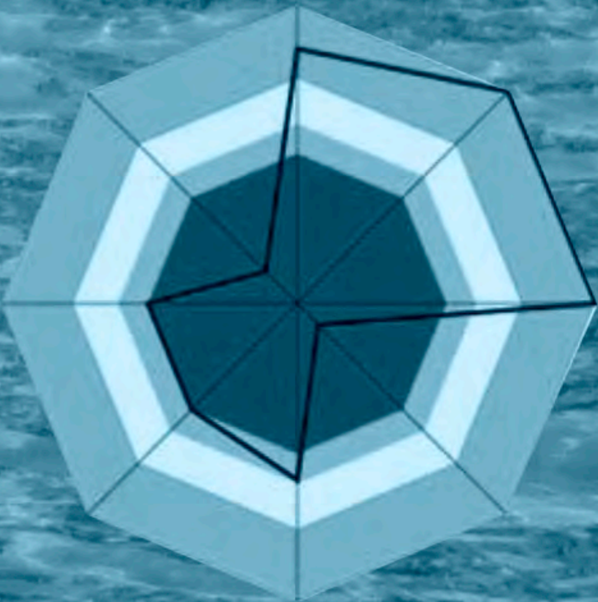

# Guidelines for using the web-enabled WATER SAFETY PLAN TOOL

Unathi Jack & Philip de Souza

WATER RESEARCH COMMISSION

TT 515/12

# Guidelines for using the web-enabled Water Safety Plan Tool

**Unathi Jack and Philip de Souza**

Report to the
**Water Research Commission**
by
**Emanti Management (Pty) Ltd**

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## Abbreviations

| | |
|---|---|
| BDC | Blue Drop Certification |
| BDS | Blue Drop System |
| DEAT | Department of Environmental Affairs and Tourism |
| DoH | Department of Health |
| DWA | Department of Water Affairs |
| eWQMS | electronic Water Quality Management System |
| IMESA | Institution of Municipal Engineers of South Africa |
| IWA | International Water Association |
| SALGA | South African Local Government Association |
| SANS | South African National Standard |
| WHO | World Health Organisation |
| WRC | Water Research Commission |
| WSAs | Water Service Authorities |
| WSI | Water Service Institution |
| WSPs | Water Service Providers |
| WTW | Water Treatment Works |

# Table of Contents

## List of Figures

## Glossary of Terms / Definitions

**Acceptable Drinking Water Quality** – water deemed to have an acceptable health risk as defined by SANS 241, i.e. water that is considered to be safe for lifetime consumption implying an average consumption of 2L of water per day for 70 years by a person that weighs 60kg

**Acute Health** – **1** – routinely quantifiable determinand that poses as immediate unacceptable health risk if consumed with water at concentration values exceeding the numerical limits specified in SANS 241

**Acute Health – 2** – determinand that is presently not easily quantifiable and lacks information pertaining to viability and human infectivity which, however, does pose immediate unacceptable health risks if consumed with water at concentration values exceeding the numerical limits specified in SANS 241

**Aesthetic** – determinand that taints water with respect to taste, odour and colour and that does not pose an unacceptable health risk if present at concentration values exceeding the numerical limits specified in SANS 241

**Chronic Health** – determinand that poses an unacceptable health risk if ingested over an extended period if present at concentration values exceeding the numerical limits specified in SANS 241

**Contracted bulk provider** – water services authority that receives water in bulk from a water services provider

**Critical control point** – step at which control can be applied and that is essential to prevent or eliminate a water safety hazard (biological, chemical or physical), with potential to cause a health effect or reduce it to an acceptable level

**Determinand/Parameter** – micro-organism, physical or aesthetic property or chemical substance of which the risk posed is classified under either acute health – 1, acute health – 2, aesthetic, chronic health, or operational

**Disinfection Residual** – disinfection that remains in solution after disinfection

**Distribution area** – specific area supplied from a borehole, treatment system, reservoir or tower

**Hazard** – determinand with the potential to cause an adverse health effect or to affect the quality of the water

**Operational** – determinand that is essential for assessing the efficient operation of treatment systems and risks to infrastructure

**Risk** – likelihood and consequence of the presence of an identified hazard in the final water at values that exceed the numerical limits in this part of SANS

**Risk assessment** – process of identifying and documenting all potential hazards and risks within the water supply system

**Routine Monitoring Programme** – ongoing monitoring programme intended to validate the effectiveness of control measures at critical control points and to assess the quality of water based on the location of routine sampling points, sampling frequency and determinands

**Routine sampling point** – identifiable sampling point within the routine monitoring programme where a representative sample is collected to determine water quality

**Sampling frequency** – time interval between consecutive sampling events at a specific sampling point or the number of samples taken over a given period

**SANS 241** – South African drinking water quality standards

**Verification of Water Quality** – assessment of compliance with the numerical limits specified in SANS 241

**Water Safety Planning** – systematic process that aims to consistently ensure acceptable drinking water quality that does not exceed the numerical limits in SANS 241 by implementing an integrated water quality management plan, which includes a risk assessment and risk management approach from catchment to point of delivery

**Water Services Authority (WSA)** – any municipality that has executive authority to provide water services within its area of jurisdiction in terms of the relevant national legislation or the ministerial authorisations made in terms of the relevant national legislation

**Water Services Institution (WSI)** – water services authority or water services provider or both

**Water Services Provider (WSP)** – a person who has a contract with a water services authority or another water services provider to sell water to that authority or provider

OR

a water services authority that provides either both of the services described above itself

OR

any person who has a contract with  water services authority to assume operational responsibility for providing water services to one or more consumers (end users) within a specific geographic area (retail water services provider)

**Water Supply System** – geographically defined area within which water intended for human consumption may come from one or more sources and within which the water quality may be regarded as being approximately uniform

**Water Treatment System/Works/Plant** – process or combination of processes undertaken to render intake water acceptable for drinking as defined in SANS 241 that includes conventional treatment plants, disinfection of groundwater or any other process used for treating water to an acceptable drinking water quality

# Guidelines for using the web-enabled Water Safety Plan Tool

## INTRODUCTION

Past and recent studies in South Africa have shown that it is apparent that for a significant proportion of municipalities, sustained provision of service and quality are under threat due to failing infrastructure. The Department of Water Affairs (DWA) reported that there has been significant improvement in terms of water quality monitoring within Water Service Authorities, however there still needs to be improvement until all Water Services Authorities are monitoring as per current SANS 241 requirements (DWA, 2010).

In order to take proper action, the existing situation has to be analysed and required corrective measures must be identified and implemented.

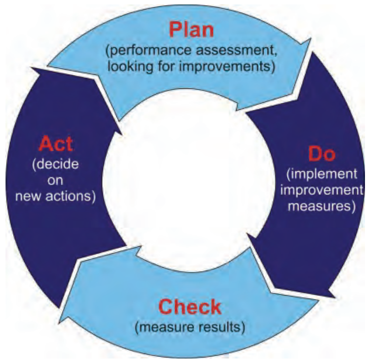
The Water Research Commission (WRC) project K5/1993//3 "*Web enablement of a water safety plan and incorporation of existing similar supply system assessment tool*" aimed to establish a methodology to identify and manage the risks of water services infrastructure and the means by which Water Services Institutions (WSIs) are better able to identify and manage these through use of Water Safety Planning.

**Note**

The tool assists in developing a Water Safety Plan. Implementation thereof (e.g. taking required actions, implementing corrective actions, developing and implementing management and communication procedures) of the Water Safety Plan depends on the Water Services Institution (WSI).

**Top Tips**

Water Safety planning is a process of identifying and implementing possible and known risks in the water supply system. The process aims at ensuring acceptable drinking water quality through all stages of the water supply system. The Water Safety Planning process in turn assists the user in developing a Water Safety Plan which is a guiding plan with respect to managing, avoiding, minimising/reducing chances of water contamination in the water supply system. The process requires development of the plan, implementation of the plan, review of performance and amendment or modification to the plan to ensure that it remains relevant. The entire process is demonstrated in the figure.




**Note**

The Water Safety Plan tool developed through this study is a desktop electronic based tool that requires detailed knowledge of the water supply system. Some of the required information is available within the municipality, whereas other information can only be obtained via site visits. Site visits are therefore an essential part of the process and should be conducted prior to using the tool. The tool should also be used in conjunction with the current SANS 241 water quality requirements (i.e. link current SANS 241 determinands to identified risks). This is explained further in this guide.

## PURPOSE OF THIS MANUAL

The purpose of this manual is to:

- Introduce Water Safety Planning to the reader.
- Highlight key steps to be considered when developing a Water Safety Plan.
- Provide step-by-step guidance as to how to use the Water Safety Plan Tools currently hosted on the electronic Water Quality Management System (eWQMS)/Emanti.

**IN THE PIPELINE**

The tool will also be available on the WRC website: www.wrc.org.za.

## WHO COULD USE THE GUIDE AND TOOLS?

This manual is intended for use by:

- Managers of drinking water services within a WSI
- Water quality managers
- Environmental health practitioner
- Department of Water Affairs staff
- South African Local Government Association (SALGA), Institution of Municipal Engineers of South Africa (IMESA), Department of Health (DoH) and Local Government and Housing (LGH) departments
- Water resources people
- Any person responsible for drinking water services status

# 1 Introduction to Water Safety Planning

Water Safety Planning is a systematic process that aims to consistently ensure acceptable drinking water quality that does not exceed the numerical limits in SANS 241 by implementing an integrated water quality management plan, which includes a risk assessment and risk management approach from catchment to point of delivery. In so doing the process allows for better understanding of water supply systems. Once the risk has been identified, control measures can be put into place to mitigate these risks. The process also needs to identify systems by which these measures are implemented and monitored. Management plans describing actions taken during normal operation or incident conditions and documenting the system assessment (including upgrade and improvement), monitoring and communication plans and supporting programmes, should be included. Key components of a Water Safety Planning (WHO/IWA, 2009; Thompson and Majam, 2009) include:

- **System assessment** – determine whether the supply system (i) can deliver safe water, and (ii) is meeting SANS 241 targets. This should be undertaken for both current and planned new systems.
- **Identifying control measures** – conduct a risk assessment to collectively control identified risks and hazardous events and ensure that SANS 241 targets are met. For each control measure identified, an appropriate means of operational monitoring should be defined that will ensure that any deviation from required performance is rapidly detected in a timely manner.
- **Management plans and risk management** – to develop plans describing actions to be taken during normal operation or incident conditions and documenting the system assessment (including upgrade and improvement), monitoring and communication plans and supporting programmes.

The approach adopted when developing a Water Safety Planning typically comprises the following sequential steps:

1. Assemble project team
2. Document and describe the present Water Supply System
3. Assess the Water Supply System
4. Undertake a hazard/risk assessment
5. Identify control measures
6. Verify that the Water Safety Plan is operational
7. Draft management procedures
8. Develop supporting programmes
9. Establish document and communication procedures
10. Review the Water Safety Plan

## 2 Identification of a typical Water Supply System

In order to understand what needs to be monitored and protected, a detailed understanding of a water supply system management (that is from source to point of use) is required. A typical conventional water supply system comprises the following:

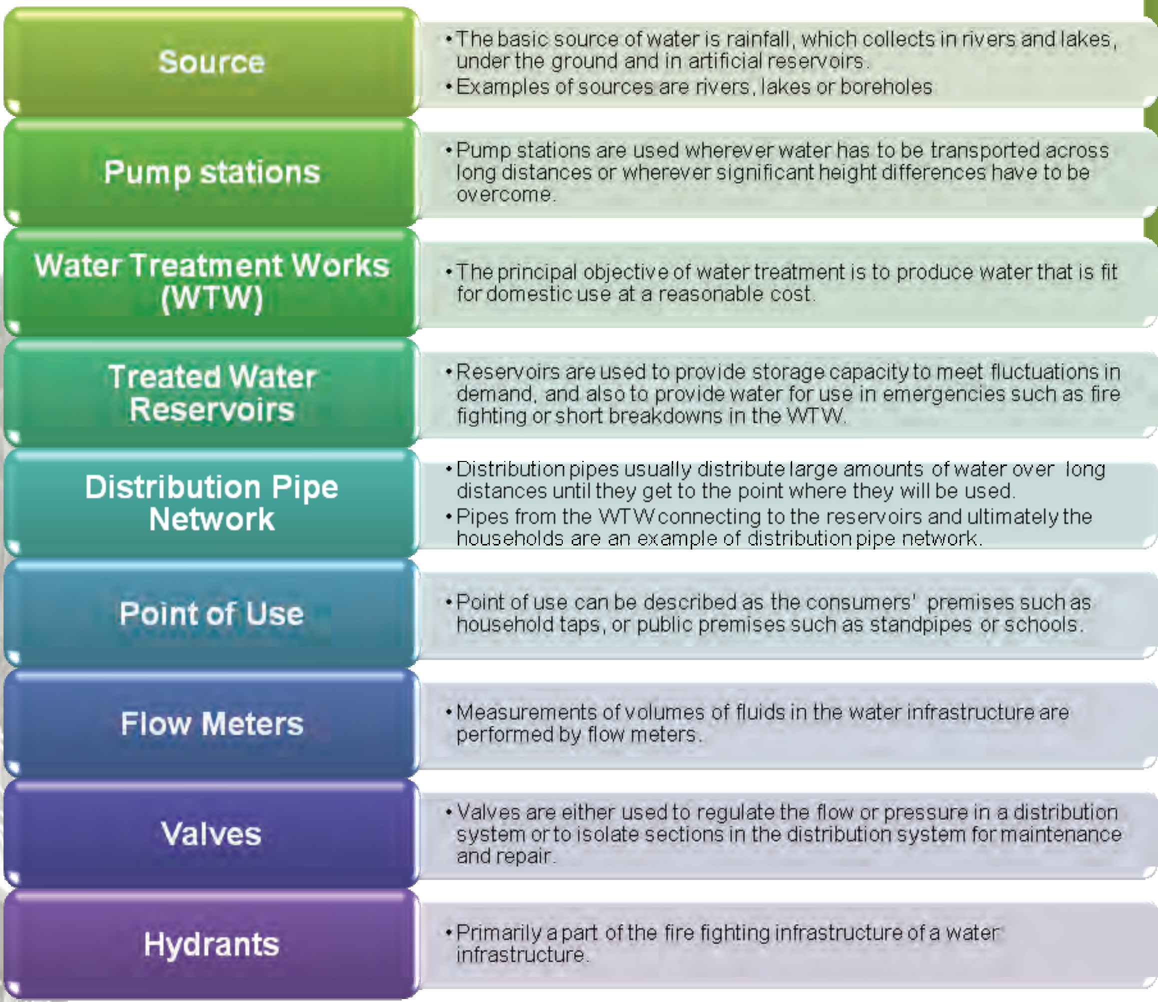
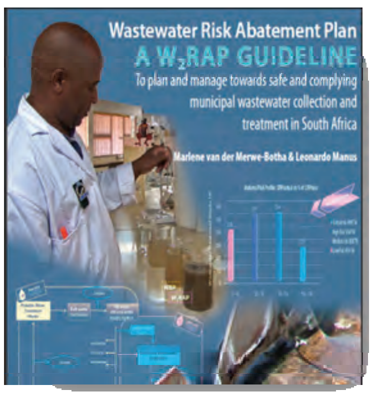



**Figure 1:** *Typical water supply system components*

Small systems typically consist of a groundwater source (normally a borehole), storage (where treatment by disinfection is normally practised) and distribution network to the consumer.

The drinking water supply system covers from source to point of use or consumer, however wastewater has an impact on the source that brings consideration of wastewater system into the concept. Wastewater risk management (which is closely linked to Water Safety Planning) is covered in the Wastewater Risk Abatement Planning ($W_2$RAP) process discussed in the $W_2$RAP Screenshot of this guideline is shown below.



# 3 COMMONLY UTILISED WATER SAFETY PLANNING GUIDES AND TOOLS IN SOUTH AFRICA

## 3.1 General Steps and Consideration

Most literature sources utilise a similar methodology for Water Safety Planning. The two most commonly utilised methodologies in South Africa are those presented by IWA/WHO (2009) and Thompson and Majam (2009) through the WRC. These guides highlight the following:

**Top Tips**

- A Water Safety Plan cannot be done solely as a desktop study. It must involve site visits to confirm the knowledge, information and schematics available to the WSI. Site visits need to include inputs from those who work at the sites and/or within catchments and have detailed local knowledge.
- The WSI should take lead in the Water Safety Planning approach but it is advised not to do this in isolation.

The following stepwise approach is used:

1. *Assemble the Project Team and Key Stakeholders* – responsible people making up the water safety planning team.
2. *Document and Describe the Present Water Supply System* – components of each and specific water supply system are documented and described.
3. *Assess the Water Supply System* – identify possible hazards and hazardous events for each component of the water supply system.
4. *Undertake a Risk/Hazard Assessment* – determine risks associated with hazards and hazardous events identified.
5. *Identify Control Measures* – identify corrective actions and/or ways to control hazards and hazardous events identified.
6. *Verify that the Water Safety Plan is Operational* – ensure that the Water Safety Plan is implemented and effective.
7. *Draft Management Procedures* – develop procedures such as indication of responsibilities, operational and maintenance procedures, etc.
8. *Develop Supporting Programmes* – develop programmes such as emergency protocols to respond to failure, safety procedures, etc.
9. *Establish Document and Communication Procedures* – develop documents indicating procedures such as communication protocols, community consultation, etc.
10. *Review Water Safety Plan* – evaluate the implementation of the plan, any adjustments to be made.

