BASIC

GUIDE TO MANAGE DRINKING WATER SUPPLIES

WATER RESEARCH COMMISSION

Obtainable from:
Water Research Commission
Private Bag X03
Gezina
0031

Disclaimer

Production editor: Lani van Vuuren
Design and layout: Anja van der Merwe
Printed in the Republic of South Africa

This booklet is based on the report, ***Quality of domestic water supplies Volume 5: Management guide***
(**WRC report no. TT 162/01**)

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INTRODUCTION

A constant supply of clean drinking water is essential to the health and wellbeing of every community. The freshwater we use for drinking, washing and for preparing food (source water) comes from rainwater, surface water sources (such as rivers or dams), or groundwater sources (such as boreholes and springs).

Water services are defined in the Water Services Act (Act no. 108 of 1997) as water supply services and sanitation services. Water supply services, which this booklet focuses on, are defined as the services necessary for the reliable supply of sufficient quantity and quality of water to households, including informal households, to support life and personal hygiene.

The sources of our domestic water supply are subject to a number of threats, including a growing population, chemical use, agricultural and industrial activities, stormwater from residential areas etc. These threats will impact on the water quality and quantity of water sources if not properly managed, which will in turn affect the domestic water user. Water conservation, using water sparingly and wisely, and fixing leaks also contributes to ensuring that the country's scarce water resources are also to support communities for longer periods of time.

This guide provides a summary to potable water supply agencies, water resource managers, workers in the field as well as communities throughout South Africa, with information they need to assess the following:

- Whether a source would be suitable for domestic water supply
- How to prevent contamination at selected points in the domestic water supply system
- If something goes wrong at a specific point in the domestic water supply system in terms of water quality, what can be or should be done, especially during emergencies (floods and droughts)

Basic water supply is defined as:

Quantity – A minimum of 25 litres per person per day or 6 kilolitres per household per month. It is not considered to be adequate for a full, healthy and productive life, which is why it is considered as a minimum

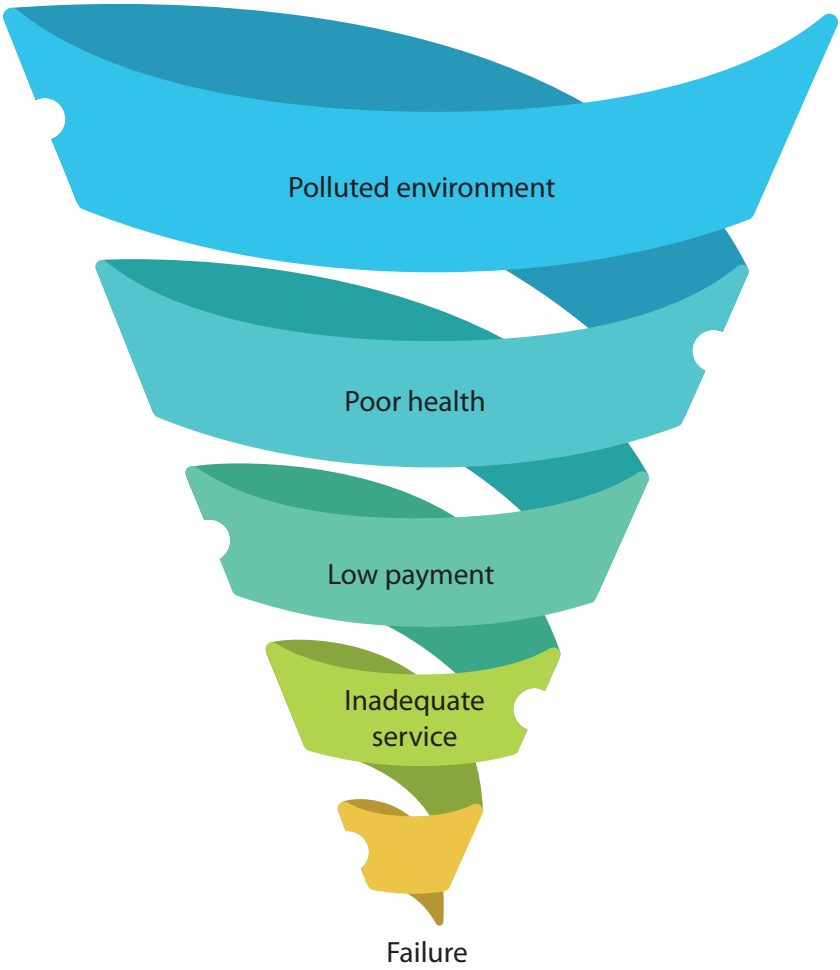
Cartage – The maximum distance that a person should have to cart water to their dwelling is 200 m. In steep terrain this distance may have to be reduced to take account of the extra effort required to cart water up steep slopes.

Availability – The flow rate of water from the outlet should not be less than 10 litres a minute and the water should be available on a regular, daily basis.

Assurance of supply – The supply should provide water security for the community. Firstly, schemes for domestic water supply should ensure the availability of untreated or 'raw' water for 98% of the time. This means that the service should not fail (failure means less water due to drought more than one year in fifty, on average). Secondly, the operation and maintenance of the system must be effective so that there are no water disruptions lasting more than one week a year.

Quality – It is a statutory requirement that treated drinking water complies with the South African National Stand (SANS 241). Drinking water should meet the prescribed parameters determining the allowable chemical and microbial contaminants and also meet criteria with regards to potability, taste, odour and appearance.

INADEQUATE OPERATION AND MANAGEMENT OF WATER TREATMENT FACILITIES



The disaster spiral of inadequate operation and management of water treatment facilities.

Decisions on the suitability of water for domestic use is largely determined by the health-related drinking class of the water.

- 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 that there may in some situations be a need 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.
- When water falls into the **Purple** class the public should be warned not to use the water, or to use emergency treatment where possible.

Class / Colour	Description	Effects
Class 0 - Blue	Ideal water quality	**Drinking health**: No effects, suitable for many generations **Drinking aesthetic**: Water is pleasing **Food preparation**: No effects **Bathing and laundry**: No effects
Class 1 - Green	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 and laundry**: Minor effects on bathing or on fixtures

Class / Colour	Description	Effects
Class 2 - Yellow	Marginal water quality	**Drinking health**: May be used without health effects by the majority of users, 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 users **Bathing and laundry**: Slight effects on bathing or on fixtures
Class 3 - Red	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 and laundry**: Significant effects on bathing or on fixtures
Class 4 - Purple	Unacceptable water quality	**Drinking health**: Severe acute health effects, even with short-term use **Drinking aesthetic**: Taste and appearance may lead to rejection of the water **Food preparation**: Severe acute health effects, even with short-term use **Bathing and laundry**: Serious effects on bathing or on fixtures

INSTITUTIONAL RESPONSIBILITIES – WHO DOES WHAT?

This section briefly describes the roles and responsibilities of the different institutions and organisations involved in making sure clean water reaches households. Not every institution will be involved in all the water supply routes and some may do the work of others in certain areas.

