Section B2
Microbiological quality

MICROBIOLOGICAL WATER QUALITY

- Faecal coliforms
- Free available chlorine (Residual)
- Total coliforms

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Section C2
Physical quality

PHYSICAL WATER QUALITY

- Electrical Conductivity
- pH Value
- Turbidity

Section D2
Chemical quality

CHEMICAL WATER QUALITY

- Arsenic
- Cadmium
- Calcium
- Chloride
- Copper
- Fluoride
- Iron
- Hardness (Total)
- Magnesium
- Manganese
- Nitrate/Nitrite as N
- Potassium
- Sodium
- Sulphate
- Zinc

Nice to know

What are faecal coliforms?

Faecal coliforms (FC) are the most commonly used bacterial indicator of faecal pollution. Faecal coliforms are bacteria which normally inhabit the digestive system of all warm-blooded animals, including humans.

Where are faecal coliforms found?

Faecal coliform bacteria are found in water wherever the water is contaminated with faecal waste of human or animal origin.

FC counts in raw sewage are typically in excess of one million organisms per 100 mℓ. In deep uncontaminated underground water the count may be zero, while in pristine surface waters counts of 1 – 10 are common. Polluted water can contain counts anywhere in the range 10 – 1 000 000 (one million) organisms per 100 mℓ, depending on the degree of contamination.

Effects caused by faecal coliforms:

Health effects:

Faecal coliforms (FC) are indicators of the presence of faecal pollution in water and, as such, give an indication of the adequacy or otherwise of disinfection, as well as indicate the possible presence of disease-causing micro-organisms such as bacteria, viruses or parasites which may give rise to gastro-intestinal diseases, typically characterised by diarrhoea, and sometimes by fever and other secondary complications.

Dehydration from diarrhoea may be life threatening, particularly in infants.

Aesthetic effects:

Faecal coliforms *per se* have no aesthetic effects.

Sensitive groups:

(1) HIV positive individuals.
(2) Some infants under the age of 2 years.
(3) Individuals on immuno-suppressive medication, e.g. chemotherapy.

Treatment:

Various levels of treatment are applicable. Conventional treatment processes such as flocculation, coagulation and filtration will all result in reduction in the bacterial count. However, full removal needs effective disinfection, either with chemical (e.g. chlorine), or physical methods (e.g. ultra filtration or UV light). Home treatment may also be used in emergencies, such as the addition of a teaspoon of bleach to a bucket of water and allowing this to stand for 30 minutes before use, or boiling for at least 20 minutes.

Disinfection, i.e. inactivation of the coliform bacteria and associated micro-organisms with, for example, chlorine is more easily achieved in clear water than in turbid waters. The coliform bacteria may survive disinfection processes within suspended matter.
It is advisable to maintain a free available chlorine residual in the range of 0,2 mg/ℓ to 0,5 mg/ℓ to ensure disinfection in the distribution system. (See Table 7 p32-34 for details)

Faecal coliforms guideline

FAECAL COLIFORMS RANGE (Counts/100 mℓ)	DRINKING		FOOD PREPARATION	BATHING	LAUNDRY
	(Health) 	(Aesthetic) 			
0	B No detectable chance of infection	B No effects	B No effects	B No effects	B No effects
0-1	G Insignificant chance of infection	B No effects	G Insignificant chance of infection	G Insignificant effects	G Insignificant effects
1-10	Y Clinical infections unlikely in healthy adults, but may occur in some sensitive groups	B No effects	Y Clinical infections unlikely in healthy adults, but may occur in some sensitive groups	G Insignificant effects	G Insignificant effects
10-100	R Clinical infections common, even with once-off consumption	B No effects	R Clinical infections common, even with once-off consumption	Y Slight risk	Y Slight risk
>100	P Serious health effects common in all users	B No effects	P Serious health effects common in all users	R Possibility of infection	R Possibility of infection

🟦 **Blue - Ideal** 🟩 **Green - Good** 🟨 **Yellow - Marginal** 🟥 **Red* - Poor** 🟪 **Purple* - Completely unacceptable**

*Not to be used without treatment

Nice to know

What are total coliforms?

Total coliform bacteria comprise bacterial species of faecal origin, as well as several other bacterial groups.

Total coliforms are indicative of the general hygienic quality of the water.

Where are total coliforms found?

Total coliform bacteria are found in high numbers wherever there is faecal contamination of water, or where there is contamination by bacteria commonly occurring in soil. Bacterial counts are high in surface water receiving untreated human or animal waste. Counts may be zero in unpolluted deep groundwater, while pristine surface water may contain counts of 1 – 10 per 100 mℓ. Polluted water often contains counts anywhere in the range 100 – 100 000 per 100 mℓ. Raw sewage has a total coliforms count in excess of 1 000 000 per 100mℓ. Where pit latrines are used, concentrations in groundwater may be high.

Effects & problems caused by total coliforms:

Health effects:

Total coliforms (TC) are indicators of the presence of faecal pollution, and thus the possible presence of disease-causing micro-organisms, such as bacteria, viruses or parasites which may give rise to gastro-intestinal diseases.These are typically characterised by diarrhoea, and sometimes by fever and other secondary complications. Dehydration may be life threatening from diarrhoea, particularly in infants.

Aesthetic effects:

Total coliforms *per se* have no aesthetic effects.

Sensitive groups:

(1) HIV positive individuals.
(2) Some infants under the age of 2 years.
(3) Individuals on immuno-suppressive medication, e.g, chemotherapy.

Treatment:

Various levels of treatment are available: Conventional treatment processes such as flocculation, coagulation and filtration will all result in reduction in the bacterial count. However, full removal needs effective disinfection, either with chemical (e.g. chlorine), or physical methods (e.g. ultrafiltration or UV light). Home treatment may also be used in emergencies, such as the addition of a teaspoon of bleach to a bucket of water, and allowing this to stand for 30 minutes before use, or boiling for at least 20 minutes. Containers should be covered to prevent secondary contamination.

Disinfection, i.e. inactivation of the coliform bacteria, and hopefully associated micro-organisms with, for example chlorine, is more easily achieved in clear water than in turbid waters. The coliform bacteria may survive disinfection processes within suspended matter.

It is advisable to maintain a free available (residual) chlorine concentration in the range of 0,2 – 0,5 mg/ℓ to ensure disinfection in the distribution system.

Total coliforms guideline

TOTAL COLIFORMS RANGE (Counts/100 mℓ)	DRINKING		FOOD PREPARATION	BATHING	LAUNDRY
	(Health)	(Aesthetic)			
					
0	B No detectable chance of infection	B No effects	B No detectable chance of infection	B No effects	B No effects
0-10	G Insignificant chance of infection	B No effects	G Insignificant chance of infection	G Insignificant effects	G Insignificant effects
10-100	Y Clinical infections unlikely in healthy adults, but may occur in some sensitive groups	B No effects	Y Clinical infections unlikely in healthy adults, but may occur in some sensitive groups	G Insignificant effects	G Insignificant effects
100-1000	R Clinical infections common, even with once-off consumption	B No effects	R Clinical infections common, even with once-off consumption	Y Slight risk	Y Slight risk
>1000	P Serious health effects common in all users	B No effects	P Serious health effects common in all users	R Possibility of infection	R Possibility of infection

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*Not to be used without treatment

Nice to know

What is free available chlorine?

Free available (residual) chlorine is the free chlorine concentration remaining 30 minutes after breakpoint disinfection of the water with chlorine.

The free available chlorine is an indication of the efficacy of the disinfection process and thus a rapid indicator of the probable microbiological safety or otherwise of the treated water.

Where is free available chlorine found?

Free available chlorine does not occur in nature. It is the un-reacted free chlorine excess remaining in water at least 30 minutes after breakpoint disinfection of the water using chlorine as the disinfectant.

Effects caused by free available chlorine:

Health effects:

Health effects may arise firstly where free available chlorine is absent after treatment of the water with chlorine. Absence of free available chlorine means that either the water was not treated with chlorine, or that insufficient chlorine was used to successfully disinfect the water.

Where the untreated water contains pathogenic micro-organisms, the absence of free available chlorine indicates that there is a risk of microbiological infection. If the concentration of chlorine is too high then irritation of mucous membranes, nausea and vomiting may occur.

The chlorine residual also protects against secondary contamination in the distribution system.

Aesthetic effects:

Elevated concentrations of free available chlorine impart a disinfectant like taste and odour to the water.

There is no truly “ideal” free available chlorine level from an aesthetic viewpoint which will still be acceptable from a health viewpoint. It is, therefore, not possible to obtain Blue water which has been treated with chlorine.

Sensitive groups:

(1) Infants under the age of 2 years.
(2) Individuals with sensitive skins or allergies.

Treatment:

NB: Where there are high turbidity or iron levels in the water being chlorinated it may be very difficult to achieve breakpoint chlorination and thus, after 30 minutes, have a relatively stable free available chlorine residual. Where turbidity or iron levels are high, a treatment expert should be consulted. Control of the free available chlorine residual is normally achieved by chlorination process control. Free available chlorine can be removed by the use of activated carbon. Boiling the water also reduces the free available chlorine concentration.

Allowing the water to stand in a covered container will also reduce the free available chlorine.

If consumers are concerned about the chlorine taste of water, they may use activated carbon filters.