## 3.2 World Health Organisation (WHO) / International Water Association (IWA) 2009 Water Safety Planning

### 3.2.1 Water Safety Plan Manual: Step by step risk management for drinking water suppliers

The World Health Organisation (WHO) manual (WHO, 2009), continues from the Third Edition of the WHO Guidelines for Drinking-water Quality (2009) that describes the principles of the Water Safety Planning approach. The aim of the WHO manual is to provide practical guidance to facilitate Water Safety Planning development focusing particularly on organised water supply systems managed by a water services institution. The water quality standards used in the guide are WHO drinking water standards. The manual includes case studies on developing Water Safety Planning in different countries.

Different approaches, that is quantitative or semi quantitative and simplified qualitative approaches are introduced in this manual. Quantitative or semi quantitative approach is based on estimation of likelihood or frequency and severity or consequence. Examples of this kind of approach are presented below.

| Process step | Hazardous event (source of hazard) | Hazard type | Likeli-hood | Severity | Score | Risk rating (before consideration of controls) | Basis |
|---|---|---|---|---|---|---|---|
| Source (groundwater) | Cattle defecation in vicinity of unfenced wellhead causing source of potential pathogen ingress in wet weather | Microbial | 3 | 5 | 15 | High | Potential illness from pathogens from cattle, such as *Cryptospondium* |
| Source | Cocktail of pesticides from agricultural uses | Chemical | 2 | 4 | 8 | Medium | Potential introduction of toxic chemicals which could lead to concentrations in finished water above national standards and WHO Guideline values |
| Source | Potential for informal solid waste disposal | Microbial and chemical | 1 | 1 | 1 | Low | Potential for hazardous waste plus rainfall event causing contamination to water supply is low |
| Storage tank | Unroofed reservoir allows birds to congregate and defecate in treated water | Microbial | 2 | 5 | 10 | High | Potential illness from pathogens such as *Salmonella* and *Campylobacter* |
| Treatment | No back-up power supply | Microbial and chemical | 2 | 5 | 10 | High | Potential loss of treatment and pumps/pressure |
| Distribution | Leaks on trunk main and distribution system | Microbial | 5 | 3 | 15 | High | Leaks are a potential source of microbial pathogens and contribute to high % of unaccounted for water |

**Figure 2:** *Example of hazard and risk assessment using semi quantitative approach*

| High risk ≥20<br>Medium risk 10-19<br>Low risk <10 | | | | Consequence | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | Wholesome water<br>Insignificant<br>1 | Short term or localised, not health related non compliance or aesthetic<br>Minor<br>2 | Widespread aesthetic issues or long term non compliance not heath related<br>Moderate<br>4 | Potential long term heath effects<br>Major<br>8 | Potential illness<br>Catastrophic<br>16 |
| Likelihood | Has not happened in the past and it is highly improbable that it will happen in the future | Most unlikely | 1 | 1 | 2 | 4 | 8 | 16 |
| | Is possible and cannot be ruled out completely | Unlikely | 2 | 2 | 4 | 8 | 16 | 32 |
| | Is possible and under certain circumstances could happen | Forseeable | 3 | 3 | 6 | 12 | 24 | 48 |
| | Has occurred in the past and has the potential to happen again | Very likely | 4 | 4 | 8 | 16 | 32 | 64 |
| | Has occurred in the past and could happen again | Almost certain | 5 | 5 | 10 | 20 | 40 | 80 |

**Figure 3:** *Example of hazard and risk assessment using quantitative approach*

A simplified qualitative approach is based on expert judgement of the Water Safety Planning team. An example of such approach is presented below.

| Descriptor | Meaning | Notes |
|---|---|---|
| Significant | Clearly a priority | The risk should be considered further to determine whether additional control measures are required and whether a particular process step should be elevated to a key control point in the system. It is necessary to validate existing control measures before defining whether additional control measures are required. |
| Uncertain | Unsure if the event is or is not a significant risk | The risk may require further studies to understand if the event is really a significant risk or not. |
| Insignificant | Clearly not a priority | Note that the risk will be described and documented and will be revisited in future years as part of the WSP rolling review. |

**Figure 4:** *Example of hazard and risk assessment using simplified qualitative approach*

### 3.2.2 WHO/IWA Water Safety Plan Quality Assurance Tool (2009)

The Water Safety Plan Quality Assurance tool is an Excel based tool which is intended to assist WSIs managing organised/formal water supply systems to assess the completeness of their Water Safety Planning and the effectiveness of its implementation. The tool is closely aligned with the WHO/IWA manual. The major benefits in applying the tool (as indicated within the tool) are highlighting of:

- Areas where progress is being made with the Water Safety Planning implementation, and
- Opportunities for improvements

A screenshot of the hazard/risk assessment part of the tool is presented below.

| | | |
|---|---|---|
| | Name of water supply system | |
| 5.1 | Have stakeholders been identified? | |
| | a. Catchment | |
| | b. Treatment | |
| | c. Distribution | |
| | d. Consumer premises | |
| 5.2 | Have stakeholders been contacted and are they engaged in the WSP process? | |
| | a. Catchment | |
| | b. Treatment | |
| | c. Distribution | |
| | d. Consumer premises | |
| 5.3 | Number of stakeholder groups identified | |
| | a. Catchment | |
| | b. Treatment | |
| | c. Distribution | |
| | d. Consumer premises | |
| 5.4 | Number of stakeholder groups contacted regarding water safety responsibilities | |
| | a. Catchment | |
| | b. Treatment | |
| | c. Distribution | |
| | d. Consumer premises | |
| 5.5 | Has hazard identification been conducted? | |
| | a. Catchment | |
| | b. Treatment | |
| | c. Distribution | |
| | d. Consumer premises | |
| | Were site visits made for visual inspection and was local input obtained to inform the hazard identification? | |

**Figure 5:** *Hazard/Risk assessment section screenshot on the WHO/IWA Quality Assurance tool*

## 3.3 WRC Guides and Tools

### 3.3.1 The Development of a Generic Water Safety Plan for small community water supply

This guide has incorporated the World Health Organisation manual basic principles as well as additional information obtained during a literature review of various other Water Safety Plans that have already been established in other countries. This guide focuses on the methodology that can be used to develop a Water Safety Planning for small community water supply in South Africa. South African National Standard (SANS) 241 is drinking water quality standards considered in determining hazards. The guide includes common hazards and hazardous events that can be considered for each component of the system and a list of possible control measures that can be considered.

**IN THE PIPELINE**

A guide building on the existing generic guide is being developed through this project. The guide provides the key steps to be considered when developing a Water Safety Plan. It also provides an extended list of common hazards and possible control measures that can be considered. A step by step guide on how to use the developed tool is also included.

### 3.3.2 WRC Water Safety Planning Tools

The purpose of the tools is to:

- Highlight key steps to be considered when conducting Water Safety Planning
- Provide step-by-step guidance as to how to develop and implement a Water Safety Plan and
- Manage to rate the identified risks as high, medium or low
- Check the status of implementation of Water Safety Plan

An example of risk matrix used is presented below.

| Shortcut | Likelihood | Rating | Shortcut | Consequence | Rating |
|---|---|---|---|---|---|
| A1 | Almost Certain<br>Once a day or Permanent Feature | 1 | A2 | Catastrophic<br>Death expected from Exposure | 100 |
| B1 | Likely<br>Once per Week | 0.8 | B2 | Major<br>Population exposed to significant illness | 70 |
| C1 | Moderately Likely<br>Once per Month | 0.5 | C2 | Moderate<br>Large Aesthetic Impact | 20 |
| D1 | Unlikely<br>Once per Year | 0.2 | D2 | Minor<br>Small Aesthetic Impact | 2 |
| E1 | Rare<br>1 in 5 Years | 0.1 | E2 | Insignificant<br>No Impact | 1 |

Likelihood is determined by "how often' or "how likely" a hazard or a hazardous event occurs. It must take into account hazards that have occurred in the past and their likelihood of re-occurrence and must also predict the likelihood of hazards and events that have not occurred to date.

Consequence looks at the severity of the results of the hazard/hazardous event and the seriousness or intensity of the impact of the hazard. When dealing with impact we are concerned with human health only.

RISK RATING = LIKELIHOOD X CONSEQUENCE

| Risk Rating | Range |
|---|---|
| Low | 0-10 |
| Medium | 11-56 |
| High | 57-100 |

**Figure 6:** *Risk Assessment Matrix*

A comprehensive checklist for conducting a Water Safety Plan has also been included to ensure the proper development and maintenance of a Water Safety Planning. The checklist assists in terms of identifying where one is in terms of developing and reviewing a Water Safety Planning. A screenshot of the checklist is presented below.

| | | YES ✓ | NO ✗ |
|---|---|---|---|
| 1. | Has a multi-disciplinary team of experts been assembled to carry out the water safety plan? | ☐ | ☐ |
| 2. | Has the team been informed of their duties and commitment? | ☐ | ☐ |
| 3. | Has the water treatment system been described?<br>(i.e. has each step in the system been considered for range and magnitude of hazards that may be present and the ability of existing processes and infrastructure to manage actual or potential risks) | ☐ | ☐ |
| 4. | Following the description of the system above, has all the information been documented? | ☐ | ☐ |
| 5. | Has a flow diagram of the entire water supply system been constructed using the symbol chart? | ☐ | ☐ |
| 6. | Have existing as well as potential hazards in the system been identified? | ☐ | ☐ |
| 7. | Have these hazards been prioritised using the hazard assessment matrix provided? | ☐ | ☐ |

**Figure 7:** *Checklist on how for conducting a Water Safety Plan*

This checklist has been reviewed and enhanced in this study to a tool rather than a checklist. This tool considers typical steps of the Water Safety Planning status process and asks five key questions per step. A colour coded "spider diagram" output is an indication of the status. Screenshots are presented below.

| 1. Water Safety Plan Team | | |
|---|---|---|
| 1.1 | A multi-disciplinary team of experts has been assembled to carry out the WSP | 4 |
| 1.2 | The WSP team has been informed of their duties and is committed to the process | 4 |
| 1.3 | A WSP methodology (e.g. steps 1 - 10) has been defined and agreed by the WSP team | 4 |
| 1.4 | The WSP team regularly meets to discuss issues, review progress, etc | 4 |
| 1.5 | WSP development and implementation is funded and supported by top management | 4 |

| 2. Water Supply System Assessment | | |
|---|---|---|
| 2.1 | The water supply system has been described from catchment to consumer | 4 |
| 2.2 | The wastewater system has been described from collection to discharge | 2 |
| 2.3 | A flow diagram of the entire water and wastewater system has been developed using the symbol chart | 4 |
| 2.4 | The water & wastewater system description has been confirmed by site visits, interactions with stakeholders, etc | 3 |
| 2.5 | The water & wastewater system description information has been documented | 3 |

| Scoring Rules | |
|---|---|
| Strongly disagree or don't know | 0 |
| Disagree | 1 |
| Neutral or not applicable | 2 |
| Agree | 3 |
| Strongly agree | 4 |

**Figure 8:** *Water Safety Planning status Checklist questions*


**Figure 9:** *Checklist Water Safety Plan Status*

Top Tips

When using Water Safety Planning tools, and in particular when conducting risk assessments, it is important to use the same methodology throughout the WSI (i.e. all supply systems within that WSI are assessed using the same tool/risk rating methodology).

Note

What will Water Safety Planning tools **not** help you with? The limitation of these tools is that they do not provide answers to what the user does not know, rather they need to be provided with information themselves. The tools **do** provide guidance to possible hazards and control measures to be considered. The hazards and control measures presented in the tool are not the only existing hazards and control measures, therefore the user should consider what is applicable in their own situation and include those for assessment.

**IN THE PIPELINE**

The tool will be continuously reviewed and updated, therefore the user should make sure that the most recent tool at that time is used.

# 4 CONDUCTING WATER SAFETY PLANNING

## Step 1: Formulate a Water Safety Planning team

In this step, the WSA identifies people who should form part of the team. It is recommended that, if possible, the Water Safety Plan team consist of the following persons: (1) water services managers, engineers and technicians, (2)operational staff of treatment plants (if applicable), (3) water quality managers/specialists, (4) catchment managers, (5) Water Service Providers, (6) environmental, public health or hygienist professionals and (7) consumer representatives.

**Top Tips**

- Choose a Leader for the process.
- Consider location (who is impacting, who are the users)

## Step 2: Document and describe all water supply systems within your area of concern

Define each water supply system by identifying all its components starting from source to point of use. Each water supply system has different components and/or design of the system. It is important to identify and describe each component of each water supply system. This includes capacities (e.g. plant, reservoirs, etc.), process/es used (e.g. flocculation, filtration, etc.), material of construction (e.g. PVC pipes, cement tanks, etc.), age, etc.).

**Note**

In some cases, treated bulk water may be provided by a water service provider; therefore the area of responsibility starts at the reservoir (inclusive or exclusive) to the point of use.

**Top Tips**

In such cases, a Service Level Agreement (SLA) between the water service provider and water service authority should be drafted indicating responsibilities, area of provision and service quality expected. Communication, inclusion of the Water Service Provider and Water Services Authority in the team is essential.

**Top Tips**

Things to consider:

- Source (type, yield, quality)
- Water Treatment Works (processes, capacity)
- Reservoirs (types, capacity)
- Network (pump stations, valves, pipes, etc.)
- Refer to as-built drawings, documents, etc.
- If don't know, find out (and improve record keeping)
- If you still don't know conduct site visits!

A flow diagram indicating each component of the assessed water supply system could be drawn. An example of a flow diagram is presented below.

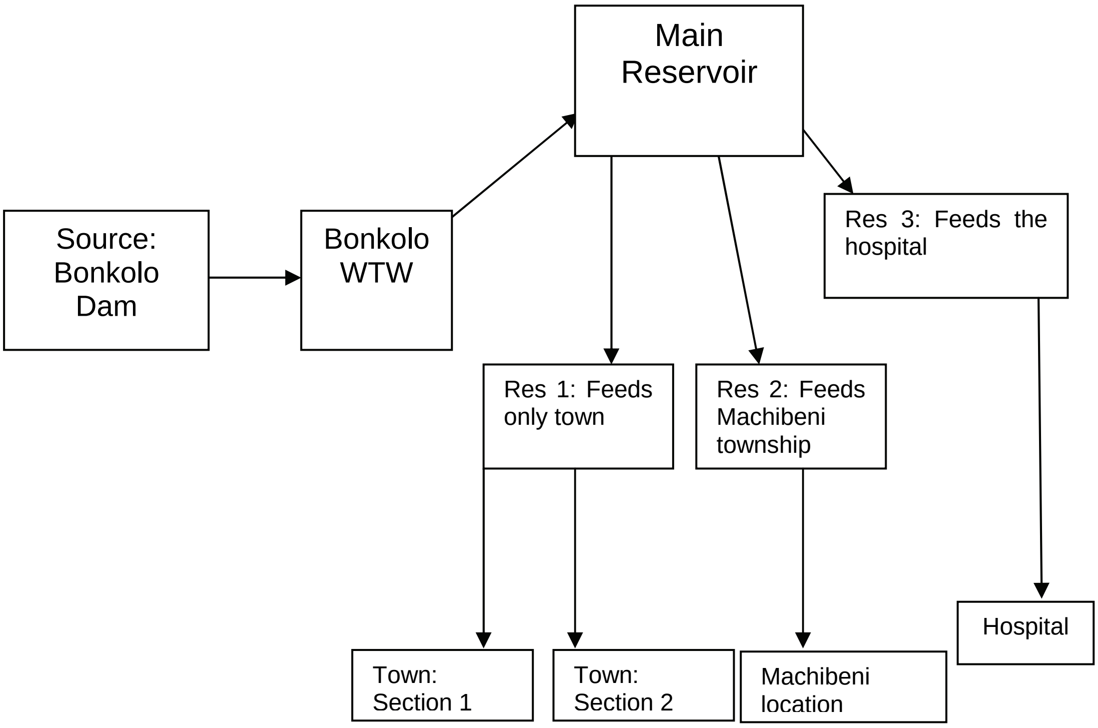



**Figure 10:** *Example of system description*

**Note**

Always take into consideration valves, hydrants, meters as part of the water supply system.

**IN THE PIPELINE**

Provision to upload system components photos will be made.

## Step 3: Assess the water supply system

Evaluation of water supply system is conducted to obtain an idea of the typical hazards/hazardous events faced at each component. This will assist with completing the risk assessment. Assessment of the water supply system includes:

- Identification of potential pollution sources at each component (e.g. livestock, human activities at water source).
- Identify the hazards associated with the pollution source (e.g. if there are livestock, human activities at the source; *E. coli* / faecal content is likely to be experienced).
- Treatment processes at each component (e.g. pre-treatment at source, chlorination at reservoirs, etc.).

This should be aligned with known challenges and risks associated with each component (e.g. water treatment works operating above design capacity). Any size drinking water treatment system should be assessed whether low or high technology system.

**Note:** Assessment may be conducted by a team or information obtained from a team that works from different components of the water supply system.

## Step 4: Conduct site visits

The information could be easily available within the municipality (as as-built drawing, charts, etc.); however in some cases the records are not available. Investigations should be conducted (whether by consulting retired people, physically going out to the field following every lead) to gather the information.

**Note:** Site visits should be conducted, GPS co-ordinates gathered for each component of the water supply system, photos for any issue identified.

**Top Tips:** Identified hazards should form part of the water supply system monitoring programme. That is, identified hazards should be monitored.

## Step 5: Undertake Hazard/Risk assessment

Determine the risks associated with the hazards identified by considering the likelihood (probability) (e.g. has it happened in the past, is it likely to happen) and consequence (impact should it happen) of a potential hazardous event.

Judging how likely a hazardous event is to occur is normally based on historic experience and /or recent observations. Determining the consequence or impact should the hazardous event happen needs an understanding of health, physical and chemical categorisation of SANS determinands. Therefore the SANS limits for hazardous determinands should be understood so as to associate them with frequency of monitoring and developing preventative measures.

