DRINKING WATER SAFETY PLANNING

A Practical Guide For Pacific Island Countries

Australian Government
AusAID

SOPAC

The World Health Organization

South Pacific Office

Suva, Fiji

&

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World Health Organization and Pacific Islands Applied Geoscience Commission

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Preface

Morbidity and mortality from the consumption of unsafe drinking water continues to impact communities in Pacific Island Countries. Access to safe drinking water is a basic need and is one of the most important contributors to public health.

The Millennium Development Goals put in place at the UN Summit (2000) set targets to be achieved by 2015 that included halving the proportion of people without access to safe drinking water. The World Health Organization Guidelines for Drinking Water Quality (Third Edition, 2005) outline a framework for safe drinking water. This framework includes Drinking Water Safety Plans (DWSPs), which can be implemented by those responsible for supplying drinking water to help improve the safety of drinking water in the Pacific.

The need for improved, and holistic, drinking water supply management was highlighted during the Pacific consultation meeting for the Tokyo Summit, held in Sigatoka, Fiji in late 2002. The resolutions developed during the meeting were summarized in the Regional Action Plan for Sustainable Water Management in the Pacific, which was endorsed by 18 PICs and signed off by 16 Heads of States.

This was further entrenched in the Regional Action Framework on Drinking Water Quality Monitoring (Nadi, 2005), where a specific resolution on the need for Pacific Island Countries to adopt the Drinking Water Safety Plan approach was first made.

This regional framework was further endorsed by the Health Ministers of PICs in the Samoa Commitment, providing a strong policy base for the introduction of Drinking Water Safety Plans in the Pacific in 2006.

Four initial pilot countries and several "replication" countries have since developed and implemented DWSPs. The lessons learned and experiences gained from these countries provides the foundation for this Guide.

This Guide is primarily for water supply managers, engineers and operators and introduces a more proactive way of managing drinking water supplies through a comprehensive risk assessment and risk management approach. Implementing DWSPs helps achieve a more effective drinking water supply system.

While it is primarily targeted at water suppliers, this Guide should also assist other organizations, such as drinking water regulators and surveillance authorities gain a better understanding of the role played by a drinking water safety plan in improving or maintaining public health.

It is important to realize that drinking water safety is an issue that cuts across several sectors, most significantly water supply and utilities, Health and Environment, but also land and water resource management, national planning and economics, NGOs, private sector and community based organizations. As such the success of developing and implementing an effective DWSP is increased significantly by engaging other sectors rather than the water supply operators or utilities working in isolation.

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This Guide would not have been possible without the expert advice and technical support of drinking water experts from the New Zealand Ministry of Health through the PIC programme funded by NZAID and NZAID GAF.

List of acronyms

AusAID	Australian Agency for International Development
DWSP	Drinking Water Safety Plan
EU	European Union
FAC	Free Available Chlorine
GDWQ	Guidelines for Drinking Water Quality
HACCP	Hazard Analysis Critical Control Points
H2S	Hydrogen Sulphide Paperstrip Test
IAS	Institute of Applied Science (a branch of USP see below)
IEC	Information, Education and Communication
IS	Improvement Schedule
IWP	International Waters Project
MDGs	Millennium Development Goals
MoH	Ministry of Health
NGOs	Non Government Organizations
NSCs	National Steering Committees
NZAID	New Zealand Agency for International Development
NZGAF	New Zealand Government Agencies fund
NZODA	New Zealand Official Development Assistance
PICs	Pacific Island Countries
SOP	Standard Operating Procedure
SOPAC	Pacific Islands Applied Geoscience Commission
SPC	Secretariat of the Pacific Community
SPREP	South Pacific Regional Environment Programme
UN	United Nations
USP	University of the South Pacific
WHO	World Health Organization
WQM	Water Quality Monitoring
WSPs	see DWSPs

About this guide

Purpose of this guide

The 'Drinking Water Safety Planning – A Practical Guide for Pacific Island Countries' has been developed to assist drinking water supply operators and managers improve the day-to-day management of the water supply with the objective of producing safe drinking water for consumers.

'Drinking Water Safety Planning – This guide has been developed based on lessons learned and practical experience gained through an AusAID funded joint SOPAC/WHO programme on drinking water safety planning in Pacific Island Countries. This project involved four pilot countries (Tonga, Cook Islands, Palau and Vanuatu). The lessons learned and approaches used by these countries provide the framework for drinking water safety planning explained in this Guide. The steps and processes described in this Guide are reinforced through case studies from the pilot countries.

Structure of this guide

The Guide is divided into two parts i.e. Part 1 – Setting up National Support Processes and Part 2- Drinking Water Safety Plan Manual.

Part 1 – Setting up National Support Processes, provides guidance on establishing the appropriate national framework for promoting and sustaining the use of Drinking Water Safety Plans to ensure safe drinking water for communities. Part 1 is divided into 4 stages involved in establishing a national framework for developing and implementing DWSPs.

Stage 1: Develop national strategy

This section describes the processes that need to be initiated at the National level to facilitate the development and implementation of DWSPs, such as identifying national goals and actions to ensure safe drinking water.

Stage 2: Develop drinking water safety plans

This section is described in detail in Part 2 of the Guide.

Stage 3: Surveillance

This section describes the role of surveillance by an external agency (apart from the water utility) in verifying the safety of drinking water and ensuring that public health risks from water-borne diseases are controlled.

Stage 4: Review the national strategy

This section describes how to gauge the efficacy of the DWSP in improving drinking water safety, and thus reducing public health risks from water-borne diseases and achieving other goals established in 'Stage 1 – Develop National Strategy'.

Part 2 – Drinking Water Safety Plan Manual, provides step-by-step guidance on how to develop, implement and review Drinking Water Safety Plans. Part 2 is divided into eight (8) sections based on the eight (8) steps involved in developing and implementing a Drinking Water Safety Plan.

Step 1: Assemble the DWSP team

This section describes the process of assembling a team that will facilitate the development of the Drinking Water Safety Plan.

Step 2: Describe the drinking water supply

This section outlines how to describe a drinking water supply in a way that captures all key processes and components of the supply, allowing for risks to be easily identified.

Step 3: Identify and prioritize risks

This section explains the risk identification and prioritization process. A systematic approach to risk assessment is described.

Step 4: Identify corrective actions and improvements and develop an improvement schedule

This section describes how to develop a plan of action for implementing corrective actions and/or improvements identified by the DWSP Team.

Step 5: Develop monitoring schedule

This section explains the important role of monitoring within a drinking water supply. The section outlines the various aspects of monitoring and describes how to develop a monitoring plan.

Step 6: Improve processes that support drinking water safety

This section discusses some of the functions of a water supply, which have contributed towards ensuring drinking water safety.

Step 7: Verification

The DWSP must be verified to establish whether there has been any improvement in the drinking water safety. This section provides guidance on how a DWSP may be verified.

Step 8: Review

The DWSP must be reviewed at regular intervals. This section outlines the review process.

Contents

Introduction to drinking water safety planning

Access to safe drinking water is a basic need and is one of the most important contributors to public health and to the economic health of communities. Pacific Island Countries have yet to overcome the challenge of providing a safe and adequate supply of drinking water to its populations. Infectious, waterborne diseases, such as typhoid and cholera and newly emerging pathogens, are a major cause of morbidity and mortality within the Pacific region.

The World Health Organization (WHO) reports that about 2 million people in the world die each year due to diarrhoeal diseases, most of them are children less than 5 years of age. The worst affected are the populations in developing countries. Lack of access to safe drinking water is one of the main contributors to this situation.

Pacific Island Countries are committed to achieving targets specified in the Millennium Development Goals (2000), including halving the proportion of people without access to safe drinking water by 2015.

Drinking-water quality control is a key issue in public health policies. From 1950 to 1970 the World Health Organization (WHO) published standards for drinking-water quality that served as a scientific basis for monitoring the quality of the water produced and delivered by water suppliers. Later on, other legislative and regulatory approaches were published by the WHO and the European Union (EU): WHO Guidelines for Drinking Water (1st edition, 1984, and 2nd edition, 1993), and EU Directives 80/778/EC, and 98/83/EC (EC, 1998). This legislation was strongly focused on standards for treated drinking water and on compliance monitoring. Water quality was guaranteed by the so-called end product testing, based on spot sampling of the water produced.

Over the years, several shortcomings and limitations of the end-product testing methodology has been identified. Some of them are related to the following aspects:

a) There is a multitude of water-borne pathogens that cannot be detected or they can be detected insecurely with the classical indicators E. coli and Enterococci, particularly viruses and protozoa. There are examples of water-borne disease outbreaks (e.g., Milwaukee - U.S.A., in 1993) that occurred through water supply systems that met the standard for absence of indicator micro-organisms.

b) Often, monitoring results are available too late to initiate effective intervention to maintain the safety of a supply system. End-product testing only allows checking if the water delivered was good and safe (or unsafe) after distributed and consumed.

c) End-product testing hardly can be considered a sound method for representative water quality status. A very small fraction of the total volume of water produced and delivered is subject to microbiological and chemical analysis. Moreover, the monitoring frequency does not guarantee representative results in time and space, as well.

d) End-product testing does not provide safety in itself. Rather is a means of verification that all the supply system components and installed control measures are working properly.

Drinking water supply

The provision of safe water intended for human consumption

Safe water

Water that is free of any harmful substance (contaminants) including physical, chemical, biological and microbiological agents that may cause serious health effects.

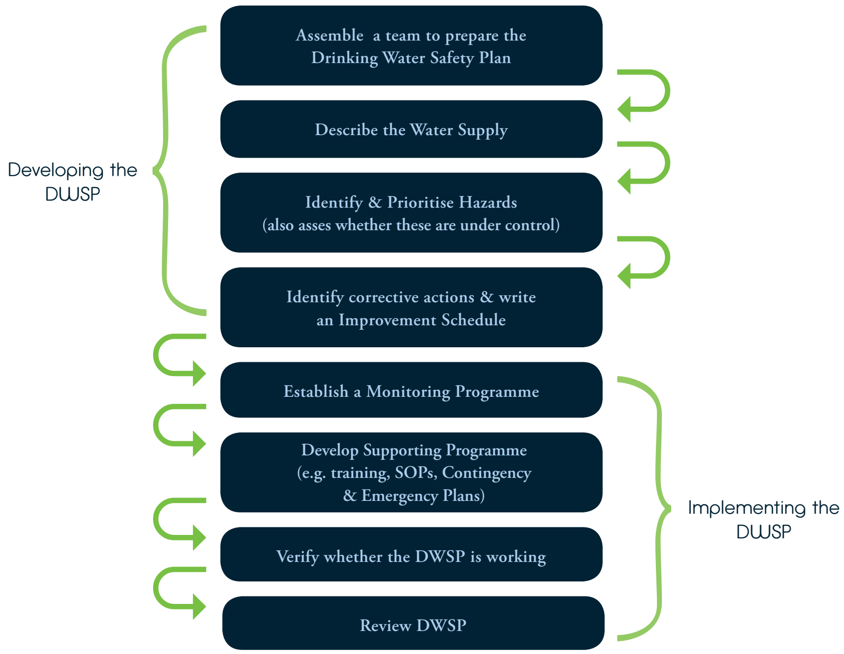
Water quality

This term "water quality" is used to describe the microbiological, physical and chemical properties of water that determine its fitness for a specific use. These properties are determined by substances which are either dissolved or suspended in water.

In recognition of these limitations, primary reliance on end-product testing is presently considered not to be sufficient to provide confidence in good and safe drinking-water, moving towards to process monitoring by introducing a management framework for safe water (Bartram et al., 2001). The 3rd edition of the WHO Guidelines for Drinking-water Quality, (GDWQ) proposes a more effective risk assessment and risk management approach for drinking-water quality control. The Guidelines emphasize the multi-barrier principle, establishing a systematic process for hazard identification and effective management procedures for their control through the application of a preventive Water Safety Plan (WSP) that comprises all steps in water protection, from catchment to the consumer.

Traditional approaches that rely on sampling and testing water have failed to achieve extensive improvement in access to safe drinking water. A new strategy is now being promoted globally that is based on risk management principles – drinking water safety planning.

Figure 1: Drinking Water Safety Planning Steps (WHO Guidelines for Drinking Water Quality, 2005)



What is a drinking water safety plan?

A Drinking Water Safety Plan (DWSP) is a comprehensive risk assessment and management tool that encompasses all steps in the drinking water supply from catchment to consumers. It draws on principles and concepts from other risk management approaches, including Hazard Analysis Critical Control Point (HACCP) and the 'multi-barrier approach'.
The key objectives of a Drinking Water Safety Plan are to:

- Prevent the contamination of source waters;
- Treat water to reduce or remove contaminants; and
- Prevent re-contamination during storage, distribution and handling of treated water.

Drinking water safety plan

"A comprehensive risk assessment approach that encompasses all aspects of a drinking water supply, from catchment to consumers, to consistently ensure the safety of drinking water supplies."

World Health Organization guidelines for drinking water quality, Third Edition, 2005.

Major benefits of developing and implementing a Drinking Water Safety Plan for drinking water supplies include:

1. Health benefit - Studies indicate that quality assurance processes such as Drinking Water Safety Plans can greatly reduce health burdens (Deere et al., 2001)
2. "Cost saving - studies have shown that by adopting the monitoring and verification process of the DWSP a cost saving of approximately 30% can be achieved" Investment planning - Increased monitoring at field level results in clearer prioritisation of system improvements
3. Greater risk assurance - Provides greater confidence in the continuous and sustainable delivery of drinking water
4. More integrated approach - Recognises the linkage between source water, treatment processes, distribution, storage and handling as potential areas of risk and suggests greater communication between agencies for integrated management
5. Improved asset management - Uses a systematic and considered approach towards identifying risks from the catchment to the consumer, providing enhanced detection of asset weaknesses e.g. leaking pipes, poor intake structures or no standard operating procedures

Developing a drinking water safety plan

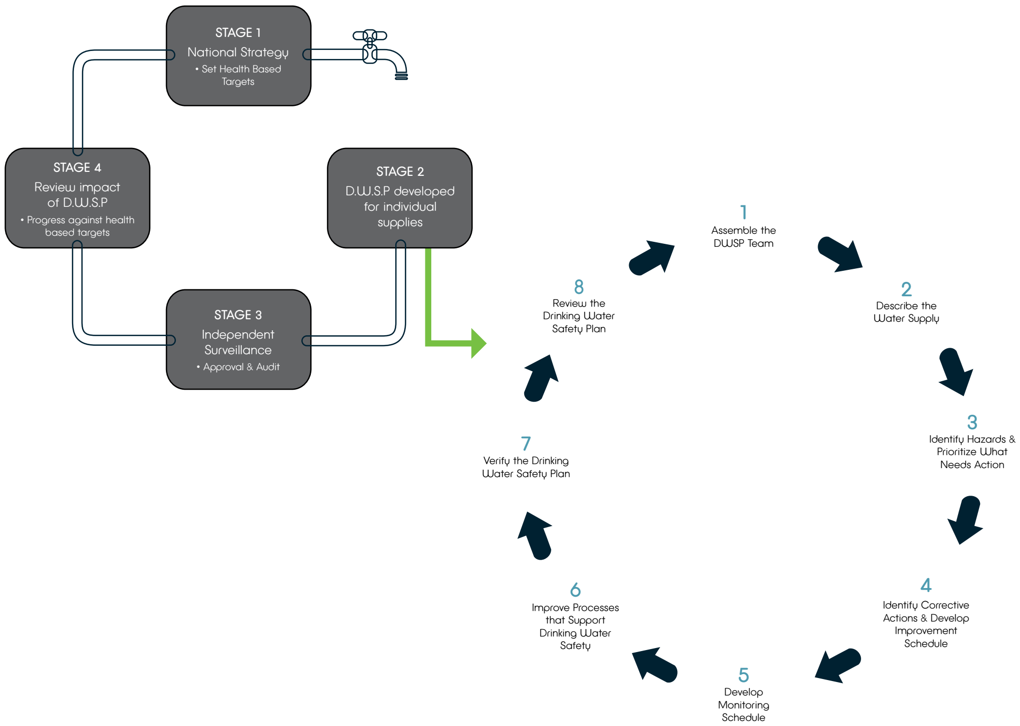
To develop a DWSP, the water authority or supplier needs to:

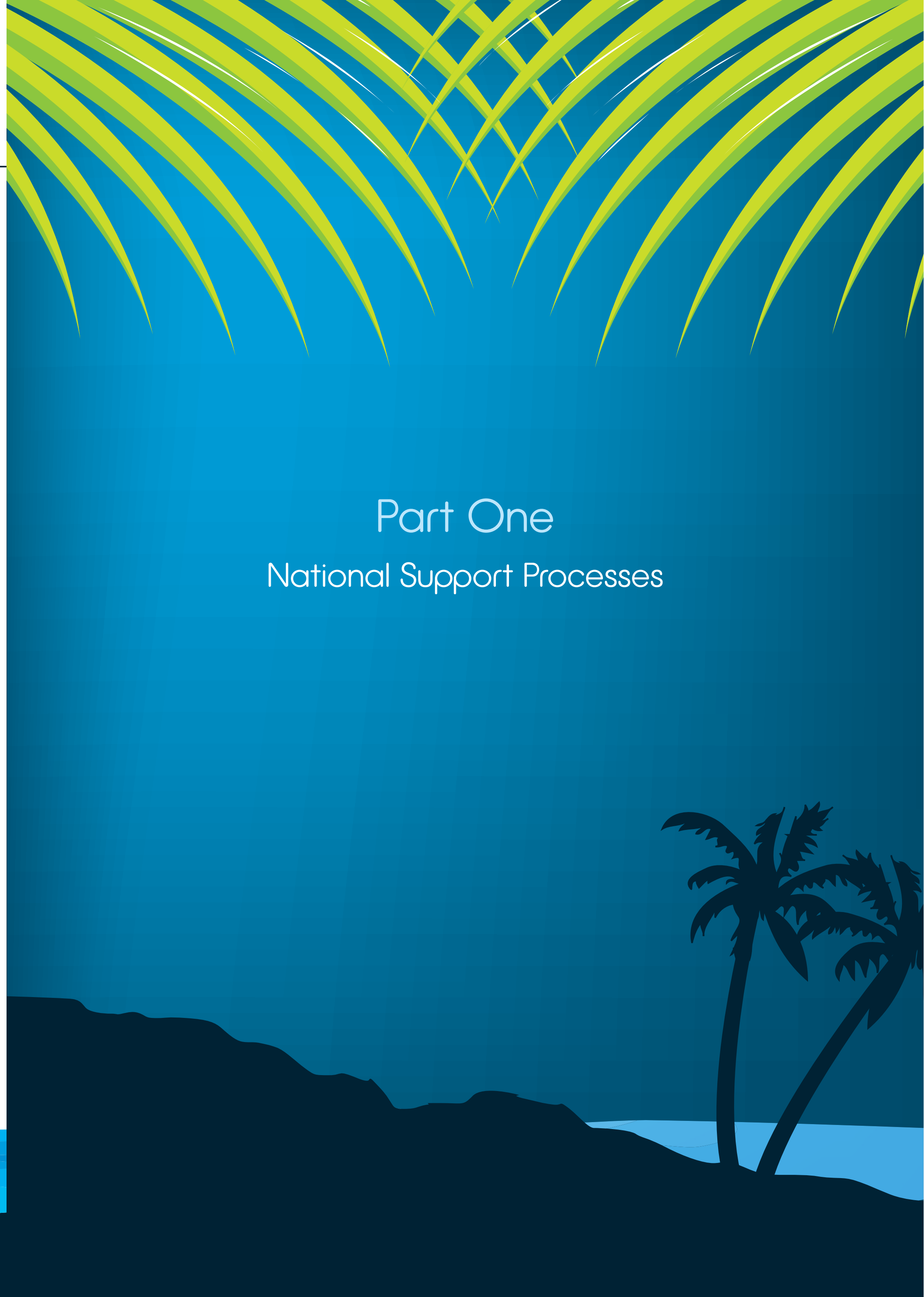
- assemble a team that understands the system;
- identify risks, hazards and hazardous events;
- identify means for controlling these risks, hazards and hazardous events;
- establish a monitoring system to ensure consistent supply of safe drinking water; and
- periodically review the Drinking Water Safety Plan.

The broader context of drinking water safety planning

The development of a DWSP for an individual drinking water supply is only one component of a wider drinking water safety planning process. In order to achieve sustainability, supporting processes - generally co-ordinated at a national level - should be put in place. The diagram below summarises the process.

Figure 2: Stages in the Drinking Water Safety Planning Process





Part One

National Support Processes

National support processes

Setting the foundations

Three important regional initiatives set the framework for drinking water safety planning in the Pacific region.

The first is the Samoa commitment, issued by Ministers of Health of Pacific Island Countries in March 2005, calling inter alia for the establishment of Water Safety Plans to ensure safe quality drinking water for Pacific communities.