Free available chlorine (Residual)

INCREASING HEALTH RISK ↑

FREE AVAILABLE CHLORINE (mg/ℓ)	DRINKING		FOOD PREPARATION	BATHING	LAUNDRY
	(Health)	(Aesthetic)			
					
<0,05	P Serious risk of infection if raw water source microbiologically contaminated	B No effects	P Serious risk of infection if raw water source microbiologically contaminated	R Risk of infection if raw water source microbiologically contaminated	B No effects
0,05-0,1	R Disinfection may be compromised	B No effects	R Disinfection may be compromised	Y Slight risk of infection	B No effects
0,1-0,2	Y Slight risk of infection	B No effects	Y Slight risk of infection	G Insignificant risk of infection	B No effects
0,2-0,3	G Insignificant risk of infection, disinfection adequate	G Slight odour	G Insignificant risk of infection, disinfection adequate	B No health risks	B No effects
0,3-0,6	B Disinfection good	G Slight odour and taste	B Disinfection good	B No health risks	B No effects
0,6-0,8	G Disinfection good; insignificant risk of health effects	Y Marked odour and disinfectant taste	G Disinfection good; insignificant risk of health effects	G No health effects, marked odour	G Insignificant effects
0,8-1,0	Y Slight risk of mucous membrane irritation	R Unpleasant odour and taste	Y Slight risk of mucous membrane irritation	Y Unpleasant odour	G Insignificant effects
1,0-1,5	R May cause nausea and mucous membrane irritation	R Unpleasant odour and taste	R May cause nausea and mucous membrane irritation	R May cause skin rashes; unpleasant odour	Y Bleaching action on some dyes
>1,5	P Danger of toxic effects, nausea and vomiting	P Repulsive odour and taste	P Danger of toxic effects, nausea and vomiting at high concentrations	P Danger of toxic effects and severe skin irritation	R Bleaching action on coloured clothing at high concentrations

INCREASING HEALTH RISK ↓

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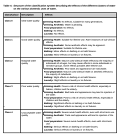
*Not to be used without treatment

PART 2

Guidelines

ROAD-MAP

Section A2
Introduction to the structure of the guidelines



INTRODUCTION

– Structure of Part 2
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Section B2
Microbiological quality

MICROBIOLOGICAL WATER QUALITY

– Faecal coliforms
– Free available chlorine (Residual)
– Total coliforms

Section C2
Physical quality

PHYSICAL WATER QUALITY

– Electrical Conductivity
– pH Value
– Turbidity

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Section D2
Chemical quality

CHEMICAL WATER QUALITY

– Arsenic
– Cadmium
– Calcium
– Chloride
– Copper
– Fluoride
– Iron
– Hardness (Total)
– Magnesium
– Manganese
– Nitrate/Nitrite as N
– Potassium
– Sodium
– Sulphate
– Zinc

Nice to know

What is electrical conductivity?

Electrical conductivity (EC) is a measurement of the ease with which water conducts electricity. Distilled water conducts electricity poorly, while sea water, with its very high salt content, is a very good conductor of electricity. The EC of the water indicates what the total dissolved salt (TDS) content of the water is. The EC measurement in mS/m can be used to estimate the TDS in mg/ℓ by multiplying the EC by the factor 6,5 i.e. TDS = EC x $6^{1}/_{2}$. The EC indicates whether the water is fresh or salty.

Where is electrical conductivity found?

Rainwater has a low EC of <1 mS/m. After falling on the earth, rainwater picks up salts on its way to the ocean, the amount depending on the nature of the geology, and the extent of evaporation, i.e. climatic conditions. Water in contact with granite has an EC of around 5 mS/m, whereas where sedimentary rock occurs the water conductivity is usually in the range 30 – 170 mS/m. In arid areas irrigation return flows and other effluents and discharges may raise the EC to as much as 300 mS/m or even higher. In arid areas groundwater may be naturally saline with a high conductivity.

Effects caused by electrical conductivity:

Health effects:

Health effects from EC occur only at levels above about 370 mS/m. Effects may include:

(1) Adverse effects on infants, i.e. disturbance of salt and water balance.
(2) Adverse effects on certain heart patients and individuals with high blood pressure.
(3) Adverse effects on individuals with renal disease.
(4) Laxative effects, where there are elevated concentrations of sulphate present.

Aesthetic effects:

Conductivities above 150 mS/m impart a salty taste to the water, and water with conductivity above 300 mS/m does not slake thirst.

Sensitive groups:

(1) Some infants under the age of 1 year.
(2) Individuals with congestive heart failure or with kidney disease who have been placed on a salt-restricted diet.
(3) Individuals with chronic diarrhoea.

Treatment:

To remove dissolved salts and associated electrical conductivity of water, energy-intensive processes are required, such as reverse osmosis or electrodialysis; distillation, or demineralisation with a mixed bed resin ion-exchange process.

All large-scale salt removal processes require high levels of operator and maintenance skills as processes are easily fouled by suspended matter or hard water. The concentrated brine produced may present disposal problems.

Home treatment kits using ion-exchange processes can be purchased, but these are expensive and treat only small volumes of water.

Electrical conductivity, (EC) total dissolved salts (TDS) guideline

ELECTRICAL CONDUCTIVITY RANGE EC:mS/m (TDS: mg/ℓ)	DRINKING		FOOD PREPARATION	BATHING	LAUNDRY
	(Health)	(Aesthetic)			
					
EC:<70 mS/m (TDS:<450mg/ℓ)	B No effects	B Water tastes fresh	B No effects	B No effects	B No effects
EC: 70-150 (TDS:450-1000)	G Insignificant effect on sensitive groups	G Water tastes good	G Insignificant effect on sensitive groups	B No effects	B No effects
EC: 150-370 (TDS:1000-2400)	Y Slight possibility of salt overload in sensitive groups	Y Water has a distinctly salty taste	Y Slight possibility of salt overload in sensitive groups	B No effects	G Insignificant corrosion
EC: 370-520 (TDS:2400-3400)	R Possible health risk to all individuals	R Water tastes extremely salty	R Possible health risk to all individuals	G Impaired soap lathering	Y Slightly corrosive
EC: >520 (TDS>3400)	P Increasing risk of dehydration	P Tastes extremely salty and bitter	P Increasing risk of dehydration	Y Impaired soap lathering	R Corrosive

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Nice to know

What is pH?

pH is a logarithmic expression of the hydrogen ion concentration in water and reflects the degree of acidity (pH less than 7) or alkalinity (pH greater than 7) of the water. In layman's language, pH indicates whether the water is sour (pH <7), or soapy (pH >7) to the taste.

What pH levels are found in water?

The pH of most unpolluted water sources lies in the range 6,5 – 8,5. pH values below 6,5 may be found wherever acidification processes occur, the most dramatic being that found in acid mine drainage where pH values as low as 3,0 may be found.

Alkalanisation processes, such as for example the exposure of water to lime or other alkalis may raise the pH above 8,5. Some waters in the Southern and Western Cape have naturally low pH.

Effects caused by pH:

Health effects:

These may either be direct or indirect. The direct effects are the consequence of the irritation or burning of mucous membranes by extremes of pH. The indirect effects are a consequence of the health effects of corrosion products formed during cooking or from distribution pipes most commonly occurring at acidic pH values.

Aesthetic effects:

Extreme pH values have a pronounced effect on the taste of the water, with low pH values resulting in a sour taste, and high pH values resulting in a soapy taste.

Sensitive groups:

(1) Some infants.

(2) People with skin problems or especially sensitive skins.

Treatment:

The pH of water may be increased with alkali reagents, such as lime, sodium hydroxide, or sodium carbonate. The pH may be lowered by use of an acidic reagent, such as sulphuric or hydrochloric acid, or in large-scale operations the use of carbon dioxide (producing carbonic acid in reaction with water).

The adjustment of water pH with an acid or alkali inevitably increases the salinity of the water. Care is required in the handling of the reagents used to adjust pH as these may cause serious burns.

pH guideline

(pH value is a measure of acid or base quality)

pH range	DRINKING		FOOD PREPARATION	BATHING	LAUNDRY
	(Health)	(Aesthetic)			
					
<3	Acid burns P	Extremely sour taste P	Acid burns P	Burns skin and eyes P	Extremely corrosive P
3-3,5	Severe irritation of mucous membranes R	Extremely sour taste P	Severe irritation of mucous membranes R	Burns skin and eyes P	Very corrosive R
3,5-4	Severe irritation of mucous membranes R	Very sour taste R	Severe irritation of mucous membranes R	Burns skin and eyes R	Very corrosive R
4-4,5	Irritation of mucous membranes Y	Sour taste Y	Irritation of mucous membranes Y	Slight skin/eye sensitivity Y	Very corrosive R
4,5-5	Mild irritation of mucous membranes G	Sour taste Y	Mild irritation of mucous membranes G	MIld skin/eye sensitivity G	Corrosive in some instances Y
5-6	No health effects B	Slightly sour taste G	No effects B	Insignificant effect G	Possible corrosion G
6-9	No health effects B	No aesthetic effects B	No effects B	No effects B	No effects B
9-9,5	No health effects B	Slightly soapy G	No effects B	Insignificant effect G	No effects B
9,5-10	Mild irritation of mucous membranes G	Soapy taste Y	Mild irritation of mucous membranes G	MIld skin/eye sensitivity Y	Mild rinsing problems G
10-10,5	Irritation of mucous membranes Y	Very soapy taste R	Irritation of mucous membranes Y	Marked skin/ eye sensitivity R	Rinsing problems Y
10,5-11	Severe irritation of mucous membranes R	Extremely soapy taste P	Severe irritation of mucous membranes R	Burns skin/eyes P	Increasing rinsing problems R
>11	Alkali burns P	Extremely soapy taste P	Alkali burns P	Burns skin/eyes P	Severe rinsing problems P

INCREASING SOUR

INCREASING SOAPY

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*Not to be used without treatment

Nice to know

What is turbidity?

Turbidity, defined scientifically as the light-scattering ability of water, is a measure of the cloudiness or muddiness of water. Crystal clear water has very low turbidity, whereas progressive degrees of cloudiness raise the turbidity.

Turbidity is caused by the presence of suspended solid matter. The solid matter usually consists of a mixture of inorganic matter, such as clay particles, and organic matter, which again usually consists of both deritrus and living organisms.

Where is turbidity found?

Water turbidity varies tremendously from < 1 NTU in clear springs or deep groundwater, to many hundreds or even thousands of NTUs in mud-laden surface waters. Turbidities are typically elevated during storm events as a consequence of rapid erosion of surface soils into rivers.