**Top Tips**

When conducting this hazard/risk assessment, it is important to understand the current SANS 241 standards.

**Note**

It is recommended to have the team of all the people involved in water services to collectively identify potential hazards and discuss likelihood and consequence of the identified hazards. This allows for different views of analysing the risks and therefore agreeing on the most appropriate rating.

There are a number of tools (e.g. WHO/IWA, WRC) available that can be used to calculate and rate the risks identified. The user should understand the concept and use of the tool used. As indicated earlier, it is important that the same methodology be used throughout the WSI (i.e. all supply systems within that WSI are assessed using the same tool/risk rating methodology).

**IN THE PIPELINE**

A further enhancement to the existing tool is recalculation of the residual risk once corrective actions have been implemented. This enhancement will be included in future tool amendments.

## Step 6: Identify control measures

For each and every hazard/hazardous event, control measures should be developed (e.g. redundancy, alternatives, back-ups, etc.). Control measures include consideration of what needs to be done to rectify the situation and also identifying measures of preventing, minimising and/or eliminating the situation. It could be noted that there are existing control measures for some situations, however not implemented. There also could be control measures in place, however not effective.

**Note**

If the control measures were identified to be ineffective, a review should be conducted to identify if a new measure replacing the existing is required or the existing measure should be strengthened.

**Note**: A list of possible control measures is provided in Appendix B. These are just examples; therefore the user should identify control measures applicable to the user situation.

**Top Tips**: It would be a good practice to also collectively discuss suggested control measures as a team.

**IN THE PIPELINE**: An extended or revised list of possible control measures will be provided.


## Step 7: Implement control measures

Considering the summarised findings from the assessment, and the desired control/intervention measures, create a prioritised plan of items that will be addressed by ranking the risks. It is suggested that this be limited to high and medium risks, and have short, medium and long term action period (e.g. immediately, 3-6 months, 3 years). A plan to monitor low risks should be considered. It is essential that appropriate budget and responsibilities are assigned to address the highest risks identified.

Implementation of newly developed control measures is required whilst review of the effectiveness of existing control measures should be conducted. Assign budgets, roles and responsibilities, time frames, etc. for proposed improvements. Sign off by management is necessary to ensure that control measures are implemented.

**Top Tips**: Consider (1) quick wins, (2) Cost: Risk Reduction, (3) social impact/consumer confidence, (4) environmental impact (5) Commitment and funding

## Step 8: Verify that the Water Safety Plan is operational

Verification is necessary to ensure that the Water Safety Plan is implemented and effective. Verification process requires assessment of a range of performance indicators. Verification includes both operational audit water quality analyses using a range of indicators (e.g. operational monitoring programmes). Operational audit should include the systematic review of operational procedures and documentation to ensure that the Water Safety Plan is working. A key element of the audit process is to identify when monitoring results show deviation from critical limits and what operational shortcomings may have been the cause. The audit should identify short comings in the overall Water Safety Plan and identify modifications and improvements required for the Water Safety Plan (Thompson and Majam, 2009).

**Top Tips**

In the process of verification, the following should be considered and understood:

- What should I be checking on a regular basis to make sure my control measures are effective?
- Development of risk based monitoring programme.

## Step 9: Draft Management Procedures

For a plan to be implemented successfully, it is of utmost importance to set out all the required steps needed to achieve the desired end results, the order in which they ought to take place, and the necessary resources (e.g. both the people and material involved).

## Step 10: Develop supporting programmes

Supporting programmes are activities that ensure the operating environment, equipment used and people themselves do not become an additional source of potential hazards to the drinking water supply (Thompson and Majam, 2009).

**Top Tips**

Supporting programmes could include:

- Operation and maintenance manuals
- Protocols to respond to failure
- Safety procedures
- Emergency procedures

## Step 11: Establish document and communication procedures

Documentation of all aspects of drinking-water quality management is essential. Documents should describe activities that are undertaken and how procedures are performed. They should also include detailed information on:

- assessment of the drinking-water system (including flow diagrams and potential hazards and the outcome of validation);
- control measures and operational monitoring and verification plan;
- routine operation and management procedures;
- incident and emergency response plans; and supporting measures, including:
    - training programmes
    - research and development
- procedures for evaluating results and reporting
- performance evaluations, audits and reviews
- communication protocols
- community consultation.

## Step 12: Review Water Safety Plan

The Water Safety Plan should be reviewed annually. Reviewing a Water Safety Plan includes identifying any changes that have happened in that period (e.g. hazards that could be as a result of new developments, new activities, climatic changes, etc.), reviewing effectiveness of control measures, management programmes, documents and communication procedures. Identify if there are any improvements required.

**Note**

- Site visits are essential in conducting Water Safety Planning
- Municipal management ownership and sign off is necessary
- Implementation of control measures is vital
- Having strategies documents, procedures in place that are properly used is necessary
- Improving on existing methods is a good practice
- Taking ownership, budgeting and having supporting programmes and responsible management are as important.

**Top Tips**

Have regular meetings to check the following…
• Where are we?
• What have we done?
• What must we still do?
• Renewed management commitment!
• Required actions, responsibilities, sign-off, money!!

# 5 USING THE WATER SAFETY PLANNING TOOLS

## 5.1 Introduction

Both Excel spreadsheet and web based tools are available on eWQMS. The aim of the project was to web enable the tool, however it was deemed necessary to have both. Initial key advantages identified from using the web-based Water Safety Plan tool (in favor of the spreadsheet tool) include:

1) Enhanced sharing (parties can access/edit a database at the same time)
2) Enhanced security (sensitive information can be easily protected and users can be protected from making mistakes – e.g. deleting information, loading incorrect information)
3) Efficiency and cost effectiveness (minimise duplication, economies of scale – enhancements rapidly available to all),
4) Enhanced reporting (format the same data many ways in various reports create more interactive features/outputs),
5) Ease of maintenance and lowered downtime (less likely to break than spreadsheet),
6) Repository of information (hold much greater numbers of records than spreadsheets),
7) Ability to conduct strategic analysis if sufficiently adopted (e.g. identify key threats/hazards/risks on a national basis),
8) Less duplication (duplication of existing information in a new spreadsheet or creation of copies of existing spreadsheets which is the latest/correct version?).

Although the above has shown that the web-tool has numerous advantages over the spreadsheet tool, many municipalities continue to use the spreadsheet tool. Although the focus has been on keeping the web-tool up-to-date, a need therefore exists to also ensure that the spreadsheet tool is also up-to-date.

The web tool does not need to be filled in all at once and completed at the same time, that is, the user can stop anytime, save the information and continue later by clicking 'continue later' button at the bottom of each page.

Note

As mentioned earlier, the tool will be continuously reviewed and updated, therefore the user should make sure that the most recent version is utilised.


**Figure 11:** eWQMS *continue later function*

The current steps below form part of the WRC Water Safety Planning tool on the electronic Water Quality Management System (eWQMS):

## 5.2 Using the Tool

Users who do not have eWQMS login details can access the tool via Emanti website: www.emanti.co.za.

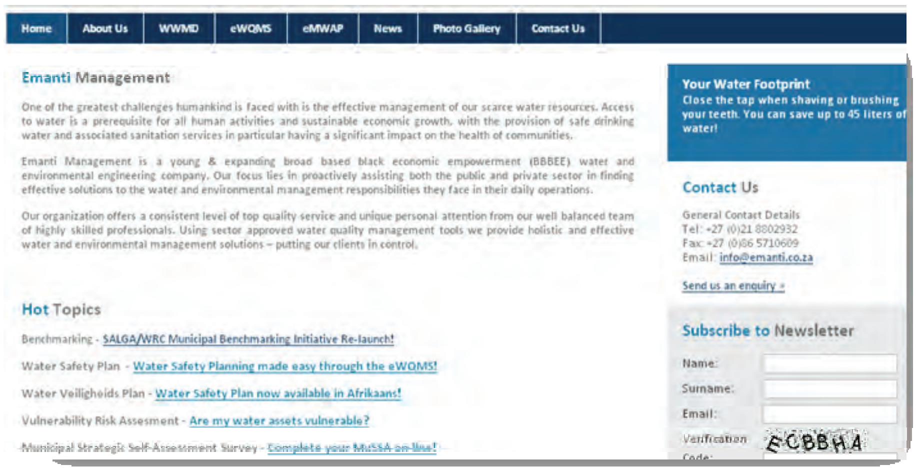



**Figure 12:** *Emanti home page*

Users who have eWQMS login details can access and use the tool through the steps explained below.

## Step 1: Login to eWQMS

- Go to www.wqms.co.za
- Complete your username and password.
- Click “Login”

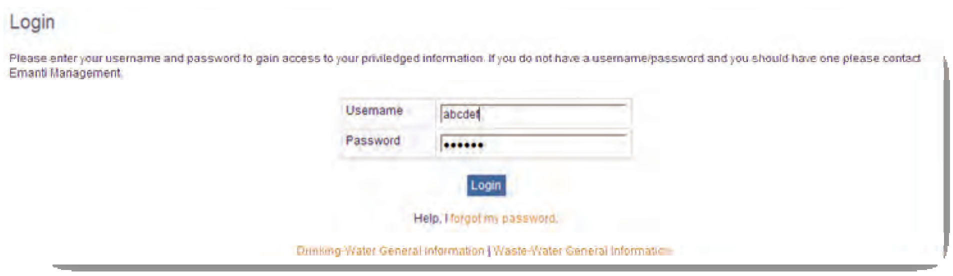



**Figure 13:** *eWQMS login page*

- Once logged in, the Dashboard will open.

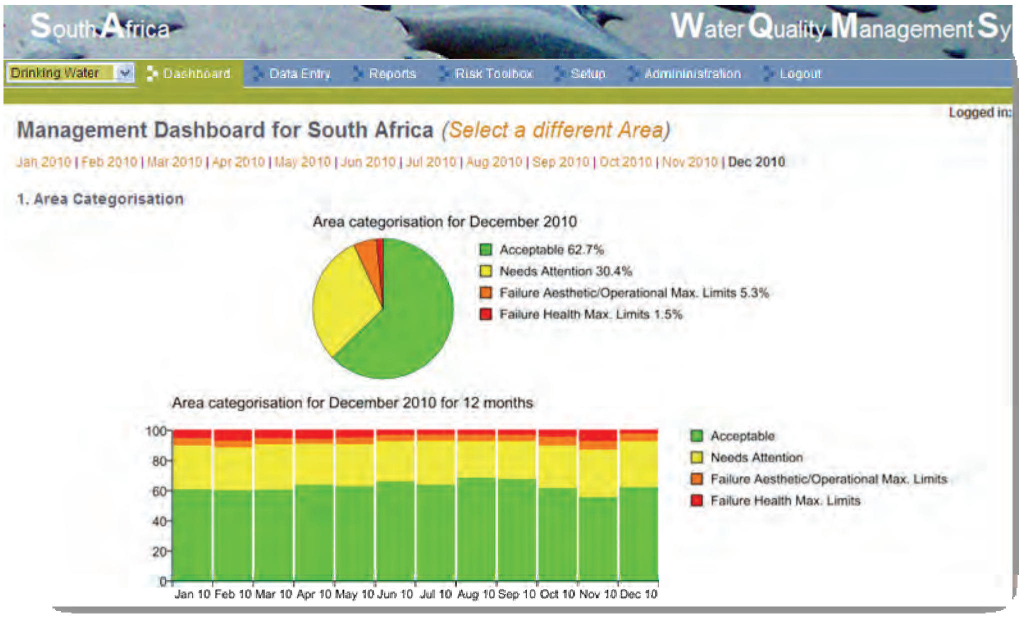



**Figure 14:** *eWQMS Dashboard page*

***Go to Risk Toolbox and access the Water Safety Plan tool***

- Using the tabs, go to “Risk Toolbox”
- Select WRC Water Safety Plan Tool

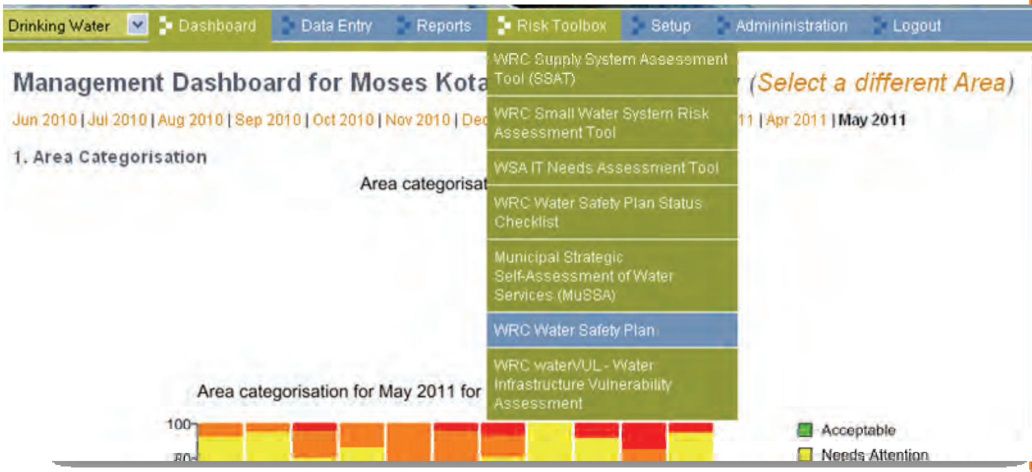


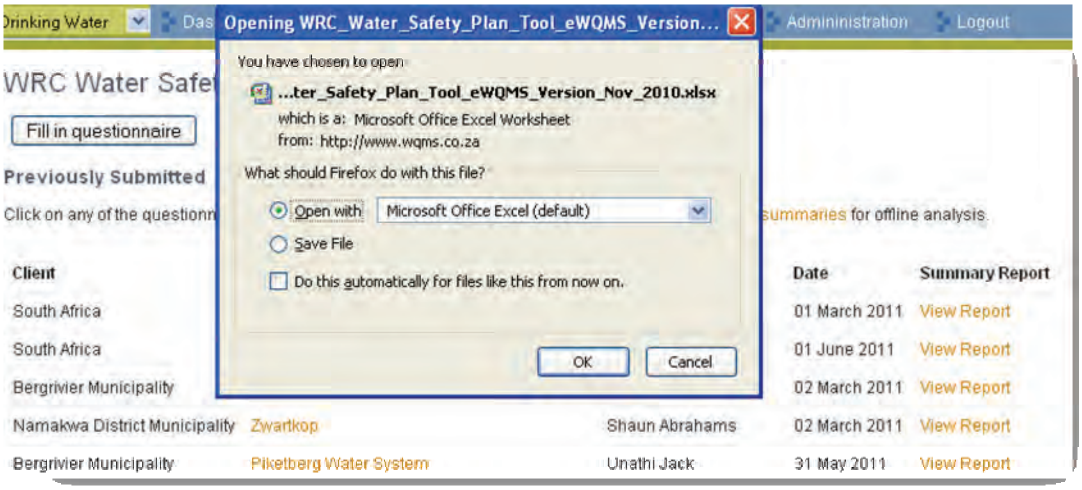

**Figure 15:** *eWQMS Risk Toolbox options*

***Fill in the Water Safety Plan questionnaire***

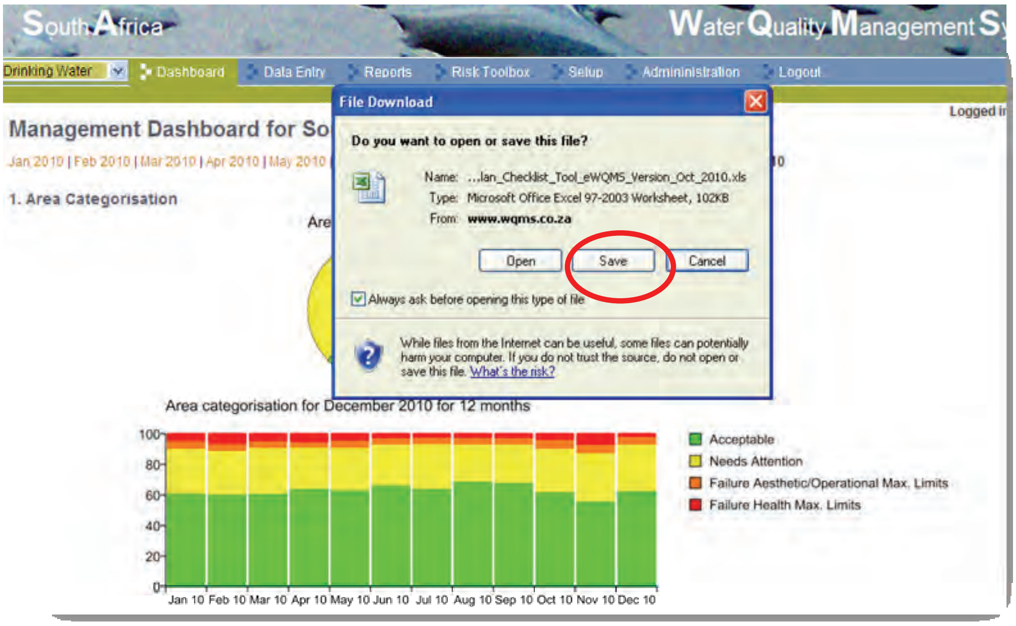
- Click “fill in questionnaire”
- All present systems within the area of jurisdiction of the user should be registered separately (i.e. as individual water supply systems).

***To download the Excel tool via eWQMS, after selecting “Risk Toolbox”:***

- On the bottom left corner click on “additional resources”
- A message box will ask if you want the spreadsheet file to be saved.




Select the location to save the spreadsheet file as shown below.