The second is the Regional Action Framework on Drinking Water Quality Monitoring (Nadi, 2005), which was endorsed by Health Ministers of PICs in the Samoa Commitment.

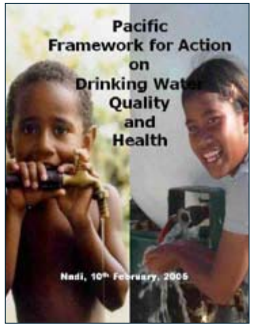
The third is the Regional Action Plan for Sustainable Water Management in the Pacific (Sigatoka, 2002), which was developed by the South Pacific Applied Geo-science Commission with support from the Asian Development Bank. The Regional Action Plan was endorsed by 18 countries and signed by 16 Head of States.

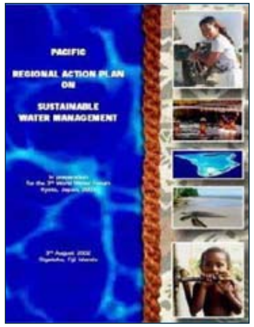
Following an indication of political interest, the SOPAC/ WHO Drinking Water Safety Plan project introduced the Drinking Water Safety Plan (DWSP) concept to the pilot countries by undertaking introductory workshops with participants from various agencies within the water sector.

The introductory workshops focused on explaining the key steps in developing a DWSP and completing a DWSP for an urban and a rural water supply as a means of demonstrating the feasibility and advantages of the approach. It is envisaged that other countries within the Pacific could replicate this approach, potentially involving experienced individuals from the pilot countries to assist in the introductory workshop.

For Drinking Water Safety Plans (DWSP) to be successful in the Pacific, drinking water supplies require external, independent support systems at a national level. Support is required in a number of areas. Experience obtained during the pilot country phase of the project highlighted the following key areas for national support:

- Development of policy, plans, objectives to support drinking water safety planning
- Provision of technical advice / guidance
- Co-ordination of agency responsibilities
- Provision of training / education / capacity-building programmes
- Provision or co-ordination of financial support





Initiate high level interest in drinking water safety planning

Link with millenium development goals & pacific regional action plan on sustainable water management & pacific framework for action on drinking water quality & health

↓

Establish a national steering committee

Identify relevant stakeholders & establish national committee to drive the drinking water safety planning process in the country. Identify the agency to 'lead' the national dwsp process.

↓

Undertake an introductory workshop with agencies involved in drinking water supplies

Complete example DWSP to demonstrate feasability & advantages of approach

↓

Begin the drinking water safety planning process

National-level processes (covered in Part 1 of this manual)
Individual supply level processes (covered in Part 2 of this manual)

Figure 3: Drinking Water Safety Planning Steps (WHO Guidelines for Drinking Water Quality, 2005)

In addition to these identified areas of support, international guidelines provide further advice on the support that is most usefully provided at a national level. In the revision of their Guidelines for Drinking-water Quality, the World Health Organization (WHO) identified that the establishment of health-based targets and independent public health surveillance of water safety are also activities most commonly undertaken at a national level.

The following section provides more detail on these areas where national level support and intervention is considered useful to the implementation of DWSP. It draws heavily on the experience gained from the national strategies and approaches identified and the resulting national plans that were developed by the pilot countries.

Before the detail of national-level support can be determined, however, Pacific Island Countries first need to ask the question:

Who should drive drinking water safety planning in the country?

Who should drive the drinking water safety planning process?

In most Pacific Island Countries, different agencies have the mandate and responsibility for different aspects of drinking water supply management. It is typical for an environmental agency to be responsible for catchment management and/or integrated water resource management; water suppliers (either operated by a utility, village or privately) are likely to be responsible for the abstraction, treatment, storage and distribution of drinking water; while a health agency may be responsible for drinking-water quality monitoring and health surveillance.

This segmentation is not unique to the Pacific, but does provide challenges when all agencies have a role with drinking water safety planning. So which agency should drive the drinking water safety planning process at a national level? International experience has shown that often it is the national health agency that will drive drinking water safety planning. There are limitations to this approach and in a Pacific context, resource limitations of vesting responsibility with one agency may be hard to overcome and/or restrict progress with drinking water safety planning. Ultimately it is up to the individual country to determine which agency is best suited to leading the process.

Pilot Country solution – Establishment of National steering committees

Instead of vesting responsibility for drinking water safety planning completely to one agency, the pilot countries all established 'National Steering Committees' with representatives from key agencies.

The role of the National Steering Committee was specifically aimed at co-ordinating the activities of the various key agencies. The steering committee generally appointed a 'lead agency' within the group.

Amongst other things, the steering committees:

- Identified the actions required for implementation of DWSP at the National level
- Identified the appropriate linkages between DWSP and existing national policies and legislations
- Developed activity and responsibility matrices to identify the specific roles and responsibilities of participating agencies in the development and/or implementation of DWSPs
- Formalized agreement on institutional arrangements and multi-agency cooperation
- Developed a list of expected outputs
- Developed a system for review and evaluation of drinking water safety planning

Forming a national steering committee in Tonga

In Tonga, the National Steering Committee for drinking water safety planning was developed during the initial SOPAC/WHO scoping mission. Representatives of the Tonga Water Board held consultative meetings with various stakeholders on an individual basis. These agencies were then invited to a roundtable meeting hosted by the Tonga Water Board, during which the establishment of a Drinking Water Safety Plan Steering Committee was further discussed.

During the meeting, the stakeholders identified their areas of interest and how they could assist in the development of a drinking water safety plan for the Nuku'alofa Water Supply (used as a trial example). The Chief Executive Officer of the Tonga Water Board was appointed as Chairperson and a structure for the Steering Committee was discussed and endorsed.

Forming too many committees was avoided, and existing committees were utilised where possible. For example in the Cook Islands the International Waters Project (IWP) National Steering Committee was renamed as the DWSP Steering Committee because the IWP was coming to an end and the committee had the same membership that was required for the DWSP programme. The lead agency was changed from the National Environment Service to the Ministry of Works.

Similarly, in Vanuatu, the existing National Water Resources Committee was given the responsibility for management of the Drinking Water Safety Planning Programme. The committee appointed Department of Geology, Mines and Water Resources (DGMWR) as co-ordinator of the programme.

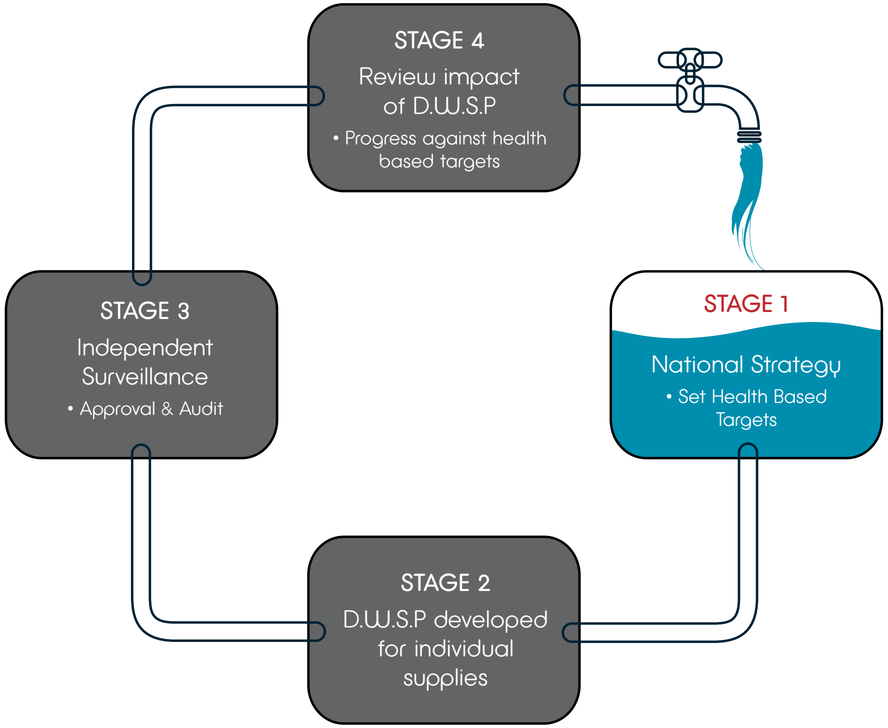
Development of drinking water quality standards

Most Pacific Island Countries do not have their own drinking water quality standards. National development of drinking-water standards may aid the use of targets that are realistic for the individual country. National standards may also have additional benefits in terms of intervention when standards are not met. However, where national water quality standards do not exist, the WHO or USEPA guidelines can be applied.

Development of legislation

Some of the pilot countries also suggested that they would like to develop legislation to support improvements in drinking-water quality / drinking-water supply management. This may be too ambitious for all Pacific Island Countries but where resourcing is available, this should be pursued. There are likely benefits in terms of achieving national coverage of drinking water quality, drinking water management improvements, sustainability and accountability. More information on drinking water legislation can be found at www.moh.govt.nz.

Implementation of a drinking water safety planning programme should never be delayed because of lack of appropriate legislation or national drinking water quality standards.



Purpose

The key objective of 'Stage 1 – Develop a National Strategy' is to identify the national goals and actions to ensure safe drinking water. In addition, the national plans, policies, legislation, etc. need to be established or strengthened to provide a sound framework for implementing actions to improve drinking water safety.

Establish national policy

A national policy is responsible for setting the public health and/or drinking water safety goals and objectives (for example it may link to achieving the Millennium Development Goals for access to safe drinking water supply and sanitation). A review of existing national policies and plans is important. Common linkages can often be found with existing health, water resource, water service and sustainability policies and plans. Existing policies and plans can contribute to drinking water safety planning and in the same way drinking water safety planning can contribute to reaching objectives in existing policies and plans.

It is essential that the national strategy or policy is endorsed by highest level in the government in order to promote accountability.

The national policy should set out clear goals and objectives and identify appropriate milestones that ensure progress towards those goals. These targets must be realistic, relevant to the local conditions and culturally appropriate. In order to allow realistic targets to be set, it is important to have a clear understanding of where the country currently sits in relation to the specified target prior to implementation of drinking water safety planning.

Health-based targets must take account of the varying nature, size and management of drinking-water supplies within the country and therefore not be too prescriptive in order to capture all (for example, there is no point in only prescribing performance targets that require monitoring equipment that is not available to community-managed supplies).

Generally it will be appropriate to set more than one type of health-based target. All targets, however should be designed to lead to improvements in public health outcome. Health-based targets are usually developed by the national health (or public health) agency with input from other relevant sectors.

The WHO Guidelines for Drinking-water Quality outline four categories of health-based targets: Health outcome, Water quality, Performance and Specified technology. These are further explained in the first four rows of Table 1. The fifth row includes a further target that recognises that problems associated with quantity and access to piped water supply have not been overcome in Pacific Island Countries and are inextricably linked to water quality targets. These water quantity and access issues have significant impact on overall access to safe drinking water.

Health based targets

Targets to monitor performance (both in terms of quality and access) of drinking water supplies against the health of consumers.

Type of target	Nature of target	Potential use by Pacific Island Countries (PIC)
Health outcome	Reduction in detected water-borne disease incidence or prevalence	This type of target is useful where reliable surveillance of disease rates is in place, and particularly in circumstances where waterborne disease contributes significantly to a measurable burden of disease. Targets should aim for a realistic, quantifiable reduction in disease rates and need to take into consideration the contribution of other exposures (not drinking-water related) to the overall rate of disease.
Water quality	Guideline values applied to water quality	Most PICs do not have their own drinking water quality standards or guidelines. Where there is an absence of national guidelines or standards, the WHO or USEPA guidelines could be used. The target may be presented in terms of the percentage of drinking water supplies meeting water quality guidelines or incremental improvement towards meeting the guideline values.
Performance	Generic performance target for removal of contaminants	This target would generally only be applied to larger, utility owned supplies, with equipment in place to monitor treatment processes (e.g. turbidity levels post filtration). It would normally involve some form of independent assessment of the process (e.g. by health authority). The target could be expressed in terms of percentage of supplies complying with predetermined performance criteria.
Specified technology	National authorities specify specific processes or technology that will adequately address contaminants	WHO report that this is the target most frequently applied to small community supplies and to devices used at a household level. It has the potential to be a useful target category for PICs (see case study below). Potential applications could include: • National authority 'approves' specific treatment equipment for specific uses (approves the technology as being capable of removing or inactivating the contaminant of concern). The target is expressed in terms of percentage of drinking water supplies with 'approved technology' • Drinking-water supplies are assessed in terms of the presence of the four barriers to contamination*. The target is expressed in terms of percentage of drinking water supplies with effective barriers to contamination in place. • National authority or national working group develops model DWSP for particular types of water supply system e.g rainwater harvesting. The target is expressed in terms of percentage of drinking water supplies that have implemented the model DWSP.
Water access / quantity	National authority specify specific requirements for water quantity, accessibility, affordability and continuity	This type of target is important in the Pacific because many countries have existing issues related to interruption of supply and lack of access to a piped water supply. Target could be expressed in terms of proportion of the population served by drinking water supplies that meet the pre-determined criteria. **

* The four barriers to contamination are: (1) Preventing contaminants entering the source water. (2) Removing particles from the water. (3) Killing germs in the water (Disinfection) . (4) Preventing recontamination

** More information on classifications of water quantity, accessibility, affordability and continuity can be found in WHO Guidelines for Drinking-water Quality (third edition) (2004).

Development of drinking water quality standards

Most Pacific Island Countries do not have their own drinking water quality standards. National development of drinking-water standards may aid the use of targets that are realistic for the individual country. National standards may also have additional benefits in terms of intervention when standards are not met. However, where national water quality standards do not exist, the WHO or USEPA guidelines can be applied.

Development of legislation

Some of the pilot countries also suggested that they would like to develop legislation to support improvements in drinking-water quality / drinking-water supply management. This may be too ambitious for all Pacific Island Countries but where resourcing is available, this should be pursued. There are likely benefits in terms of achieving national coverage of drinking water quality, drinking water management improvements, sustainability and accountability. More information on drinking water legislation can be found at www.moh.govt.nz.

Implementation of a drinking water safety planning programme should never be delayed because of lack of appropriate legislation or national drinking water quality standards.

Strengthen multi-agency co-operation

As stated above, in Pacific Island Countries, many different agencies have responsibility for aspects of drinking water quality and management. A common theme amongst the pilot countries was the lack of co-ordination of the activities undertaken by the various agencies and in some cases lack of co-operation.

Co-ordinating the responsibilities of the various agencies has a number of benefits:

- A wider range of technical expertise from all sectors is available for facilitating the implementation of drinking water safety planning
- Facilitates the sharing of information and data, greater use can be made of collected data, potential reduction in duplication of work with possible cost savings
- Gap analysis can be completed to identify key activities not undertaken by any of the contributing agencies
- Encourages an approach that encompasses the philosophy of integrated water resource management. Water sources usually have many competing uses of which drinking water may only be one. Greater co-ordination between agencies takes a step in the right direction towards co-ordinated management of water resources.
- National co-ordination of agency responsibilities can help to achieve some of these benefits.

Examples of mechanisms used by the pilot countries to achieve a co-ordinated approach:

- Establishing the National Steering Committees with membership from key agencies
- Established agreement on institutional arrangements
- Developed activity and responsibility matrices to address the list of actions required, clearly indicating which agency was responsible
- Development of inter-agency plans
- Establish a working group that would collate data and prepare annual reports on water quality monitoring and water-borne disease surveillance

Some local co-ordination will still be necessary, particularly in circumstances where private or village supplies do not have a collective national representative.

Developing drinking water quality standards for Fiji

The Fiji Water and Sewerage Department, in consultation with the Ministry of Health, initiated discussions towards the development of a National Drinking Water Quality Standards in mid 2006. A National Drinking Water Quality task force, comprising of key government agencies including the WSP, Ministry of Health, Mineral Resources Department, Pacific Applied Geoscience Commission (SOPAC), University of the South Pacific and World Health Organization (WHO) was established in late 2006. The Ministry of Health was nominated as chair and SOPAC as secretariat.

Following a few months of deliberations a WHO consultant was hired by the MoH to help the National Task Force develop the draft national drinking water quality standards. The draft standards were developed over four weeks through wide consultations with relevant stakeholders, NGOs and community based organizations.

The national drinking water quality standards prioritizes drinking water characteristics which have significant effects on human health and sets maximum acceptable values (MAVs) to each water quality parameter. These include micro-organisms such as bacteria, protozoa and viruses; and chemicals such as nitrates, arsenic and fluoride. The standards also list contaminants that do not have a health risk, however, are of aesthetic value such as odour, unpleasant taste and ability to cause stains.

The standards specifies monitoring requirements for each parameter (e.g. daily monitoring of E-coli at the treatment plant) and the respective responsibilities of each agency in terms of monitoring or surveillance. The monitoring requirements are categorized into urban and rural supplies.

The draft standards also propose the development of DWSPs for urban and rural water supplies. The draft national drinking water quality standards are currently being reviewed before it is tabled in Parliament.

Tamavua Treatment Plant, Suva, Fiji

Strengthening multi-stakeholder cooperation in Palau

Multi-stakeholder cooperation in Palau was strengthened in 2007 when the National Congress endorsed the previously ad hoc National Drinking Water Safety Committee, which comprise of the Bureau of Water Works, Division of Environmental Health (MoH), Environmental Quality Protection Board, Ministry of Lands and Resource Development and Meteorological Service.

As a result, there has been a greater collaboration between agencies responsible for various aspects of drinking water and water resource management in Palau.

This was further strengthened by the Integrated Water Resource Management programme, which identified the roles and responsibilities of various agencies and established a national framework for multi-stakeholder cooperation towards better water resource and water supply management.

Koror-Airai Treatment Plant, Koror, Palau

Training / education programmes

Many training and education needs will be similar across a country so it is sensible to develop and co-ordinate training at a national level.

In the case of rural drinking water supplies, there are often significant gains when the national agency responsible for surveillance takes a supportive role aimed at enhancing community management and implementing training and education programmes rather than taking a strict enforcement of minimum standards stance. This type of education programme should aim at gathering information that will drive overall lessons for improving drinking water safety for all drinking water supplies.

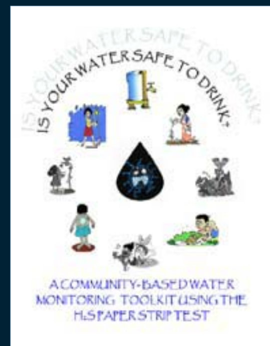
These national education programmes may target areas such as:

- Empowering community involvement in drinking water supply management
- Areas such as catchment protection and management, simple water quality testing (such as H2S test), conducting a sanitary survey of drinking water supply, emergency and household treatment options
- Development of brochures, posters to be used for promoting community awareness. For some issues, Information Education and Communication (IEC) materials have already been developed by regional organisations (e.g. SOPAC, SPREP, WHO, SPC, Live and Learn) or by various NGOs
- Promoting the linkages between drinking water quality and health issues
- Training in how to develop and implement a DWSP
- Promoting community awareness e.g. household water conservation measures
- Promoting community awareness of risks that may occur at the household level, e.g. re-contamination of drinking water within the household (storage tank management, cross connections or leaky domestic pipe-work)
- Broader community interest issues such as sanitation and hygiene
- Promoting the use of sustainable water supply options, e.g. rainwater harvesting

Financial support

Improving drinking water supplies sometimes costs money, as does developing and undertaking community awareness and education programmes. Of particular concern are rural drinking water supplies that may struggle to finance identified improvement needs themselves. While interim, partial solutions may be implemented in the short-term, the drinking water safety planning concept does expect that measures will be implemented to adequately address unacceptable risk to public health In some cases, the necessary improvements will involve capital expenditure.

Education and awareness materials developed by Live & Learn Environmental Education, an NGO based in Port Vila, Vanuatu



This is where a DWSP can be a powerful tool, guiding limited financial resources into areas of improvement that have been prioritised by the drinking water safety planning process. The pilot countries saw value in using the improvement schedules from individual drinking water supplies DWSP as a good method of identifying and demonstrating where needs arose, with the risk assessment demonstrating a systematic process for how that improvement was identified and prioritized.