Effects caused by turbidity:

Health effects:

Turbidity *per se* does not have direct health effects. However, it is one of the indicators of microbiological water quality and of inefficient water treatment. Depending on the nature of the origin of the suspended matter causing the turbidity, there may be associated health effects. As suspended clay particles, often a major contributor to turbidity in surface waters, provide large surfaces for colonisation by bacteria and other micro-organisms, proper disinfection of water of necessity implies that the suspended matter responsible for the turbidity must be removed.

Aesthetic effects:

The presence of turbidity in water results in a cloudy or muddy appearance, and may also affect the taste and colour of the water.

Sensitive groups:

As elevated turbidities are often associated with the possibility of microbiological contamination, the sensitive groups would in particular be certain infants under the age of 2 years.

Treatment:

Excessive turbidity in water can cause problems with water purification, flocculation and filtration processes. There is also a tendency to an increase in trihalomethane (THM) precursors, with elevated THM levels where highly turbid waters are chlorinated. Excessive turbidities also make it difficult to disinfect the water properly.

The choice of process or processes to be used to remove turbidity depends on the nature and degree of turbidity present. Typical processes include flocculation, settlement and filtration. Modification of treatment is usually required during peaks of turbidity in the source water.

Home treatment filtration kits are available, but treat only small volumes of water.

Turbidity guideline (NTU)

(Nephelometric Turbidity Units)

TURBIDITY RANGE (NTU)	DRINKING		FOOD PREPARATION	BATHING	LAUNDRY
	(Health)	(Aesthetic)			
					
<0.1	B No effects	B Water crystal clear	B No effects	B No effects	B No aesthetic effects
0.1-1	G Slight risk of potential health effects	G Water has good transparency	G Slight risk of indirect health effects (e.g., salads)	B No effects	B No aesthetic effects
1-20*	Y Possibility of secondary health effects	Y Water slightly cloudy	Y Slight risk with e.g. salads	G Insignificant effects	G Insignificant aesthetic effects
20-50*	R Secondary health effects	R Water has a muddy appearance	R Secondary health effects	Y Slight risk of infection if ingested	Y Possibility of staining of white clothing
>50*	P Serious health effects common in all users	P Water has a increasingly muddy appearance	P Secondary health effects	R Risk of infection if ingested	R Staining of clothing

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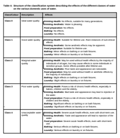
*Note: Turbidity can have indirect health effects in association with microbiological contaminations

PART 2

Guidelines

ROAD-MAP

Section A2
Introduction to the structure of the guidelines



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Microbiological quality

MICROBIOLOGICAL WATER QUALITY

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- Free available chlorine (Residual)
- Total coliforms

Section C2
Physical quality

PHYSICAL WATER QUALITY

- Electrical Conductivity
- pH Value
- Turbidity

Section D2
Chemical quality

CHEMICAL WATER QUALITY

- Arsenic
- Cadmium
- Calcium
- Chloride
- Copper
- Fluoride
- Iron
- Hardness (Total)
- Magnesium
- Manganese
- Nitrate/Nitrite as N
- Potassium
- Sodium
- Sulphate
- Zinc

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Nice to know

What is arsenic?

Arsenic is a poisonous semi-metal, which is sometimes used as a rat poison. In very small quantities it is essential and plays a role in the integrity of the immune system – as well as in skin and hair integrity.

Where is arsenic found?

The concentration of arsenic in unpolluted water is usually less than 0,010 mg/ℓ. Elevated concentrations may be found in groundwater, sometimes exceeding 0,500 mg/ℓ where water soluble arsenic minerals occur.

Elevated concentrations may also occur as a consequence of pollution, e.g. from mining activities, or from arsenic-containing pesticides, e.g. in cattle dips.

Effects caused by arsenic:

Health effects:

Arsenic poisoning is normally chronic, the predominant symptom being the presence of characteristic skin lesions.

At high concentrations, arsenic can cause acute poisoning, with sensory loss in the peripheral nerves and gastrointestinal symptoms often occurring.

Arsenic may be absorbed through the skin and cause health effects with bathing.

Aesthetic effects:

Important to note: Arsenic in water has no taste, smell or colour.

Sensitive groups:

(1) Some infants under the age of 2 years.
(2) Individuals with kidney disease.
(3) Individuals with high water intakes (e.g. under hot conditions).

Treatment:

Arsenic is readily removed from water in the pentavalent form by flocculation with ferric salts. Preoxidation with an oxidant is required if the arsenic is in the trivalent form.

Arsenic removal processes require skilled monitoring and analysis to ensure that the arsenic does not break through into the treated water.

Home treatment kits using ion-exchange processes can be purchased, but these are expensive and treat only small volumes of water.

Arsenic guideline

ARSENIC RANGE (mg/ℓ)	DRINKING		FOOD PREPARATION	BATHING	LAUNDRY
	(Health) 	(Aesthetic) 			
<0,010	B No health effects	B No aesthetic effects	B No health effects	B No effects	B No effects
0,01-0,05	G Insignificant health effects in sensitive groups	B No aesthetic effects	G Insignificant health effects in sensitive groups	B No effects	B No effects
0,05-0,2	Y Increasing effects in sensitive groups	B No aesthetic effects	Y Increasing effects in sensitive groups	G Insignificant health effects in sensitive groups	G Insignificant effects
0,2-2,0	R Risk of chronic health effects	B No aesthetic effects	R Risk of chronic health effects	Y Increasing effects in sensitive groups	Y Slight health effects
>2,0	P Risk of acute health effects	B No aesthetic effects	P Risk of acute health effects	R Chronic health effects in all individuals	R Risk of health effects

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Nice to know

What is cadmium?

Cadmium is a soft metal, chemically similar to zinc. Cadmium is found in galvanising and is also used to protect metals against corrosion. Cadmium is highly poisonous when ingested.

Where is cadmium found?

The concentration of cadmium in unpolluted water is usually less than 0,001 mg/ℓ. Concentrations up to 0,005 mg/ℓ may be found where water has been in contact with galvanising. Concentrations exceeding 0,005 mg/ℓ are rare and typically occur at the point of use where cadmium plated containers have been allowed to stand for long periods in contact with acidic fruit juices.

Effects caused by cadmium:

Health effects:

Acute health effects from cadmium present as food poisoning-like symptoms (i.e. nausea, vomiting and diarrhoea), which is clinically indistinguishable from microbiological food poisoning. Chronic health effects include kidney damage and pain in the bones ("ouch-ouch" or "itai-itai' disease).

Aesthetic effects:

Important to note: Cadmium has no aesthetic effects, taste, odour or colour.

Sensitive groups:

(1) Individuals with sub-optimal zinc intakes and malnutrition.
(2) Heavy smokers.
(3) Individuals with high water intakes (e.g. under hot conditions).

Treatment:

Cadmium is partially removed from water by the conventional water purification process, using flocculation with a ferric salt. Full removal may be effected by raising the pH with lime, followed by settlement, filtration, and pH readjustment.

Efficient removal of cadmium from water requires skilled operation and monitoring of the treatment process.

Home treatment kits using ion-exchange processes can be purchased, but these are expensive and treat only small volumes of water.

Cadmium guideline

CADMIUM RANGE (mg/ℓ)	DRINKING		FOOD PREPARATION	BATHING	LAUNDRY
	(Health)	(Aesthetic)			
					
<0,003	B No health effects	B No aesthetic effects	B No health effects	B No effects	B No effects
0,003-0,005	G Insignificant health effects in sensitive groups	B No aesthetic effects	G Insignificant health effects in sensitive groups	B No effects	B No effects
0,005-0,020	Y Increasing effects in sensitive groups	B No aesthetic effects	Y Increasing effects in sensitive groups	G Insignificant health effects in sensitive groups only	B No effects
0,020-0,050	R Risk of chronic health effects in sensitive groups	B No aesthetic effects	R Risk of chronic health effects in sensitive groups	Y Increasing effects in sensitive groups	B No effects
>0,050	P Acute health effects in all individuals	B No aesthetic effects	P Acute health effects in all individuals	R Health effects if water ingested	R Health effects if clothing sucked, e.g. by infant

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Note: Cadmium can be a problem in some fruit juice machines if the power is switched off for an extended period of time

Nice to know

What is calcium?

Calcium is an alkaline earth metal which reacts with water to form calcium hydroxide (slaked lime).

Calcium is an essential nutrient for the building and maintenance of a healthy bone structure. Calcium in hard waters can contribute significantly to the required daily calcium intake.

Where is calcium found?

In rain water or soft waters the calcium content is typically less than 10 mg/ℓ. In hard groundwaters the calcium concentration may be several hundred mg/ℓ.

Effects caused by calcium:

Health effects:

Relatively large amounts of calcium are required for maintenance of a healthy bone structure and, at the concentrations normally found in surface waters, calcium has a beneficial health effect. In sensitive individuals, however, high calcium concentrations may contribute to the incidence of kidney stones.

Aesthetic effects:

Calcium generally imparts a pleasant taste to water, except at very high concentrations, where the water tastes “hard”.

Distribution effects:

Calcium at elevated concentrations causes scaling (together with magnesium) in distribution systems and appliances.

Where calcium is absent or in very low concentrations (soft waters), corrosion may occur in the distribution system and appliances.

Sensitive groups:

(1) Individuals with a history of kidney or gall-bladder stones.
(2) Individuals with high water intakes (e.g. under hot conditions).

Treatment:

Calcium can be removed from water by cation exchange softening, which replaces calcium with sodium, or by demineralisation techniques, such as ion exchange.

Chemical precipitation and sedimentation are most frequently used when large volumes of water are treated.

Home treatment kits using ion-exchange processes can be purchased, but these are expensive and treat only small volumes of water.