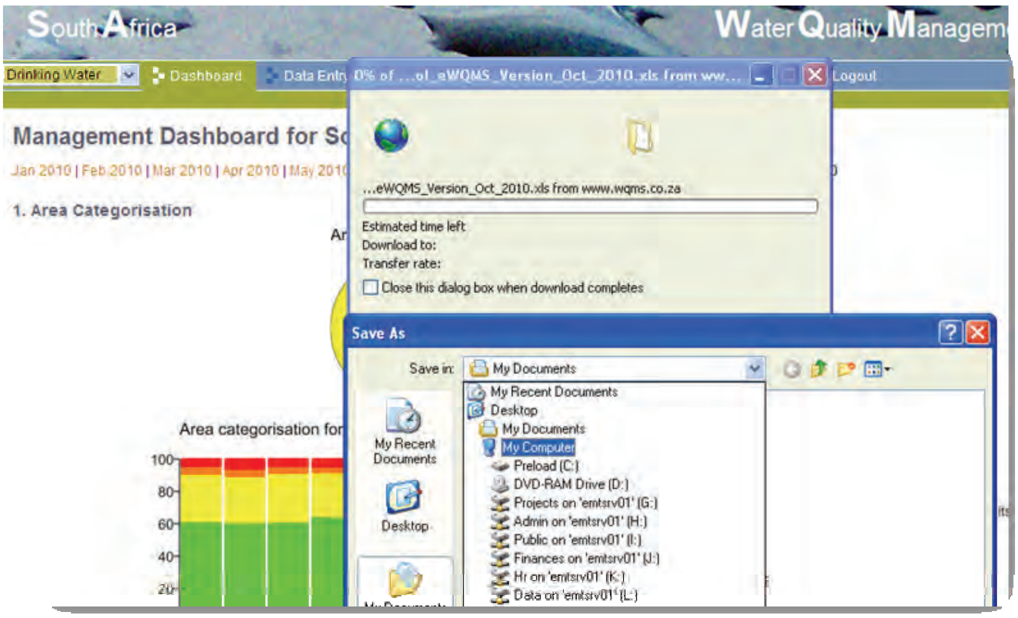




**Figure 16:** *eWQMS selecting and saving the tool*

Whether the Water Safety Plan is filled in through the spreadsheet or directly on eWQMS, the same steps to develop a Water Safety Planning are followed and are indicated below.

## Step 2: Capture the name of the system

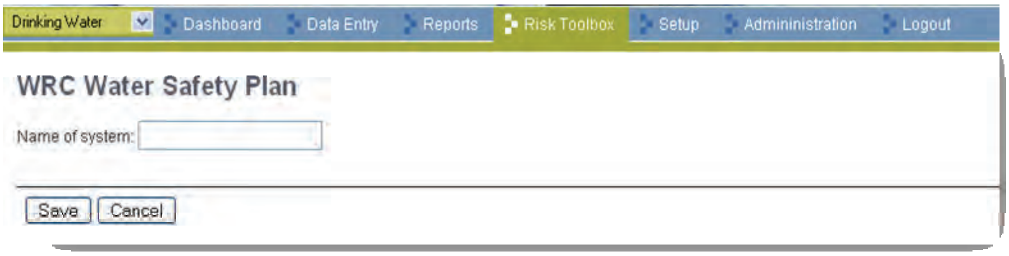
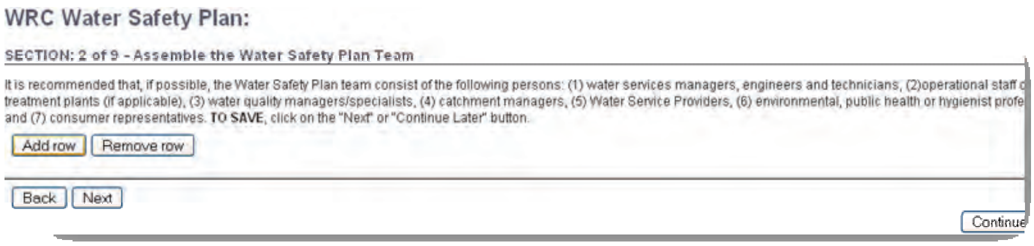



**Figure 17:** *eWQMS capturing the name of the system*

## Step 3: Capture Project Team and Key Stakeholders

Using the Water Safety Planning tool, capture the details of the individuals making up the Water Safety Planning team, including appropriate roles and responsibilities, and associated contact details as shown in the figures below.

- Click ‘add row’ to create as many rows as the number of the people making up the Water Safety Planning Team. More rows can be added or removed when there are changes to be made.




*Capturing Water Water Safety Planning Team using the web format*

- Capture details of the team as according to the fields required.


*Capturing Water Safety Planning Team using the Excel format*

Water Safety Plan Tool
Step 2 of 11

**Assemble the Water Safety Plan Team**

This step is: Incomplete

Capture the details of the WSP team. It is recommended that, if possible, the Water Safety Plan team consist of the following persons: (1) water serv managers, engineers and technicians, (2)operational staff of treatment plants (if applicable), (3) water quality managers/specialists, (4) catchment managers, (5) Water Service Providers, (6) environmental, public health or hygienist professionals and (7) consumer representatives.

| | Name | Organisation | Title/Job Description | Role in WSP Team | Tel | Fax | Mobile | E-mail |
|---|---|---|---|---|---|---|---|---|
| 1 | Mr Thabo Smit | ABC Municipality | Technical Manager | Team Leader | +2742123456 | +2742123456 | +2783456789 | tsmit@abc.gov |
| 2 | Ms ABC | ABC Municipality | Water Quality Manager | Water quality specialist | etc | etc | etc | etc |
| 3 | Mr DEF | ABC Municipality | Engineer | O&M specialist | | | | |
| 4 | Ms XYZ | DWA | Assistant Director | Regulation specialist | | | | |
| 5 | Mr IJK | IJK River Catchment Management Agency | Manager | Catchment Management specialist | | | | |
| 6 | etc | etc | etc | etc | | | | |

**Figure 18:** *Capturing details of Water Safety Planning Team*

## Step 4: Capture the details of the individual responsible for providing information of the Water Safety Planning

It is important to fill in a record of completion indicating who filled in the tool and the period. This would assist the WSI in determining the need to revise the tool and check if there are any updates required to be made. It is recommended that the information is completed by the individual responsible for conducting the assessment or the Water Safety Planning team leader. An example of record of completion is provided below.

*Capturing details of responsible person using the web format*

SECTION: 1 of 9 - Record of Completion

TO SAVE, click on the "Next" or "Continue Later" button

1. Name
   Mfoba
2. Title/Job Description
   Water Quality Manager
3. Locality
   Venterstad
4. Address
   16 Church Street, Venter
5. Province
   Eastern Cape
6. Telephone
   04735647899
7. Fax
   086 0001111
8. Mobile
   083 123 4567
9. E-mail
   mfobane@venterstad.g

*Capturing details of responsible person using the Excel format*

| The following information should be completed by the individual responsible for conducting the assessment and/or any additional revisions. | |
|---|---|
| Name | Thabo Smit |
| Title | Technical Manager |
| Water Services Authority | ABC Municipality |
| Water System Name | Town D |
| Address | 32 Main Road |
| Province | Eastern Cape |
| Postal Code | 7500 |
| Telephone | +2742123456 |
| Fax | +2742123456 |
| Mobile | +2783456789 |
| Email | tsmit@abc.gov.za |

**Figure 19:** *Capturing details of person responsible for providing information of the Water Safety Plan*

## Step 5: Document and Describe the present Drinking Water Supply System

First identify which components of the water supply system are applicable to the particular system by using examples below.

- Using the down arrow keys, choose yes or no indicating which components are available or not for that particular water supply system.

*Documentation and description of water supply system using the web format*

**3.2 Raw Water Storage**

1. Open reservoir

   Yes

2. Closed reservoir

   No

**3.3 Pre-Treatment**

1. Fluoride removal

   No

2. Iron and manganese removal

   No

3. Taste and odour removal

   No

4. Pre-disinfection

   Yes

**3.4 Water Treatment Processes**

1. Coagulation

   Yes

2. Flocculation

   Yes

3. Sedimentation

*Documentation and description of water supply system using the Excel format*

**Step 3 of 11**

**Document and Describe the Water System**

| This step is: | | Incomplete |
|---|---|---|
| Which of the following elements form part of your water system? | | |
| 1 | Source Water | |
| | Ground | Surface |
| 2 | Raw Water Storage Reservoir | |
| | Open | Closed |
| 3 | Pre-Treatment | |
| | Fluoride | Iron_and_Manganese |
| | Tast_and_odour_removal | Pre_Disinfection |
| 4 | Water Treatment Processes | |
| | Coagulation | Flocculation |
| | Sedimentation | Filtration |
| | pH_adjustment | Disinfection |
| 5 | Distribution | |

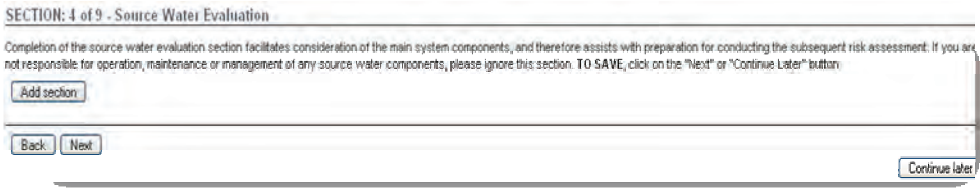
**Figure 20:** *Documentation and description of water supplysystem*

## Step 6: Assess the Water Supply System (from source to consumer)

Using the tool, assess each component of the water supply system to obtain an idea of the typical hazards/risks faced.

On the tool, start with source assessment. If bulk water is received, this sectioned can be skipped.

- To fill in the information on source assessment, click add section



SECTION: 4 of 9 - Source Water Evaluation

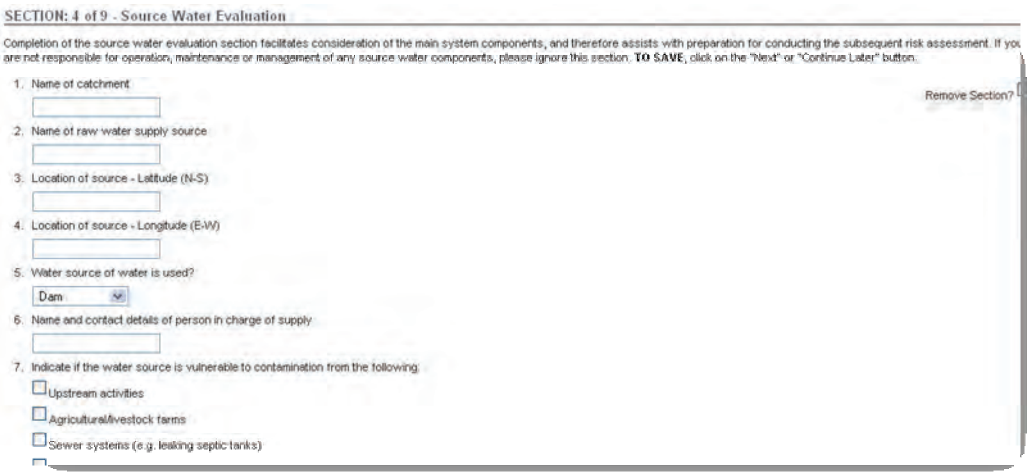
Completion of the source water evaluation section facilitates consideration of the main system components, and therefore assists with preparation for conducting the subsequent risk assessment. If you are not responsible for operation, maintenance or management of any source water components, please ignore this section. TO SAVE, click on the "Next" or "Continue Later" button.

Add section

Back Next

Continue later

- Fill in the information according to the required fields



SECTION: 4 of 9 - Source Water Evaluation

Completion of the source water evaluation section facilitates consideration of the main system components, and therefore assists with preparation for conducting the subsequent risk assessment. If you are not responsible for operation, maintenance or management of any source water components, please ignore this section. TO SAVE, click on the "Next" or "Continue Later" button.

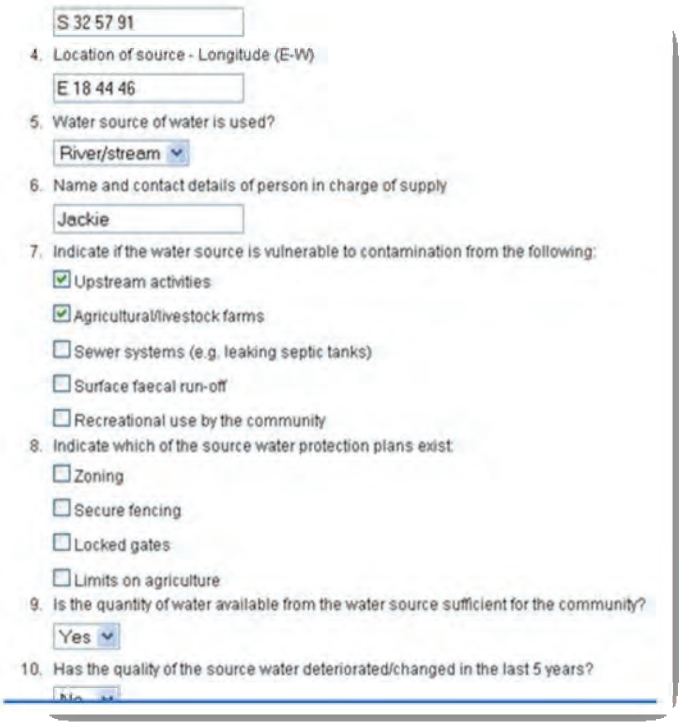
Remove Section?

1. Name of catchment
2. Name of raw water supply source
3. Location of source - Latitude (N-S)
4. Location of source - Longitude (E-W)
5. Water source of water is used?
   Dam
6. Name and contact details of person in charge of supply
7. Indicate if the water source is vulnerable to contamination from the following
   - Upstream activities
   - Agricultural/livestock farms
   - Sewer systems (e.g. leaking septic tanks)

- If source assessment is not applicable for the system, click 'next' without clicking 'add section'

Possible source related hazards (which are also included in the tool are listed in Appendix A.

*Assessing source water using the web format*


S 32 57 91

4. Location of source - Longitude (E-W)

E 18 44 46

5. Water source of water is used?

River/stream

6. Name and contact details of person in charge of supply

Jackie

7. Indicate if the water source is vulnerable to contamination from the following:

☑ Upstream activities

☑ Agricultural/livestock farms

☐ Sewer systems (e.g. leaking septic tanks)

☐ Surface faecal run-off

☐ Recreational use by the community

8. Indicate which of the source water protection plans exist

☐ Zoning

☐ Secure fencing

☐ Locked gates

☐ Limits on agriculture

9. Is the quantity of water available from the water source sufficient for the community?

Yes

10. Has the quality of the source water deteriorated/changed in the last 5 years?

*Assessing source water using the Excel format*

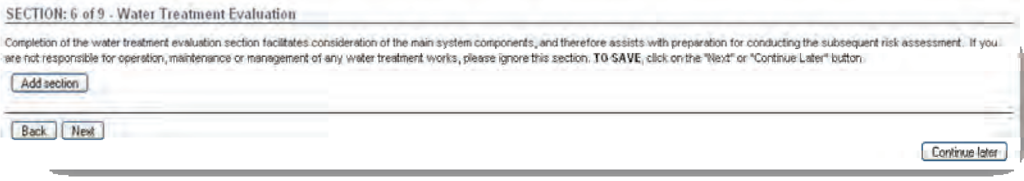
| Evaluation of Catchment and Raw Water Source | | | |
|---|---|---|---|
| | **Aspect** | **1** | **Comments** |
| | **Date of Assessment** | | |
| 1 | Name of catchment | | |
| 2 | Name of raw water supply source | | |
| 3 | Location of the source (GPS) | | |
| 4 | What source of water is used? | River/Stream | |
| 5 | Name of person in charge of supply | | |
| 6 | Contact details of person in charge of supply (phone, email, address) | | |
| 7 | Is the water source vulnerable to contamination from the following? | | |
| | - Upstream industries | Yes | |
| | - Agricultural/livestock farms | No | |
| | - Sewer systems such as leaking septic tanks, etc | Yes | |
| | - Surface faecal run-off | Yes | |
| | - Recreational use by the community | Yes | |
| | - Other (specify) | No | |
| 8 | Indicate which of the source water protection plans exist? | | |
| | - Zoning | No | |
| | - Secure fencing | No | |
| | - Locked gates | No | |
| | - Limits on agriculture (e.g. phosphorous, pesticides) | Yes | |

**Figure 21:** *Assessing Source Water*

## Drinking Water Treatment Assessment

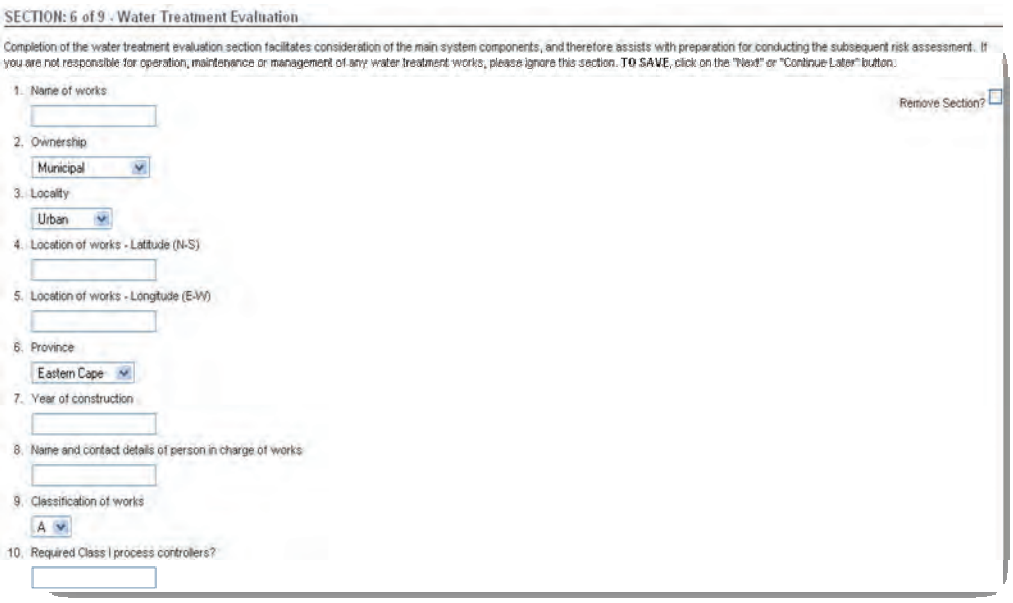
This section should be filled in by users who have a water treatment system, whether it is a system that use conventional treatment methods or a simple small treatment system. Using the tool, assess each unit of the drinking water treatment system to obtain an idea of the typical hazards/risks faced. If there is no water treatment system, this section can be skipped.