THE ROLE OF THE DEPARTMENT OF WATER AND SANITATION (DWS)

The role of the DWS in the water sector can be divided into two distinct areas:

- Managing the nation's water resources in the public interest, which includes the protection, development, management and control of use of raw water (surface and groundwater); and
- Ensuring that all citizens have access to adequate water and sanitation services

Protection of water resources means:

- To maintain the quality of surface and groundwater so that it can be used in an ecologically sustainable way
- To prevent degradation of the river or aquifer
- To rehabilitate the river of aquifer

Naturally occurring water can only effectively be managed within a river basin or catchment area. Since, in many cases, provincial and / or political boundaries divide catchment basins, and because water is a strategic national resource, water resource management is defined as a national function in the Constitution.

DWS plays a less direct role in the provision of water and sanitation services. The department must ensure that the provisions of the Water Services Act are implemented effectively and fairly across the land. This requires monitoring and guidance with setting up of institutions and how they work, assisting with capital infrastructure funding and with interpreting and distribution information.

The National Water Act (Act no. 36 of 1998) makes provision for DWS to firstly establish catchment management agencies (CMAs) and secondly, delegate specific responsibilities to the CMAs. This ensures that the responsibility for the development, apportionment and management of water resources is delegated to a catchment level. Certain responsibilities that are currently DWS responsibilities could therefore be CMA responsibilities in future.

Provincial governments share the responsibility with DWS for assuring service provision by local authorities, specifically through the promotion of effective local government. It is of utmost importance that the closest cooperation be maintained between DWS and the provinces given their joint interest in the development of the capacity of local government to provide water and sanitation services on an equitable and effective basis.

THE ROLE OF THE DEPARTMENT OF HEALTH (DOH)

The Health Act (Act no. 63 of 1977) places the custodianship of the health of the citizens of South Africa in the hands of the Department of Health. As such, the DoH is responsible for investigating and ameliorating any impact from the general living and working environment that may have a negative effect on human health.

The DoH, in collaboration with other relevant sectors, is responsible for the improvement of South Africa's environmental health status. It therefore endeavours to limit the health risks which arise from the physical and social environment.

Environmental health officers are responsible to ensure that environmental health services are distributed at community level. Thus, based on community needs and risk assessments, environmental health service interventions, including the promotion of clean water, adequate sanitation provision, and food safety, are part of an environmental health officer's responsibilities. Furthermore, communities are empowered through the dissemination of environmental health and hygiene information.

THE ROLE OF WATER SERVICE AUTHORITIES (WSAS)

A WSA regulates how water supply and sanitation services are provided and who provides them within its area of jurisdiction. The WSA is the local government structure – usually metropolitan municipalities and / or local municipalities. Water services can only be obtained through a water service authority and its contracted water service providers (WSPs).

The Municipal Systems Act (Act no. 32 of 2000) describes the responsibilities of local authorities with regards to service provision. These responsibilities include:

- Prepare a water services development plan outlining how water services will be provided
- Involve communities in drawing up the plan and report on how it is being implemented
- Carry out the functions of the water services provider itself, or make use of contractors
- Create by-laws, and set tariff structures for payment.

THE ROLE OF WATER SERVICE PROVIDERS (WSPS)

A WSP does the work of providing water services to customers. The WSA can also be the WSP or the WSA can contract a community-based organisation, a water board, a private company, an non-governmental organisation or an adjoining local authority, to be a water service provider. No WSP, not even ordinary water vendors, may operate without permission from a WSA.
The tasks and duties of a WSP are to:

- Operate the water services provision system
- Handle customer relations
- Collect revenue payments for water services

THE ROLE OF HOUSEHOLDERS

Householders are the final users of water for domestic purposes. The householder can get domestic water from a WSP or directly from a water source, such as a borehole. The domestic water that is supplied by a WSP becomes the responsibility of the householder at the point of delivery, namely in the house, at the standpipe or from the vendor.

The domestic water that the householder acquires directly from a water source, such as a borehole or spring, is the responsibility of the householder.

The tasks and duties of householders are:

- Identify their water services needs and jointly negotiate with their WSPs so these needs can be met
- Pay agreed rates for water services provided
- Monitor their WSP and their water services
- Support the WSPs by reporting leaks and illegal connections
- Ensure that water used directly from a source be at least treated with bleach or boiled before it is used as drinking water
- Ensure that the containers in which water is kept or transported are clean, and that containers in which water is stored are kept covered

It is the role of the water service provider (usually a municipality) to maintain the water distribution system.

WATER SUPPLY INFRASTRUCTURE

Water used for domestic purposes can be acquired via numerous water supply routes. Some of these routes are inherently riskier than others. Water supplied for domestic purposes via supply route that incorporates abstraction, treatment, and distribution as services, has a much lower risk for contamination than water supplied via a supply route that incorporates no service (user abstracts and delivers water).

ABSTRACTION FROM WATER SOURCES

Rainwater harvesting means the accumulation of roof runoff water during the rainy season.

Groundwater is mainly abstracted by means of boreholes and handpumps. Smaller communities in rural areas generally use groundwater. Springs are not always a reliable source of water.

Rivers and dams are surface water sources. Water in river systems is stored in dams to ensure that a constant supply of is available even during dry months.

WATER SUPPLY INFRASTRUCTURE CONCEPT AND DEFINITIONS

In water supply there are four basic actions, relevant to water supply infrastructure, namely:

- Abstraction from source
- Treatment (i.e. cleaning)
- Distribution
- Use

In each of these there are various options and / or alternatives as explained below.

Treatment

Surface water and groundwater should, in most cases, be treated to make it fit for domestic use. The level of treatment required is related to the physical, chemical or bacteriological impurities in the water. The treatment of water can be done in different ways. The WSP is responsible for ensuring that an acceptable water quality for domestic purposes is supplied.

Home treatment – This can be done in the home, using materials which are common in most households or which are readily available, such as boiling of the water, household bleach for disinfection or straining water through a cloth.

Basic treatment – This can be done by the community using materials such as chlorine pills.

Conventional treatment – This can be done in a treatment plant constructed for this purpose. Conventional treatment includes coagulation, flocculation, filtration, and disinfection. 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.

Distribution

Several systems are available to distribute water to users and include a wide spectrum of methods.

Fetching water – The householder fetches water directly from a river, dam, borehole etc. This is a high-risk method of using water for domestic purposes since the water from a river, dam or borehole has not been treated.

House connection – This is a pipe system from a reservoir to each house. This can be a connection to the house or yard of a property.

Standpipe – The objective of the DWS is to at least have water at 200 m interval standpipes available for domestic use.

Vendor – A vendor can source water directly from a dam or river, reservoir, standpipe or tanker for further distribution. The selling of bottled water is also a vendor activity. The control over vendors is limited and their only responsibility is towards their clients.

Tanker – A tanker is a mobile reservoir transporting water from a distant source, for example, a reservoir, dam etc. The WSP is responsible to ensure that water delivered in this manner is safe for domestic purposes.

Reservoirs – Reservoirs are required to allow temporary storage of water. Water is used by communities during daylight hours with peak abstractions occurring at about 5-8 am and again at about 4-9 pm. Sufficient storage is therefore required to the reservoir to balance inflow and outflow. Storage is also require to provide backup supply during times when delivery is interrupted due to pump failure and other breakdown.