Calcium guideline

CALCIUM RANGE (mg/ℓ)	DRINKING		FOOD PREPARATION	BATHING	LAUNDRY
	(Health) 	(Aesthetic) 			
0-10	No health effects B	No effects B	No effects B	No effects B	Corrosion of appliances Y
10-16	No health effects B	No effects B	No effects B	Insignificant effects on lathering of soap G	Insignificant impairment of lathering of soap. Some corrosion of appliances G
16-32	No health effects B	No effects B	No effects B	Insignificant effects on lathering of soap G	Insignificant impairment of lathering of soap. Some protection against corrosion B
32-80	No health effects B	No effects B	No effects B	Slightly impaired lathering of soap G	Lathering of soap slightly impaired. Some scaling G
80-150	Insignificant effects G	Insignificant effects G	No effects B	Lathering impaired Y	Lathering impaired. Highly scaling Y
150-300	Increased effects in sensitive groups only Y	Slight effect on taste Y	Insignificant effects G	Lathering severely impaired R	Lathering severely impaired. Severe scaling R
>300	Chronic health effects in sensitive groups only R	Effect on taste R	Slight effects in sensitive groups only Y	Lathering of soap very severely impaired R	Lathering very severely impaired. Very severe scaling R

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Nice to know

What is chloride?

Chloride is the negatively charged or anionic component of table salt. Elevated chloride imparts a salty taste to water and accelerates corrosion of metals.

Where is chloride found?

In fresh water, chloride concentrations are typically less than 10 mg/ℓ. Higher concentrations are found wherever salt pollution or marine intrusion is found, and chloride concentrations of up to 700 mg/ℓ are common in arid areas with saline soils.

Effects caused by chloride:

Health effects:

Chloride at the concentrations normally encountered in fresh water does not cause health effects. Health effects such as nausea and vomiting may occur at chloride concentrations in excess of 1200 mg/ℓ in sensitive individuals in whom it disturbs the salt/water balance.

Aesthetic effects:

At elevated concentrations chloride imparts a salty taste to water.

Distribution effects:

Chloride accelerates the corrosion of iron at elevated concentrations.

Sensitive groups:

(1) Some infants under the age of 1 years.

(2) Individuals with congestive heart failure, or hypertension, who have been placed on a salt-restricted diet.

Treatment:

Chloride is difficult to remove from water and requires energy-intensive processes, such as reverse osmosis, electrodialysis, distillation, or resin ion-exchange demineralisation.

Processes to remove chloride require high operator skills and maintenance, and a concentrated brine is produced which may present disposal problems.

Treatment processes are easily fouled by suspended matter or hard water.

Home treatment kits using ion-exchange processes can be purchased, but these are expensive and treat only small volumes of water.

Chloride guideline

CHLORIDE RANGE (mg/ℓ)	DRINKING		FOOD PREPARATION	BATHING	LAUNDRY
	(Health) 	(Aesthetic) 			
< 100	B No health effects	B No aesthetic effects	B No health effects	B No effects	B No significant effects
100-200	G Insignificant health risk	G Insignificant effects	G Insignificant health risk	B No effects	G Slight corrosion
200-600	Y Increasing health risk to sensitive groups	Y Distinctly salty taste	Y Increasing health risk to sensitive groups	B No effects	Y Moderate corrosion
600-1200	R Possible long-term health effects	R Objectionable salty taste	R Possible long-term health effects	B No effects	R Corrosive
>1200	P Dehydration in infants, nausea & vomiting	P Repulsively salty taste	P Dehydration in infants, nausea & vomiting	B No effects	P Very corrosive

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Nice to know

What is copper?

Copper is an orange coloured metal which is a good conductor of heat and electricity.

Copper is needed in small quantities for the integrity of the fatty covering of nerve fibre sheaths.

Where is copper found?

Copper concentrations in water sources are typically less than 0,1 mg/ℓ.

Copper concentrations of greater than 1 mg/ℓ occur where low pH waters corrode the copper pipes in distribution systems. This leads to a characteristic blue-green appearance of the water.

Effects caused by copper:

Health effects:

Copper generally does not have negative health effects on healthy individuals at the concentrations normally found in water. However, individuals with Wilson's disease are particularly sensitive to the chronic health effects of copper.

At very high concentrations copper causes nausea and vomiting and can cause acute damage to the liver and kidneys.

Aesthetic effects:

The presenting signs of copper concentrations above 1 mg/ℓ are aesthetic, i.e. metallic taste of the water, and a green staining of clothing, fixtures and hair.

Sensitive groups:

(1) The sensitive groups for the health effects of copper are individuals with the rare genetic defect known as Wilson's disease.
(2) Individuals with high water intakes (e.g. under hot conditions).

Treatment:

Copper is readily removed from water by adjustment of the pH to 6 – 7 and flocculation with aluminium or ferric salts. High concentrations may require the use of lime and precipitation of the copper as copper hydroxide at alkaline pH.

Home treatment kits using ion-exchange processes can be purchased, but these are expensive and treat only small volumes of water.

Copper guideline

COPPER RANGE (mg/ℓ)	DRINKING		FOOD PREPARATION	BATHING	LAUNDRY
	(Health) 	(Aesthetic) 			
0-0,5	B No health effects	B No effects	B No effects	B No effects	B No effects
0,5-1	B No health effects	G Insignificant effects	G Insignificant effects	B No effects	G Insignificant effects
1-1,3	G Insignificant effects	Y Very slight taste	G Very slight taste	G Insignificant effects	G Insignificant effects
1,3-2,0	Y Slight effects in sensitive groups	Y Noticeable taste	Y Noticeable taste	Y Slight staining	Y Slight staining
2,0-15	R Chronic effects in sensitive individuals	R Very objectionable taste	R Very objectionable taste	R Marked staining	R Severe staining
>15	P Acute effects nausea & vomiting	P Repulsive taste	P Repulsive taste	P Severe staining	P Excessive staining

🟦 Blue - Ideal 🟩 Green - Good 🟨 Yellow - Marginal 🟥 Red - Poor 🟪 Purple - Completely unacceptable

Nice to know

What is fluoride?

Fluoride is the most electro-negative element and readily foms complexes with many metals. **It is needed in trace quantities during tooth formation to harden the tooth enamel.**

Where is fluoride found?

The concentration of fluoride in unpolluted surface water is typically 0,1 – 0,3 mg/ℓ. In groundwater fluoride ranges from 0,1 – 3 mg/ℓ, with some groundwater containing 12 mg/ℓ or more.

Effects caused by fluoride:

Health effects:

Chronic intake of high fluoride levels can damage the skeleton, causing a hardening of the bones and making them brittle. Brittle bones break easily under mild stress and crippling can occur. Acute poisoning by high doses is characterised by vomiting, abdominal pain, nausea, diarrhoea and convulsions.

Aesthetic effects:

Discolouration of the teeth occurs where fluoride is ingested during the tooth formative years in concentrations in excess of the optimum level needed for healthy tooth enamel. **Please note** that fluoride has no taste, colour or smell, and cannot be detected aesthetically, even at high concentrations.

Sensitive groups:

(1) Children up to the age of 3 years.
(2) Individuals with HIV infection.
(3) Individuals with suboptimal dietary calcium.
(4) Individuals with liver or kidney disease.
(5) Individuals with malnutrition, particularly those with zinc deficiency.
(6) Individuals with a high daily water intake.
(7) Individuals on renal dialysis.

Treatment:

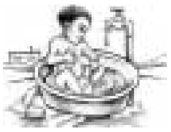
Fluoride is difficult to remove from water at low concentrations. For effective removal advanced technology is required, using, for example, activated alumina or bone char to absorb the fluoride. Desalination with ion-exchange resins can also be used.

Home treatment with clay or calcium carbonate chips may ameliorate high concentrations, but does not usually reduce the fluoride to optimum concentrations.

High levels of skill and maintenance are needed for the successful implementation of fluoride removal technology.

Home treatment kits using ion-exchange processes can be purchased, but these are expensive and treat only small volumes of water.

Fluoride guideline

FLUORIDE RANGE (mg/ℓ)	DRINKING		FOOD PREPARATION	BATHING	LAUNDRY
	(Health)	(Aesthetic)			
					
<0,7	B No health effects	B No effects	B No effects	B No effects	B No effects
0,7-1,0	G Insignificant health effects in sensitive groups and insignificant tooth staining	B No effects	G Insignificant health effects in sensitive groups	B No effects	B No effects
1,0-1,5	Y Increasing effects in sensitive groups and tooth staining	B No effects	Y Increasing effects in sensitive groups	B No effects	B No effects
1,5-3,5	R Possible health effects in all individuals and marked tooth staining	B No effects	R Possible health effects in all individuals	B No effects	B No effects
>3,5	P Increasing risk of health effects and severe tooth staining	B No effects	P Increasing risk of health effects	B No effects	B No effects

🟦 Blue - Ideal 🟩 Green - Good 🟨 Yellow - Marginal 🟥 Red - Poor 🟪 Purple - Completely unacceptable

Nice to know

What is iron?

The metallic element iron in its pure state is silvery-white, but iron usually appears brown or black in colour because of oxidation of the surface of the metal. The reddish colour of soil is due to iron.

Iron is an essential nutritional micro-nutrient needed for formation of the oxygen-carrying red blood pigment, haemoglobin.

Where is iron found?

Dissolved iron is often found in water, due to dissolution from soils or sediments under anaerobic reducing conditions. The concentration of iron in unpolluted fresh water ranges from 0,001 – 0,5 mg/ℓ. Where water is polluted by acid mine drainage, concentrations may be much higher.

Effects caused by iron:

Health effects:

As the normal total dietary intake of iron by an adult is as much as 20 mg/day, health effects in adults do not occur at water concentrations below 10 mg/ℓ. Health effects due to intake of excessive amounts of iron are of two types:

(1) Acute poisoning in infants and young children from exposure to massive concentrations.
(2) Chronic iron poisoning – or haemochromatosis – due to many years' intake of excessive iron concentrations, usually from food cooked in cast iron pots and consumed on a daily basis.