- To fill in the information on water treatment system, click add section




- Fill in the information according to the required fields

*Assessing Drinking Water Treatment system using web format*




- If water treatment assessment is not applicable for the system, click ‘next’ without clicking ‘add section’

Possible drinking water treatment related hazards (which are also included in the tool) are provided in Appendix A.

*Assessing Drinking Water Treatment system using Excel format*

| Evaluation of Waterworks Treatment, Design and Operation | | | |
|---|---|---|---|
| | Aspect | 1 | Comments |
| | Date of Assessment | | |
| 1 | Name of works | | |
| 2 | Ownership | DWA | |
| 3 | Locality | Urban | |
| 4 | Location of the works (GPS) | | |
| 5 | Province | Free State | |
| 6 | Year of construction | | |
| 7 | Name of person in charge of works | | |
| 8 | Contact details of person in charge of works (phone, email, address) | | |
| 9 | Classification of works | A | |
| | - Required class of process controller/operator (per shift) | Class IV | |
| | - Required class of supervisor (need to be available at all times) | Class V (on-site) | |
| 10 | Number of required process controllers/operators | | |
| | - Full time | 1 | |
| | - Day time | 2 | |
| | - Part time | 1 | |

**Figure 22:** *Assessing Drinking Water Treatment system*

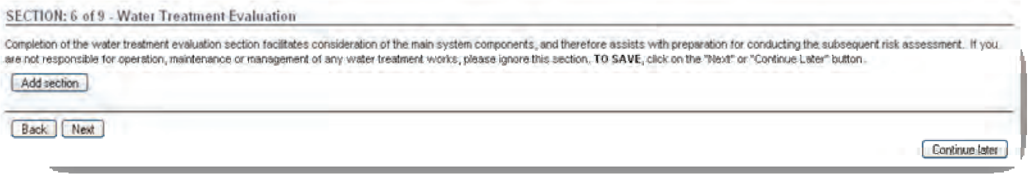
**Drinking Water Network Assessment**

Network includes bulk mains, network distribution pipes, on site and off site reservoirs, booster stations, valves, standpipes and house connections. Assess the drinking water network to obtain an idea of the typical challenges/risks faced.

Using the tool, assess each unit of the drinking water network to obtain an idea of the typical hazards/risks faced.

Possible drinking water network hazards (which are also included in the tool) are listed in Appendix A.

- To fill in the information on drinking water network system, click add section




- Fill in the information according to the required fields

Using the tool, drinking water network information should be documented and hazards applicable for that drinking water network should be identified by selecting the appropriate answer. Examples of treatment evaluation are shown in the figures below.

*Assessing Drinking Water Network using web format*

**8.2 Primary Mains**

1. Is there evidence of leakage in the vicinity of the pipe?
   No
2. Is there evidence of human/animal faeces in the vicinity of the pipe?
   No
3. Is there evidence of solid waste in the vicinity of the pipe?
   No
4. Is there evidence of excessive algal growth in the vicinity of the pipe?
   No
5. Is there evidence of recreational use by the community in the vicinity of the pipe?
   No
6. Does the primary main pass through stagnant water?
   No

**8.3 On-Site Service Reservoirs**

1. Are the vents covered?
   No
2. Are the inspection covers or concrete around cover damaged or corroded?
   No
3. Is there any observable part of the inside of the tank corroded or damaged (including: ladders, roof struts, walls)?
   No

*Assessing Drinking Water Network using Excel format*

| Evaluation of Distribution Network | | | |
|---|---|---|---|
| | **Aspect** | **1** | **Comments** |
| 1 | Safety policies and procedures are in place and adhered to (as per Occupation Health and Safety Act requirements) distribution network. | Yes | |
| 2 | Appropriate safe work procedures, permit to work systems and lock-out procedures are available and implemented | Yes | |
| | **Primary Mains** | | |
| 1 | Is there evidence of the following in the vicinity of the pipe? | | |
| | - Leakage | Yes | |
| | - Human/animal faeces | Yes | |
| | - Solid waste | Yes | |
| | - Excessive algal growth | Yes | |
| | - Recreational use by the community | Yes | |
| | - Other (specify) | Yes | |

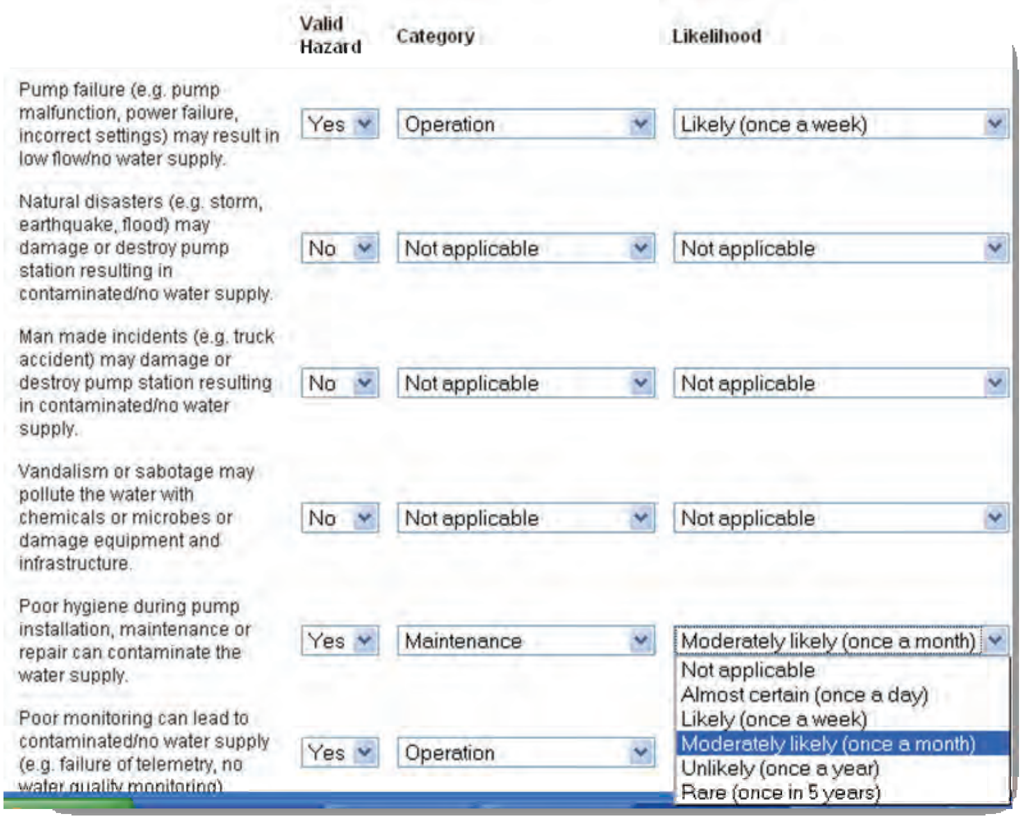
**Figure 23:** *Assessing Drinking Water Network*

## Step 7: Undertake a Risk assessment

From the hazards identified for each water supply system component, determine the risk associated with them. On the tool it would be already indicating by a yes or no if the hazard is valid or not (if the assessment page has already been filled in). Focus should be given to those hazards already indicated as valid.

- Select the option under likelihood indicating the likelihood of that hazard to happen as shown in the figures below.

*Determining likelihood of valid hazards using the web format*




*Determining likelihood of a valid hazards using the Excel format*

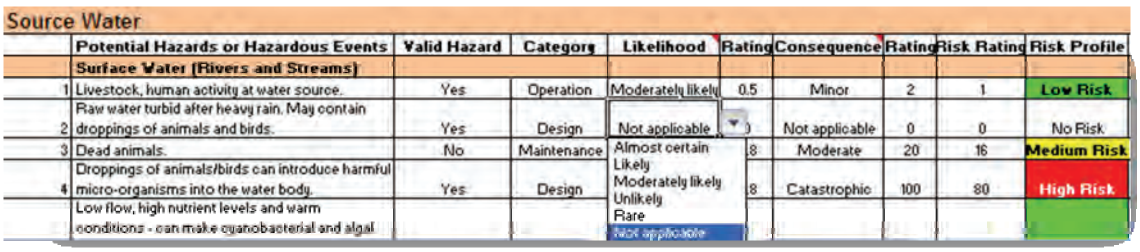
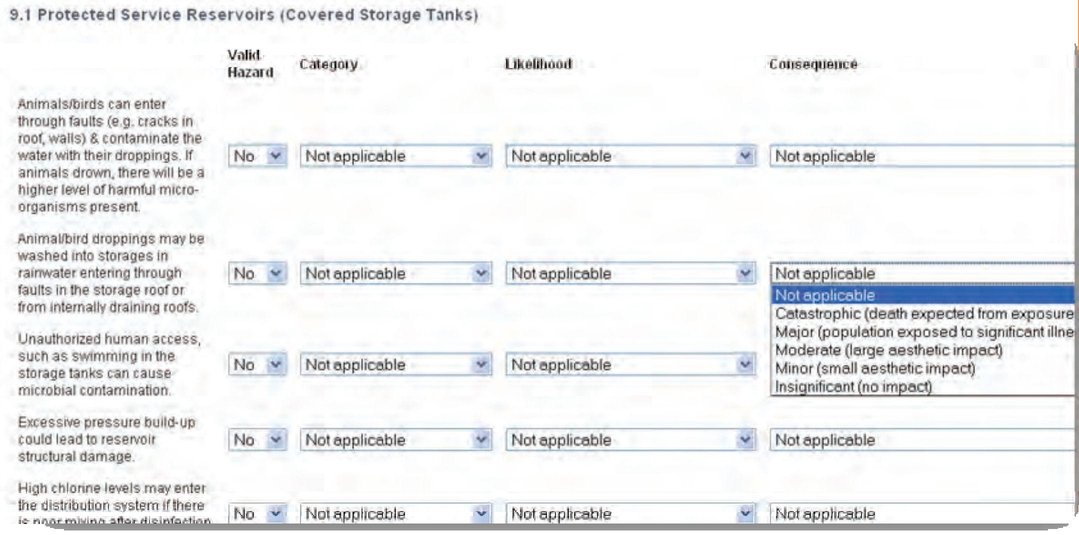



**Figure 24:** *Determining likelihood of valid hazards*

- Once the likelihood has been determined, determine the consequence should that hazard happen.
- Select the option under consequence indicating the impact the hazard would have as shown in the figure below.

If the valid hazard is not on the available list, the user can add the hazard/s by going down the page of risk assessment and click


*Determining consequence of a valid hazards using the web format*




*Determining consequence of a valid hazards using the Excel format*

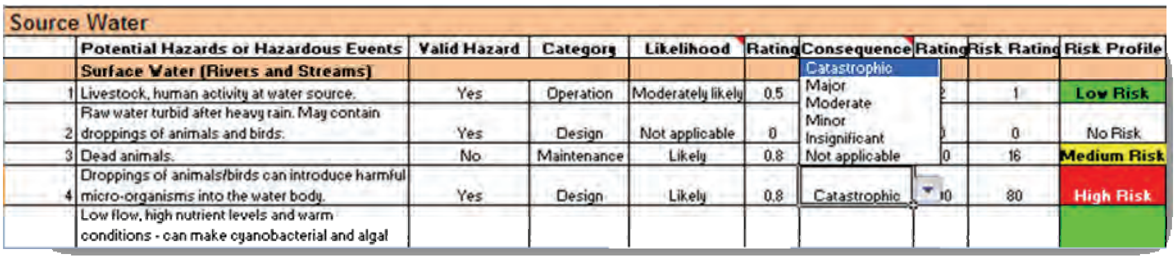



**Figure 25:** *Determining consequence of a valid hazards*

Using the tool, four columns to be filled in are:

1. Identify if the hazard is valid or not on the "valid hazard" column
2. Determine likelihood of the hazard on the "Likelihood" column
3. Determine the consequence of the hazard on the "consequence" column
4. The category column can be filled in to identify if the hazard is design, operational or maintenance related. This should assist in correctly assigning corrective measures to the responsible person or team.

- Using the web based tool, click “view summary report” at the end of the questionnaire to view the intensity of the risk.
- This can be viewed on the “Risk Profile” column on the Excel format with colour code as seen on the figures.

*Risk summarisation using the web format*

| Component | Hazard | Valid Hazard | Category | Risk Rating | Risk Profile |
|---|---|---|---|---|---|
| 9.5 Distribution System | Pipe bursts/leaks can interrupt supply. Contamination can occur where pipes are below/close to stormwater/sewage pipes or septic tanks. Entry of soil may increase turbidity. | Yes | Operation | 56.00 | Medium Risk |
| 9.3 Pump Stations | Pump failure (e.g. pump malfunction, power failure, incorrect settings) may result in low flow/no water supply. | Yes | Operation | 56.00 | Medium Risk |
| 9.1 Protected Service Reservoirs (Covered Storage Tanks) | Poor monitoring can lead to contaminated/no water supply (e.g. failure of telemetry, no water quality monitoring). | Yes | Operation | 56.00 | Medium Risk |
| 7.1 General | Power supply can result in interrupted treatment/loss of process control. | Yes | Operation | 56.00 | Medium Risk |
| 7.1 General | Non optimised treatment processes can result in poor water quality. | Yes | Operation | 56.00 | Medium Risk |

*Risk summarisation using the Excel format*

**Water Safety Plan Tool**

**Step 11 of 11**

**Summary**

NOTE: The results presented below are automatically populated from previous inputs - DO NOT MODIFY HERE

*To prioritise residual risks (considering control measures), users need to click on the arrow on "Risk Rating" (column F), then select "Sort Largest to Sm*

**Summary Status and Ranking**

| Component | Hazard | Valid Hazard / Hazardous Event | Hazard Category | Hazard Name (Water Quality Determinand) | Risk Rating | Risk Profile | Control Measure in Place (if any) | Correctiv |
|---|---|---|---|---|---|---|---|---|
| Source | | Yes | Operation | 0 | 1 | Low Risk | 0 | New fenc |
| Source | | Yes | Design | 0 | 10 | Low Risk | Effective monitoring & treatment | Not require |
| Source | Dead animals. | No | Maintenance | 0 | 16 | Medium Risk | 0 | 0 |
| Source | Droppings of animals/birds can introduce harmful micro-organisms into the water body. | Yes | Design | 0 | 0 | No Risk | 0 | 0 |
| Source | Low flow, high nutrient levels and warm conditions - can make cyanobacterial and algal growth more likely. | Yes | Operation | 0 | 2 | Low Risk | 0 | 0 |
| Source | Falling water levels due to drought or drawdown of water body. | No | Maintenance | 0 | 0 | No Risk | 0 | 0 |
| Source | Vandalism or sabotage may pollute the water with chemicals or microbes or damage equipment and infrastructure. | Yes | Design | 0 | 16 | Medium Risk | 0 | 0 |

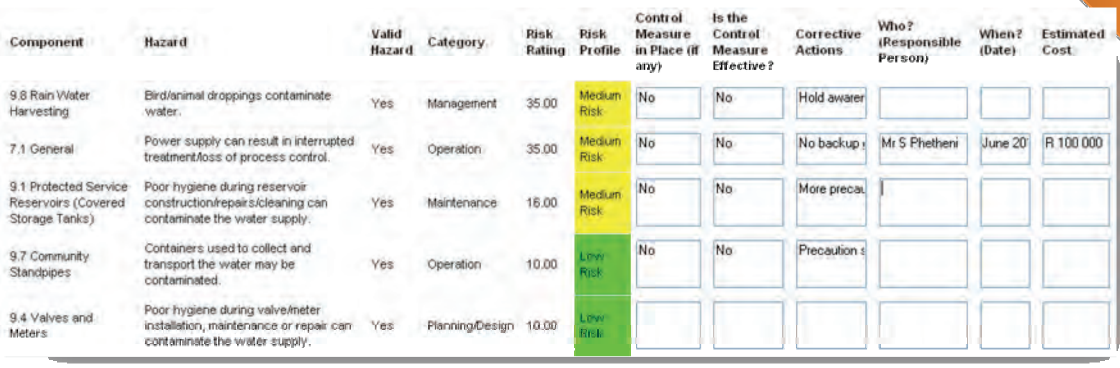
**Figure 26:** *Risk Summary representation*

## Step 8: Identify control measures

Identify existing control/intervention measures, determine effectiveness thereof (e.g. redundancy, alternatives, back-ups, etc.) and identify desired control/intervention measures and assign budgets, roles and responsibilities, time frames, etc. for proposed improvements. There is limited space on the web to see full sentences.

- Fill in control measures directly onto the web
- When done, click 'submit corrective actions' at the end of the page.