Bulk supply – Water is conveyed from the water source (e.g. river) to the bulk water reservoir by means of bulk water pipelines. These pipelines are the responsibility of either the WSA or the WSP.

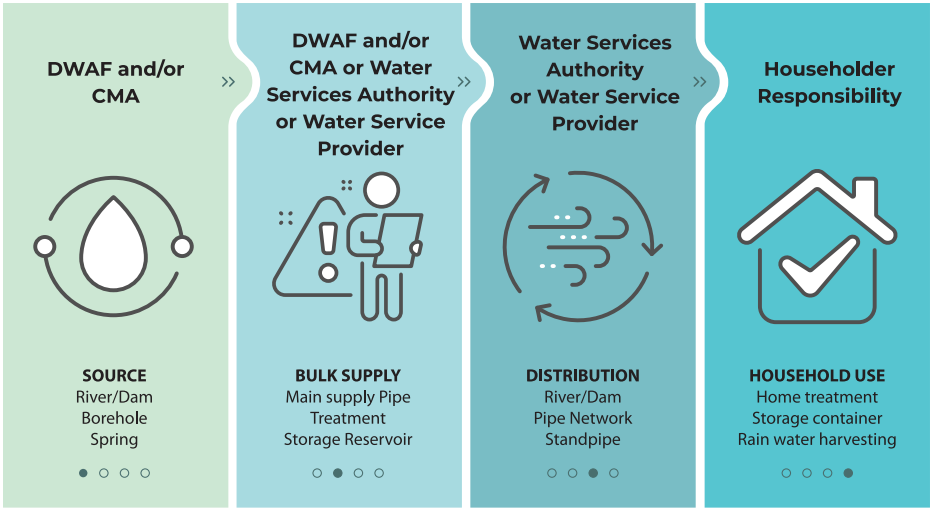
Use

Water at the house can be used for drinking, food preparation, bathing and washing. The protection of the quality of the water in the house is the responsibility of the householder.

BASIC WATER SUPPLY DELIVERY ROUTES

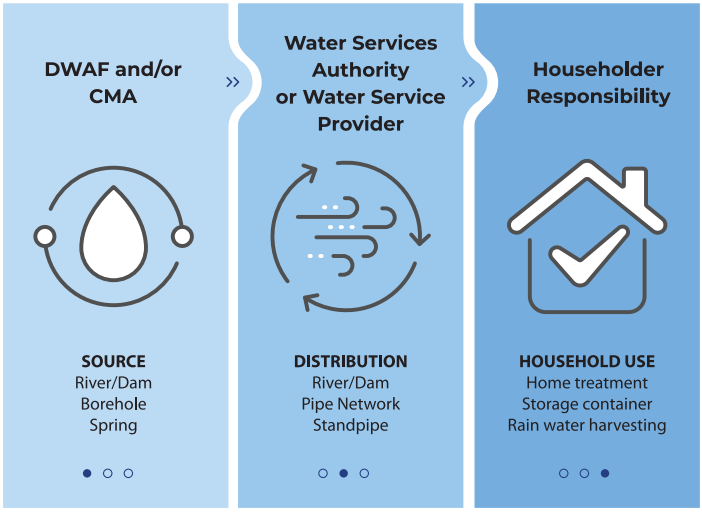
Four generic supply routes are shown below. The user of this guide should be able to relate to a water supply route that describes their situation best.

Route 1 depicts a full service, which includes the abstraction of water for domestic purposes, the treatment of the water and finally the distribution of the treated water to the householder. This service ensures that the risk for contamination is very low, but this service will also be the most expensive option.



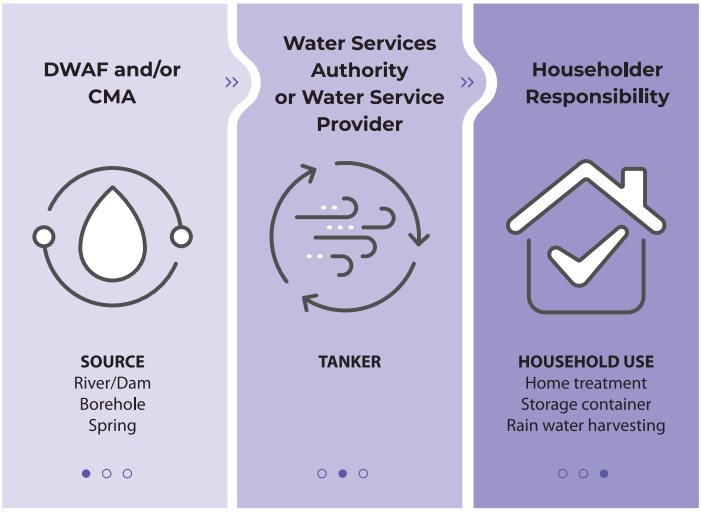
Route 1: Abstraction, treatment and distribution (full service).

Route 2 depicts a partial service, which includes the abstraction of water for domestic purposes and the distribution of the untreated water to the householder, but where no provision is made for a treatment facility. This service would normally be applied in areas where the water source is of excellent natural quality and where the risk of potential contamination is low, such as protected springs and groundwater sources.

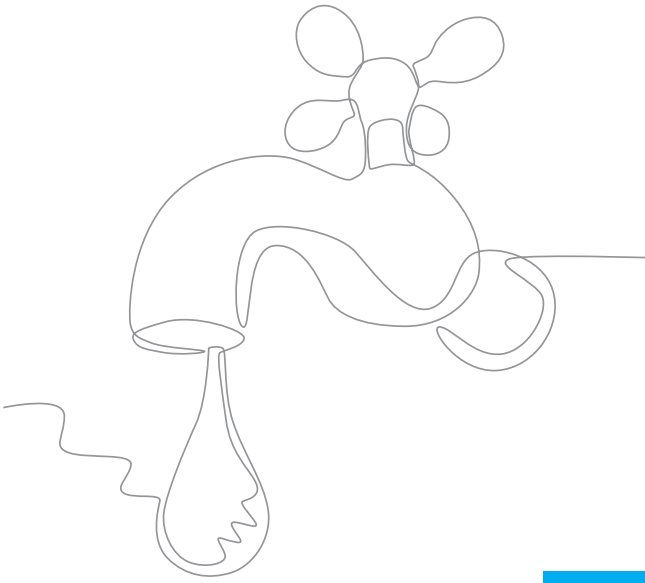


Route 2: Abstraction and distribution, with no treatment (partial service).

Route 3 depicts a low service, which includes the abstraction of water for domestic purposes and the delivery of the untreated water via tankers to the householder. No provision is made for a treatment facility or formal distribution system. This service has a higher potential for contamination because the water is not treated, and the delivery method could result in contamination (e.g. tankers are not cleaned on a regular basis).



Route 3: Abstraction and delivery, no treatment or distribution (low service).



SOMETHING HAS GONE WRONG – WHAT NOW?

This section focuses on identifying what can go wrong, what is the possible effect, how will you know, and what can you do to rectify the situation. This is described for the four basic components of water, namely abstraction, treatment, distribution and use.

