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.
Acknowledgements

The World Health Organization and Pacific Applied Geoscience Commission are thankful to everyone who have contributed to the development of this guide. They include:

The authors wish to thank Mr. Steven Iddings (WHO), Mr. Marc Overmars, Mr. Tasleem Hasan, Mr. Kamal Khatri and Ms. Lala Bukarau (SOPAC) for their invaluable contributions, encouragement and support throughout the development of this guide.

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
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


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’.


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.
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 have 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 it is a means of verification that all the supply system components and installed control measures are working properly.
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 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.

**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.

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

- Assemble a team to prepare the Drinking Water Safety Plan
- Describe the Water Supply
- Identify & Prioritise Hazards (also assess whether these are under control)
- Identify corrective actions & write an Improvement Schedule
- Establish a Monitoring Programme
- Develop Supporting Programme (e.g. training, SOPs, Contingency & Emergency Plans)
- Verify whether the DWSP is working
- Review DWSP

**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
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

National support processes

Initiate high level interest in drinking water safety planning

Link with millennium 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 feasibility & 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.

<table>
<thead>
<tr>
<th>Type of target</th>
<th>Nature of target</th>
<th>Potential use by Pacific Island Countries (PIC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Health outcome</td>
<td>Reduction in detected water-borne disease incidence or prevalence</td>
<td>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 (e.g. drinking-water related) to the overall rate of disease.</td>
</tr>
<tr>
<td>Water quality</td>
<td>Guideline values applied to water quality</td>
<td>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.</td>
</tr>
<tr>
<td>Performance</td>
<td>Genetic performance target for removal of contaminants</td>
<td>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.</td>
</tr>
</tbody>
</table>
| 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.

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.

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.
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 drinking water supply management 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, 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 DWS
- 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.

**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-stakeholders 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 DWS
- 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

**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 are, with the risk assessment demonstrating a systematic process for how that improvement was identified and prioritised.

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.

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 ISs 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.

**Stage 2**

**Develop drinking water safety plan(s)**

**Stage 1**

- National Strategy
  - Set Health Based Targets

**Stage 2**

- D.W.S.P developed for individual supplies

**Stage 3**

- Independent Surveillance
  - Approval & Audit

**Stage 4**

- Review impact of D.W.S.P
  - Progress against health based targets

**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

**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 ISs 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**
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.

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.
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, 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.
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.
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 practice 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 benefits - Studies indicate that quality assurance processes such as Drinking Water Safety Plans can greatly reduce health burdens (Deere et al., 2001)
- 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.

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.
Step 1
Assemble a drinking water safety plan team

Figure 5: The Drinking Water Safety Planning Cycle

1. Assemble the DWSP Team
2. Describe the Water Supply
3. Identify Hazards & Prioritize What Needs Action
4. Identify Corrective Actions & Develop Improvement Schedule
5. Develop Monitoring Schedule
6. Improve Processes that Support Drinking Water Safety
7. Verify the Drinking Water Safety Plan
8. Review the Drinking Water Safety Plan

1. Assemble the DWSP Team
2. Describe the Water Supply
3. Identify Hazards & Prioritize What Needs Action
4. Identify Corrective Actions & Develop Improvement Schedule
5. Develop Monitoring Schedule
6. Improve Processes that Support Drinking Water Safety
7. Verify the Drinking Water Safety Plan
8. Review the Drinking Water Safety Plan
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).