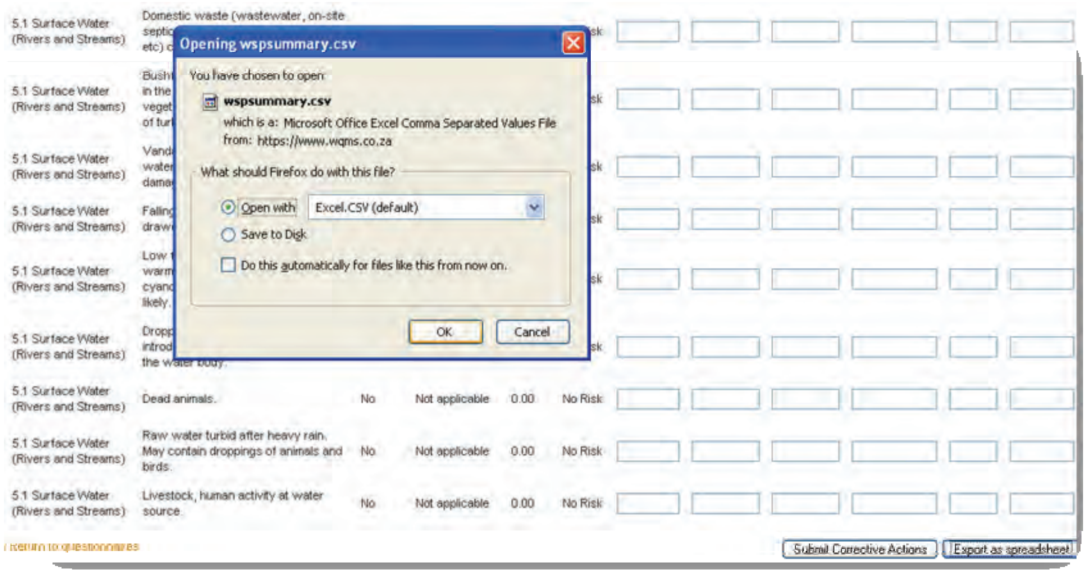
*Capturing and evaluating effectiveness of control measures using the web format*



| Component | Hazard | Valid Hazard | Category | Risk Rating | Risk Profile | Control Measure in Place (if any) | Is the Control Measure Effective? | Corrective Actions | Who? (Responsible Person) | When? (Date) | Estimated Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 9.8 Rain Water Harvesting | Bird/animal droppings contaminate water. | Yes | Management | 35.00 | Medium Risk | No | No | Hold awarer | | | |
| 7.1 General | Power supply can result in interrupted treatment/loss of process control. | Yes | Operation | 35.00 | Medium Risk | No | No | No backup | Mr S Phetheni | June 20 | R 100 000 |
| 9.1 Protected Service Reservoirs (Covered Storage Tanks) | Poor hygiene during reservoir construction/repairs/cleaning can contaminate the water supply. | Yes | Maintenance | 16.00 | Medium Risk | No | No | More precau | | | |
| 9.7 Community Standpipes | Containers used to collect and transport the water may be contaminated. | Yes | Operation | 10.00 | Low Risk | No | No | Precaution s | | | |
| 9.4 Valves and Meters | Poor hygiene during valve/meter installation, maintenance or repair can contaminate the water supply. | Yes | Planning/Design | 10.00 | Low Risk | | | | | | |

Alternatively export the report to Excel.

- Click export as spreadsheet at the end of the page
- A message box will ask if you want the spreadsheet file to be opened or saved
- Open the spreadsheet and fill in the control measures, estimated costs and estimated time for the control measure to be implemented



| Hazard | Valid Hazard | Category | Risk Profile | Control Measure | Is the Control Measure Effective? | Corrective Actions | Who? (Responsible Person) | When? (Date) | Estimated Cost |
|---|---|---|---|---|---|---|---|---|---|
| Bird/animal droppings contaminate water. | Yes | Managem | Medium Risk | No | No | Hold awarenss campaigns educating the public about the importance of protrected(covered) rain water harvesting tankers aor collectors | Councillor Shushu | Immedia tely | To be determined |
| supply can result in interrupted | Yes | Operation | Medium Risk | No | No | No backup generator at the plant, need to put plans in place to invest in a back up generator. | Mr Phetheni | Jun-12 | R100 000 |
| Poor hygiene during reservoir | Yes | Maintena | Medium Risk | No | No | More precaustion should be taken when reservoir cleaning occurs. | | | |

**Figure 27:** *Developing control measures*

Outputs from the completed web based and/or Microsoft Excel spreadsheet can be copied and pasted into a document to compile a Water Safety Plan Report.

As indicated earlier that the tool assists in developing Water Safety Planning, management of identified risks depends on the actions taken thereafter. The tool therefore provides suggested corrective actions, therefore implementation of corrective actions, communication procedures, management procedures development and implementation depends on the Water Services Institution (WSI). The next steps of the Water Safety Planning are not included in the tool, however should be considered as discussed earlier. The steps include:

## 5.3 Water Safety Plan status Checklist

The Water Safety Plan should be reviewed annually. A Water Safety Plan status checklist is also available on eWQMS.

This tool allows one to rapidly assess progress in the Water Safety Planning process (i.e. "where we are and what do we still need to do"). It considers typical steps of the Water Safety Planning process and asks 5 key questions per step. A colour-coded "spider-diagram" output is provided of the status. The tool assists in reviewing the Water Safety Plan.

### Step 1: Login to eWQMS

- Go to www.wqms.co.za
- Complete your username and password.
- Click "Login"

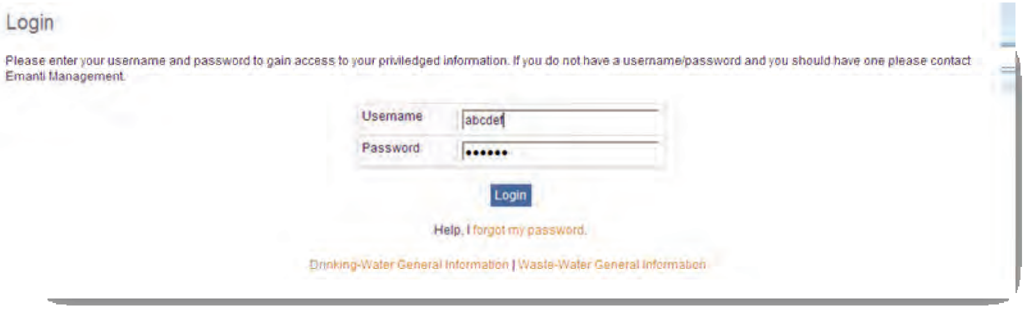



**Figure 28:** *eWQMS login page*

- Once logged in, the Dashboard will open.

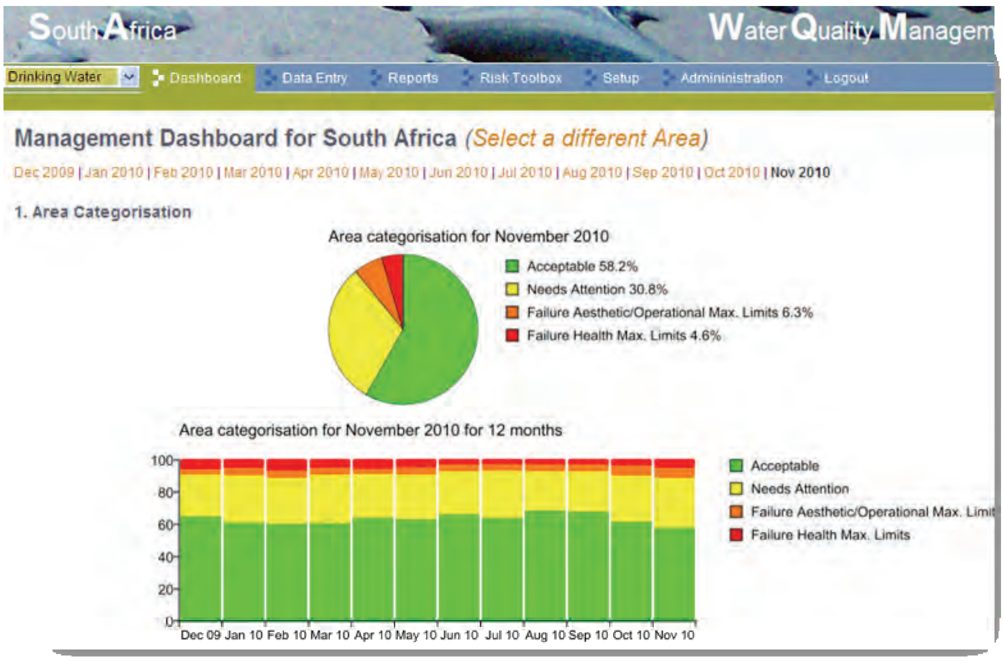



**Figure 29:** *eWQMS Dashboard page*

## Step 2: Go to "Risk Toolbox" and Access Water Safety Plan Status Checklist Tool

- Using the tabs, go to "Risk Toolbox"
- Select the option: Water Safety Plan Status Checklist Tool (web)
- A screen will open asking you to complete the assessment


**Figure 30:** *Selecting the Water Safety Plan Status Checklist Tool*

## Step 3: Complete the Water Safety Plan Status Checklist Tool

- Answer all questions presented in the checklist by clicking on the appropriate answer
- Remember to click on "Save" or the information will be lost
- Once you have fully completed all questions, click on "Complete"
- A report with an associated Spider Diagram will be generated once the checklist has been completed (similar to Figure 4).

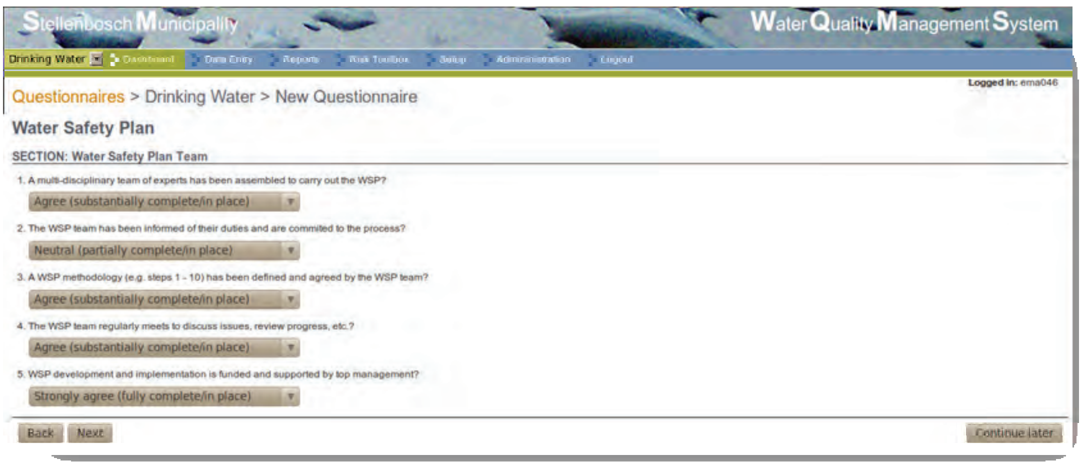



**Figure 31:** *Completing the Water Safety Plan Status Checklist Tool*

At the end, click 'view spider chart'.

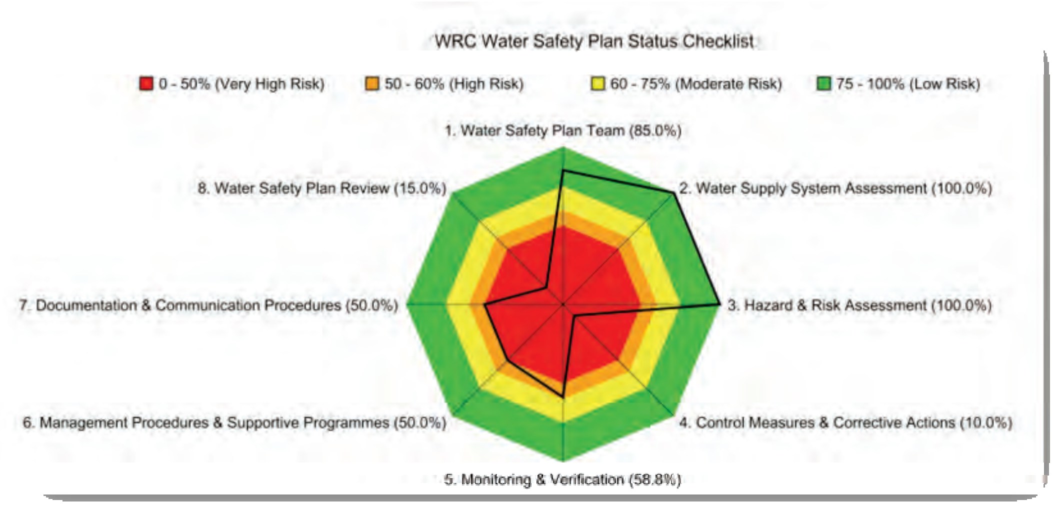



**Figure 32:** *Water Safety Plan Status Report*

The tools are available on eWQMS. As indicated earlier, the tools are continuously reviewed and enhanced therefore any feedback is acceptable. Please provide feedback to the task team on info@emanti.co.za

A report template and other resources are available under additional resources at the bottom of the Water Safety Plan Tool page (see screenshot below).

# 6 WAY FORWARD

The following refinement needs have been identified by users and therefore will be part of the future updated tool:

- Further expand the current hazard/risk database

> **Note** Although the risk/hazard database of the current WRC Water Safety Planning Tool is rapidly growing (based on user feedback/requests for amendments/additions), it is not exhaustive and opportunity therefore exists for the sector to continue to contribute site specific risks/hazards to the database (i.e. the list of hazards/risks will never be finalised). In particular, the ability for users to define their own hazardous events is required.

- Calculation of residual risk (after implementation of corrective actions).
- Ability to link specific hazards (e.g. determinants that need to be monitored) to hazardous events.
- Alignment of water safety plan to new SANS 241:2011 requirements, and in particular allow development of a risk management based drinking-water quality management programme.
- Photo diary of hazards/risks identified through site visits that can be added to risk assessments. This can also serve as evidence that site visits/assessments were actually conducted.

## REFERENCES


1. Department of Water Affairs (2010) *South African Drinking Water Quality Management Performance*. Blue Drop Report Version 1
2. Electronic Water Quality management System (www.wqms.co.za)
3. John M Nicholas (1990) *Managing Business & Engineering Projects, Concepts & Implementation.* Upper Saddle River, New Jersey, 1990, ISBN: 0-13-551854-7
4. SANS 241:2011. Drinking water Part 1: Microbiological, physical, aesthetic and chemical determinands. SABS, Pretoria, South Africa.
5. Thompson P and Majam S (2009) *The Development of a generic Water Safety Plan for small community water supply*. Report No. TT 415/09, Water Research Commission, Pretoria, South Africa
6. World Health Organisation (2009) Bartram J, Corrales L, Davison A, Deere D, Drury D, Gordon B, Howard G, Rinehold A, Stevens M. *Water safety plan manual: step-by-step risk management for drinking-water suppliers*. World Health Organisation. Geneva, 2009

# APPENDIX A

While some hazards are generic, implying that they may apply to every physical component of water services infrastructure (e.g. destruction of property, explosive devices), some threats are only specific to a specific component. The following tables provide examples of the water supply system possible hazards.

**Table A1:** *Source water possible hazards*

| **Source Water** | |
|---|---|
| | **Potential Hazards or Hazardous Events** |
| | **Surface Water (Rivers and Streams)** |
| 1 | Livestock, human activity at water source. |
| 2 | Raw water turbid after heavy rain. May contain droppings of animals and birds. |
| 3 | Dead animals. |
| 4 | Droppings of animals/birds can introduce harmful micro-organisms into the water body. |
| 5 | Low flow, high nutrient levels and warm conditions – can make cyanobacterial and algal growth more likely. |
| 6 | Falling water levels due to drought or drawdown of water body. |
| 7 | Vandalism or sabotage may pollute the water with chemicals or microbes or damage equipment and infrastructure. |
| 8 | Intake screens become clogged or damaged. |
| 9 | Bushfires can result in fire retardants in the water source. Loss of vegetation can result in the presence of turbidity and organic matter. |
| 10 | Domestic waste (wastewater, on-site septic tanks, litter, municipal landfills, etc.) can pollute the water. |
| 11 | Industrial and agricultural activity can pollute the water (e.g. harmful organisms, toxic chemicals, air deposits, air pollution, land spreading of manure, feedlot runoff, etc.). |
| 12 | Gaseous emissions from industrial accidents or forest fires can pollute the water (e.g. explosions, fires, etc.). |
| 13 | Traffic accidents can lead to spillage of toxic or other chemicals, harmful substances, etc. |
| 14 | Leaking pipelines can pollute the water body with harmful organisms or chemicals. |
| 15 | Earthquake, landslides can pollute the source. |
| 16 | Salt water intrusion (e.g. from sea) can contaminate fresh water sources. |
| 17 | Contaminated stormwater can pollute the source. |
| 18 | An accident, equipment defect, power failure, sabotage, vandalism, etc. can lead to failure of the source monitoring system. |
| | **Boreholes** |
| 1 | Livestock, human activity at water source. Shallow boreholes in highly permeable solids or fractured rock aquifers, are more vulnerable to contamination. |
| 2 | Groundwater may contain health related chemicals (e.g. arsenic, barium, fluoride, uranium, radium) as a result of local geology. |
| 3 | Surface water entering a borehole can increase the turbidity and/or may contain the droppings of animals or birds which contain harmful micro-organisms. |
| 4 | Aquifer not sufficiently fed with water can lead to a shortage of resources. |
| 5 | Vandalism or sabotage may pollute the water with chemicals or microbes or damage equipment and infrastructure. |
| 6 | Water may contain naturally occurring iron and manganese. |
| 7 | Domestic waste (wastewater, on-site septic tanks, litter, municipal landfills, etc.) can pollute the borehole. |
| 8 | Industrial and agricultural activity can pollute the borehole (e.g. harmful organisms, toxic chemicals, air deposits, air pollution, fuel stations – hydrocarbon contamination, land spreading of manure, feedlot runoff, etc.). |