National-level activities relevant to Pacific Island Countries may include:

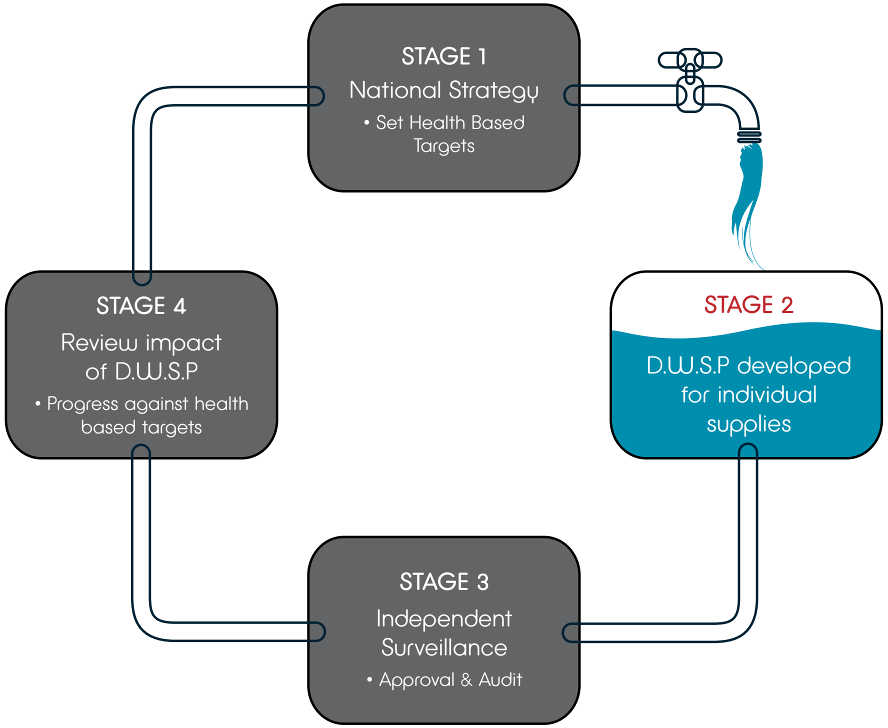
- Identification of funding sources (generally from national budget by may also facilitate the prioritisation of donor aid).
- Establish a national advisory service to prepare funding proposals and prioritise the use of any funding secured.
- Re-prioritisation of existing national budgets.

Although some financial support may arise from national processes, it is important to note that local initiatives may also play an important role in relation to funding.

Drinking Water Safety Plan provides guidance on using EU Drinking Water Infrastructure Project funding in Tonga

A recent programme of water risk assessment in Tonga has taken the approach of planning the mitigation of these risks through the creation of Water Safety Plans (WSP), a World Health Organization (WHO) tool to systematically address drinking water quality risks from water resources, through the water supply system to the consumer in their home. These WSPs include Improvement Schedules (IS) for urban and rural reticulated water supply schemes as well as household rainwater harvesting. These IS's have formed the basis for the design consultations with Tongan stakeholders for the EDF 9 National B Envelope Project "Reducing water supply scarcity and pollution vulnerability in the Kingdom of Tonga". The project will look into mainstreaming risk management through drought resilience and would provide 1.1 million Euros to implement the Water Safety Plans improvement schedules as part of disaster preparedness."

Locality Plan for Nukualofa Urban Water Supply



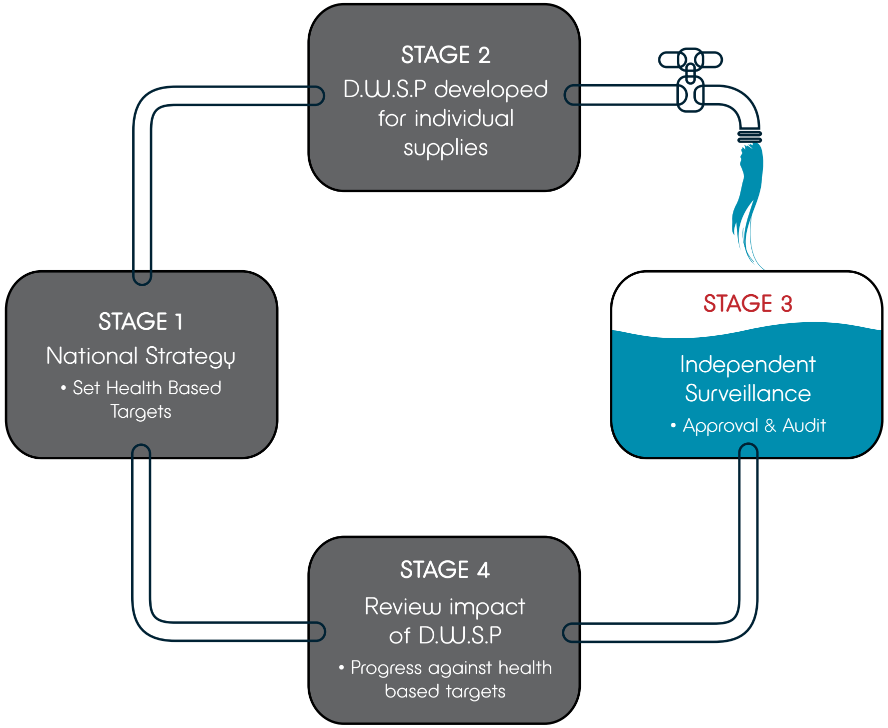
Purpose

The key objective of 'Stage 2 – Develop DWSPs' is to provide guidance on developing and implementing DWSPs for water supplies to improve safety of drinking water and reducing public health risks from water-borne diseases.

- **Refer to Part 2 - Drinking Water Safety Planning Manual for more details**

Stage 3

Surveillance



Purpose

The key objective of 'Stage 3 – Surveillance' is to describe the role of surveillance by an external agency (apart from the water utility) in verifying the safety of drinking water and ensuring that public health risks from water-borne diseases are controlled.

The World Health Organization 'Guidelines for Drinking-water Quality' (2004) state that 'in order to protect public health, a dual-role approach, differentiating the roles and responsibilities of service providers from those of an authority responsible for independent oversight of public health ('drinking-water supply surveillance') has proven to be effective'.

In Pacific Island Countries, this surveillance role is usually undertaken by the Ministry of Health through its environmental or public health function. Countries in the Northern Pacific are an exception to this, as the drinking water surveillance role is undertaken by the Environment Protection Agency, however, the MoH is still responsible for water-borne disease surveillance.

Existing surveillance in Pacific Island Countries may include:

- Drinking water surveillance (tests such as Free Available Chlorine and E.coli), although the focus is often on urban supplies.
- Some countries perform independent drinking-water treatment plant inspections (Environmental Health Officers working for the Ministry of Health in Fiji perform this function).
- Water-borne disease surveillance.

Surveillance activities relevant to water safety planning can be described in four main categories:

- Assessment and approval of new DWSP
- Audit of the implementation of DWSP
- Drinking water quality surveillance
- Waterborne disease surveillance

Surveillance must follow a planned approach and different strategies may need to be put in place for rural supplies, taking into consideration the challenges posed when a country has a large number of rural supplies that are widely distributed and may be isolated and remote. It is important that surveillance efforts are not solely focused on urban supplies, as it is often rural communities that suffer the greatest exposure to unsafe drinking water.

Surveillance

An investigative activity undertaken to identify and evaluate potential health risks associated with drinking water. Surveillance contributes to the protection of public health by promoting improvement of the quality, quantity, accessibility, coverage, affordability and continuity of drinking-water supplies. The surveillance authority must have the authority to determine whether a water supplier is fulfilling its obligations.

(The WHO Guidelines for Drinking Water Quality, Third Edition, 2005)

Assessment and approval of drinking water safety plans

To ensure that there is some form of control over the development and implementation of DWSPs by drinking water supplies, especially if this is done to demonstrate compliance with national drinking water legislation, it is strongly suggested that the DWSP be 'approved' by an external body.

Generally, the external agency tasked with surveillance of drinking water quality (e.g. MoH or EPA) will undertake the function of assessment and approval of new DWSP. The assessment should be undertaken as a technical review of the DWSP. The aim of the assessment and approval process is to ensure that the DWSP developed are consistent with the drinking water safety objectives outlined in national plans, policy and health-based targets.

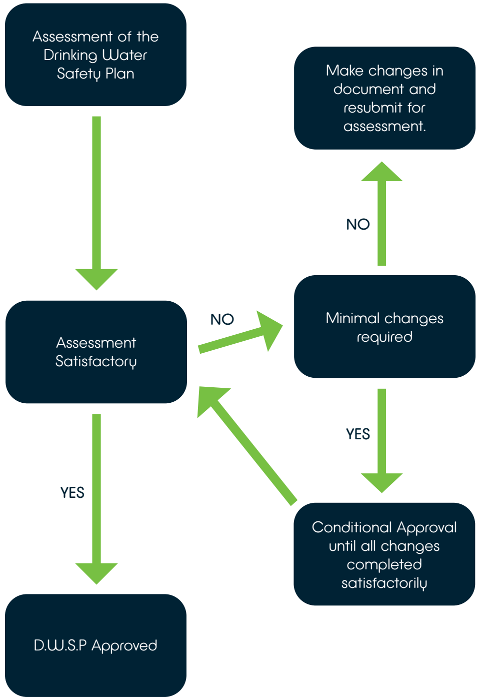
The assessment process may include:

- Consideration of whether the appropriate people or groups have been involved in the DWSP development.
- Review of the full DWSP document supplied by the water supplier, including any supporting documentation that may be referenced in the DWSP.
- Assessment against best practice guidance, for example where model DWSP have been developed for specific treatment systems.
- Determination of whether all required steps in drinking water safety planning have been adequately covered.

Based on the outcome of the Assessment, the DWSP may be approved, granted provisional approval or rejected. The WHO Guidelines for Drinking Water Quality (Chapter 4) suggests three possible scenarios following assessment of the new DWSP:

- DWSP is approved in full and is ready for implementation. This approval would be time-bound and a date for the next review would be set at this time (usually 2-5 years from the initial review);
- DWSP receives provisional approval and can be implemented subject to ensuring identified information gaps are filled. In this situation the DWSP would be likely to adequately cover most areas of concern in delivery of safe drinking-water, but may have some gaps in knowledge. Provisional approval allows implementation, but should set time limits for the resolution of identified problems;
- DWSP is rejected as inadequate and the supplier is required to go back and develop a new DWSP. This situation would only occur when the supplier had failed to cover the major risks or issues.

Figure 4: Approval process for DWSPs



Assessing DWSPs (Public Health Risk Management Plans - PHRMPs) in New Zealand

The Ministry of Health in New Zealand is responsible for the regulation of public health under the Health Act 1956 and subsequent amendments. A safe drinking-water supply is a fundamental pre-requisite of public health.

In the past, public health management of drinking water supplies relied largely on monitoring the quality of the water produced by individual water suppliers to check that it complied with the DWSNZ (Drinking Water Standards New Zealand). Monitoring is always important, but by the time it shows that contaminants are present, something has already gone wrong and a health hazard is already in the water.

In 2001, the Ministry of Health (MoH) introduced the concept of Public Health Risk Management Plans (PHRMPs). Implemented PHRMPs reduce the likelihood of contaminants entering drinking water supplies in the first place. A PHRMP is a systematic assessment of every aspect of providing safe drinking water that will identify and manage the events that could compromise the safety of drinking water. However, at this stage it was not mandatory for drinking water suppliers to develop PHRMPs.

The Health (Drinking Water) Amendment Act 2005, strengthened and improved existing legislation and provided a statutory framework for those processes that were already operating. Among other things, the Act introduced PHRMPs as a way of demonstrating compliance to the National Drinking Water standards (DWSNZ), especially for small supplies. The Act also provides for officers appointed by the Ministry to act as assessors. These officers are known as Drinking Water Assessors (DWA). DWAs are tasked with verifying that the requirements of the Act have been complied with, including the assessment and monitoring of PHRMPs.

By law, every water supply, large or small, in New Zealand are required to develop PHRMPs as part of demonstrating compliance to National Drinking Water Standards (DWSNZ). These PHRMPs must be submitted to a Ministry appointed DWA for assessment and approval. Once a PHRMP is approved, the DWA will then monitor implementation of the PHRMP and ensure that it is adhered to by the supplier.

[NZ Ministry of Health]

Audit implementation of drinking water safety plans

Once the new DWSP has been approved and implemented by the drinking water supplier, the surveillance agency should undertake periodic audits to ensure the actions outlined in the DWSP for management of the supply are being followed.

What is the purpose of the audit?

The audit is aimed at checking that the water supplier is carrying out the activities and managing the supply as is documented in their DWSP. The audit process should cover all aspects of the supply from catchment, treatment, storage and distribution and include management aspects such as training of people involved in operation of the supply. In order to determine if the DWSP has been implemented, the audit could include the following activities:

- Interviewing people who look after the day-to-day operation of the water supply
- Observing standard operational practices e.g filter backwashing, pipe maintenance work
- Reviewing records of monitoring undertaken, including corrective actions in response to adverse monitoring results
- Assessing progress towards completion of items on the improvement schedule.

The audit results should be documented by the person carrying out the assessment at the time that the observations are made and should be reported back to key stakeholder groups.

Frequency of audit

The frequency of these audits will depend greatly on the resources available within the country, but should be based on risk associated with the water supply, for example taking into consideration:

- Size of the population served by the water supply
- Risk associated with existing source water and treatment (for example, a surface water source with no treatment should be given higher priority than a groundwater sources with filtration and chlorination).
- When risk has been shown to increase due to incidents associated with the supply (e.g. waterborne disease outbreak linked to the supply)
- Any changes to the supply, as changes to the source or treatment or area served by the drinking water supply.

Water quality surveillance

Most Pacific Island Countries have established mechanisms for independent water quality analyses (usually through the Ministry of Health or Environment Protection Agency) as a surveillance measure (i.e water quality testing that is in addition to the monitoring undertaken by the water supplier themselves, i.e. 'checking on the checking').

These water quality analyses commonly include tests such as Free Available Chlorine and E.coli.

Water quality surveillance is useful as an additional measure of checking that the DWSP is implemented and is successfully achieving its objective. Water quality surveillance that detects poor results should provide a trigger to investigate further why the DWSP is not achieving satisfactory results and could be regarded as a trigger for review of the DWSP.

There are some pre-requisite requirements for effective drinking water quality surveillance:

- Access to laboratory / analytical facilities
- Staff that are adequately trained to undertake sampling
- Capacity to assess findings
- Capacity to report to water suppliers and communities and to follow-up to ensure that adequate action has been taken as a response.

Water quality surveillance programmes should generally be prioritised to target drinking water supplies of greatest risk, taking into consideration factors such as population on the supply, previous history of problems with water quality and adequacy of existing treatment systems.

Waterborne disease surveillance

Systems to detect, notify, record, investigate and report on cases of waterborne disease are a critical component of the independent surveillance role. The Ministry of Health or its regional public health offices will usually carry out this role.

Reliable disease data is important for setting health-based targets and measuring incremental progress towards meeting these targets. In Pacific Island Countries, public health surveillance generally includes:

- Ongoing monitoring of notifiable diseases, many of which may be caused by waterborne pathogens
- Outbreak detection and investigation
- Limited long-term trend analysis
- Limited geographic and demographic analysis

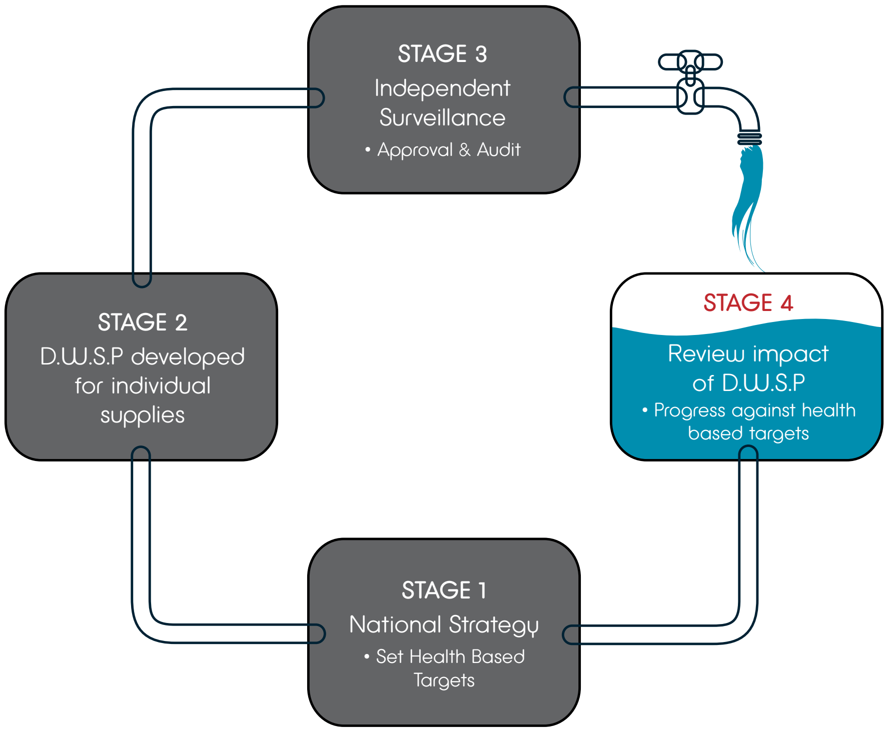
Further information on disease surveillance in Pacific Island Countries is available under the 'Public Health Surveillance and Communicable Disease Control' section of the Secretariat of the Pacific Community (SPC) website (www.spc.int).

Detection of outbreaks of waterborne disease or ongoing high rates of disease within communities that are provided drinking water by water supplies with DWSP should trigger further investigation and review aimed at addressing why the DWSP is not achieving its objectives.

Reporting / feedback to drinking water suppliers and communities is an area of waterborne disease surveillance that is desirable and may require further development in some Pacific Island Countries. A common area identified for improvement by the pilot countries was the need for improved sharing of waterborne disease data.

Stage 4

Review the strategy



Purpose

The key objective of 'Stage 4 – Review' is to gauge the efficacy of the DWSP in improving drinking water safety, reducing public health risks from water-borne diseases and achieving other goals established in 'Stage 1 – Develop National Stategy'.

Progress against health-based targets

As discussed above, the purpose of setting health-based targets is to establish a baseline and mark out milestones to chart progress towards the stated health goal.

Surveillance information should be examined periodically to determine whether incremental progress is being achieved towards meeting the health-based targets. Care will need to be taken (particularly where health-outcome targets are used) to consider other potential factors that may have impacted on the recorded data. Factors such as changes to disease notification procedures or the impact of non-waterborne exposures may have significant impact on data.

Where incremental progress has not been achieved, those agencies responsible for the review (potentially the National Steering Committee as favoured by the pilot countries) should undertake an evaluation of current policy and its implementation. Can improvements be made that will assist drinking water safety planning? Time will certainly be a factor and it may take a number of years before DWSP are sufficiently implemented across the country before national improvements in health-based targets will be achieved. Replication strategies for achieving good national coverage are discussed below.

National replication strategies

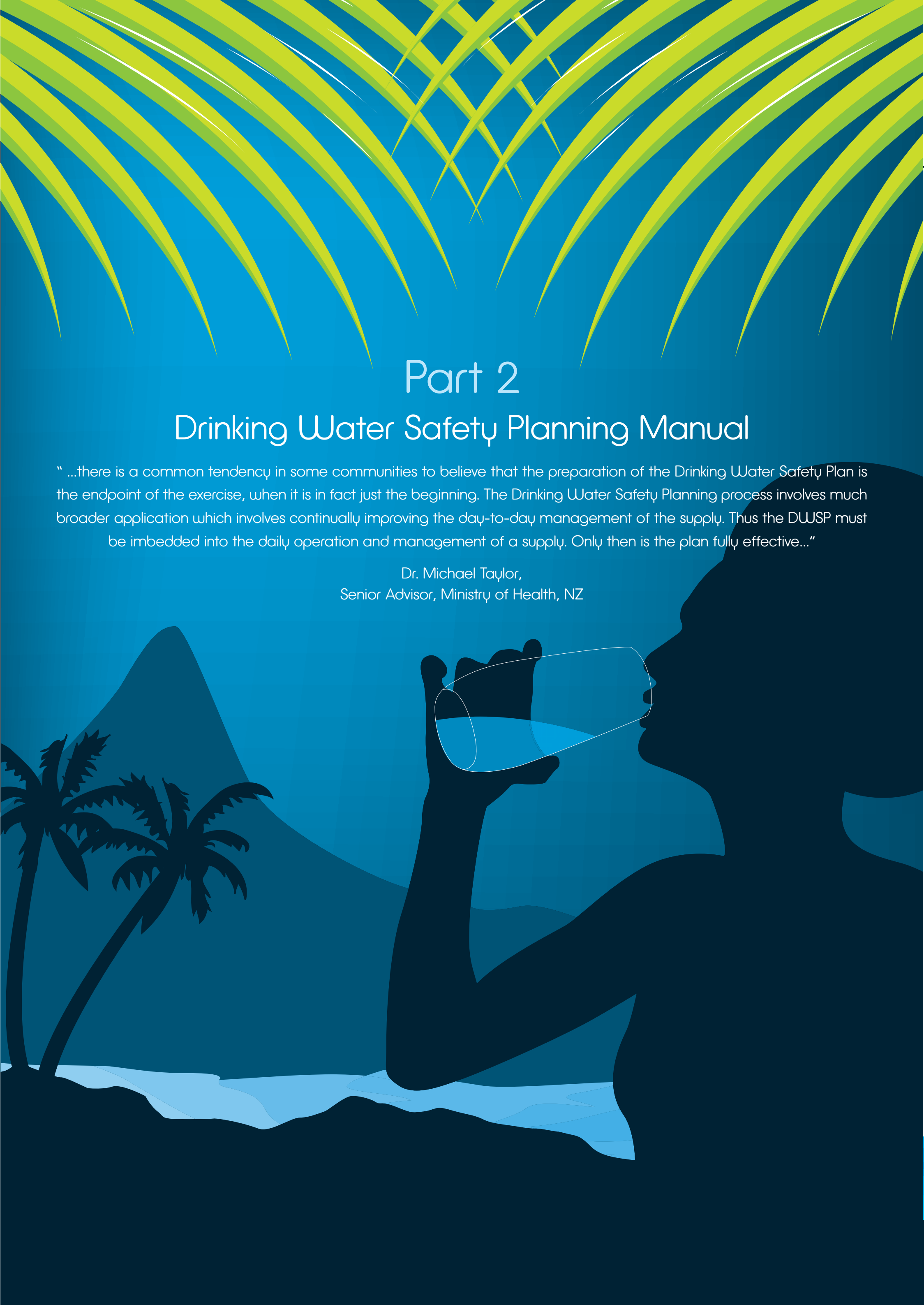
Due to the existence of technical expertise and resources, DWSP are generally most easily developed and implemented by urban, utility operated water supplies. This provides good coverage in terms of population served by the supply, but does not always address the drinking water supplies that pose the greatest risk to consumers. Supplies that pose the greatest risk to consumers are often rural, community-managed supplies as these are generally the supplies with least access to resources to undertake improvements.