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

<table>
<thead>
<tr>
<th>Name</th>
<th>Position</th>
<th>Organization</th>
<th>Area of Responsibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mr. Tachur Rengulbai</td>
<td>Head</td>
<td>Bureau of Public Works (BPW)</td>
<td>Management, staff recruitment</td>
</tr>
<tr>
<td>Mr. David Dengokl</td>
<td>Manager</td>
<td>Koror-Ari Atau Treatment Plant</td>
<td>Management &amp; Operation, staff recruitment, training</td>
</tr>
<tr>
<td>Mr. Grant Ngirigchin</td>
<td>Operator</td>
<td>Koror-Ari Atau Treatment Plant</td>
<td>Operation &amp; monitoring</td>
</tr>
<tr>
<td>Ms. Portia Franz</td>
<td>Chief Executive</td>
<td>Environment Quality Protection Board (EQQPB)</td>
<td>Surveillance</td>
</tr>
<tr>
<td>Ms. Kinnie Ngirigchel</td>
<td>Manager</td>
<td>EQPB Laboratory</td>
<td>Surveillance - laboratory</td>
</tr>
<tr>
<td>Mr. Jerome Sakurai</td>
<td>Laboratory Technician</td>
<td>EQPB Laboratory</td>
<td>Surveillance - laboratory</td>
</tr>
<tr>
<td>Ms. Jeanne Maigeng Seiroy-Kingoso</td>
<td>Head</td>
<td>Division of Environmental Health (DEH)</td>
<td>Public Health Surveillance</td>
</tr>
<tr>
<td>Ms. Vernice Stefano</td>
<td>Programme Manager – National GIS</td>
<td>PALARIS – Bureau of Lands</td>
<td>Lands resource management &amp; development of GIS system for BPW</td>
</tr>
<tr>
<td>Hon. Santy Asanuma</td>
<td>Senator</td>
<td>Palau National Congress</td>
<td>Policy &amp; legislation</td>
</tr>
</tbody>
</table>

Who should be part of the DWSP team?

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).

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

<table>
<thead>
<tr>
<th>Name</th>
<th>Position</th>
<th>Organization</th>
<th>Area of Responsibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mr. Tachur Rengulbai</td>
<td>Head</td>
<td>Bureau of Public Works (BPW)</td>
<td>Management, staff recruitment</td>
</tr>
<tr>
<td>Mr. David Dengokl</td>
<td>Manager</td>
<td>Koror-Ari Atau Treatment Plant</td>
<td>Management &amp; Operation, staff recruitment, training</td>
</tr>
<tr>
<td>Mr. Grant Ngirigchin</td>
<td>Operator</td>
<td>Koror-Ari Atau Treatment Plant</td>
<td>Operation &amp; monitoring</td>
</tr>
<tr>
<td>Ms. Portia Franz</td>
<td>Chief Executive</td>
<td>Environment Quality Protection Board (EQQPB)</td>
<td>Surveillance</td>
</tr>
<tr>
<td>Ms. Kinnie Ngirigchel</td>
<td>Manager</td>
<td>EQPB Laboratory</td>
<td>Surveillance - laboratory</td>
</tr>
<tr>
<td>Mr. Jerome Sakurai</td>
<td>Laboratory Technician</td>
<td>EQPB Laboratory</td>
<td>Surveillance - laboratory</td>
</tr>
<tr>
<td>Ms. Jeanne Maigeng Seiroy-Kingoso</td>
<td>Head</td>
<td>Division of Environmental Health (DEH)</td>
<td>Public Health Surveillance</td>
</tr>
<tr>
<td>Ms. Vernice Stefano</td>
<td>Programme Manager – National GIS</td>
<td>PALARIS – Bureau of Lands</td>
<td>Lands resource management &amp; development of GIS system for BPW</td>
</tr>
<tr>
<td>Hon. Santy Asanuma</td>
<td>Senator</td>
<td>Palau National Congress</td>
<td>Policy &amp; legislation</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Name</th>
<th>Organization / Department</th>
<th>Position / Title</th>
<th>Role in the WSP Team</th>
<th>Contact Telephone / E-mail</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
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**

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.

**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.

(See the WHO Guidelines for Drinking Water Quality, Third Edition, 2005)
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 into 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.

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.

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 feeds 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).