| | |
|---|---|
| 9 | Domestic waste (wastewater, on-site septic tanks, litter, municipal landfills, etc.) can pollute the borehole. |
| 10 | Traffic accidents can lead to spillage of toxic or other chemicals, harmful substances, etc. |
| | **Boreholes** |
| 11 | Graveyards can pollute the borehole. |
| 12 | Salt water intrusion (e.g. from sea) can contaminate fresh water sources. |
| 13 | Contaminated stormwater can pollute the source. |
| 14 | An accident, equipment defect, power failure, sabotage, vandalism, etc. can lead to failure of the source monitoring system. |
| | **Springs** |
| 1 | Spring must be designed to protect spring from livestock, human activity at water source. Shallow boreholes in highly permeable soils or fractured rock aquifers, are more vulnerable to contamination. |
| 2 | Groundwater/spring water may contain health related chemicals (e.g. arsenic, barium, fluoride, uranium, radium) as a result of local geology. |
| 3 | Surface water entering the spring can increase the turbidity and/or may contain the droppings of animals or birds which contain harmful micro-organisms. |
| 4 | Aquifer not sufficiently fed with water can lead to a shortage of resources. |
| 5 | Vandalism or sabotage may pollute the water with chemicals or microbes or damage equipment and infrastructure. |
| 6 | Water may contain naturally occurring iron and manganese. |
| 7 | Domestic waste (wastewater, on-site septic tanks, litter, municipal landfills, etc.) can pollute the spring. |
| 8 | Industrial and agricultural activity can pollute the spring (e.g. harmful organisms, toxic chemicals, air deposits, air pollution, fuel stations – hydrocarbon contamination, land spreading of manure, feedlot runoff, etc.). |
| 9 | Domestic waste (wastewater, on-site septic tanks, litter, municipal landfills, etc.) can pollute the spring. |
| 10 | Traffic accidents can lead to spillage of toxic or other chemicals, harmful substances, etc. |
| 11 | Salt water intrusion (e.g. from sea) can contaminate fresh water sources. |
| 12 | Contaminated stormwater can pollute the source. |
| 13 | An accident, equipment defect, power failure, sabotage, vandalism, etc. can lead to failure of the source monitoring system. |
| | **Impoundments (Dams)** |
| 1 | Urban areas and wastewater discharge (permitted or unauthorised) can lead to pollution of water with harmful organisms. Extent of pollution will be dependent on level of treatment and management of sewage collection system and extent of dilution in the catchment storage (e.g. on-site septic tank systems). |
| 2 | Urban areas can pollute water via unauthorised discharge of chemicals or spills from stored chemicals. |
| 3 | Recreational activities can cause: microbial (faecal waste) and chemical (boating) contamination and soil erosion (off road vehicles). |
| 4 | Waste water discharge can lead to an increase in nutrient levels in catchments and reservoirs. |
| 5 | Urban areas can be a source for turbidity, litter and plant debris in the water body (e.g. domestic waste dumping, municipal landfills). |
| 6 | Access to reservoirs can lead to accidental damage to infrastructure and increased contamination from spills. |
| 7 | Agricultural activities involving livestock can pollute the water with harmful organisms (e.g. land spreading of manure or fertilizer). The concentration of pollutant is dependent of intensity of activity and level of access to storage area. |
| 8 | Industrial or agricultural practices may lead to contamination by toxic chemicals including herbicides, pesticides, heavy metals, pharmaceutical residuals, spillage of diesel and petroleum products. |
| 9 | Gaseous emissions from industrial accidents or forest fires can pollute the water (e.g. explosions, fires, etc.). |

| | |
|---|---|
| 10 | Agricultural practices may increase nutrient levels in water due to entry of fertilizers or nitrogenous compounds associated with livestock (e.g. feedlot runoff). |
| 11 | Forestry involving the development of timber plantations can lead to the discharge of pesticides and herbicides. |
| 12 | Agricultural practices and livestock can cause erosion on the water body and lead to an increase in turbidity. |
| 13 | Forestry can cause erosion on the water body and lead to an increase in turbidity. |
| 14 | After heavy rain, water entering impoundment may be turbid (soil, sand) and contain droppings of animals/birds, contaminants and contain high levels of organic matter. |
| 15 | Dead animals. |
| 16 | Low flow, high nutrient levels and warm conditions – can make cyanobacterial and algal blooms/growth more likely. |
| | **Impoundments (Dams)** |
| 17 | Water stratification can lead to low oxygen concentrations at lower levels. Promotes algal growth and releases iron and manganese from sediments. |
| 18 | Falling water levels due to drought or drawdown of water body. |
| 19 | Bushfires can result in fire retardants in the water source. Loss of vegetation can result in the presence of turbidity and organic matter. |
| 20 | Traffic accidents can lead to spillage of toxic or other chemicals, harmful substances, etc. |
| 21 | Vandalism or sabotage may pollute the water with chemicals or microbes or damage equipment and infrastructure. |
| 22 | Intake screens become clogged or damaged. |
| 23 | Earthquake, landslides can pollute the source. |
| 24 | Leaking pipelines can pollute the water body with harmful organisms or chemicals. |
| 25 | Salt water intrusion (e.g. from sea) can contaminate fresh water sources. |
| 26 | Contaminated stormwater can pollute the source. |
| 27 | An accident, equipment defect, power failure, sabotage, vandalism, etc. can lead to failure of the source monitoring system. |
| | **Surface Water Intake and Transport** |
| 1 | Physical obstacles at the intake can lead to a shortage/unavailability of water. |
| 2 | Failure of the intake can lead to a shortage/unavailability of water. |
| 3 | Failure of the pumping system (e.g. power failure) can lead to a shortage/unavailability of water. |
| 4 | Pipe burst (mains, transport tunnels) can result from aging infrastructure/poor conditions/external factors leading to a shortage/unavailability of water. |
| 5 | An accident, equipment defect, power failure, sabotage, vandalism, etc. can lead to failure of the source monitoring system. |
| | **Groundwater Abstraction and Transport** |
| 1 | Physical obstacles (trees, roots, cracks) can damage the abstraction facility and lead to a shortage/unavailability of water. |
| 2 | Failure of the abstraction facility can lead to a shortage/unavailability of water. |
| 3 | Failure of the pumping system (e.g. power failure) can lead to a shortage/unavailability of water. |
| 4 | Pipe burst (mains, transport tunnels) can result from aging infrastructure/poor conditions/external factors leading to a shortage/unavailability of water. |
| 5 | An accident, equipment defect, power failure, sabotage, vandalism, etc. can lead to failure of the source monitoring system. |
| | *End* |

**Table A2:** *Drinking water treatment system possible hazards*

| **Drinking Water Treatment** | |
|---|---|
| | **General** |
| 1 | The site is not secure (i.e. no fencing, gates, locks, safety/warning signs, inadequate security). |
| 2 | No documentation available at the works (e.g. Classification Certificate, Water Use Authorisation). |
| 3 | Issues of concern are not addressed due to inadequate reporting (e.g. malfunctions, compliance reports). |
| 4 | Staff safety is compromised as they do not have proper PPE (personal protective equipment). |
| 5 | Inadequate storage of chemicals can compromise staff safety. |
| 6 | Non optimised treatment processes can result in poor water quality. |
| 7 | Poor quality raw water can impact treatment process. |
| 8 | Insufficient flow can have a negative impact on treatment process. |
| 9 | Capacity of the works is not sufficient for needs. |
| 10 | Poor or inappropriate materials of construction can lead to treatment failure. |
| 11 | Instrumentation failure (e.g. telemetry, SCADA) can lead to loss of process control. |
| 12 | Poor operational monitoring can lead to water quality failures (e.g. ineffective/insufficient monitoring at various control points). |
| 13 | Power supply can result in interrupted treatment/loss of process control. |
| 14 | By-pass facility for untreated water due to inadequate treatment/treatment failure. |
| 15 | On-site reservoirs can be compromised/contaminated. |
| 16 | Inappropriate maintenance can lead to treatment failure. |
| 17 | Natural disasters (e.g. storms, earthquake) can damage treatment unit operations. |
| | **Pre-oxidation** |
| 1 | Under dosing of oxidant due to dosing malfunction, power failure, oxidant supply runs out or increased demand on raw water. |
| 2 | Overdosing of oxidant due to dosing system malfunction or decreased demand of water. |
| 3 | Pre-oxidation cause cyanobacteria to burst and release toxins. |
| 4 | Treatment chemicals of poor quality/unapproved treatment chemicals. |
| | **Coagulation, Flocculation and Sedimentation** |
| 1 | Dosing malfunction can reduce floc formation and thus the inefficient removal of harmful micro-organisms, organic material, colour and turbidity. |
| 2 | Chemical supply runs out so treatment effectively stops. |
| 3 | Large changes in flow rate or turning the works on/off can impair coagulation and flocculation. |
| 4 | Poor control of pH and alkalinity can reduce coagulation and floc formation. |
| 5 | Flocculation and particle removal can be reduced if mixing of chemicals poor (insufficient turbulence). There is not enough contact time for floc formation or floc does not settle properly. |
| 6 | Inadequate floc settling can result from wind and/or low temperatures. |
| 7 | Coagulation, flocculation and sedimentation can be compromised if biofilm growth is not controlled. |
| 8 | Changes in raw water quality can occur either seasonally or following events such as bushfire or floods. If dosing of coagulant and flocculant is not modified in response to water quality changes, treatment will be impaired. |
| 9 | Use of wrong chemicals can impair treatment and contaminate product water. |
| 10 | Treatment chemicals of poor quality/unapproved treatment chemicals. |

| | |
|---|---|
| | **Filtration (e.g. Rapid, Slow Sand, Multimedia, MF/UF)** |
| 1 | Sudden increase in flow rate can lead to inadequate removal of turbidity (and particles) and harmful micro-organisms. |
| 2 | Hydraulic shock due to sudden open and closing of valves can lead to inadequate removal of turbidity (and particles) and harmful micro-organisms. |
| 3 | Incomplete or insufficient backwash (too short, rate to low, air scour inadequate or too short) can lead to inadequate removal of turbidity (and particles) and harmful micro-organisms. |
| 4 | Rapid start up following backwashing can lead to inadequate removal of turbidity (and particles) and harmful micro-organisms. |
| 5 | Failure to reduce flow rates during backwashing can lead to inadequate removal of turbidity (and particles) and harmful micro-organisms. |
| 6 | Media displacement, cracking or loss can lead to inadequate removal of turbidity (and particles) and harmful micro-organisms. |
| 7 | Media blockage including mudballs can lead to inadequate removal of turbidity (and particles) and harmful micro-organisms. |
| 8 | Trapping of air bubbles including air binding can lead to inadequate removal of turbidity (and particles) and harmful micro-organisms. |
| | **Powdered/Granular Activated Carbon** |
| 1 | Poor operation leading to inadequate removal of cyanobacterial (blue-green algae) toxins. |
| 2 | Poor operation leading to inadequate removal of taste and odour compounds (geosmin and MIB). |
| 3 | Poor operation leading to inadequate removal of pesticides and organic compounds. |
| 4 | Poor operation leading to inadequate removal of naturally occurring organic matter, increasing turbidity. |
| 5 | Inadequate design (e.g. insufficient empty bed contact time) results in insufficient removal of target contaminants. |
| 6 | Inadequate maintenance leading to increased head loss and insufficient production capacity. |
| 7 | Inadequate backwashing/maintenance leading to increased biological growth in filters and poor water quality. |
| | **Chlorination (Including Secondary Chlorination)** |
| 1 | Dosing malfunction due to equipment failure or power failure. Possible interruption to chlorination (chlorine under dosing, chlorine overdosing). |
| 2 | Disinfection chemical supply runs out. |
| 3 | Chlorine under dosing (inadequate contact time) may occur due to increased chlorine demand in raw water or increased water flows. Changes in water quality could be seasonal or due to events such as heavy rain or bush fires. |
| 4 | Chlorine overdosing may occur due to decreased chlorine demand in raw water or decreased water flows. |
| 5 | Low free chlorine residual in the distribution system reduces protection against faecal contamination and free living organisms. |
| 6 | Treatment chemicals of poor quality/unapproved treatment chemicals. |
| 7 | Chlorination facilities not complying to safety regulations can lead to chlorine gas leakages. |
| | **Ozonation** |
| 1 | Inappropriate pre-treatment may result in particles in the water and ineffective disinfection. |
| 2 | Ozonation may be interrupted due to equipment malfunction, exhaustion or power failure (e.g. failing air compressor, failing oxygen supply, failing ozone generator). |
| 3 | Failure or incorrect calibration of the gas meter or dissolved ozone meter can lead to the ozone dose being too low. |
| 4 | Increased water flows can lead to under dosing (inadequate contact time). |
| 5 | High pH (> 8) or high turbidity can result in under dosing. |
| 6 | Bromide may be present in raw water. |

| | |
|---|---|
| | **Ultraviolet Radiation** |
| 1 | Inappropriate pre-treatment may result in particles in the water and ineffective disinfection. |
| 2 | Incorrect dosing location results in too short reaction time for disinfection. |
| 3 | Disinfection may be interrupted by equipment malfunction, aging equipment or power failure. |
| 4 | Inadequate irradiation (disinfection) may be due to increased turbidity or colour in raw water or increased flows. |
| | **Softening** |
| 1 | Softened water can be corrosive and leach chemicals from pipes. |
| 2 | Softening of very hard waters using ion exchange can lead to increased concentrations of sodium in the water. |
| 3 | Organic material may accumulate in resins (where used) and support microbial growth. |
| 4 | Where lime softening is used incorrect dosing or poor pH control can reduce the efficiency of the process and may interfere with other treatment processes (e.g. if used in conjunction with coagulation, flocculation and sedimentation). |
| 5 | Where lime softening is used, treatment chemicals may be of poor quality. |
| 6 | If NF membranes are used and inadequate electricity supply exists, the process cannot operate. |
| 7 | If NF membranes are used and inadequate skills exist, system failure may occur. |
| 8 | Source water very hard (> 200 mg calcium carbonate). |
| | **Stabilisation** |
| 1 | Unstablised water can be corrosive and leach chemicals from pipes. |
| 2 | Where lime stabilisation is used incorrect dosing or poor pH control/lack of CO2 can reduce the efficiency of the process. |
| 3 | Where lime stabilisation is used, treatment chemicals may be of poor quality. |
| 4 | Where limestone stabilisation is used, lack of maintenance (e.g. flushing of bed, irregular topping up of limestone bed) can lead to poor performance. |
| 5 | Source water very soft (0 mg calcium carbonate). |
| | **Membrane Filtration** |
| 1 | If membranes are incorrectly operated and maintained (i.e. erratic hydraulic stress, inadequate pre-treatment, poor cleaning), system failure may occur. |
| 2 | If membranes are used and inadequate skills exist, system failure may occur. |
| 3 | If membranes are used and inadequate spares/back-up equipment exist, system failure may occur. |
| | **Desalination** |
| 1 | If RO membranes are used and inadequate electricity supply exists, the process cannot operate. |
| 2 | If RO membranes are used and inadequate skills exist, system failure may occur. |
| 3 | If RO membranes are used and inadequate spares/back-up equipment exist, system failure may occur. |
| | **Ion Exchange** |
| 1 | Spent resin is disposed of in an appropriate manner. |
| | *End* |