During the pilot country workshops, the participants worked on a developing a DWSP for an urban supply and for a rural supply. In some cases a simplified DWSP format was preferred for the rural supplies.

National replication strategies must respond to the range of water supplies present in the country and different strategies may be necessary for rural, community-managed supplies, taking into consideration factors such as technical skills and literacy.

Potential strategies to consider for rural, community-managed drinking water supplies:

- An expert group (possibly appointed from members of the National Steering Committee) conducts a national assessment of typical rural, community-managed water supplies. An individual drinking water supply from each of the identified 'supply types' is selected as a pilot example and a DWSP developed in partnership with the community for that drinking water supply. The completed examples are then used to assist other rural, community-managed supplies within that category to write their own DWSP.
- An expert group conducts a national assessment of typical rural water supplies. Model DWSPs are developed for common supply types (e.g. rainwater harvesting). Community representatives are trained in the 'doing' components of the DWSP and may potentially alter the model DWSP to suit local circumstances.



Part 2

Drinking Water Safety Planning Manual

" ...there is a common tendency in some communities to believe that the preparation of the Drinking Water Safety Plan is the endpoint of the exercise, when it is in fact just the beginning. The Drinking Water Safety Planning process involves much broader application which involves continually improving the day-to-day management of the supply. Thus the DWSP must be imbedded into the daily operation and management of a supply. Only then is the plan fully effective..."

Dr. Michael Taylor,
Senior Advisor, Ministry of Health, NZ

Drinking water safety plans

A Drinking Water Safety Plan (DWSP) is a comprehensive risk assessment and management tool that encompasses all steps in the drinking water supply from catchment to consumers. It draws on principles and concepts from other risk management approaches including Hazard Analysis Critical Control Point (HACCP) and the 'multi-barrier approach'.

The key objectives of a Drinking Water Safety Plan are to:

- Prevent the contamination of source waters;
- Treat water to reduce or remove contaminants; and
- Prevent re-contamination during storage, distribution and handling of treated water.

Traditional methods have relied on end-point testing of water quality, but there are limitations to this approach. The detection of contaminants in water during monitoring indicates that something has already gone wrong, and that consumers may already have been exposed to unsafe water. A more effective way of protecting public health is to stop contamination in the first place (a preventative approach).

In practise this means moving away from an approach focused on "product quality control" to a more proactive approach, which embraces "process quality control".

Drinking Water Safety Planning takes this preventative approach and guides water suppliers to look at what can possibly go wrong in a water supply, pinpoint what the causes of this event may be and take actions to reduce the likelihood of the event occurring.

Major benefits of developing and implementing a Drinking Water Safety Plan for drinking water supplies include:

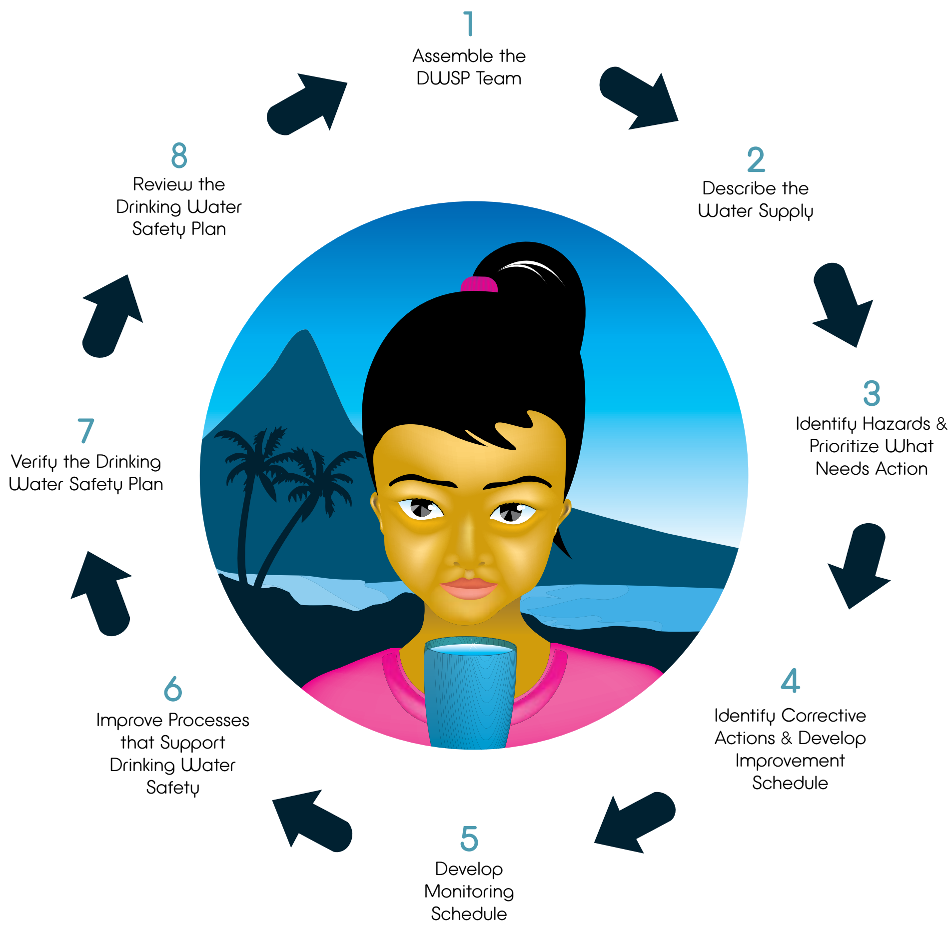
- Health benefit - Studies indicate that quality assurance processes such as Drinking Water Safety Plans can greatly reduce health burdens (Deere et al., 2001)
- last sentence - "Cost saving - studies have shown that by adopting the monitoring and verification process of the DWSP a cost saving of approximately 30% can be achieved"
- Investment planning - Increased monitoring at field level results in clearer prioritization of system improvements
- Greater risk assurance - Provides greater confidence in the continuous and sustainable delivery of drinking water
- More integrated approach - Recognizes the linkage between source water, treatment processes and distribution as potential areas of risk and suggests greater communication between agencies for integrated management
- Improved Asset Management - Uses a systematic and considered approach towards identifying risks from the source to tap, providing enhanced detection of asset weaknesses e.g. leaking pipes, poor intake structures or no standard operating procedures.

Developing a Drinking Water Safety Plan

To develop a DWSP, the water authority or supplier needs to:

- assemble a team that understands the system;
- identify and prioritize risks;
- identify means for controlling these risks;
- establish a monitoring system to ensure consistent supply of safe drinking water; and
- periodically review the Drinking Water Safety Plan.

Figure 5: The Drinking Water Safety Planning Cycle



Purpose

The key objective of step 1 is to assemble a team of professionals with knowledge and experience in all aspects of the drinking water supply system, and sufficient management authority to:

- prepare the drinking water safety plan; and
- implement improvements and changes identified.

The Drinking Water Safety Plan (DWSP) must be developed around a strong understanding and knowledge of all aspects of a drinking water supply, from the catchment to the consumers, and must involve people who are well versed with the various aspects of that supply.

While the preparation of a DWSP is primarily the role of the water supply organisation, other government departments, agencies and non-government organisations that have a role in the wider water sector, should be engaged to ensure a holistic approach to the development of the DWSP.

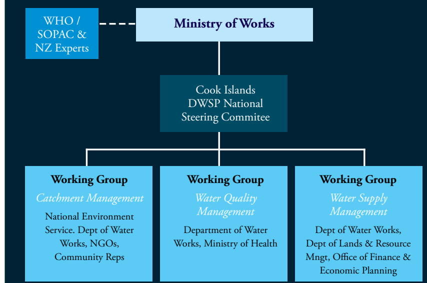
Who should be part of the DWSP team?

Think about involving the following:

- People who are responsible for the day-to-day operation of the water supply and who will be the ones 'using' the DWSP.
- People who know about the history of the water supply (things that may have caused problems in the past).
- People with authority to make decisions about spending money, training, recruiting staff and/or making changes to the water supply.
- People who use the water supply (the community).
- External agencies that have responsibility for part of the water supply system (e.g. an environmental agency with responsibility for the water supply catchment, an NGO responsible for community awareness programmes).

National steering committees

The Pilot countries established a multi-stakeholder committee to develop Drinking Water Safety Plans for the respective drinking water supplies. The committee consisted of representatives of the department responsible for the water supply, which was also elected as the chair of the committee. Other key agencies including Health, Environment, Land & Resource Management, Disaster Management, Finance & Economic Planning, Agriculture & Forestry were also represented in the National Steering Committee. In addition, representatives from village committees, NGOs and other civil society groups were also encouraged to participate.



While the National Steering Committee was regarded as a National coordinating body, Pilot countries preferred forming sub-committees or working groups for specific components of the DWSP.

Involving other agencies

The involvement of other agencies and groups may depend on the size and nature of the water supply.

Table 2 - Example of a DWSP Team (Republic of Palau)

Name	Position	Organization	Area of Responsibility
Mr. Techur Rengulbai	Head	Bureau of Public Works (BPW)	Management, staff recruitment
Mr. David Dengokl	Manager	Koror-Airai Treatment Plant	Management & Operation, staff recruitment, training
Mr. Grant Ngirengchin	Operator	Koror-Airai Treatment Plant	Operation & monitoring
Ms. Portia Franz	Chief Executive	Environment Quality Protection Board (EQPB)	Surveillance
Ms. Kimie Ngirchechol	Manager	EQPB Laboratory	Surveillance - laboratory
Mr. Jerome Sakurai	Laboratory Technician	EQPB Laboratory	Surveillance - laboratory
Ms. Joanne Maireng Sengebau-Kingzio	Head	Division of Environmental Health (DEH)	Public Health Surveillance
Ms. Vernice Stefano	Programme Manager – National GIS	PALARIS – Bureau of Lands	Lands resource management & development of GIS system for BPW
Hon. Santy Asanuma	Senator	Palau National Congress	Policy and legislation

Team size

Team numbers will vary according to the size of the organization and complexity of the water supply. Ideally, the team should be big enough to allow for a multi-disciplinary approach, but small enough to ensure that the team does not have difficulty in making decisions. The use of sub-teams is common and might for example include, water catchment and intake, water treatment and storage & distribution operations.

1. Assembling the DWSP team

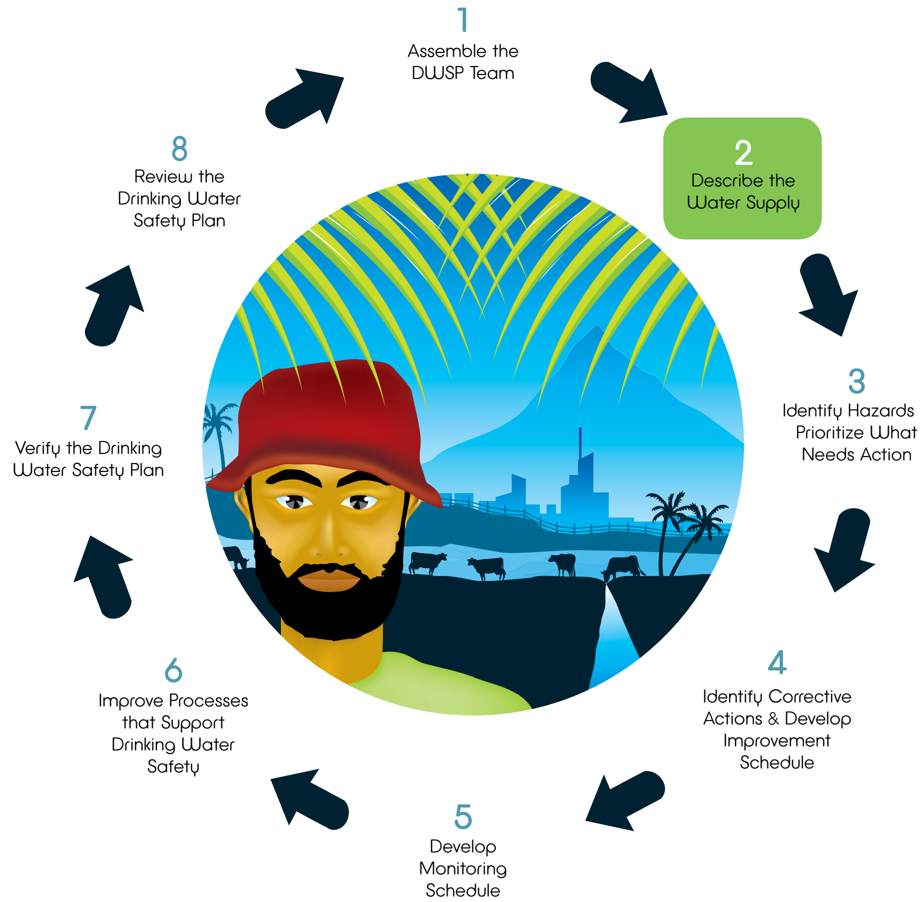
Ensure that the following are considered when forming the DWSP Team:

- ❑ A good understanding of the catchment and intake issues and concerns
- ❑ Familiarity with treatment processes
- ❑ Familiarity with water supply operations
- ❑ A good understanding of the water supply infrastructure
- ❑ Familiarity with water quality monitoring processes
- ❑ Some understanding of current local health issues related to drinking water supply
- ❑ Familiarity with risks associated with various stages of the water supply
- ❑ Authority to endorse improvements or changes identified in the DWS

2. What to include in the DWSP

- ❑ Include the names and details of every member of the DWSP Team
- ❑ Indicate the respective responsibilities of each member in the DWSP Team

Name	Organization / Department	Position / Title	Role in the WSP Team	Contact Telephone / E-mail



Purpose

The key objective of step 2 is to describe the drinking water supply in a way that provides the DWSP Team with a thorough understanding of the system that will serve as a basis for assessing the risks to water safety.

The first step in developing a Drinking Water Safety Plan is to access detailed and comprehensive knowledge of the system. A good understanding of the drinking water supply is vital for identifying the hazards that may exist and the processes and infrastructure needed to control those hazards.

The supply description must be specific to the individual water supply and must describe both physical (infrastructure) and operational components of the supply. It usually involves the following two stages:

1. Describing the supply using narrative, a flow diagram or schematic, photos, maps or a combination of all of these; and
2. Visiting and assessing the supply

Describing the water supply

Drawing a flow diagram is a simple way to describe the physical components of the supply. The flow diagram should start from the water supply catchment and flow through intake, treatment plant, storage facilities and distribution.

Visiting & assessing the water supply

The accuracy of the system description, including any maps or schematics, must be confirmed by visiting the water supply (i.e. "walking the system" from catchment to distribution).

The system assessment must cover all aspects of the supply including:

- Catchment and intake
- Treatment
- Storage and Distribution
- Personnel (e.g Training, Operating instructions, Management)

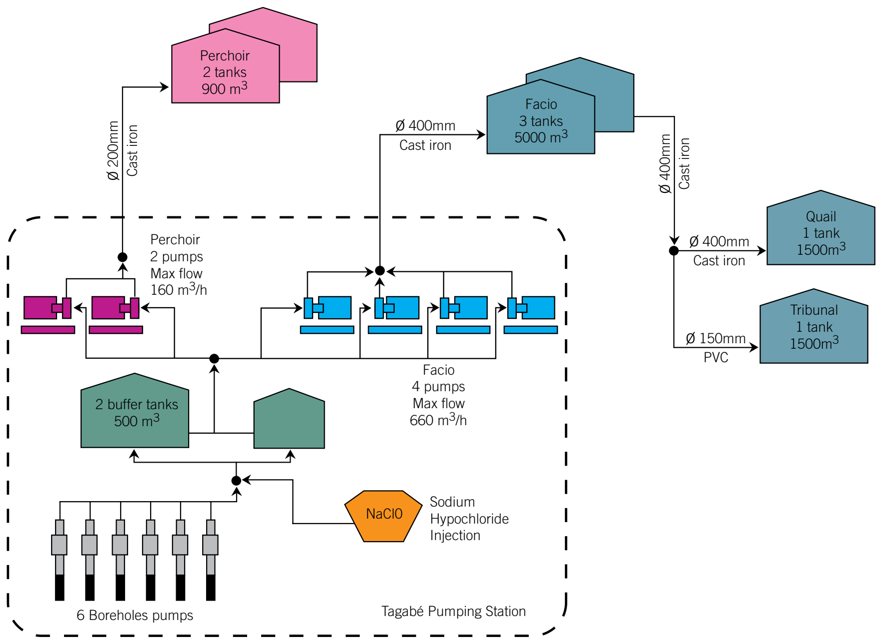
In addition to 'walking the system', further useful information that should be collected includes:

- Drinking-water quality standards;
- Treated water quality monitoring results;
- Data on source water quality and quantity, including information on competing water uses;
- Water supply files, maps and diagrams; and
- Accounts from staff and members of the community regarding things that have gone wrong with the supply in the past; minutes from water supply manager / operator meetings; etc.
- Alternative water sources and contingency arrangements to minimize disturbance during service disruptions or system failures

System assessment checklist

Developing a checklist prior to conducting the system assessment could be quite useful to ensure that no aspect of the supply is left out. A sample checklist is provided below.

Figure 5 : Schematic of Port Vila water supply, Vanuatu



Pilot country experience

The pilot countries found it useful to include a combination of narrative description, schematics, maps and photographs to illustrate the various components of the respective water supplies. The narrative description was often used to provide a general outline of the system as well as a description of the characteristics of various components of the supply. The schematics were generally used to illustrate the water supply process, including all infrastructural components, while the maps and photos further enhanced this description.

(The WHO Guidelines for Drinking Water Quality, Third Edition, 2005)

System description for Port Vila water supply, Vanuatu

Catchment

The main source for Port Vila water supply is groundwater. There are six boreholes each at a depth of between 15 – 20m A submersible pump at each borehole pumps water to two buffer tanks. All six boreholes are regulated with the buffer tanks and the number of boreholes in use at any particular time is directly related to the level of water in the buffer tanks.

The Catchment has been zoned as a restricted development area by the Ministry of Lands and the Tagabe River Management Committee has been established as an advisory group for proper management of the catchment area. There are some agricultural activities in and around the catchment. There are no residential areas within the catchment, however, nearby communities make use of the river frequently for domestic purposes e.g. bathing or washing. The catchment area is not fenced so people and animals have easy access to the catchment and Tagabe River.

Storage & Treatment

Water from the boreholes is pumped into two 'Buffer tanks' with a total capacity of 500m3. One of the tanks is a Steel (bolted) tank while the other is a Timber tank. Both tanks are connected and water from the Steel tank flows into the Timber tank.

Treatment is via chlorination. Sodium hypochlorite (NaClO) solution is added to the water in the Steel Tank. Chlorinated water from this tank then flows into the Timber tank prior to distribution.

After treatment, water is pumped into one of two major reservoirs i.e. Facio and Perchoir. Two of the six pumps are dedicated to pump water to the Perchoir Reservoirs at a maximum rate of 160m3/hr, while the other four pumps are dedicated to pump water to the Facio reservoirs at a maximum rate of 660m3/hr.