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 standards
- 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

[Extract from draft Port Vila Water Safety Plan]
Step 3
Identify hazards & prioritize what needs action

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
- prioritize 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).
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

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

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

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.

Judging priorities

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

Table 5: The Risk Matrix - Likelihood Analysis

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

Table 6: The Risk Matrix - worked example 3

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

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

Table 7:

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

Table 8: The Risk Matrix - worked example 4

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

Table 9: Risk Matrix – Priorities

<table>
<thead>
<tr>
<th>Likelihood</th>
<th>Consequence</th>
<th>Priority</th>
</tr>
</thead>
<tbody>
<tr>
<td>insignificant (1)</td>
<td>Minor (2)</td>
<td>Urgent (20)</td>
</tr>
<tr>
<td>Minor (3)</td>
<td>Moderate (4)</td>
<td>Urgent (25)</td>
</tr>
<tr>
<td>Major (5)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Very High (6)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High (7)</td>
<td>Medium (8)</td>
<td>Medium (10)</td>
</tr>
<tr>
<td>Urgent (9)</td>
<td>Low (10)</td>
<td>Low (11)</td>
</tr>
<tr>
<td>Medium (11)</td>
<td>Low (12)</td>
<td>Low (13)</td>
</tr>
<tr>
<td>Medium (13)</td>
<td>Medium (14)</td>
<td>Medium (15)</td>
</tr>
<tr>
<td>High (14)</td>
<td>Medium (15)</td>
<td>Medium (16)</td>
</tr>
</tbody>
</table>

Table 10: Risk Matrix – worked example 5

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

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.

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.

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

<table>
<thead>
<tr>
<th>Hazard</th>
<th>Cause / Hazard Event</th>
<th>Priority</th>
<th>Corrective Action</th>
<th>Improvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contaminated raw water</td>
<td>Seepage from septic tanks from villages upstream to intake</td>
<td>High</td>
<td>Boil water advisory (SOP #056); Increase Chlorine dose (SOPM #097)</td>
<td>Find alternative source, move intake upstream or enhance treatment process</td>
</tr>
<tr>
<td></td>
<td>Seepage of faecal waste from piggery located upstream to intake</td>
<td>High</td>
<td>Boil water advisory (SOP #056); Increase Chlorine dose (SOPM #097)</td>
<td>Find alternative source, move intake upstream or enhance treatment process</td>
</tr>
<tr>
<td>Raw water turbidity above 1.0 NTU</td>
<td>Heavy rain in catchment</td>
<td>High</td>
<td>Shut down inlet (SOPPR #1) or adjust coagulant dosing (SOPM #32)</td>
<td>Find alternative source: Add pre-treatment storage and settling tank</td>
</tr>
<tr>
<td>Intake cannot deliver sufficient water to meet demand</td>
<td>Power failure</td>
<td>High</td>
<td>Advise public of water supply disruptions (SOPPS #95)</td>
<td>Invest in a back-up generator</td>
</tr>
<tr>
<td>Low water level due to drought</td>
<td>Low water level due to Drought</td>
<td>Medium</td>
<td>Advise public of water supply disruptions (SOPPS #95); Enhance water use restrictions</td>
<td>Explore groundwater source</td>
</tr>
</tbody>
</table>

### Table 12: Improvement Schedule - worked example 7

<table>
<thead>
<tr>
<th>Improvement description</th>
<th>Responsibility</th>
<th>Resources needed</th>
<th>Timeframe</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Find alternative source, explore groundwater sources</td>
<td>Chief Engineer</td>
<td>56.995 to dig new borehole</td>
<td>Medium-term</td>
<td></td>
</tr>
<tr>
<td>Move intake upstream</td>
<td>Chief Engineer</td>
<td>50,000 for new pipe-works + intake infrastructure</td>
<td>Short-term</td>
<td></td>
</tr>
<tr>
<td>Enhance treatment process - add pre-treatment storage and settling tank</td>
<td>Chief Engineer, Management</td>
<td>200,000 for constructing two new 1ML pre-treatment settling tanks</td>
<td>Long-term</td>
<td></td>
</tr>
<tr>
<td>Enhance treatment process – invest in gaseous chlorine dioxide for disinfection</td>
<td>Management</td>
<td>43,870 for switching from liquid to gaseous chlorine</td>
<td>Short-term</td>
<td></td>
</tr>
<tr>
<td>Invest in a back-up generator</td>
<td>Management</td>
<td>75,000 for purchase of 120KW new power generator</td>
<td>Short-term</td>
<td></td>
</tr>
</tbody>
</table>
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.