TYPICAL WATER QUALITY PROBLEMS IN SOUTH AFRICA

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

Problems in surface water

The water quality of South Africa's surface waters has deteriorated over the years. The most common problems are:

- **Faecal pollution** – high faecal and total coliform counts occur in most surface waters, especially those near dense human settlements.
- **Colour and stability** – The rivers that drain the mountain catchments along the southern coastline of the Cape have waters that are highly coloured due to organic acids. These waters have characteristically low TDS concentrations and a low pH. Colour removal requires precise chemical dosing, and together with the stabilisation of the water (specific chemical dosing to control pH), treatment is costly and not easy.
- **Salinity (total dissolved solids) or electrical conductivity (EC) –** 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 distinctive salty taste. Salt removal by means of reverse osmosis or ion exchange is expensive, and most communities accept the water after clarification and disinfection.
- **Eutrophication (high algal concentrations) –** Some dams 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 dissolved air flotation instead of the more conventional sedimentation in the clarification process.

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 predominating geological formulations 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 de-ionisation.
- **Fluoride** – Fluoride concentrations in groundwater in some areas tend to be high, especially in the central and western parts of the country. Fluoride removal is expensive.
- **Sulphate and chloride** – Water with high TDS concentrations tend to have high sulphate concentrations as well. Sulphate removal is expensive and normally not considered viable.
- **Calcium and magnesium** – The groundwater in the dolomitic areas in the northern parts of the country tend 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 elements in hot water appliances. The cost of replacement and maintenance of these appliance 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 generally cheap and easy, consisting of oxidation by means of aeration, or by adding chlorine.

SUBSTANCES WHICH ARE GENERAL INDICATORS OF WATER QUALITY

Numerous substances can be found in water. However, only a few of these commonly occur in concentrations high enough to be of concern to domestic 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 the following tables.

Group A 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 water.	
Electrical conductivity (TDS)	Conductivity is an indicator of 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 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 the concentrations are too high it may cause an unpleasant taste and smell to the water.

Group B The presence / concentration of Group B substances should be determined before the water is supplied. The frequency of testing depends on the source and treatment applied. Note that substances of concern due to pollution sources in the area, may have to be added to Group B.	
Nitrate and 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. 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.

Group C Group C substances should be tested for at point-of-use only in areas of the country where soft water of a low pH is used.	
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 D The presence of these 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.	
Manganese	This commonly causes the 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 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 or 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.
Calcium	This can cause scaling and can reduce the lathering of soap.
Magnesium	This affects the taste of water. It is bitter at high concentrations. Common in some areas, it adds to the effect of calcium.

POSSIBLE PROBLEMS IN THE WATER SUPPLY SYSTEM

The section below describes potential high-risk areas for contamination and emergency situations that could arise at the four basic components of water supply. It is important to have a monitoring programme in place for the entire domestic water supply delivery route.

IMPORTANT NOTE!

Without water quality data the suitability of the water cannot be assessed. The water, whether from the source, treatment plant, bulk supply or distribution network should be analysed for substances in Group A, B and D. It is expensive to analyse for all variables on a regular basis. Therefore, focus should be placed on indicator variables (such as electrical conductivity, which is an indicator of salt content of water).

After the water has been analysed and assessed the following general guide can be used as a quick reference, but a thorough assessment by an expert should be done soonest:

- Water within the Blue and Green classes can be used without concern.
- Water within the Yellow class must be used with caution.
- Water in the Red class may only be used for emergency situations if no other source is available.
- Water in the Purple class may not be used at all.

Abstraction

The abstraction section indicates all the possible raw water sources available to the domestic user for abstraction. Raw water can be sourced from a river or dam, from a borehole, spring (groundwater), or rainwater harvesting.

Rivers			
What can go wrong?	**What is the possible effect?**	**How will you know?**	**What to do**
Drought (low flow conditions)	Water quality will deteriorate.	For river sampling focus should be placed on general substances (Group A). Taste and odour will be prominent in affected water. During flood conditions the focus should be on bacteriological pollution. If industrial pollution is suspected the focus should be on toxic substances (Group B and C).	Water rationing may be necessary in severe drought. Chlorine dosing may need to be increased under flood conditions to ensure disinfection. With pollution, source control measures should be implemented. Options to consider when assessing the fitness-for-use of source water: • Assess whether different sources can be mixed to achieve the required water quality • Make use of emergency treatment options or change the treatment process to cater for problem substances • If a pollution source can be identified address the problem at the source • Assess whether other sources are available, such as groundwater or tankers
Floods	Increased turbidity makes treatment and disinfection difficult.		
Pollution	Change in water quality due to: • Industrial effluent/ sewage discharges • Agricultural activities • Urbanisation		

Dams/ lakes			
What can go wrong?	**What is the possible effect?**	**How will you know?**	**What to do**
Drought (low flow conditions)	Low offtakes have to be used: • Poorer water quality • Increased salts due to evaporation	For dam / lake sampling, focus should be placed on general substances (Group A). During flood conditions the focus should be on bacteriological pollution. If industrial pollution is suspected the focus should be on toxic substances (Group B and C). Special analysis should be done to determine lead and hydro-carbon contamination. (Specialist required to assess and interpret data). Eutrophication (green water in dam, causes taste and odour problems).	Options to consider when assessing the fitness-for-use of source water: • Assess whether different sources can be mixed to achieve the required water quality • Make use of emergency treatment options or change the treatment process to cater for problem substances • If a pollution source can be identified address the problem at the source. • Assess whether other sources are available, such as groundwater sources or tankers Once a dam has been contaminated it is difficult to rectify the situation. The only viable option is to adapt water treatment processes to overcome the problem.
Pollution	Change in water quality due to: • Industrial effluent/ sewage discharges • Agricultural activities • Urbanisation		
Recreational activities	Change in water quality due to oils and fuel from boats		

Groundwater: Boreholes and springs			
What can go wrong?	**What is the possible effect?**	**How will you know?**	**What to do**
Drought	Change in water quality due to lower feed rates and higher mineralisation (concentration of salts in the water).	For drought conditions focus should be placed on general substances (Group A).	Alternate source for drinking and cooking if change in water quality is too high. Install treatment plant for drinking water only.
Pollution	Change in water quality due to: • Septic tanks • VIP toilets • Solid waste sites • Industries • Feedlots	For pollution conditions focus should be placed on toxic substances and bacteriological pollution (Group B and C).	For pollution conditions address source of contamination. Treat water until problem is solved or supply from alternative source.
Over-exploitation	Change in water quality due to reduced yield and water quality.	For overexploitation conditions focus should be placed on classifying water to determine its fitness for use.	If source is overexploited develop additional source or allow enough time for source to recover.

Treatment processes

There are numerous treatment processes. For the purposes of this guide these processes are subdivided into home treatment, basic treatment, conventional treatment and advanced treatment.

The basic, conventional and advanced treatment processes can be affected by the lack of funds / resources, shortage of chemicals, inability of operator to manage treatment works, power failures, fluctuations in raw water quality, floods and drought conditions.