Aesthetic effects:

At the concentrations normally encountered in water iron has an aesthetic rather than a toxic effect. Iron imparts a metallic taste to water, as well as giving the water a brownish discoloration.

Sensitive groups:

(1) Some infants under the age of 4 years.
(2) Individuals with a hypersensitivity to iron.

Treatment:

Where water is low in organic content, and the iron is uncomplexed (such as in groundwater), aeration of the water may be effective in precipitating the iron from solution. Conventional coagulation and flocculation techniques, especially when coupled with the use of a strong oxidant and treatment, if necessary, with lime, are usually effective in removing iron from water.

Uncomplexed iron is relatively easily removed from water. Where the iron is complexed to organic matter, however, removal is difficult and requires the use of strong chemical oxidants and lime treatment.

Home treatment kits using ion-exchange processes can be purchased, but these are expensive and treat only small volumes of water.

Iron guideline

IRON RANGE (mg/ℓ)	DRINKING		FOOD PREPARATION	BATHING	LAUNDRY
	(Health) 	(Aesthetic) 			
<0,01	B No effects	B No effects	B No effects	B No effects	B No effects
0,01-0,2	B No effects	G Slight taste or colour	B No effects	B No effects	G Insignificant effects
0,2-0,5	B No effects	Y Increasing taste and colour	B No effects	B No effects	Y Slight staining of white clothes
0,5-1,0	G Insignificant effects	Y Increasing taste and colour	G Insignificant effects	B No effects	Y Slight staining of white clothes
1,0-2,0	Y Increasing effects in sensitive groups	Y Increasing taste and colour	Y Increasing effects in sensitive groups	B No effects	Y Slight staining of white clothes
2,0-5,0	Y Increasing effects in sensitive groups	R Objectionable taste & appearance	Y Increasing effects in sensitive groups	G Insignificant effects	R Staining of clothes
5,0-10,0	R Chronic health effects	R Objectionable taste & appearance	R Chronic health effects	Y Increasing risk to sensitive groups where water ingested	R Staining of clothes
>10,0	P Risk of iron-poisoning, particularly in sensitive groups	P Repulsive taste and appearance	P Risk of iron-poisoning, particularly in sensitive groups	Y Increasing risk to sensitive groups where water ingested	P Severe staining of clothes

🟦 Blue - Ideal 🟩 Green - Good 🟨 Yellow - Marginal 🟥 Red - Poor 🟪 Purple - Completely unacceptable

Nice to know

What is total hardness?

Total hardness (T.H.) is the sum of calcium and magnesium concentrations expressed as mg/ℓ calcium carbonate [$CaCO_3$] and is calculated as follows:

T.H. = [2.497 x calcium (mg/ℓ)] + [4.118 x magnesium (mg/ℓ)].

The total hardness value indicates whether the water is soft or hard, and relates to the ease or difficulty of lathering of soap.

Where is total hardness found?

Total hardness is low in rainwater and very fresh soft waters with little calcium and magnesium.

In some underground waters total hardness may be very high where soluble calcium and magnesium minerals are present.

Effects caused by total hardness:

Health effects:

Some total hardness in water is beneficial to health as it contributes to the need for the essential elements calcium and magnesium.

Excessive total hardness should be avoided by sensitive groups.

Aesthetic effects:

Elevated total hardness impairs the lathering of soap and also affects the taste of the water, especially for brewing tea or coffee.

Distribution effects:

Excessive total hardness is associated with scaling problems in pipes and hot water appliances. Low total hardness is associated with corrosion problems.

Sensitive groups:

(1) Individuals with a history of kidney or gall-bladder stones (where calcium is the main contributor to the total hardness).

(2) Infants under the age of 1 year (where magnesium is the main contributor to the total hardness).

Treatment:

Total hardness can be removed from water by cation exchange softening, or by demineralisation techniques, such as mixed-bed ion-exchange desalination.

Other desalination techniques can also be used.

Chemical precipitation and sedimentation are most frequently used when large volumes of water are treated.

Home treatment kits using ion-exchange processes can be purchased, but these are expensive and treat only small volumes of water.

(Total) hardness guideline (T.H.)

TOTAL HARDNESS AS $CaCO_3$ (mg/ℓ)	DRINKING		FOOD PREPARATION	BATHING	LAUNDRY
	(Health) 	(Aesthetic) 			
0-25 (very soft)	B No effects	B No effects	B No effects	B Ideal lathering of soap	Y Ideal lathering, but corrosion of appliances
25-50 (soft)	B No effects	B No effects	B No effects	G Insignificant impairment of lathering	G Insignificant impairment of lathering, but some corrosion of appliances
50-100 (moderately soft)	B No effects	B No effects	B No effects	G Insignificant impairment of lathering	B Insignificant impairment of lathering. Some protection against corrosion
100-150 (slighty hard)	B No effects	B No effects	G Slight scaling of kettles	G Lathering slightly impaired	G Lathering slightly impaired
150-200 (moderately hard)	B No effects	B No effects	G Some scaling of kettles	Y Lathering impaired	Y Lathering impaired, some scaling
200-300 (hard)	G Insignificant effects	G Insignificant effects	Y Scaling of kettles	Y Increased impairment of lathering	Y Lathering impaired, increasing scaling
300-600 (very hard)	Y Possible chronic effects in sensitive groups only	Y Effect on taste	R Severe scaling of kettles	R Lathering severely impaired	R Lathering severely impaired, severe scaling
>600 (extremely hard)	R Chronic effects in sensitive groups only	R Marked effect on taste	R Very severe scaling of kettles	R Lathering severely impaired	R Lathering very severely impaired. Extreme scaling

🟦 **Blue - Ideal** 🟩 **Green - Good** 🟨 **Yellow - Marginal** 🟥 **Red* - Poor** 🟪 **Purple* - Completely unacceptable**

*Not to be used without treatment

Nice to know

What is magnesium?

Magnesium is an alkaline earth metal which burns with brilliant light (thus its use in flares) to form magnesium oxide. Magnesium hydroxide is well known as a stomach antacid in the form of Milk of Magnesia and as magnesium sulphate as the well known purgative, 'Epsom salts'. Magnesium is an essential nutritional element needed for normal functioning of muscles. The total dietary intake is about 250 mg/day in adults.

Where is magnesium found?

In unpolluted fresh water the magnesium concentration is usually less than 10 mg/ℓ, except in some hard groundwaters where the magnesium concentration may rise to several hundred mg/ℓ.

Effects caused by magnesium:

Health effects:

The potential health effects from ingestion of large amounts of magnesium, such as suppression of the central nervous system, are rarely seen as the bitter taste of magnesium at elevated concentrations discourages consumption of large amounts. The most common health effect seen with magnesium is diarrhoea, usually where magnesium is found in association with sulphate.

Aesthetic effects:

Magnesium at concentrations above 70 mg/ℓ imparts a bitter taste to water.

Distribution effects:

Magnesium at elevated concentration causes scaling (together with calcium) in distribution systems and appliances.

Sensitive groups:

(1) Some infants under the age of 1 year.
(2) Individuals with high water intakes (e.g. under hot conditions).

Treatment:

The usual method used for reducing the magnesium concentration in water is lime softening followed by re-carbonation. Other techniques that can be used are the use of ion-exchange resins or precipitation of the magnesium at high pH.

Methods to remove magnesium from water require skilled operation and high maintenance skills.

Home treatment kits using ion-exchange processes can be purchased, but these are expensive and treat only small volumes of water.

Magnesium guideline

MAGNESIUM RANGE (mg/ℓ)	DRINKING		FOOD PREPARATION	BATHING	LAUNDRY
	(Health) 	(Aesthetic) 			
<30	B No health effects	B Pleasing taste	B No health effects	B No effects	B No effects
30-70	B No health effects	G Tastes reasonable	B No health effects	G Lathering of soap slightly impaired	G Lathering of soap slightly impaired
70-100	G Insignificant health effects in sensitive groups only	Y Slightly bitter taste	G Insignificant health effects in sensitive groups only	Y Lathering of soap moderately impaired	Y Lathering of soap moderately impaired
100-200	Y Increasing effects in sensitive groups only	R Bitter taste	Y Possibility of diarrhoea in sensitive groups	R Lathering of soap highly impaired	R Lathering of soap highly impaired
200-400	R Potential diarrhoea in all individuals	P Very bitter taste	R Potential for diarhoea	R Lathering of soap highly impaired	R Lathering of soap highly impaired
>400	P Diarrhoea in all individuals	P Very bitter taste	P Diarrhoea and very bitter taste	R Lathering of soap highly impaired	R Lathering of soap highly impaired

🟦 Blue - Ideal 🟩 Green - Good 🟨 Yellow - Marginal 🟥 Red - Poor 🟪 Purple - Completely unacceptable

Nice to know

What is manganese?

Manganese is a metal, common in soils and often associated with water, which is responsible for the dark tea-like colour of some water sources. (Note: the tea-coloured water of the Southern and Western Cape is due to organic material present in the water together with manganese.)

Where is manganese found?

The typical concentration of manganese in unpolluted water is 0,001 to 0,2 mg/ℓ. In humic waters the concentration may be naturally as high as 3 mg/ℓ. Manganese concentrations in excess of 5 mg/ℓ may arise in cases of pollution, or from bottom waters of dams.

Manganese is also found in tea.

Effects caused by manganese:

Health effects:

Manganese intake from food is at least 2 mg per day. Manganese does not cause any health effects below this intake. Manganese is nutritionally essential in small amounts for cartilage integrity. Long-term exposure to excessive manganese concentrations may cause brain damage, giving rise to a disease resembling Parkinsonism. Health problems associated with manganese concentrations in water are rare.

Aesthetic effects:

Manganese at the concentration usually encountered in water causes aesthetic effects rather than health effects. Typically a combination of brown or black staining of laundry, fixtures, or the water itself is noted. There may also be a metallic taste.