Distribution

There are four storage sites within the Port Vila system i.e. Perchoir, Tribunal, Quai and Facio. The Perchoir reservoir supplies water directly to consumers via gravity. The Facio reservoir supplies water to consumers and also feed the distribution tanks at Tribunal and Quai. These distribution tanks then supply water directly to consumers via gravity. The distribution network consists of mainly 150mm PVC pipes. All household connections are metered. A special device has been installed to allow for easy disconnection. It consists of a 'lock device' with a special 'key'. This mechanism makes it very difficult for consumers to tamper with connections and practically eliminates the possibility of illegal connection or reconnection (after being disconnected).

[Extract from draft Port Vila Water Safety Plan]

1. System description - what to include?

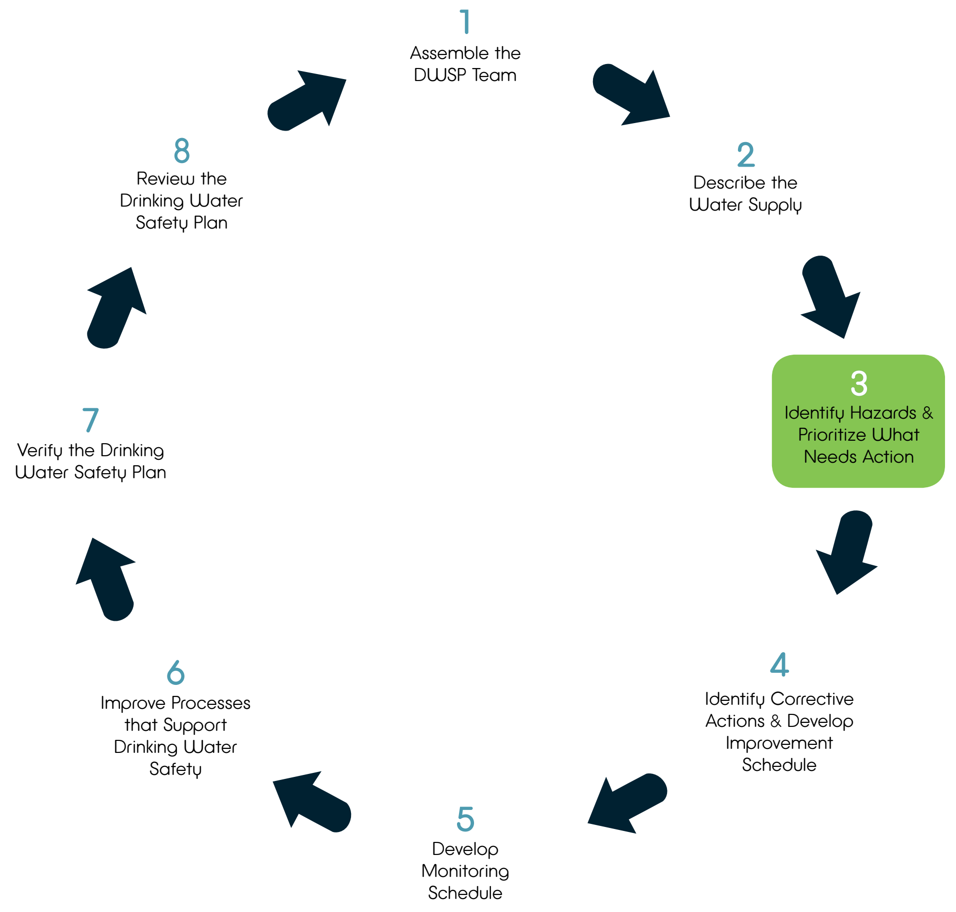
Ensure that the following are considered when writing a system description:

- ☐ Organization details e.g. utility name, operations and / or management contact
- ☐ Name and location of intakes, treatment plants, distribution zones etc...
- ☐ List of potential "users" and intended "uses" of the water
- ☐ Information on any legislative requirements on quality of drinking water e.g. drinking water satndards
- ☐ Description of the source and intake of the drinking water, including summary of water quality data if available
- ☐ Description of the catchment characteristics e.g. size, land-use etc...
- ☐ State the production capacity, demand etc...
- ☐ Information on treatment processes (and how quality is improved after each process)
- ☐ Information relating to storage of water
- ☐ Details of how the water is distributed, including any zoning
- ☐ A schematic of the water supply
- ☐ Maps
- ☐ Photos

Describe the Drinking Water Supply

Step 3

Identify hazards & prioritize what needs action



Purpose

The key objectives of step 3 are to:

- conduct a systematic assessment of existing and potential hazards or hazard events,
- identify whether these are under control, and
- prioritise them to identify priority areas where improvement to the water supply will have the most benefit.

This step involves identification of all existing and potential hazards or hazardous events which may pose risk to the safety and quality of drinking water; identifying and evaluating the control measures that are in place to manage these hazards; and assessing the level of risk posed by each hazard or hazardous event.. Thus, this step is divided into three stages.

1. Identify potential hazards

With a detailed System Description, the DWSP team should have sufficient information about the water supply to identify things that could go wrong, ultimately resulting in unsafe drinking water.

When identifying hazards, it is often useful to distinguish between a hazard and a hazardous event. A hazard is an "agent" that could potentially make the water unsafe. This could be physical (e.g. turbidity), chemical (e.g. heavy metals) and/or micro-biological (e.g. viruses). In comparison, a hazardous event is defined as any "mechanism" that could introduce a hazard (physical, chemical or microbiological) into the water supply or fail to remove it from the drinking water, or anything that could prevent enough water from being available to consumers.

For example, heavy rainfall is a hazardous event, which could lead to increased turbidity in the source water, affecting the coagulation / separation process (table below).

Hazard

A hazard is any physical, biological or chemical agent that can cause harm to public health or result in no water for consumers.

Hazardous event

An event that introduces hazards to, or fails to remove them from, the water supply or an event that causes interruption to the supply of water to consumers.

Risk

The likelihood of identified hazards causing harm in exposed populations, including the magnitude and/or consequences of that harm.

Table 3: The Risk Matrix - worked example 1

Hazard	Cause / Hazard Event	Control measure / barrier	Likelihood	Consequence	Priority
Contaminated raw water	Seepage from septic tanks from villages upstream to intake				
	Seepage of faecal waste from piggery located upstream to intake				
Raw water turbidity above 1.0 NTU	Heavy rain in catchment				
Intake cannot deliver sufficient water to meet demand	Power failure				
	Low water level due to Drought				

2. Determine efficacy of existing controls

A control measure can be defined as a step or process in a drinking water supply that directly affects drinking water quality. They are activities and processes applied to prevent hazard occurrence or at least reduce the likelihood of a hazard occurring.

Some of the hazardous events identified will already be adequately managed by existing control measures (with associated inspections, checks, monitoring and maintenance to ensure the control measure is operating effectively). Other hazardous events will be 'an accident waiting to happen' with no effective control.

Control measures often fall into four main categories (often referred to as 'the four barriers to contamination')

- Preventing contaminants from entering the source water
- Removing particles from the water
- Killing or inactivating pathogens (or germs)
- Preventing recontamination of water during distribution, storage and handling

Table 4: The Risk Matrix - worked example 2

Hazard	Cause / Hazard Event	Control measure / barrier	Likelihood	Consequence	Priority
Contaminated raw water	Seepage from septic tanks from villages upstream to intake	Rapid sand filter and Chlorine disinfection			
	Seepage of faecal waste from piggery located upstream to intake	Rapid sand filter and Chlorine disinfection			
Raw water turbidity above 1.0 NTU	Heavy rain in catchment	Jar test to determine correct coagulant dose			
Intake cannot deliver sufficient water to meet demand	Power failure	None			
	Low water level due to Drought	None			

3. Prioritize what needs attention – determine level of risk

To help prioritise what needs attention, it is useful to consider the risk associated with each of the hazardous events. Some of the identified hazard events will be more likely to happen than others and some are more likely than others to make people sick.

A systematic assessment (semi-quantitative) that ranked the risk according to a combination of the likelihood of the hazard occurring and the consequence to public health if the event occurred, was most favoured by the pilot countries. The tables that were used for this systematic risk assessment can be found below.

Judging priorities

i. For each hazard event, decide on the likelihood of the event happening

Table 5: The Risk Matrix - Likelihood Analysis

Likelihood Score	Possible Descriptions	Risk Score
Almost Certain	Very common event, occurs on a regular basis	5
Likely	The event has happened before and can probably occur again	4
Possible	The event could occur	3
Unlikely	The event may not occur	2
Rare	Very uncommon event – probably will never occur	1

Table 6: The Risk Matrix - worked example 3

Hazard	Cause / Hazard Event	Control measure / barrier	Likelihood	Consequence	Priority
Contaminated raw water	Seepage from septic tanks from villages upstream to intake	Rapid sand filter and Chlorine disinfection	Possible		
	Seepage of faecal waste from piggery located upstream to intake	Rapid sand filter and Chlorine disinfection	Possible		
Raw water turbidity above 1.0 NTU	Heavy rain in catchment	Jar test to determine correct coagulant dose	Likely		
Intake cannot deliver sufficient water to meet demand	Power failure	None	Likely		
	Low water level due to Drought	None	Unlikely		

ii. For each hazard event, decide on the consequence to people's health if it did happen.

Table 7:

Consequence Score	Possible Descriptions	Risk Score
Insignificant	No potential to cause harm to public health within a community	1
Minor	Potential to cause minor irritation or discomfort	2
Moderate	Potential to cause illness	3
Major	Potential to cause illness and hospitalisation of people within a community	4
Catastrophic	Potential to cause death(s) within a community	5

Table 8: The Risk Matrix - worked example 4

Hazard	Cause / Hazard Event	Control measure / barrier	Likelihood	Consequence	Priority
Contaminated raw water	Seepage from septic tanks from villages upstream to intake	Rapid sand filter and Chlorine disinfection	Possible	Major	
	Seepage of faecal waste from piggery located upstream to intake	Rapid sand filter and Chlorine disinfection	Possible	Major	
Raw water turbidity above 1.0 NTU	Heavy rain in catchment	Jar test to determine correct coagulant dose	Likely	Major	
Intake cannot deliver sufficient water to meet demand	Power failure	None	Likely	Major	
	Low water level due to Drought	None	Unlikely	Major	

Identify Hazards & Prioritise what needs Action

iii. For each hazard event, look up the likelihood and consequence scores in this table to find the corresponding priority (very low, low, medium, high, very high)

Table 9: Risk Matrix – Priorities

Likelihood	Consequence				
	insignificant (1)	Minor (2)	Moderate (3)	Major (4)	Catastrophic (5)
Almost Certain (5)	Medium (5)	Medium (10)	High (15)	Urgent (20)	Urgent (25)
Likely (4)	Low (4)	Medium (8)	High (12)	High (16)	Urgent (20)
Possible (3)	Low (3)	Medium (6)	Medium (9)	High (12)	High (15)
Unlikely (2)	Low (2)	Low (4)	Medium (6)	Medium (8)	Medium (10)
Rare (1)	Low (1)	Low (2)	Low (3)	Low (4)	Medium (5)

Low 1-4 ; Medium 5-10 ; High 11-18 ; Urgent 19-25

Table 10-: Risk Matrix – worked example 5

Hazard	Cause / Hazard Event	Control measure / barrier	Likelihood	Consequence	Priority
Contaminated raw water	Seepage from septic tanks from villages upstream to intake	Rapid sand filter and Chlorine disinfection	Possible	Major	High
	Seepage of faecal waste from piggery located upstream to intake	Rapid sand filter and Chlorine disinfection	Possible	Major	High
Raw water turbidity above 1.0 NTU	Heavy rain in catchment	Jar test to determine correct coagulant dose	Likely	Major	High
Intake cannot deliver sufficient water to meet demand	Power failure	None	Likely	Major	High
	Low water level due to Drought	None	Unlikely	Major	Medium

Identifying hazards and hazardous events

Ensure that all existing and potential hazards and hazardous events are identified. The following should be considered:

- ❑ Microbiological contamination potential e.g. piggery waste discharge upstream to the intake
- ❑ Chemical contamination potential e.g. agricultural runoff upstream to the intake
- ❑ Operational failures e.g. power shutdown
- ❑ Infrastructural fault e.g. clarifier breakdown
- ❑ Treatment failure e.g. insufficient chlorine dosing
- ❑ Operator error e.g. over or under dosing of coagulants
- ❑ Accidental contamination e.g. grease spill in water during mains repair
- ❑ Natural Hazards e.g. earthquake or cyclone
- ❑ Man-made disasters e.g. sabotage

Calculating risk

All hazards and hazardous events identified needs to be assessed based on the likelihood (how likely is it that the event will occur) and consequence (what effect will this have on health of people).

Assigning priorities

Not all risks are a threat, some may already be under control by means of barriers or control measures either during intake, treatment, storage or distribution. Such risks do not pose a direct threat, unless the control measures fail. Priority should however given to risks which are not currently under control. Corrective actions and improvements are needed to bring these risks under control. Therefore greater attention and resources must be allocated to such risks.

Name	Organization / Department	Position / Title	Role in the WSP Team	Contact Telephone / E-mail

Purpose

The key objectives of step 4 are to:

- identify corrective actions to manage significant risks, which are not currently under control;
- identify step-wise improvements that can be undertaken that will ensure risks are consistently under control; and
- document a plan of action (Improvement Schedule) to address the areas of significant risk identified during Step 3.

Now that the DWSP Team have identified significant risks that need priority attention so that the water does not become unsafe to drink, consideration needs to be given to what corrective actions need to be undertaken to control these significant risks and to develop a plan of action to implement these corrective actions (or improvements).

Corrective actions are the short-term, immediate response actions that are taken if control is lost, while improvements are actions that are identified as a long-term (or permanent) solution to a problem. For example if there is a risk of microbial contamination the corrective action could be issuing a boil water advisory (and immediate action you would take as soon as the threat arises), while an improvement could be installing a chlorine disinfection unit (something that you would do in the long-term).

Identifying corrective actions (or improvements)

Usually, significant risks exist when either there are no control measures in place or the existing control measures are deemed ineffective. For each significant risk identified in Step 3, corrective actions or improvements are needed.

Table 11: Corrective Action - worked example 6

Hazard	Cause / Hazard Event	Priority	Corrective Action	Improvement
Contaminated raw water	Seepage from septic tanks from villages upstream to intake	High	Boil water advisory (SOP #056); Increase Chlorine dose (SOP# 097)	Find alternative source, move intake upstream or enhance treatment process
	Seepage of faecal waste from piggery located upstream to intake	High	Boil water advisory (SOP #056); Increase Chlorine dose (SOP# 097)	Find alternative source, move intake upstream or enhance treatment process
Raw water turbidity above 1.0 NTU	Heavy rain in catchment	High	Shut down inlet (SOP#011) or adjust coagulant dosing (SOP# 32)	Find alternative source. Add pre-treatment storage and settling tank
Intake cannot deliver sufficient water to meet demand	Power failure	High	Advise public of water supply disruptions (SOP#54),	Invest in a back-up generator
	Low water level due to Drought	Medium	Advise public of water supply disruptions (SOP#54), Enforce water use restrictions	Explore groundwater source

What to focus on in the improvement schedule

The Improvement Schedule is a plan of action for the implementation of corrective actions and/or improvements needed to manage significant risks. It describes who should take responsibility for implementing respective corrective actions or improvements; identifies short, medium or long-term targets; and specifies the resources needed to complete each corrective action or improvement.

The improvement schedule often contains a list of actions or improvements arranged in an order of priority. The priority is often determined based on the seriousness of the risk; costs involved in implementing the improvement; and the time needed to complete the improvement.

The objective is to achieve maximum improvement in drinking water safety with minimum resources in as short time as possible. It has often been noticed that some improvements with a 'Very high' priority may involve spending a lot of money over a long period of time. These usually include construction of new components within the system. However, a significant amount of improvement can be brought about in the drinking water safety through simple changes in water supply processes and/or operation, that do not require large sums of money and are often achievable within very short periods of time.

When considering improvements, consideration should be given to the multi-barrier approach. The multi-barrier approach encourages effective controls to be put in place in the following four areas:

- Preventing contaminants from entering the source water
- Removing particles from the water
- Killing or inactivating pathogens (or germs)
- Preventing recontamination of water during distribution, storage and handling

Through a multi-barrier approach, several small-scale "soft" improvements can be combined to make a large difference in drinking water safety, as soft improvements complement each other to progressively improve drinking water quality.

A well structured Improvement Schedule can be very useful for financial planning and budgeting of limited financial resources by the utility or water supply department.

Table 12: Improvement Schedule - worked example 7

Improvement description	Responsibility	Resources needed	Timeframe	Status
Find alternative source, explore groundwater sources	Chief Engineer	56,995 to dig new borehole	Medium-term	
Move intake upstream	Chief Engineer	50,000 for new pipe-works + intake infrastructure	Short-term	
Enhance treatment process - add pre-treatment storage and settling tank	Chief Engineer, Management	200,000 for constructing two new 1ML pre-treatment settling tanks	Long-term	
Enhance treatment process – invest in gaseous chlorine dioxide for disinfection	Management	43,870 for switching from liquid to gaseous chlorine	Short-term	
Invest in a back-up generator	Management	75,000 for purchase of 120KW new power generator	Short-term	

DWSP Checklist:

Step 4: Identify corrective measures & develop improvement schedule

Identifying corrective actions

Ensure that corrective actions or improvements are identified for risks which are not under control. Corrective actions or improvements could include:

- ❑ Updating operational procedures e.g. reviewing and updating Standard Operating Procedures
- ❑ Improving treatment efficiencies e.g. allowing more contact time in treated water reservoir prior to distribution
- ❑ Infrastructure improvement e.g. installing a pre-settlement tank for highly turbid source water
- ❑ Improving operational monitoring e.g. installing turbidity meters at each rapid sand filter
- ❑ Operator efficiency e.g. through more training, awareness
- ❑ Improving communications with other relevant agencies e.g. Ministry of Health or EPA for issuing boil water advisories

Documentation

Corrective actions, especially those that are mostly procedural changes, must be documented and should be easily accessible to all staff.

Improvement schedule

The Improvement Schedule is a water operator's "wish list" or "menu of options" for improving their drinking water safety. The following should be considered when developing the Improvement Schedule for a supply:

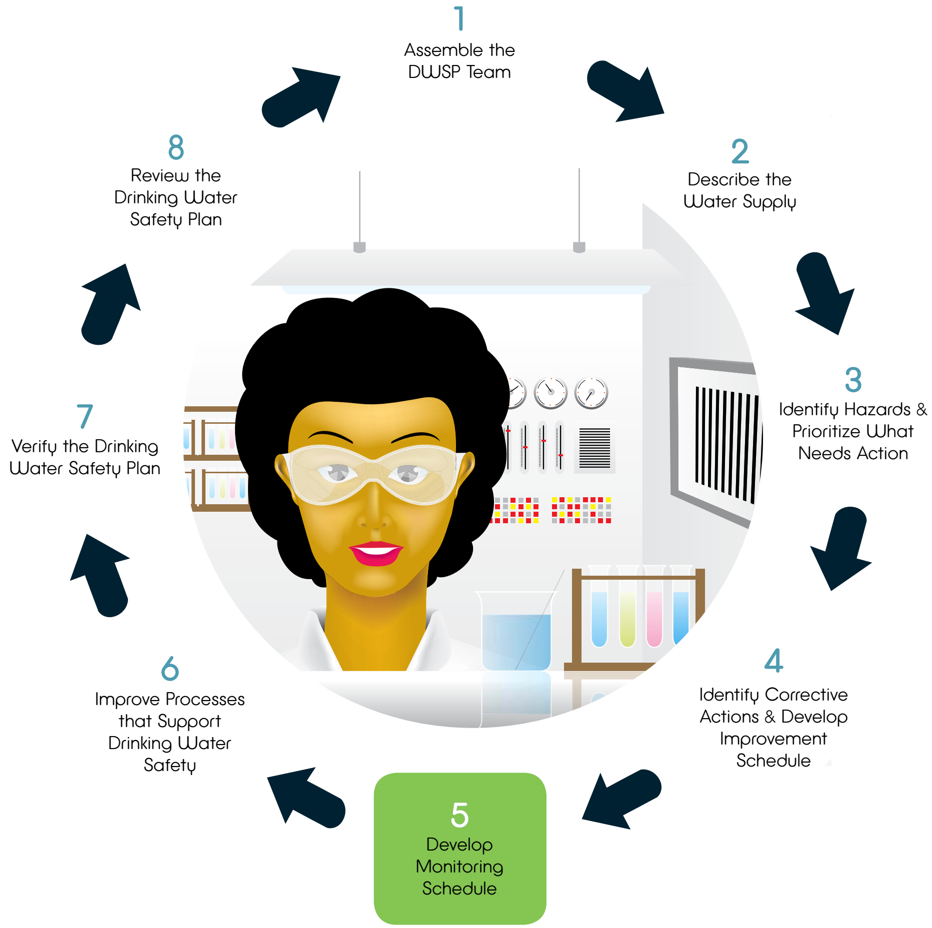
- ❑ Improvements that can be achieved through little or no financial resources e.g. operational changes etc should be prioritized over improvements that require large amount of funding and will take longer to implement
- ❑ Identify an agency or a person who should take responsibility for implementing each improvement
- ❑ Identify a time frame (short, medium or long term) and estimate the resources needed

Fill improvement table below.