**Table A3:** *Drinking Water Network possible hazards*

| **Distribution Network** | |
|---|---|
| | **Protected Service Reservoir (Covered Storage Tank)** |
| 1 | Animals/birds can enter through faults (e.g. cracks in roof, walls or floor) and contaminate the water with their droppings. If animals drown, there will be a higher level of harmful micro-organisms present. |
| 2 | Animal/bird droppings may be washed into storages in rainwater entering through faults in the storage roof or from internally draining roofs. |
| 3 | Unauthorised human access, such as swimming in the storage tanks can cause microbial contamination. |
| 4 | Excessive pressure build-up could lead to reservoir structural damage. |
| 5 | High chlorine levels may enter the distribution system if there is poor mixing after disinfection of storages. |
| 6 | Resuspension of sediments containing slimes and odour producing micro-organisms may occur. |
| 7 | Water quality may deteriorate due to aging of water caused by low turnover rates, uneven hydraulic mixing, etc. |
| 8 | Poor hygiene during reservoir construction/repairs/cleaning can contaminate the water supply. |
| 9 | Natural disasters (e.g. storm, earthquake, flood) may damage or destroy reservoir resulting in contaminated/no water supply. |
| 10 | Man made incidents (e.g. truck accident) may damage or destroy reservoir resulting in contaminated/no water supply. |
| 11 | Vandalism or sabotage may pollute the water with chemicals or microbes or damage equipment and infrastructure. |
| 12 | Poor monitoring can lead to contaminated/no water supply (e.g. failure of telemetry, no water quality monitoring). |
| | **Unprotected Service Reservoir (Uncovered Storage Tank)** |
| 1 | Animals/birds can enter through faults and contaminate the water with their droppings. If animals drown, there will be a higher level of harmful micro-organisms present. |
| 2 | Animal/bird droppings may be washed into storages in rainwater entering through faults in the storage roof or from internally draining roofs. |
| 3 | Growth of cyanobacteria (blue-green algae) and other algae can be a problem where storage tanks are open to sunlight. |
| 4 | Spray drifts from nearby farming activities including pesticides and agricultural chemicals can enter storage as well as dirt and other wind borne debris. |
| 5 | Bushfires may lead to retardants and large amounts of ash entering storage. |
| 6 | Unauthorised human access, such as swimming in the storage tanks can cause microbial contamination. |
| 7 | High chlorine levels may enter the distribution system if there is poor mixing after disinfection of storages. |
| 8 | Resuspension of sediments containing slimes and odour producing micro-organisms may occur. |
| 9 | Water quality may deteriorate due to aging of water caused by low turnover rates, uneven hydraulic mixing, etc. |
| 10 | Poor hygiene during reservoir construction/repairs/cleaning can contaminate the water supply. |
| 11 | Natural disasters (e.g. storm, earthquake, flood) may damage or destroy reservoir resulting in contaminated/no water supply. |
| 12 | Man made incidents (e.g. truck accident) may damage or destroy reservoir resulting in contaminated/no water supply. |
| 13 | Vandalism or sabotage may pollute the water with chemicals or microbes or damage equipment and infrastructure. |
| 14 | Poor monitoring can lead to contaminated/no water supply (e.g. failure of telemetry, no water quality monitoring). |
| | **Pump Station** |
| 1 | Pump failure (e.g. pump malfunction, power failure, incorrect settings) may result in low flow/no water supply. |
| 2 | Natural disasters (e.g. storm, earthquake, flood) may damage or destroy pump station resulting in contaminated/no water supply. |

| | |
|---|---|
| 3 | Man made incidents (e.g. truck accident) may damage or destroy pump station resulting in contaminated/no water supply. |
| 4 | Vandalism or sabotage may pollute the water with chemicals or microbes or damage equipment and infrastructure. |
| 5 | Poor hygiene during pump installation, maintenance or repair can contaminate the water supply. |
| 6 | Poor monitoring can lead to contaminated/no water supply (e.g. failure of telemetry, no water quality monitoring). |
| | **Valves and Meters** |
| 1 | Valve or meter failure (e.g. wear of mechanical parts, power failure, incorrect settings) may result in low flow/no water supply. |
| 2 | Poor hygiene during valve/meter installation, maintenance or repair can contaminate the water supply. |
| 3 | Poor pressure management (e.g. malfunctioning/failure of pressure reducing valves) can result in excess pressure in the network and result in damaged valves, water wastage, etc. |
| | **Distribution System** |
| 1 | Excessive pressure build-up could lead to reservoir structural damage. |
| 2 | Pipe burst and leaks can interrupt the water supply. Contamination can occur where water pipes are below or close to stormwater or sewage pipes or in an area with septic tanks leading to microbial and chemical contamination. Entry of soil may increase turbidity. |
| 3 | Microbial or chemical contaminants can enter the water supply system through cross-connections, unauthorised connections or backflow (e.g. pressure fluctuations, intermittent supply). |
| 4 | Poor hygiene during pipe repairs/cleaning can contaminate the water supply. |
| 5 | Entry of soil during repair and maintenance can increase turbidity and contaminate water. |
| 6 | Inadequate disinfection or flushing before commissioning of new mains results in chemical and microbial contamination. Presence of soil may increase turbidity. |
| 7 | Contaminated water may enter the system during flooding, particularly through above ground hydrants and air valves. Microbial and chemical contamination possible. Presence of soil may increase turbidity. |
| 8 | Raised temperatures (e.g. 25-30 deg C) in long, above ground pipelines can support the growth of some organisms. |
| 9 | Leaching from cement pipes, particularly during periods of low flow, can cause a high pH. |
| 10 | Changes in flow or increased concentrations of disinfectant can cause sloughing and resuspension of biofilms. |
| 11 | Opening/closing valves – reversed or changed flow disturbing deposits, introduction of stale water. |
| 12 | Third party access to hydrants – contamination by backflow, increased flow disturbing deposits. |
| 13 | Dead-end mains and low water flows can lead to stagnant water and loss of residual chlorine. |
| 14 | Unsuitable coatings and materials can leach chemicals or support bacterial growth. |
| 15 | Loss of pipe hydraulic capacity (scaling/tubercle formation) can result in reduced/insufficient or no water supply. |
| 16 | Chlorine under/over-dosing at Chlorine Booster Stations. |
| 17 | Lack of safety precautions at Chlorine Booster Stations can lead to hazardous conditions. |
| 18 | Vandalism or sabotage may pollute the water with chemicals or microbes or damage equipment and infrastructure. |
| 19 | Poor pressure management (e.g. malfunctioning/failure of pressure reducing valves) can result in excess pressure in the network and result in burst pipes, water wastage, etc. |
| 20 | Poor monitoring can lead to contaminated/no water supply (e.g. failure of telemetry, no water quality monitoring). |

| | |
|---|---|
| | **Household Connections** |
| 1 | Household plumbing can (i) leach chemicals that have health impacts or cause tastes and odours, (ii) support microbial growth that can also cause tastes and odours. |
| 2 | Household plumbing can become corroded through incorrect installation or from action of water supply on fittings. |
| 3 | Backflow from household plumbing devices or water storages (e.g. rainwater tanks, swimming pools, garden ponds) can contaminate drinking water systems. |
| | **Community Standpipes** |
| 1 | Poor access to standpipe leads to unavailability of water/interruption in supply. |
| 2 | Backflow from tankers connecting to standpipes can lead to microbial and chemical contamination of the water. |
| 3 | Water standing at access points can attract birds and animals raising vector and disease concerns. |
| 4 | Damage/vandalism to the filling point can interrupt supply and allow entry of contamination. |
| 5 | Containers used to collect and transport the water may be contaminated. |
| 6 | Spillage of chemicals (e.g. fuel/detergents from leaking containers) in proximity of the standpipe can cause contamination. |
| | **Rain Water Harvesting** |
| 1 | Roof paint contains chemical contaminants. |
| 2 | Foliage collection over/along gutters and rooftops. |
| 3 | Bird/animal droppings contaminate water. |
| 4 | First flush of water can enter storage tank. |
| | **Household Treatment and Storage** |
| 1 | Chlorine under dosing. |
| 2 | Chlorine overdosing. |
| 3 | Re-contamination of water due to incorrect/improper use of tap based filter. |
| 4 | Re-contamination of water due to storage in open containers that may be accessible to birds/animals/dust/dirt. |
| 5 | Re-contamination due to unhygienic practices when handling/drawing water from the storage container. |
| 6 | Re-contamination due to use of improper storage container (e.g. metal drums) and the container not being maintained in a clean condition. |
| | **Tanker Truck Delivery** |
| 1 | Re-contamination of water due to storage in tanker truck that is not clean from previous use or sterile. |
| | *End* |

# APPENDIX B

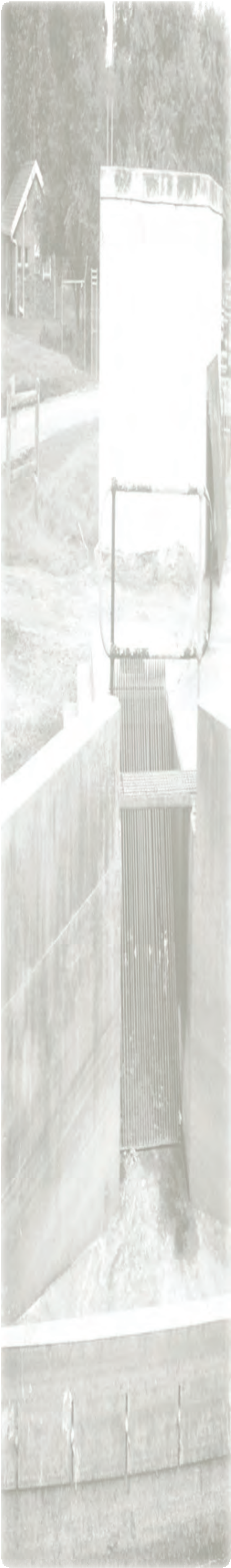
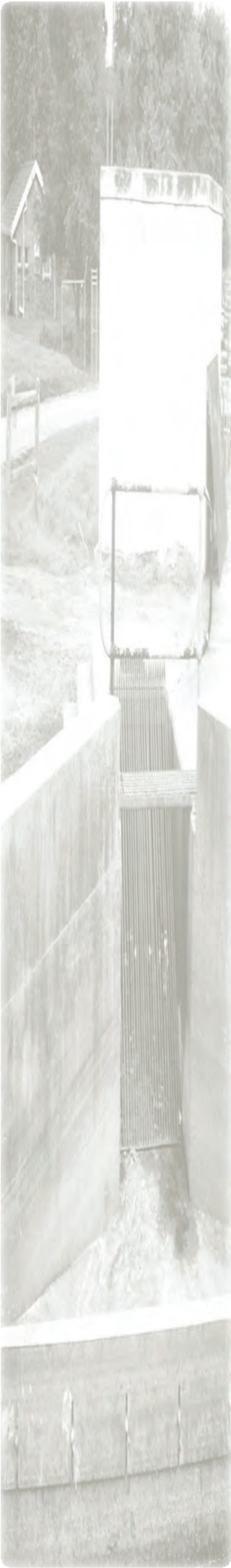


**Table B1: Possible Control Measures**

| **A** | **Policies, Plans and Procedures** |
|---|---|
| A1 | Water Master Plan prepared |
| A2 | Sewage Master Plan prepared |
| A3 | Stormwater Master Plan prepared |
| A4 | Water Services Development Plan (WSDP) prepared |
| A5 | Integrated Development Plan (IDP) prepared |
| A6 | Water treatment works operating procedure and maintenance schedule prepared |
| A7 | Reservoir operating procedure and maintenance schedule prepared |
| A8 | Distribution network operating procedure and maintenance schedule prepared |
| A9 | Sewage system operating procedure and maintenance schedule prepared |
| A10 | Wastewater treatment works operating procedure and maintenance schedule prepared |
| A11 | Human resources policy, plans and procedures prepared |
| A12 | IT systems policy, plans and procedures prepared |
| A13 | Institutional memory policy, plans and procedures prepared |
| A14 | Emergency plans, plans and procedures prepared |
| A15 | Disaster management policy, plans and procedures prepared |
| A16 | Financial management policy, plans and procedures prepared |
| A17 | Supplier/contractor contracts prepared |
| A18 | Customer contracts prepared |
| A19 | Customer information sharing policies, plans and procedures prepared |
| A20 | Customer complaints policies, plans and procedures prepared |
| **B** | **Appointments** |
| B1 | Appropriate Municipal Manager appointed |
| B2 | Appropriate Technical Manager appointed |
| B3 | Appropriate Heads of Department appointed (number and skills) |
| B4 | Appropriate Supervisors appointed (number and skills) |
| B5 | Appropriate water treatment works process controllers appointed (number and skills) |
| B6 | Appropriate wastewater treatment works process controllers appointed (number and skills) |
| B7 | Appropriate plumbers/field technicians appointed (number and skills) |
| B8 | Appropriate mechanical repairs staff or contractor appointed (number and skills) |
| B9 | Appropriate electrical repairs staff or contractor appointed (number and skills) |
| B10 | Appropriate laboratory staff or contractor appointed (number and skills) |
| **C** | **Redundancy/Alternatives/Back-ups** |
| C1 | Redundant water source(s) (e.g. surface, ground) |
| C2 | Redundant water intake structure(s) |
| C3 | Redundant raw water transfer pump(s) |
| C4 | Redundant raw water transmission line(s) |
| C5 | Redundant water treatment chemical tank(s) and dosing pump(s) |
| C6 | Redundant water treatment unit process(es) (e.g. settling tanks, filters) |
| C7 | Redundant treated water clear well(s) |



| | |
|---|---|
| C8 | Redundant treated water transfer pump(s) |
| C9 | Redundant treated water transmission line(s) |
| C10 | Redundant treated water storage option(s) |
| C11 | Redundant raw sewerage line(s) |
| C12 | Redundant wastewater treatment chemical tank(s) and dosing pump(s) |
| C13 | Redundant wastewater treatment unit process(es) (e.g. settling tanks, tanks) |
| C14 | Redundant treated effluent tertiary treatment/storage |
| C15 | Alternative disinfection chemicals |
| C16 | Alternative treatment chemicals |
| C17 | Alternative vendors (e.g. chemical suppliers) |
| C18 | Back-up of key documents |
| C19 | Back-up of key IT applications |
| C20 | Back-up of key data/information |
| **D** | **Physical Detection Measures** |
| D1 | Guard(s) |
| D2 | Signage |
| D3 | Site lighting |
| D4 | Manual remote access permission (e.g. intercom linked to camera) |
| D5 | Card-key badge system |
| D6 | Entry code or pin input system |
| D7 | Periodic local and entry code changes |
| D8 | Alarmed cameras |
| D9 | Fixed cameras |
| D10 | Manual pan-tilt-zoon cameras |
| D11 | Fence associated sensors |
| D12 | Free standing sensors |
| D13 | Boundary penetration sensors |
| D14 | Glass-break sensors |
| D15 | Interior motion sensors |
| D16 | Proximity sensors |
| D17 | Security escort service |
| D18 | Inspection of packages |
| D19 | Metal detector “doorways” |
| D20 | Security awareness program |
| D21 | Continuous process monitoring |
| D22 | Chlorine measurement systems |
| D23 | Pressure sensors in distribution network |
| D24 | Antivirus software installed and up to date |
| D25 | IT application monitoring (e.g. accounting package) |
| D26 | IT systems configuration management (e.g. use approved hardware/software) |
| D27 | Firewalls |
| D28 | IT network intrusion detection |
| D29 | Use secure IT service provider |
| D30 | Physical access control to IT systems |

| | |
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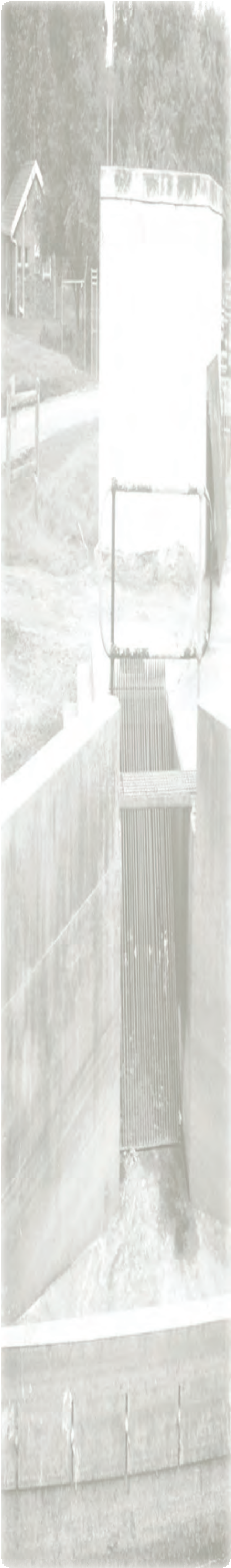
| D31 | IT referential integrity (e.g. check current/new applications to verify not tampered with) |
| D32 | Secondary user ID & password (e.g. two people make changes to critical applications) |
| D33 | Separation of IT system duties (i.e. not one person controls) |
| D34 | Technical audits of IT systems |
| D35 | Data/information encryption (e.g. on network) |
| D36 | Access to and monitoring of weather conditions (e.g. storms, floods) |
| D37 | Vendor screening process |
| D38 | Employee screening process |
| D39 | Chain of custody enforcement with chemical deliveries |
| D40 | Inspection of all packages |
| D41 | Co-ordination with local hospitals/clinics |
| D42 | Disgruntled employees monitoring (email and network access) |
| D43 | ID check procedure |
| D44 | Information classification procedure |
| D45 | Landscaping maintenance checks |
| D46 | Telephone call monitoring |
| D47 | Explosive mixture detectors (VOC) |
| D48 | Biological water contamination sensors |
| D49 | Chemical water contamination sensors |
| D50 | Total organic carbon analyzers |
| D51 | Chemical detection sensors (e.g. gases) |
| D52 | Explosive detection sensors |
| D53 | Toxicity monitoring/metering equipment |
| D54 | Radiation detection equipment for monitoring personnel/Radiological contamination sensors |
| **E** | **Physical Delay Measures** |
| E1 | Razor mesh fence |
| E2 | Chain link fence |
| E3 | Barb wire fence |
| E4 | Hardened doors |
| E5 | Hardened gates |
| E6 | Hardened ladder access |
| E7 | Hardened windows |
| E8 | Perimeter concrete wall |
| E9 | Bollards (concrete or other material post) |
| E10 | Jersey barriers/concrete barriers |
| E11 | Bullet resistant windows |
| E12 | Films for glass shatter protection |
| E13 | Backflow prevention devices – commercial |
| E14 | Backflow prevention devices – fire hydrants |
| E15 | Backflow prevention devices – residential |
| E16 | Outfall entry barrier |
| E17 | Secured fill and vent pipes |
| E18 | Secured fire hydrants |



| | |
|---|---|
| E19 | Secured manholes |
| E20 | Secured wellheads |
| E21 | Doors and windows locking procedure enforced |
| E22 | Maintain vehicular setback from buildings |
| **F** | **Physical Response Measures** |
| F1 | Boil water notice |
| F2 | Public address or other warning system |
| F3 | Media (TV, radio, news) contact |
| F4 | Automatic flow gates |
| F5 | Alternate electric switching equipment |
| F6 | Alternate power sources |
| F7 | Back-up power generation on-site |
| F8 | Personal protection equipment (PPE) for employees |
| F9 | Mitigation protection equipment (e.g. spray mace) |
| F10 | Alternative water supply |
| F11 | Remotely monitored “panic switch” |
| F12 | Emergency operating procedural plan |
| F13 | Evacuation plans (e.g. fire, bomb) |
| F14 | Co-ordination with local police |
| F15 | Co-ordination with fire department |
| F16 | Decontamination procedural plan |
| F17 | HAZMAT procedural plan |
| F18 | Development and maintenance of calibrated hydraulic models (flow) |
| F19 | Isolation and flushing procedure within distribution network |
| F20 | Scripted public relations documents |
| F21 | Off-site storage of duplication keys |
| F22 | Regional spare parts/critical equipment inventories |
| F23 | Training in all procedures (e.g. drills) |