Home treatment			
What can go wrong?	**What is the possible effect?**	**How will you know?**	**What to do**
• Use of contaminated source (direct use from river, borehole or spring) • Inadequate boiling • Inadequate use of chemicals such as bleach • Treatment option used does not cater for other contaminants such as salts and metals	• Risk of bacteriological contamination causing diarrhoea, fevers etc. • Negative health effects as a result of other contaminants	• Negative health impacts • Health officer monitoring results – classify water to determine fitness for use	• Boil water continuously for at least five to ten minutes • Add one teaspoon of domestic bleach in 20 litres (bucket) of water, mix well and leave for one hour before use • Water with a high turbidity should be left for at least two hours before use or the water should be filtered through a fine cloth prior to adding the bleach • Use a home treatment device • Use a safer drinking water source

Basic treatment			
What can go wrong?	**What is the possible effect?**	**How will you know?**	**What to do**
• Inadequate funds / resources • Shortage of chemicals • Inability of operator to manage treatment works	High risk for bacteriological contamination.	• Analyse for substances in Group A, B, and D. • Classify water to determine its fitness for use	• Initiate a process to acquire funds from other sources such as provincial or national government • Train operators to operate specific treatment works correctly
Power failure	Reduction in water quality and flow	Analyse for substances in GROUP A, B, and D	Make use of an emergency power generator
Floods	Change in water quality due to damaged treatment works.	Analyse for substances in Group A, B and D.	• Basic emergency treatment options to comply with at least a Red class water for short duration • Water within the Yellow class must be used with caution • Make use of other sources supplied by water tankers

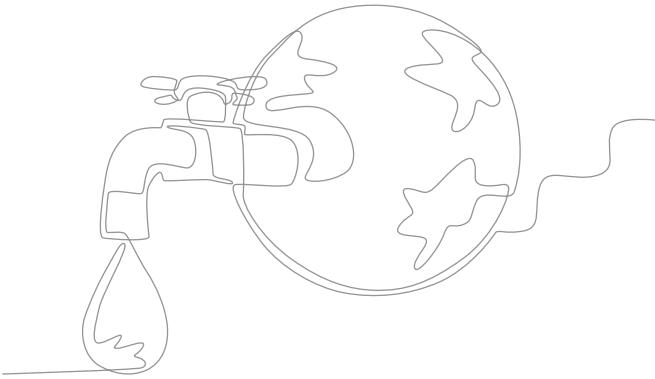
Conventional and advanced treatment			
What can go wrong?	**What is the possible effect?**	**How will you know?**	**What to do**
Inadequate funds / resources	Shortage of chemicals Inability of operator to manage treatment works.	Analyse for substances in Group A, B and D. Classify water to determine its fitness for use.	Initiate process to acquire funds from other sources such as provincial or national government and train operators to be able to operate specific treatment works.
Power failure	Reduction in volume and quality	No water if water is pumped through system during a power failure and deterioration in water quality if water is gravity fed through system.	During a power failure make use of an emergency power generator and implement basic emergency treatment options to comply to at least a Red class water for short durations.
Over-fluoridation	Over-fluoridation causes brittle-bone disease. Fluoride fixes the calcium in the bone structure and consequently, the bone becomes very hard. Brittle bones break easily under mild stress.	Discolouration of the teeth occurs where fluoride is ingested during the tooth formative years in concentrations in excess of optimum level for healthy tooth enamel. (Please note that fluoride has no taste or smell, and cannot be detected aesthetically, even at high concentrations)	Good quality control – hourly measurements are necessary when fluoridation is practiced. Care should be taken that overdosing does not occur. For the effective removal of fluoride, advanced treatment methods are required, such as activated alumina or bone char to absorb fluoride. Home treatment with clay or calcium carbonate chips may ameliorate high concentrations. Home treatment kits using ion exchange processes can be used.
Overdosing / under-dosing of other chemicals such as chlorine	Carcinogenic (THM formation). Increasing risk of cancer with long-term use when chlorine dose is excessive.	Water tastes like bleach.	Optimise chlorine and treatment chemical dosing.

Conventional and advanced treatment			
What can go wrong?	**What is the possible effect?**	**How will you know?**	**What to do**
Change in raw water quality	Deterioration in water quality – fluctuation in water quality.	Analyse for substances in Group A, B and D. Classify water to determine its fitness for use.	• Water with the Yellow class could be used but with caution • Water in the Red class may only be used for emergency situations if no other source is available – only for short-term use • Use other sources – groundwater sources and / or water tankers • Mixing of water sources to achieve better water quality
Floods	Change in water quality due to damage to treatment works.	During floods a deterioration in water quality will be noticed. The increase in turbidity will cause blocked filters. Bacteriological quality may deteriorate.	• Water within the Yellow class could be used but with caution • Water in the Red class may only be used for emergency situations if no other source is available • Use other sources – groundwater sources and / or water tankers

Conventional and advanced treatment			
What can go wrong?	**What is the possible effect?**	**How will you know?**	**What to do**
Droughts	• Stagnant water abstraction • Use of poorer quality water from bottom of dam	During drought conditions the salt content of the water will increase. Leaking sewage pipes can create bacteriological problems during drought conditions.	• Water within the Yellow class could be used but with caution • Water in the Red class may only be used for emergency situations if no other source is available • Use other sources – groundwater sources and / or water tankers • Mixing of water sources to achieve better water quality

Distribution

The distribution network includes storage reservoirs, a pipe network and standpipes. The network can be affected by having open reservoirs, silt build-up in reservoirs, sabotage, breaks and bursts of pipes and infiltration seepage from a contaminated source.



Reservoir			
What can go wrong?	**What is the possible effect?**	**How will you know?**	**What to do**
Open reservoirs	• Change in water quality due to: • Contamination from birds etc. • Growth of algae	• Physical inspection • Free chlorine sampling at strategic points • Sampling at strategic points to ensure right levels of free chlorine • Free chlorine sampling in reservoir • Sampling at strategic points for substances in Group A, B, C, D • Classify water to determine its fitness for use	• Remove foreign objects and clean reservoir regularly • Increase chlorine dosage to reduce algal growth and bacteriological contamination
Silt build-up in reservoirs	Change in water quality due to: • Increase in turbidity • Increase in bacteriological contamination	• Sampling at strategic points for substances in Group A, B, C, D • Classify water to determine its fitness for use • Physical inspection • Free chlorine sampling at strategic points	• Check and rectify filters at treatment works if a silt build-up is noticed in the reservoirs • Increase chlorine dosage to reduce algal growth and bacteriological contamination

Reservoir			
What can go wrong?	**What is the possible effect?**	**How will you know?**	**What to do**
Large reservoir – long retention time	Change in water quality due to: • No more free chlorine to disinfect water • Increase in bacteriological contamination • Increase in algal growth • Taste and smell effects	• Sampling at strategic points for substances in Group A,B,C,D • Classify water to determine its fitness for use • Free chlorine sampling at strategic points	• Increase chlorine dosage to reduce algal growth and bacteriological contamination • Change the frequency of filling or replace the water regularly in the reservoir to eliminate long retention times • Construct multiple compartments in reservoir to ensure that retention times are reduced
Sabotage	• No water • Contaminated water	• Sampling at strategic points for substances in Group A,B,C,D • Classify water to determine its fitness for use • Physical inspection	• Increase security when sabotage is suspected

Network			
What can go wrong?	**What is the possible effect?**	**How will you know?**	**What to do**
Breaks and bursts	• Increase in turbidity • Loss of water	• Physical inspection • Sampling at strategic points to establish fitness for use	• Establish and rectify the problem immediately • Supply an interim source of water
Infiltration / seepage from contaminated source	• Deterioration in water quality	Regular sampling at strategic points for indicator variables at high-risk areas, e.g. industrial sites.	