Improvement description	Responsibility	Resources Needed	Time Frame	Status

Step 5

Develop a monitoring schedule



Purpose

The key objective of step 5 is to develop a Monitoring Schedule to assess the effectiveness of the existing control measures, corrective actions or improvements at appropriate time intervals to ensure consistent supply of safe drinking water.

Monitoring is an essential component of a drinking water supply and is even more important for the verification of a Drinking Water Safety Plan, i.e. to ensure that the control measures, corrective actions and/or improvements implemented are effective in ensuring that the drinking water supplied to consumers is consistently safe.

Most importantly, monitoring is essential to establish when a barrier or control measure has failed (i.e. water safety has been compromised). If a failure is detected early on in the process, corrective actions can be put in place to address the failure and ensure safe drinking water.

Monitoring schedules can fulfil a number of functions for a drinking water supply including:

- evidence of compliance with National Drinking Water Quality Standards;
- checks to ensure infrastructure is sound and equipment are in working condition;
- verify that the control measures (barriers) are functioning effectively;
- checks to ensure that equipment are calibrated;
- SOPs are being followed accordingly; and
- Drinking water supplied is safe to drink

Monitoring can include:

- Water quality tests
- Visual checks and inspections
- Monitoring consumer complaints and feedback etc

It is important to consider throughout the supply which type of monitoring will provide the information that is needed:

- To determine if controls that make the water safe are working; and
- To determine if corrective action is needed

The following step-wise process can be followed when developing a monitoring programme:

1. Identify what needs to be monitored or checked

Identify what type of monitoring is needed (monitoring may include measurable variables, such as chlorine residual, pH and turbidity, or visual checks, such as the structural integrity of storage tanks, clarifiers etc).

2. Identify operational target

Identify a level or a limit ('Operational Limit') that signifies when the system of a process within the system is operating normally. The Operational Limit may be a number e.g. Free Available Chlorine residual of 0.5 mg/L to demonstrate effective disinfection; or where the monitoring involves observation, the limit may be a description e.g. 'no debris obstructing intake'.

3. Identify critical limit

Identify a level or a limit ('Trigger Limit') that signifies when a control measure has failed or is working ineffectively and therefore emergency action is required. The limit may be a number e.g. Free Available Chlorine residual of 0 mg/L, or where the monitoring involves observation, the limit may be a description eg 'dead vermin inside service reservoir' to indicate that vermin have found access into the reservoir and microbial contamination of the water is suspected.

4. Decide when to monitor (and how often)

Identify when and how often the monitoring should be completed (it is often useful to separate the monitoring schedule into daily, weekly, monthly monitoring tasks).

5. Specify the procedure (sop) for monitoring or checks

6. Identify who is responsible for monitoring

Identify a person (or position) responsible for carrying out the monitoring

7. Identify contingency or emergency actions to take when a critical limit has been breached

Table 13: Corrective Action - worked example 6

Hazardous Event	What to monitor?	Operational limit	Critical Limit	Monitoring			Contingency / Emergency Action
				When?	How?	Who?	
Seepage from septic tanks from villages upstream to intake	E.coli	0.0 CFU	>= 1.0 CFU	Daily	Multiple Tube method	Lab Technician	Boil water advisory (SOP #056); Increase Chlorine dose (SOP# 097)
Seepage of faecal waste from piggery located upstream to intake	E.coli	0.0 CFU	>= 1.0 CFU	Daily	Multiple Tube method	Lab Technician	Boil water advisory (SOP #056); Increase Chlorine dose (SOP# 097)
Heavy rain in catchment	Turbidity	1.0 NTU	>10NTU	Daily	HACH kit	Site Technician	Shut down inlet (SOP#011) or adjust coagulant dosing (SOP# 32)
Power failure	Power supply	Steady power supply	Power outage	Hourly	Visible check	Shift Operator	Advise public of water supply disruptions (SOP#54)
Low water level due to Drought	Water level at intake	Intake water level > 10m	Intake water level < 5m	Daily	Water level indicator stick	Site Technician	Advise public of water supply disruptions (SOP#54), Enforce water use restrictions (SOP#57)

DWSP Checklist:

Step 5: Develop monitoring schedule

What to include in the monitoring schedule

- ❑ Monitoring Parameters
- ❑ What are the Operational Limits (i.e. level which demonstrates system is operating efficientlt)?
- ❑ What are the Critical Limits (i.e. level which indicates water quality/safety has been compromised)?
- ❑ Sampling locations
- ❑ Who should monitor?
- ❑ How to monitor, test or check? (e.g. reference to laboratory method or visual checklist etc...)
- ❑ Corrective Action(s) if Critical Limit is reached or breached.

Some common operational monitoring parameters:

Water Quantity

- ❑ Stream / river flow
- ❑ Rainfall

Water Quality

- ❑ pH
- ❑ Turbidity (or particle count)
- ❑ Dissolved oxygen
- ❑ Conductivity (total dissolved solids, or TDS)
- ❑ Algae, algal toxins & metabolites
- ❑ Chemical dosage
- ❑ Disinfectant residual

Operational

- ❑ Flow rate
- ❑ Hydraulic pressure

Visual Checks

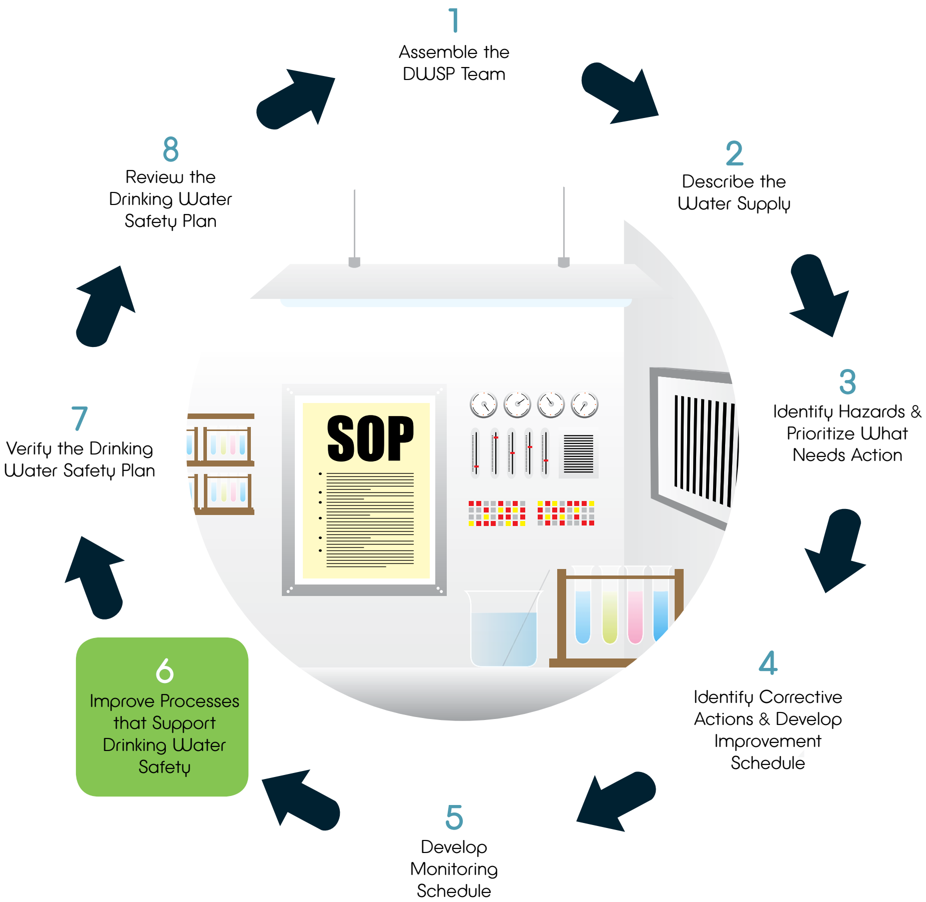
- ❑ Structural integrity of infrastructure
- ❑ Catchment & intake condition / integrity
- ❑ Signs of vandalism or sabotage
- ❑ Signs of contamination

Fill in monitoring table below.

Hazard	Hazardous Event	What to monitor?	Operational limit	Critical Limit	Monitoring			Contingency / Emergency Action
					When?	How?	Who?	

Step 6

Improve processes that support drinking water safety



Purpose

The key objective of step 6 is to establish or strengthen operational, managerial or technical processes which support the implementation of a Drinking Water Safety Plan.

There are several processes (called 'supporting programmes') within a water supply's operations and management that indirectly support drinking water safety. These processes usually cover a range of water supply functions, including operator training and refresher courses, calibration of equipment, preventive maintenance, hygiene and sanitation, legal aspects such as a programme for understanding the organization's compliance obligations and communication and staff awareness.

Due to the increasing demands on organizations in terms of business aspects and the production of many water 'products' (drinking-water, recycled water etc) (Davison and Deere, 2005; Davison et al, 2004), it is essential that organizations accordingly understand their liabilities and have programmes in place to deal with these issues.

Supporting Programmes	Purpose	Examples
Training	To ensure that operators and site technicians are properly trained on operations procedures, equipment operation and maintenance and familiar with operating new equipments / components	DWSP Training; New staff Induction; Refresher courses
Calibration	To ensure that monitoring information is reliable and accurate.	Calibration schedule
Preventative Maintenance	To ensure that equipment and components are in working order and any maintenance is foreseen and undertaken before complete breakdown of equipment	Maintenance Schedule; Proactive procurement of parts
Communication	To ensure that there is a clear and defined pathway for communicating information on the water supply	Emergency contacts of management staff, media etc; media relations strategy;
Awareness	Awareness within the Water Supply staff about the current version of DWSP, recommended changes within the system, any improvements etc	Information memos on latest updates; staff meetings
Customer Complaints	A mechanism for logging of customer complaints and action taken to address the complaints	Customer complaints center
Legal Aspects	Ensure that the water supply is meeting any legal compliance requirements	Monitoring compliance against drinking water quality standards
Contingency / Emergency Plans	Procedures for how to routinely operate the drinking water supply are covered in Standard Operating Procedures and Monitoring Plans, however sometimes events happen with little or no warning and are best managed by documented incident and emergency plans.	Major contamination or disruption to the water supply due to natural disasters or a chemical spill affecting the source water
Standard Operating Procedure (SOP)	Drinking water supply standard operating procedures (SOPs) are "how-to" guidance documents for the physical aspects of a water system's daily operation and maintenance. They give step by step guides to perform operational and maintenance tasks, describe safety issues and timetable operational and maintenance tasks with checks and check sheets	

The organization should use the examples (while not intended to be exhaustive) as a guide and assess the programmes it currently has in place and any gaps that need to be addressed including: * Updating of existing programmes; & * Development of new programmes.

Table 14: Examples of Supporting Programmes for ensuring drinking water safety

Improve Processes that Support Drinking Water Safety

What supporting processes should I consider?

❑ QA / QC system

A Quality Assurance / Quality Control system helps to ensure drinking water quality objectives are maintained and if there are major events that compromise drinking water quality, then steps are taken to ensure the event is adequately managed and corrective actions taken.

❑ Communication & awareness

Communication is critical in any organization and more so within a drinking water supply. Ensure that a clear communication strategy is established for communication of information on the drinking water quality and/or supply. Management and staff must know whom to contact if something goes wrong with the drinking water supply. This may include notifying external authorities such as the Ministry of Health or Environment agency.

❑ Record keeping

This is needed to ensure all records (monitoring results, actions taken during major events, customer complaints, compliance documents, correspondence etc) are maintained within the water supply.

❑ Training & human resource development

Keeping staff properly trained at all times is an essential component of a drinking water supply. This is particularly important when a process is changed or new equipment are installed. New staff need to be properly inducted to ensure that they are familiar with the processes, equipment and operation & maintenance procedures within the supply.

❑ Standard operating procedures

Developing and regularly updating SOPs is another essential process that supports drinking water safety. SOPs must be written for every operation or maintenance procedure. A simplified version of all SOPs must be posted at appropriate places within the supply so that all staff have easy access. SOPs ensure that all staff follow the same procedure when performing an activity (e.g. performing the Jar Test) within the supply.

❑ Calibration

All equipment must be calibrated to ensure the results are credible.

❑ Preventative maintenance

A preventative maintenance plan must be developed for all machinery / equipment to ensure they are always in working condition.

❑ Legal aspects

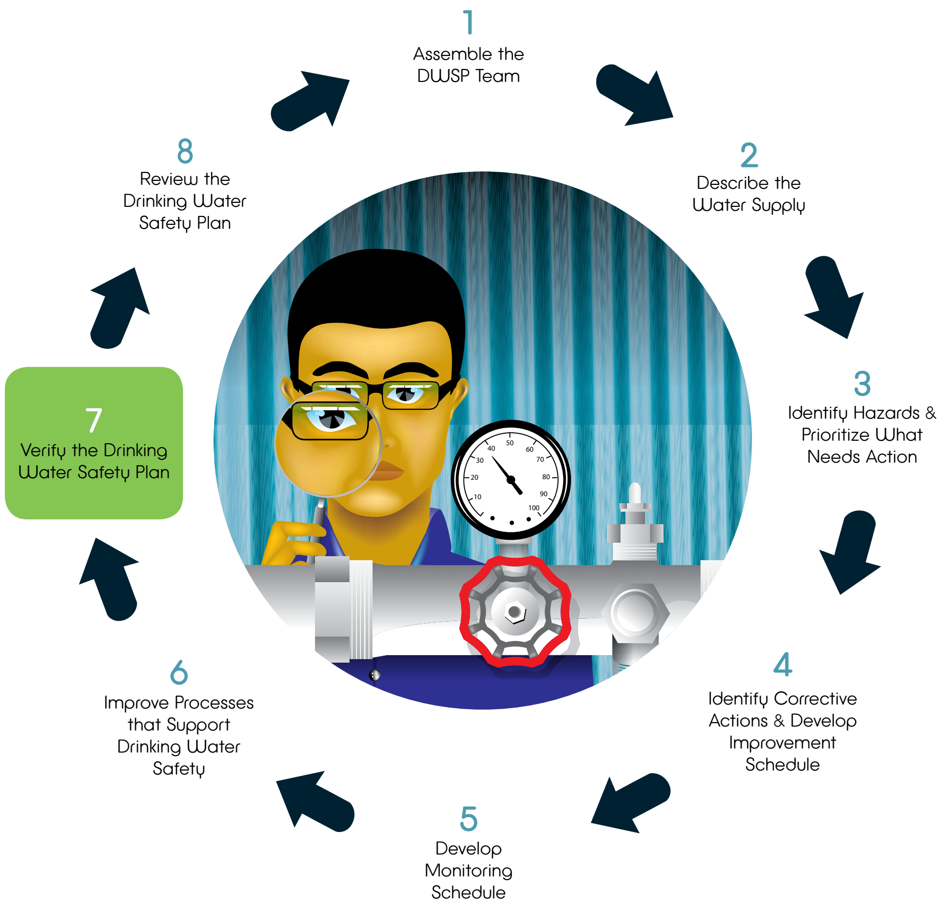
Is the supply meeting its legal requirements e.g. compliance to National Drinking Standards, if any?

❑ Contingency / Emergency plans

Drinking water supplies do not always function according to plan, Murphy's Law applies i.e. things could go wrong at any time. It is good practise to predict potential problems or accidents and have contingency or emergency plans developed in advance."

❑ SOP

SOPs need to be developed for all critical aspects of the drinking water supply operation to ensure that all operators follow a standard procedure when performing tasks. This minimizes operator error.



Purpose

The key objective of step 7 is to ensure that the DWSP is integrated into the day-to-day management and operation of the supply and verified at regular intervals to ensure that the Drinking Water Safety Plan is effective and that the water supplied to consumers is consistently safe.

The DWSP must be used in order to make a difference to drinking water safety. Generally, the actions that need to be taken are outlined in the following sections of a DWSP;

- Monitoring Plan;
- Improvement Schedule; and
- Processes that support drinking water safety.

Introducing people to the requirements of the drinking water safety plan

In some circumstances, it is possible that some people involved in day to day operation of the water supply have not been members of the DWSP team and may not be familiar with the requirements of the DWSP. It is important that all individuals with the responsibility of implementing parts of the DWSP are introduced to the DWSP concept and are trained in their required tasks. Keep in mind that this may be a completely new way of working for some people.

Depending on the size and nature of the water supply it may be worth considering;

- Undertaking a workshop to familiarise people with the DWSP concept
- Undertaking individualised training for the specific tasks required of individuals
- Assigning one person overall responsibility for management of the DWSP

Routine operational monitoring

Routine monitoring is discussed in Step 5.

Implementing the improvement schedule

Implementation of the improvement schedule developed in Step 4, is key to improving the drinking water supply and a good indicator of whether the plan is being used or not. If the DWSP does not bring about the changes needed to improve the supply, then clearly, the plan is not effective.

Improving processes that support drinking water safety

Processes that support the implementation of various components of the DWSP are key to its success. For example, a clear and concise communication strategy is effective at ensuring that problems and issues within the supply are relayed to key personnel (engineers, operators, managers etc) so that remedial action is mobilized within reasonable time. Similarly, SOPs enhance the way in which a supply is operated by ensuring that all operators follow standardized procedures when conducting tasks to minimize the risk of operator error. Contingency and Emergency Plans provide an immediate guidance to what procedures should be followed to remedy a problem. Collectively, these processes help support the DWSP and are good indicators that the plan is being used.

Consumer satisfaction

Keeping records

The level of record keeping required will depend to a large extent on national surveillance requirements and may

Verifying the plan

For the DWSP to be relied on for controlling the significant risks for which it was developed, it needs to be supported by accurate and reliable technical information. This process of obtaining evidence that the WSP is effective is known as verification. Verification is usually initiated as soon as a WSP has been operationalized and thereafter on a regular basis (e.g. annually) or as needed.

Verification of drinking-water quality provides an indication of the overall performance of the drinking-water system and the ultimate quality of drinking-water being supplied to consumers and therefore it incorporates routine monitoring of drinking-water quality, validation of the system as well as assessment of consumer satisfaction.

Verification programmes for the selected indicators will need to be undertaken on a regular basis and the surveillance agency (usually the Ministry of Health or Environment Protection Agency) should support and approve local verification programmes.

Use the Drinking Water Safety Plan

DWSP Checklist:

Step 7: Use the drinking water safety plan

Using the Plan

- ❑ Has the plan been introduced to management and operational staff of the water supply?

Have the following sections of the plan been operationalized:

- ❑ Monitoring Schedule
- ❑ Improvement Plan
- ❑ Processes that support drinking water safety (e.g. SOPs, Emergency / Contingency Plans etc)

Verifying the Plan

Verification of a DWSP is essentially an audit of the DWSP to verify whether the corrective actions and/or improvements outlined in the DWSP were effective or not.

This can usually be achieved through:

Verifying Monitoring Data

- ❑ Is monitoring being conducted according to monitoring plan in the DWSP?
- ❑ Has there been a change in monitoring parameters (addition, deletion or change in maximum acceptable value)?
- ❑ Check the monitoring records (before and after implementing the DWSP) to see whether there have been any improvements in drinking water quality.

DWSP Implementation

- ❑ If the DWSP has been implemented, check whether there has been any major changes in (i.e. events that caused deterioration of) drinking water quality since implementation. Identify what caused the event and whether corrective actions were taken.

Records

- ❑ Check records to see if DWSP objectives were met.

System Operation

- ❑ Has the supply operated within specified parameters?
- ❑ Have there been any significant changes in the processes or equipment / infrastructure within the supply.
- ❑ Check the system infrastructure to ensure that all components are operating efficiently.
- ❑ Have SOPs been developed?
- ❑ Is the staff aware of the SOPs or at least know where to find them?

Improvements

- ❑ Have improvements been completed according to the Improvement Schedule?

Step 8

Review the drinking water safety plan

Purpose

The key objective of step 8 is to review the plan based on monitoring (or verification) data to assess for new risks which may have become apparent or remove risks which are no longer applicable.

Drinking water safety planning is an ongoing process, so the drinking water safety plan should be reviewed at least annually. It is a good idea to nominate a person responsible for ensuring that the review takes place (this may be the same person who has overall responsibility for management of the DWSP).

It is helpful to insert a date on the DWSP document and change this date each time the DWSP is amended.