Sensitive groups:

(1) Some infants under the age of 2 years.
(2) Patients with kidney disease.
(3) Individuals with high water intakes (e.g. under hot conditions).

Treatment:

Processes to remove manganese include aeration, chemical oxidation – for example with chlorine – and lime treatment, followed by flocculation and filtration. Treatment with household bleach will only ameliorate, but generally not remove, manganese. Aeration is effective only where there is no organic matter in the water and the manganese is in the uncomplexed form, which is seldom the case. Strong oxidants must normally be used.

Aeration, or alkalinisation of the water with lime, may remove dissolved manganese from the water unless it is complexed to organic matter where removal is more difficult without strong oxidants.

Home treatment kits using ion-exchange processes can be purchased, but these are expensive and treat only small volumes of water.

Manganese guideline

MANGANESE RANGE (mg/ℓ)	DRINKING		FOOD PREPARATION	BATHING	LAUNDRY
	(Health)	(Aesthetic)			
					
<0,05	Negligible effects B	No effects B	No health or aesthetic effects B	No health or aesthetic effects B	No aesthetic effects B
0,05-0,1	Negligible effects B	Slight taste or colour G	No health or aesthetic effects B	May be a slight discolouration of the water G	Slight staining of white clothes G
0,1-0,4	Insignificant effects G	Increasing taste and colour Y	Insignificant effects G	Pale brown discolouration of the water Y	Moderate staining of clothes & fixtures Y
0,4-1,0	Slight health risks to sensitive groups only Y	Increasing taste and colour Y	Slight health risks to sensitive groups only Y	Pale brown discolouration of the water Y	Moderate staining of clothes & fixtures Y
1,0-4,0	Slight health risks to sensitive groups only Y	Off-putting taste and colour R	Slight health risks to sensitive groups only Y	Brown discolouration of the water R	Severe staining of clothes & fixtures R
4,0-5,0	Possible health risk to all individuals R	Off-putting taste and colour R	Possible health risk to all individuals R	Brown discolouration of the water R	Severe staining of clothes & fixtures R
5,0-10,0	Possible health risk to all individuals R	Repulsive colour and staining of fixtures P	Possible health risk to all individuals R	Repulsive colour and staining of fixtures P	Extreme staining of clothes & fixtures P
>10,0	Increasing health risk to all indivuals P	Repulsive taste and appearance P	Increasing health risk to all individuals P	Repulsive colour and staining of fixtures P	Extreme staining of clothes & fixtures P

🟦 Blue - Ideal 🟩 Green - Good 🟨 Yellow - Marginal 🟥 Red - Poor 🟪 Purple - Completely unacceptable

Note: Fe, Mn and Al in combination can cause aesthetic effects even if all are in the blue class

Nice to know

What is nitrate?

Nitrate (NO_3) is a plant nutrient, being the end product of the oxidation of ammonia (NH_3) and nitrite (NO_2). Nitrate and nitrite can be readily converted from one to the other.

Laboratory results for nitrate are sometimes reported as mg/l NO_3. To convert to mg/l (as N), in order to compare with the guideline, divide the NO_3 value by 4,427.

Where is nitrate/nitrite found?

In unpolluted water the nitrate-nitrogen concentration is typically less than 2 mg/ℓ as N . As nitrates are produced by the decay of plant, animal and human wastes, pollution of water with nitrate is typically found wherever intensive land use activities take place, and nitrate-nitrogen concentrations exceeding 20 mg/ℓ (as N) are a common occurrence in groundwater.

Effects caused by nitrate:

Health effects:

Nitrate has the potential to cause tiredness and failure to thrive. This is the most common effect and is chronic in nature. In extreme cases cyanosis and difficulty in breathing in bottle fed infants under the age of 1 year may occur. This rare condition is due to reduction of nitrate to nitrite, which then combines with the red blood pigment, haemoglobin to form methaemoglobin in the presence of an abnormal gut flora.

Aesthetic effects:

Nitrate, or nitrite as such, do not have any taste, colour or smell, and do not affect the appearance of the water.

Sensitive groups:

Some infants under the age if 1 year, particularly where they are malnourished and suffer from iron deficiency anaemia or vitamin C deficiency.

Treatment:

Methods to remove nitrate from water include ion-exchange, reverse osmosis, and biological reduction (denitrification) using a carbon source. The latter is normally used for treating large volumes of water. While effective, it is difficult to optimise and maintain and, requires advanced and intensive supervision.

Nitrate is difficult to remove from water, and treatment generally requires advanced supervision. Nitrate stimulates algal growth, and thus may indirectly lead to secondary treatment problems.

Home treatment kits using ion-exchange processes can be purchased, but these are expensive and treat only small volumes of water.

Nitrate + Nitrite (as N)

NITRATE + NITRITE RANGE mg/ℓ as N or (mg/ℓ as NO_3)	DRINKING		FOOD PREPARATION	BATHING	LAUNDRY
	(Health)	(Aesthetic)			
					
<6 mg/ℓ as N (< 26 mg/ℓ as NO_3)	B Negligible health effects	B No aesthetic effects	B Negligible health effects	B No effects	B No effects
6-10 mg/ℓ as N (26-44 mg/ℓ as NO_3)	G Insignificant risk	B No aesthetic effects	G Insignificant risk	B No effects	B No effects
10-20 mg/ℓ as N (44-89 mg/ℓ as NO_3)	Y Slight chronic risk to some babies	B No aesthetic effects	Y Slight chronic risk to some babies	G Insignificant risk	B No effects
20-40 mg/ℓ as N (89-177 mg/ℓ as NO_3)	R Possible chronic risk to some babies	B No aesthetic effects	R Possible chronic risk to some babies	Y Slight risk to babies only	B No effects
>40 mg/ℓ as N (> 177 mg/ℓ as NO_3)	P Increasing acute health risk to babies	B No aesthetic effects	P Increasing acute health risk to babies	R Possible health risk to babies	B No effects

🟦 Blue - Ideal 🟩 Green - Good 🟨 Yellow - Marginal 🟥 Red - Poor 🟪 Purple - Completely unacceptable

Note: Nitrite is not normally present in drinking water.

Nice to know

What is potassium?

Potassium is an alkali metal, and is the main intracellular positive ion in living tissues. It is an essential dietary constituent.

Where is potassium found?

The concentration in unpolluted fresh water is typically 2-5 mg/ℓ. Higher concentrations occur in runoff from irrigated lands, from fertiliser production, and in domestic wastes.

Effects caused by potassium:

Health effects:

Sudden exposure to excessive concentrations of potassium can seriously disrupt heart and muscular function, irritate mucous membranes and cause nausea and vomiting.

Aesthetic effects:

At elevated concentration potassium imparts a bitter taste to water.

Potassium does not affect either the appearance or smell of the water.

Sensitive groups:

(1) Some infants under the age of 2 years.
(2) Patients with kidney disease.

Treatment:

Potassium can be removed from water by desalination processes, such as reverse osmosis, ion-exchange demineralisation using a mixed bed resin, or by distillation.

Potassium is difficult to remove from water, and processes require high levels of operator and maintenance skills. All the processes result in a concentrated waste stream which may present disposal difficulties.

Home treatment kits using ion-exchange processes can be purchased, but these are expensive and treat only small volumes of water.

Potassium guideline

POTASSIUM RANGE (mg/ℓ)	DRINKING		FOOD PREPARATION	BATHING	LAUNDRY
	(Health) 	(Aesthetic) 			
<25	B No health effects	B No aesthetic effects	B No health effects	B No health effects	B No effects
25-50	G Insignificant health effects	G Insignificant health effects	G Insignificant health effects	B No health effects	B No effects
50-100	Y Slight risk to some sensitive groups	Y Slight bitter taste	Y Slight risk to some sensitive groups	B No health effects	B No effects
100-500	R Possible health effects	R Bitter taste	R Possible health effects	G Insignificant effects on some babies	B No effects
>500	P Definite health risk to all individuals	P Pronounced bitter taste	P Definite health risk to all individuals	Y Increasing effect on some babies	B No effects

🟦 Blue - Ideal 🟩 Green - Good 🟨 Yellow - Marginal 🟥 Red - Poor 🟪 Purple - Completely unacceptable

Nice to know

What is sodium?

Sodium is the alkali metal constituent of table salt or sodium chloride. Sodium is an essential dietary element needed to maintain electrolyte balance in the body.

Where is sodium found?

Sodium concentrations vary tremendously in water both over time and from place to place, being low in fresh waters (<50 mg/ℓ) in regions of high rainfall, and high (as much as 500 mg/ℓ) in areas with little rainfall. The concentration of sodium in sea water is 11000 mg/ℓ.

*Sodium concentrations tend to be high in ground and surface waters in the Western and Southern Cape, and also in some mine waters.

Effects caused by sodium:

Health effects:

Excessive intake of sodium salts in babies can place a strain on the kidneys and the heart, and lead to serious disturbances of the salt balance in the body with water retention.

Aesthetic effects:

The predominant effect of sodium at the concentrations usually found in fresh water is aesthetic. Together with chloride, sodium imparts a salty taste to water.

Sensitive groups:

(1) Some infants under the age of 2 years.
(2) Individuals with water retention problems, such as those with congestive heart failure, kidney disease, or high blood pressure and individuals on a low salt dietary regime.
(3) Individuals with high water intakes (e.g. under hot conditions).

Treatment:

Sodium can be removed from water only by desalination processes such as reverse osmosis or electrodialysis, ion-exchange demineralisation, and distillation.

Treatment processes for removing sodium from water require high levels of operator skills and maintenance. Processes are easily fouled by suspended matter, and are prone to scaling with hard waters.

Home treatment kits using ion-exchange processes can be purchased, but these are expensive and treat only small volumes of water.