Points of use

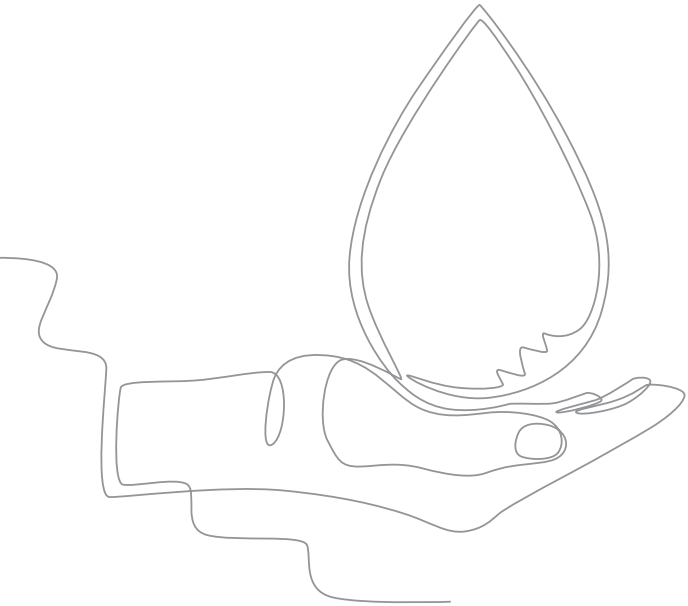
Water can be used for various purposes at the house. This water can be contaminated through the incorrect storage of water, the use of contaminated storage facilities or the use of a contaminated source.

Rainwater harvesting / storage			
What can go wrong?	**What is the possible effect?**	**How will you know?**	**What to do**
Open storage tanks	Change in water quality due to: • Bacteriological pollution • Suspended solids contamination	• Taste, odours, diarrhoea • Physical inspections • Health Officer monitoring – classify water to determine fitness for use	• Clean storage tanks regularly • Seal storage tanks

Rainwater harvesting / storage			
What can go wrong?	**What is the possible effect?**	**How will you know?**	**What to do**
Dirty roofs / contamination from septic tank / pit latrine	High risk for other variable contamination – which may lead to health effects	• Taste, odours, diarrhoea • Physical inspections • Health Officer monitoring – classify water to determine fitness for use	• By-pass first rainwater runoff from roofs • Use another safer source of water • Use water only for washing, flushing, toilets etc.

Boreholes			
What can go wrong?	**What is the possible effect?**	**How will you know?**	**What to do**
Contamination from septic tanks / pit latrine	Increased risk for bacteriological contamination	• Taste, odours, diarrhoea • Health Officer monitoring – classify water to determine fitness for use	• Use another safer source of water • Use water only for washing, flushing, toilets etc • Inform relevant authority for action
Seepage from other sources	Negative health effects as a result of other contaminants	• Taste, odours, diarrhoea • Health Officer monitoring – classify water to determine fitness for use	• Use another safer source of water • Use water only for washing, flushing, toilets etc • Inform relevant authority for action

Boreholes			
What can go wrong?	**What is the possible effect?**	**How will you know?**	**What to do**
Contamination due to long standing and / or continuous use	Increased risk for bacteriological contamination	• Taste, odours, diarrhoea • Physical inspections • Health Officer monitoring – classify water to determine fitness for use	• Clean containers regularly • Store in clean ventilated area • Cover containers



DECISION-MAKING HIERARCHY

A decision-making hierarchy is a chronological process that is followed to determine the 'best' option to implement. A decision-making hierarchy is used to guide the decision-maker to make a decision acknowledging the contributions of other affected parties and the risks involved.

For the purposes of this guide, a decision-making hierarchy is used to determine the usability of a particular water resource with regard to its water quality. The decision-making hierarchy depicted below only considers the water quality aspects and the resultant costs of producing a specific water quality.

Important Note!
Water quality is not the only aspect which needs consideration when deciding on the usability and cost implications of supplying water from a specific source. Other factors that need consideration are:

- Type and number of consumers
- User water requirements per user
- Level of service required
- Water source quality and yield
- Water supply infrastructure, and operation, maintenance and management of water supply system

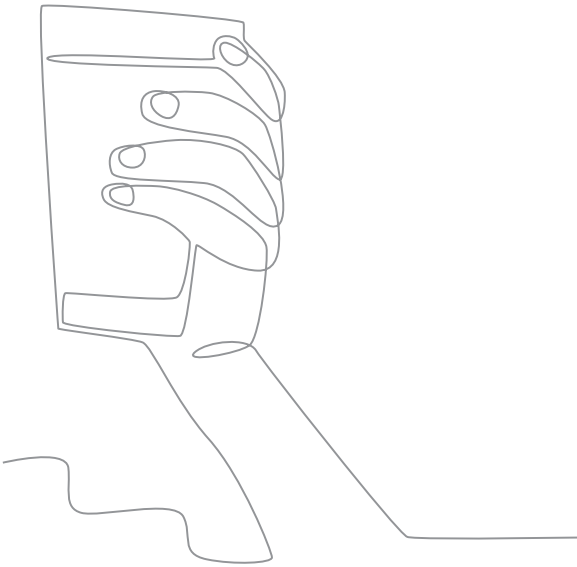
The assessment process is summarised as follows:

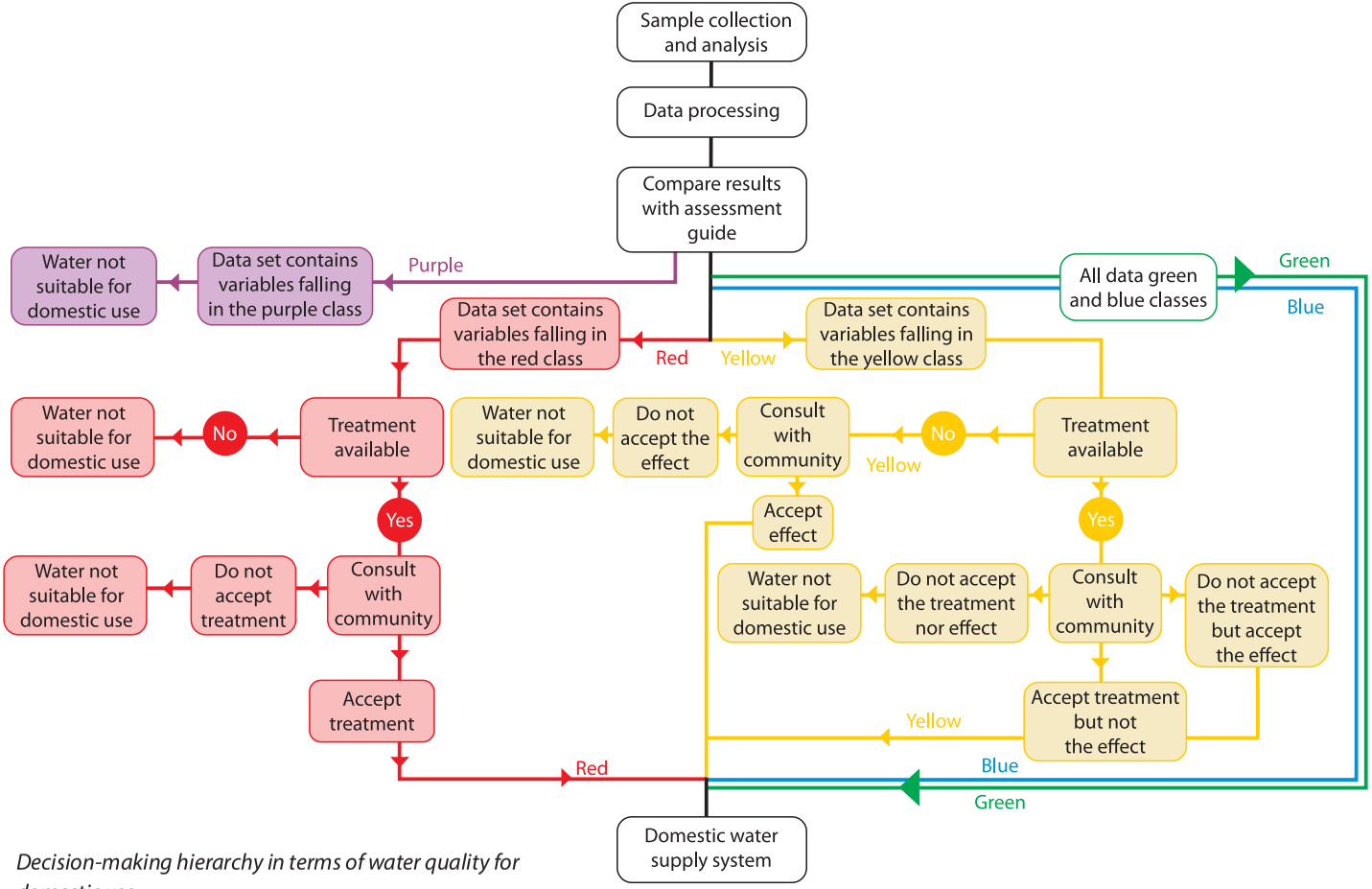
1. Decision-making on the suitability of water for domestic use is largely determined by the health-related drinking class of the water. It is therefore important to assess whether the substance causing the problem has any health effect. The following can then be used to guide decision-making:

- 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 (e.g. for infants)
- Water falling in the Red class may be used for short-term emergency supply (7 days only) where other sources are not available
- When water falls into the Purple category class the public should be warned not to use the water, or to use emergency home treatment where possible.

2. From the water quality status assessment the water source can be classified. Each variable of concern can therefore be classified in terms of its potential negative impact on the domestic user. Based on the classification of the substances, specific action (do nothing, intervene immediately or long-term action) should be taken.

If a water supply frequently falls into the Red or Purple class, it is recommended that water quality experts be consulted for more detailed advice on treatment.





Decision-making hierarchy in terms of water quality for domestic use.

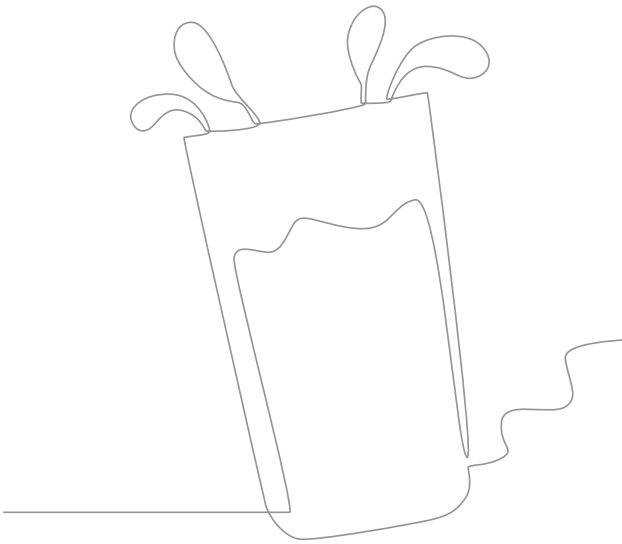
The cost implications of treating water to a desired water quality

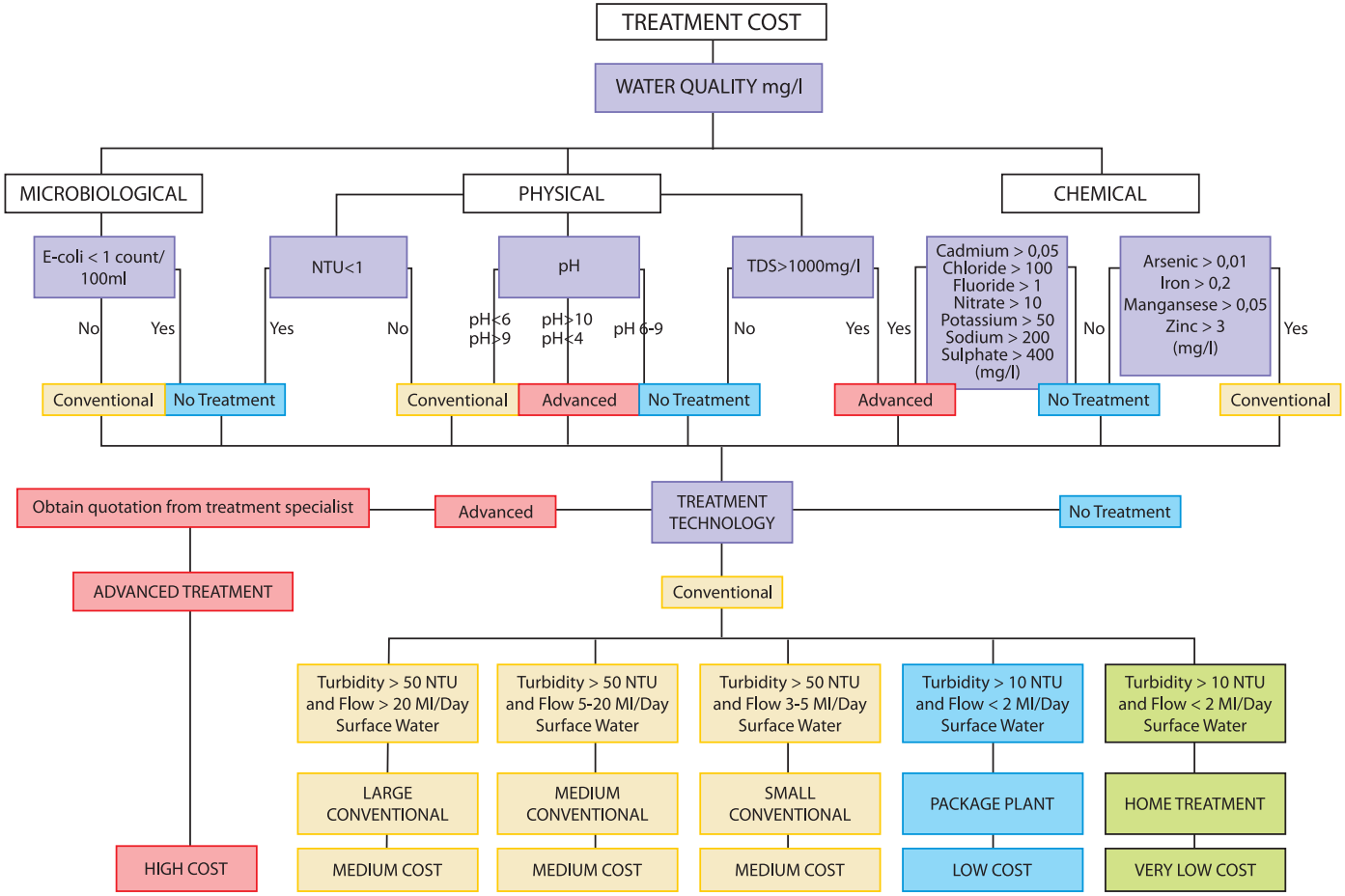
Treatment costs are mainly dependent on:

- The **volume** of water that has to be treated
- The **quality** of the water
- The **location** of the water

The water variables that affect treatment are categorised into bacteriological constituents, physical constituents and chemical constituents.

Water can be treated to remove any substance which may it unsuitable for domestic use, but certain substances may be more difficult to remove than others, which can result in more expensive treatment options. However, some substances can be removed from water using chemicals, materials or processes that are both cheap and readily available in most communities. The figure below indicates the treatment processes required for different water qualities and the estimated cost of treating that water to comply with domestic water quality requirements. The costs indicated are generic and the only purpose is to indicate a cost relative to each treatment process.





Treatment cost decision-making hierarchy.

MANAGEMENT CONCEPTS

Management relates to the activities needed to organise the overall functioning of an organisation. These actions are a continuous cycle, with the main objective to improve functioning of the organisation over time. The actions can be summarised as:

- **Planning** – Plan your activity
- **Doing** – Carry out the activity
- **Checking** – Check whether you have achieved what you have set out to do
- **Adjusting** – Adjust your plan if you did not achieve what you set out to do, or to improve on previous achievements

Operation, on the other hand, covers day-to-day activities required to run an organisation.

IMPORTANT MANAGEMENT ASPECTS

- **Strategic management** implies the anticipation of changes and making the adjustments needed to deal with these changes pro-actively.
- **Business planning** is about documenting your activities in ensuring that your goals are met.
- Monitoring is about setting goals and evaluating the performance in terms of these goals.
- **Reporting** is the full account of actions and reactions.

Important Note!

If a sufficient quantity of water is delivered to all customers, with a quality which meets potable water standards, and at a reasonable price, the system can be said to be running efficiently. Conversely, if there is insufficient water provided to meet demand, if the quality is poor or if the price is too high, the system is not performing properly.

The importance of quality control

The key to effective service delivery is quality control through the use of a systematic approach to planning, controlling, measuring and improving an organisation's performance. There are a number of formal systems available to organisations for implementing a quality control system, such as ISO 9001.

A quality control system generally comprises the following key elements:

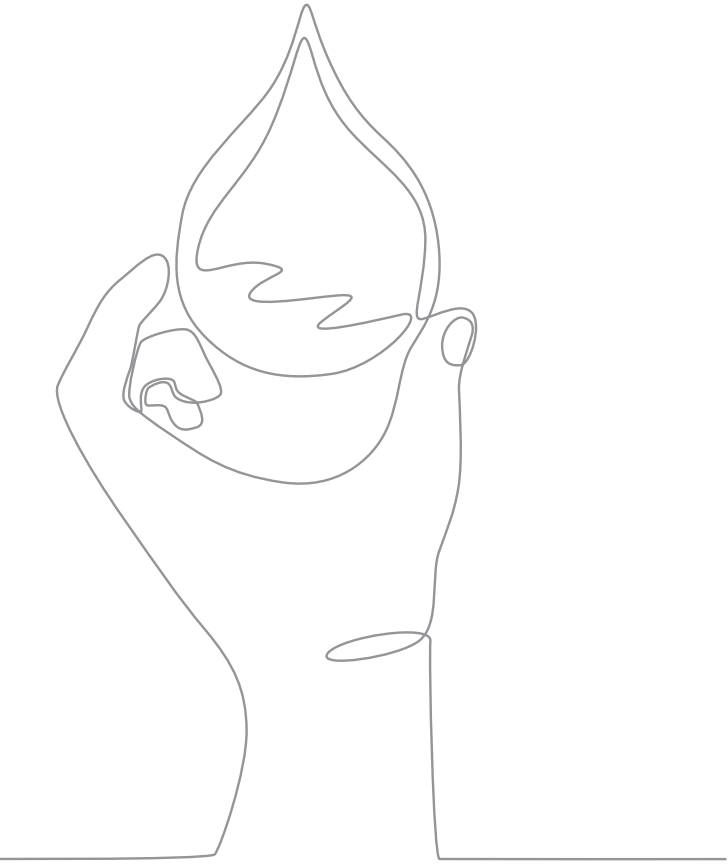
- **Quality policy** – the development of a statement of your organisation's commitment to the delivery of safe and reliable drinking water
- **Adequate resources** – funds, manpower and materials
- **Responsibilities and authorities** – establish roles and responsibilities for quality control and provide adequate services
- **Training, awareness and competence** – ensure that your employees are trained and capable of carrying out their respective responsibilities
- **System documentation** – Maintain information on your quality control and related documents
- **Process controls** – Identify, plan and manage your operations and activities in line with your policy objectives and targets
- **Document control** – Ensure effective management of procedures and other system documents
- **Emergency preparedness and response** – identify potential emergencies and develop procedures for preventing and responding to them
- **Monitoring and measurement** – monitor key activities and track performance. Conduct periodic assessments and compliance with legal requirements
- **Nonconformance and corrective and preventative actions** – identify and correct problems and prevent their recurrence
- **Records** – maintain and manage records of quality control performance
- **System audits** – periodically verify that your quality control system is operating as intended
- **Management review** – periodically review your quality control system with continual improvement in mind

Implementing a quality control system has a number of potential benefits:

- Producing a better quality product (drinking water complying to customer needs)
- Increased efficiency / reduced costs

- Enhanced employee morale
- Enhanced public image,
- Employee awareness of responsibilities

However, an effective quality control system does not just happen. A quality control system needs ongoing and visible management support and employee involvement.



FURTHER READING

- CD Swartz et al, WATCOST Manual for a costing model for drinking water supply systems (WRC report no. TT 552/13), https://wrcwebsite.azurewebsites.net/wp-content/uploads/mdocs/TT%20552-13.pdf
- DWS, South African water quality guidelines – Volume 1: domestic use, https://www.iwa-network.org/filemanager-uploads/WQ_Compendium/Database/Selected_guidelines/041.pdf
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- Palmer Development Group, Water supply services model manual (WRC report no/ KV 109/98), https://www.wrc.org.za/wp-content/uploads/mdocs/KV-109-98.pdf
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- WHO & IWA, Water safety plan manual – Step-by-step risk management for drinking-water suppliers Second edition, https://iris.who.int/bitstream/handle/10665/366148/9789240067691-eng.pdf?sequence=1

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