During the review, it may be helpful to consider the following:

- Review any hazard events that have occurred and the actions that were taken. Have these hazard events highlighted any weaknesses in the DWSP? Is there any way that the DWSP could be altered that would avoid a similar problem in the future?
- Review the water supply description and schematic to establish whether there have been any significant changes to the source, treatment, storage or distribution processes. Examples of significant changes may be: addition of a new source, installation of new treatment equipment or adding to the reticulation by extending pipe-work to another village.
- Review the improvement schedule. This will need to be updated as improvements are completed. New information or resources may mean changing the order of priority for the improvements.

Review the Drinking Water Safety Plan

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Review

Usually review of a DWSP is conducted at regular intervals (e.g. annually). During a review, the following information must be updated:

Management

- ❑ Has the roles and responsibilities of management and/or staff changed since the last review?
- ❑ Have personnel changed since the last review?

Risks

- ❑ Has there been a change in risks associated with the supply i.e. has new risks been identified and must be added or some risks no longer apply and therefore must be deleted?

Improvements

- ❑ Has a new barrier been added to the water supply e.g. new UV unit?

System operation

- ❑ Has there been a change in system operation or maintenance processes and procedures?

DWSP document

- ❑ Are contact lists, roles and responsibilities of staff up to date?
- ❑ Are documents and forms related to the DWSP same?
- ❑ If documents (e.g. SOPs or Operations Manual) been changed, has the new documents been linked to the DWSP?
- ❑ Do all staff and operators have the latest version of the DWSP?

After a review

- ❑ Make sure to change the version number on the document front page.
- ❑ Add a new date for the next review process.

Glossary

Algae

Algae are unicellular (single-celled) to multi-cellular (many cells) plants that occur in freshwater, marine waters and damp terrestrial environments (e.g. swamps). All algae are photosynthetic i.e. produce their own food. Algae are usually larger than 10 microns.

Alkalinity

Alkalinity is a measure of the buffering capacity of water. Alkalinity controls pH changes in water when it comes into contact with acidic or alkaline substances and is therefore of great significance to coagulation/flocculation, drinking water treatment processes which require optimal pH (little or no pH change) to operate efficiently.

Bacteria

A group of unicellular or multi-cellular organisms that are regarded as the simplest form of life. They possess a simple nucleus and reproduce by cellular division. Bacteria can reproduce quite rapidly if conditions are optimal. Some members of the group are pathogenic (disease causing) e.g. Salmonella Typhi, a bacteria that causes Typhoid Fever.

Barriers

Processes put in place to prevent contamination of raw water, remove contamination from raw water (treatment) and preventing re-contamination of treated water.

Blue-green algae

See Cyanobacteria

Catchment

An area of land in which precipitation (rainfall) drains to a particular stream, river, lake, etc. Sometimes it is called a watershed.

Chlorine residual

The amount of chlorine still present in water at any time during reticulation.

Coagulation

Use of metallic (cationic) salts, usually Aluminium or Iron based, to aggregate fine suspended material and colloidal particles causing them to clump together to form large, settleable particles.

Contamination

The introduction of "agents" that cause deterioration of drinking water, making the drinking water unsafe for human consumption.

Contingency plan(s)

A clear, step-by-step, procedure (usually in the form of a decision matrix/flow chart) for actions to be taken in case of a known (or predicted) risk/hazard event occurring.

Control measures

See Barriers

Corrective actions

Remedial actions taken to control a hazard / risks, usually following an incident. This is a reactive measure.

Critical limit

The limit assigned to each drinking water quality parameter (e.g. turbidity, E.coli etc) beyond which confidence in the safety of the drinking water is lost.

E.g. Turbidity > 10NTU – beyond 10 NTU, the drinking water is no longer safe to drink.

Cryptosporidium

A group of common water-borne protozoa that can cause gastro-intestinal illness with acute diarrhea in humans. Characteristic of water contaminated with faecal waste. Its relative size is between 3-6 microns (micrometers). Disinfection, especially at low doses, is basically ineffective and the most effective way of removing Cryptosporidium from water is by filtration (e.g. Rapid sand filter or cartridge filter).

Cyanobacteria

Also known as Blue Green Algae. Cyanobacteria are a group of bacteria with the ability to photosynthesize. They occur globally in fresh and saltwater and some species are known to produce an acute toxin which can be lethal to humans.

Cyanotoxins

A toxin secreted by Cyanobacteria.

Diarrhoea

Frequent and watery bowel movements; can be a symptom of infection, food poisoning, colitis or a gastrointestinal tumour.

Distribution

The part of a drinking water supply network within which all consumers receive drinking water including treated water storage, trunk mains, pumps, pressure valves, backflow prevention devices, Pipeworks, meters etc.

Disinfection

This is a drinking water treatment process aimed at destroying disease causing micro-organisms, including bacteria, viruses and protozoa, in water. Chlorination is the most common form of disinfection. Other methods used include Ultraviolet Light (UV), Ozone etc.

Disinfection by-product

A contaminant produced in the drinking water supply as a result of chlorine reacting with organic material in water. A common disinfection by-product is Tri-halo methane (THMs).

Drinking water

Water intended for human consumption, food preparation, oral hygiene or personal hygiene / sanitation.

Drinking water quality standards

Standards describe (and state) the minimum acceptable values specified for each parameter associated with quality and/or safety of drinking water. These are usually legislated and water supplies are expected to comply with the standards.

Drinking water safety plan

A comprehensive risk assessment and management approach that encompasses all aspects of a drinking water supply, from catchment to consumers, consistently ensuring safety of drinking water

Drinking water supply

The collective processes of collecting, treating and distributing drinking water to consumers.

E Coli

See Escherichia Coli

Emergency plan(s)

See Contingency Plan(s)

Escherichia coli

Escherichia Coli (E.coli) is the scientific name for a bacterium that is commonly found in the lower intestine of warm-blooded animals including humans. Most E.coli strains are harmless but their presence in water indicates possible Faecal contamination. E.coli is a common water quality indicator.

Faecal coliform

A subgroup of coliform bacteria that will grow on a specific media at 44.5 +/- 0.2oC (Thermotolerant). Presence of Faecal Coliform in water indicates faecal contamination, and presence of potentially contagious pathogens.

Filtration

A drinking water treatment process that removes suspended particles from water by passing the water through a medium (sand bed, cartridge, membrane etc). Some forms of filtration (GAC) can also remove colour, odour, taste and suspended organic material.

Flocculation

The drinking water treatment process of gathering together coagulated clumps of suspended material into floc.

Flow chart

See Schematic

Free available chlorine (FAC)

The chlorine present in water as hypochlorous acid and hypochlorite ion.

Giardia

A pathogenic, flagellated member of the protozoa family that infects the gastro-intestinal tracts of humans and some animals. They are usually 8-12 micron in size and can remain dormant in the environment in their cyst stage.

Groundwater

Water contained beneath the land surface in zones of saturated soil, which can be extracted as a drinking water source.

Hazard

Any physical, chemical, biological or radiological agent that can cause harm to public health from unsafe or inadequate drinking water.

Hazardous event

Any event that introduces hazards to, or fails to remove them from, the drinking water supply.

Hydrogen sulphide (paperstrip) test

A simple presence-absence test for bacteria in treated (disinfected) drinking water. The test detects hydrogen sulphide producing bacteria in a sample.

Indicator organisms

A micro-organism (usually E.coli) that is monitored to indicate the presence of faecal material, and thus other potential pathogenic organisms, in water.

Intake

The point of abstraction of raw water for treatment.

Micro-organism

A very small (microscopic) organism. Includes bacteria, viruses, protozoa, algae and Helminths.

Monitoring

The process of sampling and analysing drinking water (and raw water) samples to ensure consistent supply of safe drinking water. Monitoring is also used to demonstrate compliance with National Drinking Water Standards or other relevant legislation, where applicable.

Multiple barrier approach

The use of two or more “barriers” to prevent contamination of drinking water to consistently ensure its safety. The theory is that if one barrier fails, the others are likely to work and drinking water safety is maintained.

Operational limit

The limit (usually a range) assigned to each drinking water quality parameter (e.g. turbidity, E.coli etc) at which drinking water is considered safe.

E.g. E.coli <1.0 – as long as E.coli level in water is maintained at <1.0, drinking water is considered safe.

pH

Measure of the relative acidity or alkalinity of water. Defined as the negative log (base 10) of the hydrogen ion concentration. Pure water has a pH of 7; acidic solutions have lower pH levels and alkaline solutions higher pH levels in the range from 1 to 14.

Parameter

A water quality factor that is analyzed to determine the safety, or otherwise, of drinking water.

Pathogen

An organism capable of causing disease in humans.

Preventative measures

Proactive actions taken (or planned) to prevent a known hazard/risk from occurring.

Protozoa

A unicellular, heterotrophic member of the protist family. See Giardia and Cryptosporidium.

Raw water

Water abstracted from a surface or groundwater source (but has not yet been treated) with the intention for use as drinking water.

Reticulation

See Distribution

Risk

A prediction of the degree of threat to the safety of a drinking water supply based on the likelihood and consequence of a hazard occurring.

E.g. the risk of re-contamination of treated water from faecal matter is Medium (based on likelihood (i.e. unlikely) and consequence (i.e. Catastrophic)).

Risk assessment

An investigation and characterization of risks (and hazards) associated with a drinking water supply based on their likelihood of occurring and consequence.

Sanitary survey

A physical survey and inspection of the integrity of components of a drinking water supply to ensure consistent supply of safe drinking water. It usually entails identification of hazards and sources of contamination.

Schematic

A Diagrammatic representation of a drinking water supply, clearly showing different components of the supply including flow directions, pumps, valves, sources, intakes, treatment processes, distribution zone etc.

Sedimentation

The drinking water treatment process of settling out suspended particles in raw water, usually prior to treatment.

Standard Operating Procedure

A set of clear, concise, step-by-step procedure, written in a simple language, describing how to perform a task e.g. taking a drinking water sample. SOPs are developed to standardize procedures within a supply to ensure all operators, technicians etc do the same task, the same way. This minimizes the risk of operator error. Usually a hard copy of a comprehensive SOP is filed within easy access of operators, however, simplified versions are also pasted on the wall where the task is likely to occur.

Surface water

Water found on the land surface usually as a result of run-off of precipitation. It can be running (rivers and streams), or quiescent (lakes, reservoirs and impoundments).

Surveillance

The process of checking the management and operation of a drinking water supply (usually by monitoring drinking water quality in reticulation zones) commonly conducted by a Public Health Agency.

System assessment

A physical ("walk-the-system") assessment of the drinking water supply to develop a comprehensive and detailed description of the supply, which then feeds into the risk assessment stage of the drinking water safety planning process.

Thermotolerant coliforms

See Faecal Coliform

Total coliform

Bacteria that will grow on a selective media at 35 +/- 0.2oC. Used to indicate probable contamination of water by organic matter. Total coliform includes Erwina, Klebsiella, Escherichia, Citrobacter and Enterobacter.

Turbidity

A measure of the suspended particles in water that causes the water to lose its clarity by scattering light. Turbidity is measured in Nephelometric Turbidity Units (NTU).

Typhoid fever

Contracted when people eat food or drink water that has been infected with salomonella typhi. It is recognised by the sudden onset of sustained fever, severe headache, nausea and severe loss of appetite, sometimes accompanied by a hoarse cough and constipation or diarrhoea.

Ultra-violet light (UV)

Radiation that has a wavelength shorter than400nm and is outside the visibility range of the human eye. UV works by attacking the nuclei of micro-organisms, thus preventing them from replicating. This process is called "in-activation" and is not the same as "killing", but it effectively eliminates any threat from micro-organisms exposed to UV light. UV is an excellent disinfectant against bacteria, viruses and protozoa.

Validation

A rigorous, comprehensive, short-term performance assessment of the drinking water safety plan through identification of components that are functioning efficiently and those that aren't. An outcome of a validation process is identification of areas within the supply that need improvement.

Virus

A very small (microscopic) parasitic organism that can survive only inside a living host. Viruses attack the host by hijacking a normal cell and using the cell's metabolic processes to mass reproduce, eventually resulting in a burst cell, which releases more viruses into the body. Viruses are responsible for severe water-borne diseases including infectious Hepatitis and Polio.

Water borne diseases

Infectious diseases transmitted through pathogens transported in drinking water.

Water cycle

A natural process, driven by solar energy, through which water is "recycled" on earth.

Water quality standards

See Drinking water quality standards.

Water supplier

Any person or organization (utility) that owns, or is responsible for operating, all or parts of, a drinking water supply.

Water treatment

The process of making water fit for human consumption including removal of substances that may be hazardous to human health.

Water treatment plant

The point where drinking water supply enters the distribution, regardless of whether it has been treated or not. Usually, treatment plant refers to an area or location where water treatment processes take place.

Water treatment process

The process (or processes) involved in making the drinking water fit for human consumption. It includes all chemical, biological, physical and mechanical processes used to enhance the quality of drinking water and eliminate (or control) risks to human health.

Watershed

See Catchment

World Health Organization

An agency of the United Nations, founded in 1948. Its key objective is the attainment by all peoples of the highest possible level of health (Physical, Mental, Social and not merely the absence of disease).

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Appendices

Drinking water safety plan for matai urban water supply

This document was prepared by: John Dollar (Consultant)

Date:	11 / 11 / 08	**Version:** 1.2
Approved by:	Mr . Joe Ratu (Manager, Matai Water Supply)	
The DWSP is due for review on:	11 / 11 / 09	

Organization details

Name of Supply:	Matai Town Water Supply
Capacity:	30ML/day
Contact:	Joe Ratu, Manager
Address:	99 Matai Street, Matai
Phone:	678999
Fax:	678990
Email:	joe.ratu@mataiwater.com
Source 1	Wai Lailai River
Type:	Surface
Capacity:	20ML/day
Address:	25 Wai Lailai Drive, Matai
Source 2:	Wai Matai Bore
Type:	Groundwater
Capacity:	10ML/day
Address:	66 Matai Street, Mati
Treatment Plant:	Matai Treatment Plant
Address:	66 Matai Street, Matai
Contact:	Frank Treatment (Plant Manager) or Samu Backwash (Operator)
Phone:	678445 / 678544
Email:	frank.treatment@mataiwater.com or sam.backwash@mataiwater.com

Water supply information

Population served: 780 households; 2345 people

Area covered: Matai Town and Wai Lailai village – including Matai Primary and High School, Matai Chocolate factory, Matai fish processing plant, matai sugar mill and Matai Resort

Introduction

- Explain purpose of developing DWSP
- Describe the water supply setting i.e.
  - Demographics – population, economy etc
  - Health status (any major waterborne diseases reported in the past few years)
  - Per capita water use and current demand (if known)
- Describe climatic conditions such as rainfall patterns etc
- Describe any other factors that may affect drinking water quality. These may include:
  - Catchment size and vegetation type
  - Land-use
  - Other uses of the source e.g. gravel extraction, recreational use etc
  - Pollution
- Describe any compliance requirements to local legislation and/or Drinking Water Standards
- Add any other general information that relates to drinking water supply

DWSP team

Name	Position	Role in DWSP	Contact
John Dollar	Consultant	Author, Technical	j.dollar@consultant.com
Gerald Ratu	Supply Operations Manager	Technical & Management	g.ratu@mataiwater.com
Kamal Khatri	Asset Manager	Technical & Management	k.khatri@mataiwater.com
Steven Iddings	Water Supply Engineer	Engineering, planning	s.iddings@mataiwater.com
Simon Peters	Snr. Operator	Technical	s.peters@mataiwater.com
Marc Overmars	Human Resources Officer	Support	m.overmars@mataiwater.com
Wanton Wantok	Quality Manager	Support	w.wantok@mataiwater.com

System description

Describe the water supply including:

- Source – describe each source used
- Treatment – describe the treatment processes used – and identify any drawbacks, shortcomings
- Storage – describe types of storage used including material (steel, concrete etc) structural integrity (cracks, leaks etc), capacity and any other useful information

Risk identification & prioritization

- Identify all possible risks associated with the drinking water supply

  This can be achieved by considering risks at the different stages of the water supply i.e. catchment, treatment, storage & distribution
- Identify hazards that are currently under control
- Prioritize each risk that is not currently under control using the likelihood vs consequence matrix

Likelihood Scores

Likelihood Score	Possible Descriptions	Risk Score
Almost Certain	Very common event, occurs on a regular basis	5
Likely	The event has happened before and can probably occur again	4
Possible	The event could happen	3
Unlikely	The event may not happen	2
Rare	Very uncommon event – probably will never occur	1

Consequence Scores

Consequence Score	Possible Descriptions	Risk Score
Insignificant	No potential to cause harm to public health within a community	1
Minor	Potential to cause minor irritation or discomfort	2
Moderate	Potential to cause illness	3
Major	Potential to cause illness and hospitalisation of people within a community	4
Catastrophic	Potential to cause death(s) within a community	5

Likelihood vs Consequence Matrix

Likelihood	Consequence				
	insignificant (1)	Minor (2)	Moderate (3)	Major (4)	Catastrophic (5)
Almost Certain (5)	Medium (5)	Medium (10)	High (15)	Urgent (20)	Urgent (25)
Likely (4)	Low (4)	Medium (8)	High (12)	High (16)	Urgent (20)
Possible (3)	Low (3)	Medium (6)	Medium (9)	High (12)	High (15)
Unlikely (2)	Low (2)	Low (4)	Medium (6)	Medium (8)	Medium (10)
Rare (1)	Low (1)	Low (2)	Low (3)	Low (4)	Medium (5)

Appendix 1 continued...

Catchment

Hazard	Cause / Hazard Event	Control measure / barrier	Likelihood	Consequence	Priority
Microbial contamination	1.0 Source water contaminated by faecal waste from piggery	None	Likely	Major	High
	1.1 Source water contaminated by faecal waste from septic tank seepage	None	Likely	Major	High
No / inadequate water	1.2 Stream dried up during drought	Trained technicians	Unlikely	Major	Medium

Treatment

Hazard	Cause / Hazard Event	Control measure / barrier	Likelihood	Consequence	Priority
Microbial contamination	2.0 Insufficient disinfection	Hourly FAC measurements at clear water well	Likely	Major	High
Chemical Contamination	2.1 Fluoride overdosing	Trained staff	Unlikely	Major	Medium
No water	2.2 Power outage shuts plant down	None	Possible	Major	High

Appendix 1 continued...

Storage & distribution

Hazard	Cause / Hazard Event	Control measure / barrier	Likelihood	Consequence	Priority
Microbial contamination	3.0 Cross-connection with sewer since both pipes running side by side	None	Unlikely	Major	Medium
	3.1 Cross-contamination during leak repairs	Strict procedures for leak repairs	Possible	Major	High
	3.2 Cross-contamination due to backflow	None	Possible	Major	High

Corrective actions and improvement schedule

- For risks currently not under control, identify what corrective actions or improvements need to be taken to ensure that these risks are controlled
- Develop an Improvement Schedule, which is a list of all corrective actions and improvements with details on who is responsible for making the improvements, what timeframe is set to complete the improvements and what resources (e.g. funds, personnel) are required to complete the improvements.

Risk	Improvement / Corrective Action needed	Responsibility	Resources Needed	Time Frame	Status
1.0	Farmer education and awareness	Public Relations Team	IEC Material	Short-term	
2.2	Onsite back-up generator	Management	$25,000	Medium-term	
3.2	Install backflow preventers	Senior Engineer and Distribution team	$50,000	Long-term	

Monitoring schedule

This is a critical part of drinking water safety planning in that it indicates whether the risks within the supply continues to be well managed or that a something has gone wrong and needs urgent attention.