Sodium guideline

SODIUM RANGE (mg/ℓ)	DRINKING		FOOD PREPARATION	BATHING	LAUNDRY
	(Health)	(Aesthetic)			
					
<100	B Negligible effects	B Negligible effects	B Negligible effects	B Negligible effects	B Negligible effects
100-200	G Insignificant effects	G Insignificant aesthetic effects	G Insignificant effects	B Negligible effects	B Negligible effects
200-400	Y Slight risk to some sensitive groups	Y Slightly salty taste	Y Slight risk to some sensitive groups	B Negligible effects	B Negligible effects
400-1000	R Possible health risk, particularly in sensitive groups	R Salty taste	R Possible health risk, particularly in sensitive groups	B Negligible effects	B Negligible effects
>1000	P Definite health risk	P Extremely salty taste	P Definite health risk	B Negligible effects	B Negligible effects

🟦 Blue - Ideal 🟩 Green - Good 🟨 Yellow - Marginal 🟥 Red - Poor 🟪 Purple - Completely unacceptable

Nice to know

What is sulphate?

Sulphate is the oxy-anion of sulphur in the +6 oxidation state. Magnesium sulphate is sold commercially as "Epsom salts", which is used as a purgative.

Where is sulphate found?

Sulphate concentrations in unpolluted fresh water are typically less than 10 mg/ℓ. Waters polluted by acid mine drainage and effluent return flows may contain as much as 500 mg/ℓ sulphate or more.

Effects caused by sulphate:

Health effects:

The health effect of elevated sulphate is acute, causing diarrhoea, particularly in new users not accustomed to drinking water with elevated sulphate concentrations. Adaptation tends to occur with prolonged exposure.

Aesthetic effects:

Sulphate at elevated concentrations imparts a distinctive taste to the water, *viz*. a slightly bitter astringent flavour. A "rotten egg" smell may occur; due to hydrogen sulphide, which may be associated with sulphate.

Distribution system:

Elevated sulphate concentrations accelerate corrosion of metals, particularly iron.

Sensitive groups:

(1) Some infants under the age of 2 years.
(2) Individuals of all ages who are not accustomed to high levels of sulphate, thus the terminology "Travellers' diarrhoea" to describe diarrhoea of high sulphate origin.
(3) Individuals with high water intakes (e.g. under hot conditions).

Treatment:

Sulphate can be removed from water by processes such as
(1) Ion exchange with a resin,
(2) Any of the desalination processes (ion-exchange demineralisation/reverse osmosis/distillation), or
(3) Precipitation of the sulphate ion with salts of calcium, followed by settlement and filtration.

Treatment processes to remove sulphate require a high level of operator and maintenance skills.

Home treatment kits using ion-exchange processes can be purchased, but these are expensive and treat only small volumes of water.

Sulphate guideline

SULPHATE RANGE (mg/ℓ)	DRINKING		FOOD PREPARATION	BATHING	LAUNDRY
	(Health) 	(Aesthetic) 			
<100	B No effects	B No effects	B No effects	B No effects	B No effects
100-200	B No effects	B No effects	B No effects	B No effects	B Slight corrosion possible
200-400	G Insignificant health effects	G Slight, but good taste	G Insignificant health effects	B No effects	G Moderate corrosion
400-600	Y Slight chance of initial diarrhoea in sensitive groups, but disappears with adaptation	Y Slight, bitter taste	Y Slight chance of initial diarrhoea in sensitive groups, but disappears with adaptation	G Slight chance of diarrhoea if water swallowed, e.g. infants	Y Increasingly corrosive
600-1 000	R Possibility of diarrhoea. Poor adaptation in sensitive individuals	R Bitter taste	R Possibility of diarrhoea. Poor adaptation in sensitive individuals	Y Increasing chance of diarrhoea if water is swallowed e.g. in infants	R Very corrosive
>1 000	P High chance of diarrhoea. No adaptation	P Very bitter and salty taste	P High chance of diarrhoea. No adaptation	R Possibility of diarrhoea if water is swallowed	P Extremely corrosive

🟦 Blue - Ideal 🟩 Green - Good 🟨 Yellow - Marginal 🟥 Red - Poor 🟪 Purple - Completely unacceptable

Nice to know

What is zinc?

Zinc is a grey metal, relatively resistant to corrosion, and therefore used in galvanising to protect iron from corrosion by water.

Zinc is an essential nutritional trace element which is needed to ensure a healthy skin and cell membranes, as well as proper functioning of the immune system.

Where is zinc found?

The concentration of zinc in unpolluted fresh water is very low, typically around 0,015 mg/ℓ.

Elevated zinc concentrations may occur in association with industrial processes, or as a result of leaching of zinc from pipes and corrugated iron under acidic conditions.

Effects caused by zinc:

Health effects:

Zinc does not have negative health effects at the concentrations normally found in water.

At concentrations above 20 mg/ℓ nausea and vomiting may rarely occur in sensitive individuals.

Aesthetic effects:

Zinc normally has only aesthetic effects at elevated concentrations in water.

Zinc may impart a bitter metallic taste to water, as well as give a white milky colour at concentrations above 5 mg/ℓ.

Sensitive groups:

(1) Some infants under the age of 2 years.
(2) Individuals receiving chemotherapy.
(3) Individuals with high water intakes (e.g. under hot conditions).

Treatment:

Zinc is readily removed from water by raising the pH to 9,5 – 10, which precipitates the zinc as zinc hydroxide, which may be removed from the water by settlement and filtration, followed by readjustment of the water pH with a suitable acid.

Removal of zinc from water is normally relatively easy, and the process does not usually present treatment difficulties other than those of controlling and readjusting the water pH value accurately.

Home treatment kits using ion-exchange processes can be purchased, but these are expensive and treat only small volumes of water.

Zinc guideline

ZINC RANGE (mg/ℓ)	DRINKING		FOOD PREPARATION	BATHING	LAUNDRY
	(Health) 	(Aesthetic) 			
<3	B No effects	B No effects	B No effects	B No effects	B No effects
3-5	B No effects	G Slight taste and/or opalescence	G No health effects, slight taste	B No effects	B No effects
5-10	B No effects	Y Noticeable taste and opalescence	Y No health effects, noticeable taste	B No effects	B No effects
10-20	B No effects	R Astringent taste	R No health effects, astringent taste	B No effects	B No effects
>20	G Insignificant effects in sensitive individuals	P Repulsive taste	P Insignificant effects in sensitive individuals, repulsive taste	B No effects	B No effects

🟦 Blue - Ideal 🟩 Green - Good 🟨 Yellow - Marginal 🟥 Red - Poor 🟪 Purple - Completely unacceptable

In many cases it may not be possible to take and analyse samples. In such cases, data from nearby similar sources of water can be used. There are a number of places where this water quality data can be found.

- ***Department of Water Affairs and Forestry***

  This Department has an extensive and well-managed database. Both surface water and groundwater data are available for many parts of the country. Data for the microbiological variables, for trace metals, and for turbidity are less readily available, however.

  Telephone (012) 338-7500 and ask for the Water Quality Data Bank

- ***Department of Health***

  Prospective sources of drinking water have to be approved by the Department of Health. Such approval is based on the results of an analysis of a number of variables.

  Telephone (012) 312 0000 and ask for Environmental Health

- ***Water boards***

  Some of the water boards, especially the larger ones such as Rand Water and Umgeni Water, have extensive water quality data banks. Their data is, however, limited to the areas in which these water boards operate.(Not all the water boards will have extensive data sets.)

- **Local authorities**

  Local authorities that operate their own water works normally take and analyse samples. These authorities usually have information available on the turbidity, conductivity and pH of both their untreated and treated water. Some municipalities may have more extensive databases. Consult your local telephone directory for contact numbers.

- **Large industries**

  Large industries, such as Eskom and Sasol, that abstract raw water for their own use may also have certain data available.

These agencies may also be able to help you sample and analyse your own source of water.

WATER BOARDS

Bulk Water Suppliers	Area	Contact Number
Albany Coast Water Board	Eastern Cape	(046) 648-1573
Amatola Water Board IBhodi yaManzi yase-Amarole	Eastern Cape	(0431) 42-0931
Bloem Water	Free State	(051) 421-5351
Bushbuckridge Water Board	Mpumalanga	(013) 799-0395
Cape Town Water Undertaking	Western Cape	(021) 400-1111
Goudveld Water	Free State	(0565) 4361
Ikangala Water	Gauteng	083 325 4565
Kalahari East Water Board	Northern Cape	(054) 331 2174
Kalahari West Water Board	Northern Cape	(054) 331 2174
Karos-Geelkoppan Water Board	Northern Cape	(054) 902 ask for Joostespan 91-9331
Lepelle Nothern Water	Northern Province	(015) 295-4918
Magalies Water	North-West/Northern Province	(0142) 97-4636
Mhlatuze Water	Northern KwaZulu-Natal	(0351) 902-1000
Namakwa Water	Western Cape	(0251) 2 2011
North West Water Supply Authority Board	North-West	(01404) 4-1470 (0142) 338-1412
Overberg Water	Eastern Cape	(0291) 4 2476
Pelladrift Water Board	Eastern Cape	(05492) 3411 ask for 3323
Rand Water	Gauteng/North-West/ Northern Free State	(011)682-091
Umgeni Water	KwaZulu-Natal	(0331) 341-1384
Western Transvaal Water Company	Klerksdorp/Orkney/Stilfontein	(018) 482-1241

APPENDIX B : WORKSHEET 1

ANALYSES	DATA				CALCULATED	
					Maximum	Average
Arsenic (mg/ℓ As)						
Cadmium (mg/ℓ Cd)						
Calcium (mg/ℓ Ca)						
Chloride (mg/ℓ Cl)						
Conductivity (in mS/m at 25°C)						
Copper (mg/ℓ Cu)						
Faecal coliforms (No./100mℓ)						
Fluoride (mg/ℓ F)						
Free available chlorine (mg/ℓ)						
Hardness (mg/ℓ $CaCO_3$)						
Iron (mg/ℓ Fe)						
Magnesium (mg/ℓ Mg)						
Manganese (mg/ℓ Mn)						
Nitrate (mg/ℓ N)						
pH (pH units)						
Potassium (mg/ℓ K)						
Sodium (mg/ℓ Na)						
Sulphate (mg/ℓ SO_4)						
Total coliforms (no./100mℓ)						
Turbidity (NTU)						
Zinc (mg/ℓ Zn)						