- For each control measure in place, identify a parameter or indicator that indicates the control measure is working effectively

  E.g. Turbidity for the Rapid Sand Filters; or FAC for disinfection

- For each parameter, identify an OPERATIONAL LIMIT i.e. the Maximum Acceptable Value at which you know the supply is working efficiently

  E.g. Turbidity <1.0 NTU – a reasonable variation e.g. 1-10 NTU is usually acceptable

- For each parameter, also indicate a CRITICAL (or TRIGGER) Limit that indicates a serious failure of the control measure

  E.g. Turbidity >10NTU

- Identify, WHO is responsible for monitoring, WHEN (or how often) the parameter should be monitored and HOW (what tests or meters should be used)

  E.g. Turbidity Lab Technician Weekly HACH Turbidity Meter

- Identify CONTINGENCY/EMERGENCY actions to be taken when a TRIGGER limit is reached indicating failure of the control measure

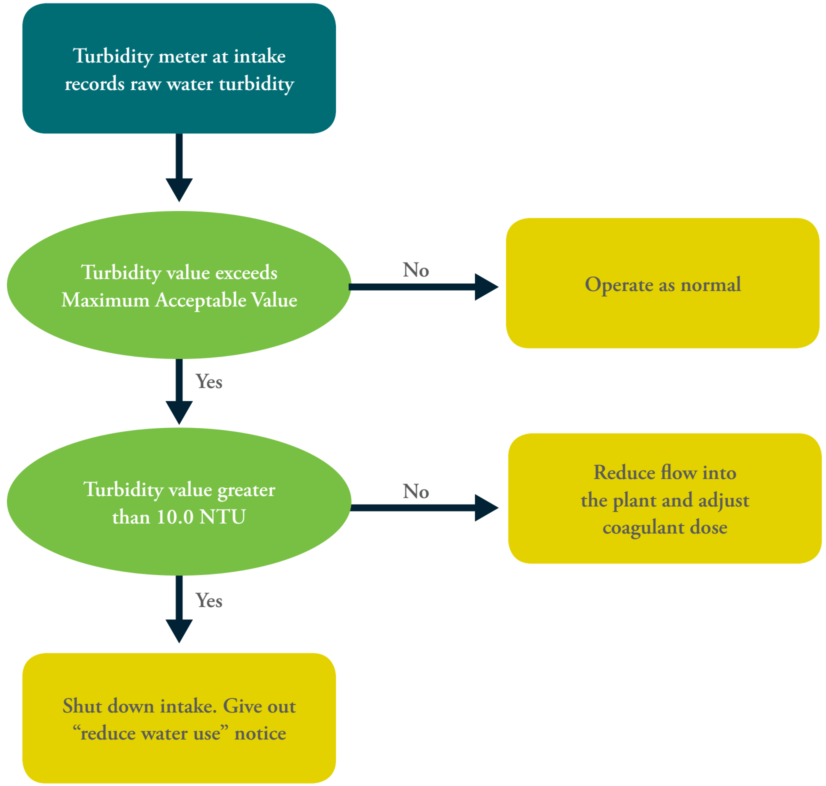
What to monitor?	Operational Limit	Critical Limit	Monitoring			Contingency / Emergency Action
			When?	How?	Who?	
Turbidity	< 1.0 NTU	> 1.0 NTU	Daily	SOP # 5.6	Joe Blue	CEP # 2.1
FAC	0.2 – 0.5/ mg/L	< 0.2 or > 0.5/ mg/L	Daily	SOP # 5.3	Joe Blue	CEP # 2.2
E-coli	< 1.0	> 1.0	Daily	SOP # 5.1	Joe Blue	CEP # 2.3

Contingency plans

- Contingency / Emergency plans are needed for events that occur despite preventative actions that may have been taken. This section outlines the Contingency and Emergency Plans in place to ensure any significant event that could affect drinking water quality is quickly managed and controlled.
- The key risks can be classified into general risk categories and a CEP developed for each. CEPs are usually in the form of a flow chart which describes the general procedures and decision making processes during an emergency.

CEP # 1.0

Highly turbid raw water



Review

This section outlines the review process for verifying the DWSP.

- Describe how the DWSP should be reviewed or verified.

SUPPLY NAME: WORKSHEET 3.1 - RISK MATRIX

Catchment, source & intake

List all hazards associated with the catchment, source and intake. For each hazard identified, describe whether it is under control (control measures/barriers). If hazard is not under control, determine the likelihood of the hazard occurring and its consequence if it did occur. Assign priority. Describe what corrective action(s) needs to be taken. If hazard under control, it can be assigned “NOT A PRIORITY”.

Hazard	Cause / Hazard Event	Control measure / barrier	Likelihood	Consequence	Priority	Corrective Action

SUPPLY NAME: WORKSHEET 3.2 - RISK MATRIX

Pre-treatment & treatment

List all hazards associated with the catchment, source and intake. For each hazard identified, describe whether it is under control (control measures/barriers). If hazard is not under control, determine the likelihood of the hazard occurring and its consequence if it did occur. Assign priority. Describe what corrective action(s) needs to be taken. If hazard under control, it can be assigned “NOT A PRIORITY”.

Hazard	Cause / Hazard Event	Control measure / barrier	Likelihood	Consequence	Priority	Corrective Action

SUPPLY NAME: WORKSHEET 3.3 - RISK MATRIX

Storage & distribution

List all hazards associated with the catchment, source and intake. For each hazard identified, describe whether it is under control (control measures/barriers). If hazard is not under control, determine the likelihood of the hazard occurring and its consequence if it did occur. Assign priority. Describe what corrective action(s) needs to be taken. If hazard under control, it can be assigned "NOT A PRIORITY".

Hazard	Cause / Hazard Event	Control measure / barrier	Likelihood	Consequence	Priority	Corrective Action

SUPPLY NAME: WORKSHEET 3.4 - RISK MATRIX

Organizational, management, operation

List all hazards associated with the catchment, source and intake. For each hazard identified, describe whether it is under control (control measures/barriers). If hazard is not under control, determine the likelihood of the hazard occurring and its consequence if it did occur. Assign priority. Describe what corrective action(s) needs to be taken. If hazard under control, it can be assigned "NOT A PRIORITY".

Hazard	Cause / Hazard Event	Control measure / barrier	Likelihood	Consequence	Priority	Corrective Action

Appendix 3

Improvement schedule - Template

SUPPLY NAME:

WORKSHEET 4.1 - IMPROVEMENT

Improvement schedule

List all Corrective Actions or Improvements identified. State who (person or department) will be responsible for implementing the respective improvements. Describe the resources needed and state a timeframe for the improvement to be completed. Monitor progress on an annual basis or at a reasonable time interval.

Improvement	Responsibility	Resources Needed	Timeframe	Progress

Appendix 4

Monitoring plan - Template

SUPPLY NAME:

WORKSHEET 5.1 - MONITORING PLAN

Organizational, management, operation

List all hazards associated with the catchment, source and intake. For each hazard identified, describe whether it is under control (control measures/barriers). If hazard is not under control, determine the likelihood of the hazard occurring and its consequence if it did occur. Assign priority. Describe what corrective action(s) needs to be taken. If hazard under control, it can be assigned "NOT A PRIORITY".

Monitoring Parameter	Operational Limit	Trigger Limit	Who	When	How	Action to be taken is trigger limit is breached

Appendix 5
Visual inspection log

SUPPLY NAME: WORKSHEET 5.3 - VISUAL

Visual inspection log

Operators visually inspect key components of the supply during an operation run e.g. taking water sample or carrying out maintenance. However, these are hardly recorded although the information is quite valuable. It is therefore prudent to keep a log of visual inspections carried out on a regular basis. This is just a template to give you an indication of what to include in the log, however all operators are encouraged to develop their own visual inspection logs.

Date	Component Inspected	Description of Problem (if any)	Requires Action? Please specify what action is needed, if any	Action completed? Signed off by a supervisor / manager

Appendix 6
Water quality monitoring log

SUPPLY NAME: WORKSHEET 5.2– WATER QUALITY

Water quality monitoring log

It is standard practise for water supplies to maintain records of drinking water quality monitoring. The following log is provided as an example of the type of information that may be recorded in a water quality monitoring log. This form may be maintained in the water quality laboratory, however, a copy of these records must be kept onsite at the treatment plant.

Sample Date: / / 2009 **Time:** : am/pm **Weather:** .... **Temp:** ....
Ambient Water

Sample No. .... **Sampler:** .... **pH:** .... **Turbidity:** .... **FAC:** ....

Date sample received: / / 2009 **Time:** : am/pm **Received by:** .... **Analyzed by:** ....

Sample No. .... **Sample condition:** ....

Results: Drinking Water / Raw Water Sample (please cross out one)

Parameter analyzed	Result	Comment	Parameter analyzed	Result	Comment	Parameter analyzed	Result	Comment
E.coli	CFU/100ml		pH	mg/L		Phosphate, Organo Phosphate, Tot P	mg/L	
Tot. Coliform	CFU/100ml		Alkalinity	mg/L		Hardness	mg/L	
Faecal Coliform	CFU/100ml		Dissolved Oxygen	mg/L		Copper	mg/L	
pH			BOD	mg/L		Lead	mg/L	
FAC	mg/L		COD	mg/L		Arsenic	mg/L	
Turbidity	NTU		Nitrate / Nitrite / Tot N	mg/L		Mercury	mg/L	

Appendix 7

Incident reporting form - Template

SUPPLY NAME: WORKSHEET 6.1

Incident reporting form

It is prudent to keep records of significant events that caused the drinking water to become unsafe or seriously compromised the quality of drinking water. The following template describes the type of information that should be recorded in an incident report.

Date: / / **Time of Incident:** : am/pm

Recorded by: .... **Verified by:** ....

Nature of Incident: ....

....

....

....

Describe remedial action required: ....

....

Follow-up:

Remedial action(s) completed? ❑ Yes ❑ No

Threat to drinking water quality eliminated? ❑ Yes ❑ No

If Yes, date action was completed: / /

If not, what further action is required? ....

....

How will the risk be managed in the meantime? ....

....

Signed off

....

Operator **Supply Manager**

Date: / / **Date:** / /

Appendix 8

Sample standard operating procedure

SOP 01: Determination of pH in water

1.0 Reference method

1.1 Clesceri, L.S., Eaton, A.D., and Greenberg, A.E. (Ed).(2005). Standard Methods for the Examination of Water and Wastewater, 21st dition. American Public Health Association (APHA), Washington, D.C;Method 4500 - H+ B.

2.0 Principles

2.1 The basic principle of electromagnetic pH measurement is the determination of the activity of the hydrogen ions by potentiometric measurement using a standard hydrogen electrode and a reference electrode. The instrument is calibrated using two buffers and its performance is checked using a third buffer.

Samples must be dilute aqueous simple solutions (<0.2M). Determination of pH cannot be made accurately in non-aqueous media, suspensions, colloids, or high-ionic-strength solutions.

3.0 Interferences

3.1 The sensitivity can be reduced by the presence of oil in the samples. Measurement errors in oil-containing waters may be prevented by washing the electrode before each measurement is taken, as in 3.2.

3.2 First rinse the electrode with soap or detergent, then rinse with water. After this, rinse the electrode with methanol (10%), followed by deionised water, which in turn is followed by dilute HCl rinse (0.1N) for approximately 10 seconds, and finally with more deionised water.

3.3 The sensitivity of the electrode may also be affected if the pH measured is either very low or very high. Measurement errors can be prevented by washing the electrode as mentioned above (3.2).

3.4 Sodium ion is the principal interference of the pH electrode, causing increasing error at high pH (pH>10) and at high temperature. Because the pH membrane is composed of low sodium error glass, error due to sodium is negligible when measuring at pH values less than 12.

3.5 Good care of the electrode is of paramount importance: see IAS SOP PMET 8.00. The electrode should be stored in electrode Storage solution or alternatively in pH buffer 7.0. Never store electrode in deionised or distilled water.

4.0 Sample collection/preservation

4.1 Teflon (TFE) bottles are the best containers for collecting water samples but in the absence of TFE, polyethylene bottles with polyethylene caps can be used.

4.2 All containers need to be rinsed with concentrated HCl or soaked for 24 hours in 10% HCl bath. To prepare 10% HCl bath, use 1:9 ratio of concentrated HCl to deionised water. Upon removal, rinse thoroughly at least 5 times with deionised water.

4.3 pH readings can be taken on site but if samples are being collected, rinse the container at least twice with sample before filling to the brim.

4.4 Do not filter or acidify samples for pH measurements.

4.5 Samples have to be analysed on the same day of collection and immediately after receipt.

5.0 Precision/bias and detection limit

5.1 By careful use of a pH meter with a good electrode, a precision of ± 0.02 pH unit and an accuracy of ± 0.05 pH units can be achieved. Detection limit is not applicable in this case.

6.0 Quality control

6.1 Calibrate the pH meter prior to use for analysis with the Buffers References: pH 7.00 ± 0.02, 4.00 ± 0.02 and check the calibration of the pH meter with Buffer Reference 9.22 ± 0.02.

6.2 Analyse samples in duplicate.

6.3 Duplicate determinations should agree within 4% of their Analyse samples in duplicate.

7.0 Apparatus

7.1 pH Meter:

7.2 Beakers:

Preferably use polyethylene or Teflon (TFE) beakers.

7.3 Stirrer:

Use either a magnetic, TFE- coated stirring bar or a mechanical stirrer with inert plastic- coated impeller.

8.0 Reagents

All reagents should be kept in polyethylene, polypropylene, polycarbonate, or polystyrene containers. Only analytical grade (AR grade) reagents are to be used, unless otherwise stated.

8.1 pH Buffers:

pH buffers may be prepared using the following methods:

- Method 1: Use of Commercial Tablets

BDH Laboratory Supplies commercial tablets are available in the laboratory, and these may be used to prepare buffer solutions. In general, the instructions (for this particular brand of tablets) are described as follows:

8.1.1 pH 4.00 ± 0.02 Buffer:

Dissolve one tablet in a small quantity of deionised water in a 50 mL beaker. Once dissolved, transfer the solution quantitatively into a 100 mL volumetric flask and make up to the mark using deionised water. Thus, a solution of pH 4.00 is produced at 20°C. This solution has a shelf life of 1 month.

8.1.2 pH 7.00 ± 0.02 Buffer:

Dissolve one tablet in a small quantity of deionised water in a 50 mL beaker. Once dissolved, transfer the solution quantitatively into a 100 mL volumetric flask and make up to the mark using deionised water. Thus, a solution of pH 7.00 is produced at 20°C. This solution has a shelf life of 1 month.

8.1.3 pH 9.22 ± 0.02 Buffer:

Dissolve one tablet in a small quantity of deionised water in a 50 mL beaker. Once dissolved, transfer the solution quantitatively into a 100 mL volumetric flask and make up to the mark using deionised water. Thus, a solution of pH 9.22 is produced at 20°C. This solution has a shelf life of 1 month.

NOTE: The instructions for solution preparation may vary, therefore, always check the bottle labels for instructions and expiry dates of the tablets.

- Method 2: Alternative to Commercial Tablets

8.1.4 Commercially prepared buffer solutions (of 4.00, 7.00, and 9.00 pH) can be used.

9.0 Procedure

Follow the IAS Standard Operating Procedure for the pH Meter (SOP No. IO 650).

9.1 Instrument Calibration:

9.1.1 Before use, remove the glass electrode from the storage solution, rinse with deionised water, and blot dry with soft tissue.

9.1.2 Calibrate the pH meter with the pH 7 buffer using the standard operation procedure.

9.1.3 Make preliminary reading of sample.

9.1.4 If pH is < 7, set slope using pH 4 and pH 7 buffers. If pH > 7, set slope with pH 7 and pH 9.22 buffers (Refer to Operational SOP for pH meter, Appendix I to Chapter 3).

9.2 Sample Analysis:

9.2.1 Remove electrode from buffer, rinse with deionised water and rinse with sample solution to be measured, blot dry, and place in test solution/sample.

9.2.2 Establish equilibrium between electrodes and sample by stirring the sample to insure homogeneity; stir gently using a stirrer to minimise CO2 entrapment. Press measure.

9.2.3 Record pH reading when READY sign appears. Record two more readings of the same sample by repeating step

10.0 Calculation

10.1 Since the pH meter gives direct pH readings, pH calculation is not necessary. Report pH as the mean of the three readings with an accuracy of 0.05 pH units for values between 2.00 and 12.00. Values below 2.00 and above 12.00 should be reported with an accuracy of 0.1 pH unit.

11.0 Recording of results

All analysis data are to be recorded on the pH in Water Worksheet (Refer to Chapter 2, Appendix I.

11.0 Issue to

Master Copy

Laboratory Bench Copy

Appendix 8 continued...

SOP 02: Operation and calibration of electrical conductivity meter

1.0 Scope

1.1 This Standard Operating Procedure (SOP) describes the operational and calibration procedure for the EC 215 Bench Conductivity Meter.

2.0 Application

2.1 This SOP is suitable for a technician and other users who have been instructed and understand the basic principle involved in using the EC 215 Conductivity Meter and who have read the EC 215 Conductivity Meter Operation Manual.

2.2 This SOP must be followed when performing routine analysis in conjunction with SOP No. WP 202.

2.3 This SOP must be followed by the Senior Technician when performing six- monthly calibrations of the EC 215 Conductivity Meter.

3.0 Principle

3.1 The measurement of electrical conductivity (EC) in water results from ions in solution from dissolved salts. Measurement of conductivity gives an estimate of the concentration of these dissolved salts.

3.2 Conductivity of an aqueous solution is the measure of its ability to carry an electric current by means of ionic motion. This ability depends on the concentration, mobility and valence ions present in solution and on the temperature of measurement.

4.0 Apparatus

4.1 EC 215 Conductivity Meter

4.2 Conductivity Probes – 4 ring probe which has built-in temperature sensor that automatically compensates for temperature changes in the liquid tested.

5.0 Procedure

5.1 Power Connection

5.1.1 Plug the 12VDC adaptor into the power supply socket.

Note: Make sure the main line is protected by a fuse.

5.1.2 Probe Connection

5.1.3 Connect the conductivity probe to the socket provided.

Note: The instrument has to be calibrated before taking conductivity measurements.

6.0 Calibration procedure

6.1 Selection of conductivity standard solutions - The conductivity standard solutions to be used will depend on the conductivity units and the conductivity measurement ranges selected:

6.1.1 When measuring in the mS ranges, use standard solution 12.88 mS at 25ºC or 80 mS at 25ºC.

6.1.2 When measuring in the µS range:

6.1.2.1 Use conductivity standard solution 1413 µS at 25ºC when calibrating in the range of 0 to 1999 µS.

6.1.2.2 Use conductivity solution 84 µS at 25ºC when calibrating in the 0 to 199 µS range.

6.2 Rinse the probe thoroughly in distilled water. This is to minimize contamination of the calibration solution and secure higher accuracy. Where possible use plastic beakers to minimize any EMC interferences. Pour a small quantity of the conductivity standard solution (refer to 6.1) into a plastic beaker.

6.3 Immerse the probe in the solution submerging the holes of the sleeve (0.5cm below) water level.

6.4 Tap the probe lightly on the bottom of the beaker to remove any air bubbles trapped inside the sleeve.

6.5 Adjust the "TEMPERATURE COEFFICIENT" knob to 2%/ 0C.

6.6 Select the appropriate range (refer to 6.1)

"199.9 µS"	for 84 µS
"1999 µS"	for 1413 µs
"19.99 mS"	for 12.88 mS
"199.9 mS"	for 80 mS

Note: If the display shows "1", there is an over-range condition.

Select the next higher range.

6.7 Allow a few minutes for the reading to stabilize and adjust the "CALIBRATION" knob to read on the Liquid Crystal Display (LCD), the value of the buffer solution at 250C (770F), e.g.12.88 mS/cm. Record the reading on the EC Meter Calibration Logbook.

6.8 All subsequent measurements will be referenced to 250C (770F).

Note: To reference the measurements to 200C (680F), adjust the "CALIBRATION" knob to read on the (LCD), the value of the buffer solution at 200C (680F), e.g. 11.67 mS/cm.

7.0 Conductivity measurements

7.1 Switch the instrument on by pressing "ON/OFF" key.

7.2 Rinse the probe with distilled water and also rinse the probe with the sample. Pour the sample into a clean beaker. Tap the probe lightly on the bottom of the beaker to remove any air bubbles trapped inside the sleeve.

7.3 Adjust the "TEMPERATURE COEFFICIENT" knob to the temperature coefficient value of the sample.

7.4 Select the appropriate conductivity range.

Note: If the display shows "1", there is an over-range condition.

Select the next higher range.

7.5 Allow a few minutes for the reading to stabilize. The LCD will display the temperature compensated conductivity reading. Record the EC reading.

7.6 Rinse the probe with distilled/deionised water after every series of measurements.

8.0 Probe maintenance

8.1 The Senior Technician will on a six-monthly basis clean the probe thoroughly with a non abrasive detergent. This is to be recorded on the EC Meter Logbook.

9.0 In built temperature sensor (refer to 4.2)

9.1 Calibration of In-Built Temperature Sensor (Within the Conductivity Meter Probe)

The Built-In Sensor will be checked against the externally calibrated Reference Thermometer on a six-monthly basis by the Senior Technician. The Reference Thermometer (with a stainless steel probe) has a resolution of 0.1°C.

Appendix 8 continued...

9.9.1 Prepare a beaker containing ice and water and another one containing hot water (at a temperature around 50°C) Place insulation material around the beakers to minimise temperature changes.

9.9.2 Immerse the conductivity meter probe in the vessel with the ice and water as near to the Reference Thermometer probe as possible. Allow a couple of minutes for the probe to stabilise.

9.9.3 Record the readings of both the Reference Thermometer and the EC Meter Built-In Temperature Sensor in the EC Meter Calibration Log Book.

9.9.4 Calculate the temperature difference (ΔTemperature):

ΔTemperature (°C) = EC T - Ref T

where Ref T = Reference Thermometer reading (°C)

EC T = EC Meter Built-In Temperature Sensor reading (°C)

The calibration passes if the ΔTemperature is less than ± 1°C. If calibration fails, repeat calibration, should it fail twice, inform the Laboratory Manager.

Appendix 9

Sample contingency / emergency plan

CEP # 1.0

Highly turbid raw water