APPENDIX C : WORKSHEET 2

Maximum concentrations

SUBSTANCE	**MAX.**	**COLOUR CLASS**					**WORST SUBSTANCE CLASS**
		Drinking Health	**Drinking Aesth.**	**Food Prep.**	**Bathing**	**Laundry**	
Arsenic (mg/ℓ As)							
Cadmium (mg/ℓ Cd)							
Calcium (mg/ℓ Ca)							
Chloride (mg/ℓ Cl)							
Conductivity (in mS/m at 25°C)							
Copper (mg/ℓ Cu)							
Faecal coliforms (No./100mℓ)							
Fluoride (mg/ℓ F)							
Free available chlorine (mg/ℓ)							
Hardness (mg/ℓ $CaCO_3$)							
Iron(mg/ℓ Fe)							
Magnesium (mg/ℓ Mg)							
Manganese (mg/ℓ Mn)							
Nitrate (mg/ℓ N)							
pH (pH units)							
Potassium (mg/ℓ K)							
Sodium (mg/ℓ Na)							
Sulphate (mg/ℓ SO_4)							
Total coliforms (no./100mℓ)							
Turbidity (NTU)							
Zinc (mg/ℓ Zn)							

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Average concentrations

SUBSTANCE	AV.	COLOUR CLASS					WORST SUBSTANCE CLASS
		Drinking Health	Drinking Aesth.	Food Prep.	Bathing	Laundry	
Arsenic (mg/ℓ As)							
Cadmium (mg/ℓ Cd)							
Calcium (mg/ℓ Ca)							
Chloride (mg/ℓ Cl)							
Conductivity (in mS/m at 25˚C)							
Copper (mg/ℓ Cu)							
Faecal coliforms (No./100mℓ)							
Fluoride (mg/ℓ F)							
Free available chlorine (mg/ℓ)							
Hardness (mg/ℓ CaCO$_3$)							
Iron(mg/ℓ Fe)							
Magnesium (mg/ℓ Mg)							
Manganese (mg/ℓ Mn)							
Nitrate (mg/ℓ N)							
pH (pH units)							
Potassium (mg/ℓ K)							
Sodium (mg/ℓ Na)							
Sulphate (mg/ℓ SO$_4$)							
Total coliforms (no./100mℓ)							
Turbidity (NTU)							
Zinc (mg/ℓ Zn)							

SUBSTANCE	WORST SUBSTANCE CLASS		SUBSTANCE CLASS (From Table 5)
	Maximum	Average	
Arsenic (mg/ℓ As)			
Cadmium (mg/ℓ Cd)			
Calcium (mg/ℓ Ca)			
Chloride (mg/ℓ Cl)			
Conductivity (in mS/m at 25°C)			
Copper (mg/ℓ Cu)			
Faecal coliforms (No./100mℓ)			
Fluoride (mg/ℓ F)			
Free available chlorine (mg/ℓ)			
Hardness (mg/ℓ $CaCO_3$)			
Iron(mg/ℓ Fe)			
Magnesium (mg/ℓ Mg)			
Manganese (mg/ℓ Mn)			
Nitrate (mg/ℓ N)			
pH (pH units)			
Potassium (mg/ℓ K)			
Sodium (mg/ℓ Na)			
Sulphate (mg/ℓ SO_4)			
Total coliforms (no./100mℓ)			
Turbidity (NTU)			
Zinc (mg/ℓ Zn)			

OVERALL WATER CLASS ☐

GLOSSARY

Activated carbon filtration	The process of passing water through a filter material containing activated carbon, whereby organic substances dissolved in the water are retained by a process known as adsorption on the activated carbon filter.
Aeration	A process whereby intimate contact of a liquid with air is facilitated, e.g. by bubbling air through the liquid, by passing the liquid over a waterfall, of by spraying the liquid through the air.
Ameliorate	To lessen the (negative) effects of.
Anaerobic biological reduction	Biologically mediated decrease in the oxidation state in the absence of oxygen.
Anion	A negative charged ion, which moves under the influence of an electric field towards the anode.
Cartilage integrity	Proper health (=integrity) of the gristle (=cartilage) lining of the bony joints in the body.
Cation	A negatively charged ion, which moves under the influence of an electric field towards the cathode.
Coagulation	The clumping together of suspended particles in water so as to form larger clumps which may be settled out by the action of gravity.
Colonisation	The process of formation of colonies, i.e. collections of micro-organisms e.g. bacteria.
Corrosive	Having a tendency to corrode a material. In terms of human skin, that which burns and destroys tissue. In terms of metals, rusting.
Cyanosis	Blue discolouration of the skin and mucous membranes due to inadequate oxygenation of the blood.
Deionisation	The process of removing dissolved ions from water, usually through use of ion exchange resins.
Demineralisation	A process whereby dissolved salts (=minerals) are removed from water.
Denitrification	The process whereby dissolved nitrates in water a removed from the water by biologically mediated chemical reduction to nitrogen gas.
Disinfection	The process of counteracting infection through the use of a disinfectant, which is a chemical substance which destroys micro-organisms such as bacteria.
Dissolved air flotation	A process whereby suspended particles are floated to the surface as scum which can be skimmed off, through passing air through the water in water treatment.
Distillation	The process whereby water is turned into steam through application of heat, and then recondensed into water. The salts remain behind and the recondensed water (=the distillate) is free of dissolved salts.
Dolomitic	As of dolomite, a rock consisting primarily of calcium and magnesium carbonates.
Electrodialysis	The movement of ions across a semi-permeable membrane assisted by an electrical potential difference.
Ferric salts	Salts of the element iron in the +3 valence state of the ion.

GLOSSARY (continued)

Filtration	The process whereby suspended solid particles are removed by passing a liquid through a porous material (=the filter) so that the liquid portion passes through the filter, and the solid particles are retained on the filter.
Flocculation	The process by which a settlable floc is made through coagulation of suspended particles into larger sized settlable particles of flocks.
Haemochromatosis	A disease syndrome where iron is deposited, among other places, in the skin and internal organs, especially the pancreas. Associated with a bronze discolouration of the skin.
Hydroxide	The compound resulting when the oxide of a metal reacts with water to form a substance with -OH (hydroxide) groups.
Hypertension	Resting systolic blood pressure which is elevated above the level considered normal for a particular age group., i.e. "high blood pressure".
Inactivation	The process of rendering inactive or harmless.
Inorganic	Not of an organic nature, i.e. chemical compounds of any element other than carbon.
Ion-exchange	The process whereby a semi-porous material, known as the ion-exchange resin exchanges charged solute particles with other solute particles of like charge in solution, but differing electronic affinity for the resin. Ion-exchange is a process whereby charged salt particles or ions, may be removed from solution.
Malnutrition	A state of inadequate nutrition due to absence of essential nutrients in a diet of poor quality.
Microbes	Microscopic organisms, especially disease-causing organisms.
Micro-organisms	Biological organisms, some of which have a disease-causing nature, of microscopic size, such as bacteria, viruses, protozoa, etc.
Mucous membranes	The naturally wet lining surfaces of higher organisms, such as the lining of the eyes, the lining of the mouth etc.
Oxidation	The process whereby a molecule loses electrons in a chemical reaction, so as to increase its oxidation state. This may occur through reaction with oxygen or any other oxidant material, which has an affinity for electrons.
Pathogens	Disease-causing organisms. Word derived from the Greek Pathos = disease and gen = giving rise to.
Pentavalent form	The valence state with a five-fold electronic charge.
Peripheral nerves	The nerve fibres exterior to the spinal cord and brain., e.g. in the extremities.
Powdered activated carbon	Powdered carbon which has been activated, usually by heat treatment, so that chemical absorption sites on the surface of the carbon particles have been activated to serve as sites for absorbing especially organic compounds. Used in water treatment to remove organic poisons.
Precipitation	The process whereby substances in clear solution appear as a solid phase, as suspended particles, which may then settle to the bottom of the container through gravitational action. The substance which settles out of solution is known as the precipitate. Where a precipitate forms a previously clear liquid becomes cloudy as a consequence of the formation of a solid precipitate.

Preoxidation	Use of an oxidant prior to use of another reagent.
Ratio	The mathematical relationship defined by dividing one number by another number.
Reagents	Chemical substances used to initiate a chemical reaction.
Recarbonation	Re-adding carbon dioxide to water, when this has been lost in the water treatment process as a consequence of pH modification. Done so as to restabilise the water with respect to the pH and buffering capacity.
Reverse osmosis	The technological process whereby water is forced under pressure against an osmotic gradient, i.e. from a more saline solution to a less saline solution on the low pressure side of a semi-permeable membrane, which is a membrane permeable to water molecules, but relatively impermeable to dissolved salts present in solution in the water.
Sedimentary rocks	Rocks which have their genesis through water deposition of sediments in ancient lakes.
Sedimentation	The process whereby suspended particles in a liquid settle to the bottom of the container containing the liquid if allowed to stand over time, as a result of the action of gravity on the suspended particles.
Semi-metal	An element with properties midway between a metal (e.g. iron), and a non-metal (e.g. sulphur). A semi-metal is neither a conductor of electricity (=metal), nor an insulator (=non-metal).
Substance/variable/ property/constituent	Those things which are present in water and which may be analysed for to determine the quality of the water with respect to fitness for use.
Toxin	A organic poison, usually of biological origin.
Trivalent form	The valence state with a three-fold electronic charge.