<table>
<thead>
<tr>
<th>Improvement description</th>
<th>Responsibility</th>
<th>Resources Needed</th>
<th>Time Frame</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Review the Drinking Water Safety Plan
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 fulfill 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 e.g. ‘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>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Seepage from septic tanks from villages upstream to intake</td>
<td>E.coli</td>
<td>0.0 CFU</td>
<td>&lt; 0.1 CFU</td>
<td>Daily</td>
<td>Lab Technician</td>
<td>Boil water advisory (SOP #056); Increase Chlorine dose (SOP #097)</td>
<td></td>
</tr>
<tr>
<td>Seepage of faecal waste from piggery located upstream to intake</td>
<td>E.coli</td>
<td>0.0 CFU</td>
<td>&lt; 0.1 CFU</td>
<td>Daily</td>
<td>Lab Technician</td>
<td>Boil water advisory (SOP #056); Increase Chlorine dose (SOP #097)</td>
<td></td>
</tr>
<tr>
<td>Heavy rain in catchment</td>
<td>Turbidity</td>
<td>1.0 NTU</td>
<td>&gt; 10NTU</td>
<td>Daily</td>
<td>HACH kit</td>
<td>Site Technician</td>
<td>Shut down inlet (SOP #011) or adjust coagulant dosing (SOP #32)</td>
</tr>
<tr>
<td>Power failure</td>
<td>Power supply</td>
<td>Steady power supply</td>
<td>Power outage</td>
<td>Hourly</td>
<td>Visible check</td>
<td>Shift Operator</td>
<td>Advise public of water supply disruptions (SOP #54)</td>
</tr>
<tr>
<td>Low water level due to Drought</td>
<td>Water level at intake</td>
<td>Intake water level &gt; 10m</td>
<td>Intake water level &lt; 5m</td>
<td>Daily</td>
<td>Water level indicator stick</td>
<td>Site Technician</td>
<td>Advise public of water supply disruptions (SOP #54), Enforce water use restrictions (SOP #57)</td>
</tr>
</tbody>
</table>
What to include in the monitoring schedule

- Monitoring Parameters
- What are the Operational Limits (i.e. level which demonstrates system is operating efficiently)?
- 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.
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.

<table>
<thead>
<tr>
<th>Supporting Programmes</th>
<th>Purpose</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Training</td>
<td>To ensure that operators and site technicians are properly trained on operations procedures, equipment operation and maintenance and familiar with operating new equipments / components</td>
<td>DWSP Training; New staff Induction; Refresher courses</td>
</tr>
<tr>
<td>Calibration</td>
<td>To ensure that monitoring information is reliable and accurate</td>
<td>Calibration schedule</td>
</tr>
<tr>
<td>Preventive Maintenance</td>
<td>To ensure that equipments and components are in working order and any maintenance is foreseen and undertaken before complex breakdown of equipment</td>
<td>Maintenance Schedule; Proactive procurement of parts</td>
</tr>
<tr>
<td>Communication</td>
<td>To ensure that there is a clear and defined pathway for communicating information on the water supply</td>
<td>Emergency contacts of management staff, media etc; media relations strategy</td>
</tr>
<tr>
<td>Awareness</td>
<td>Awareness within the Water Supply staff about the current version of DWSP, recommended changes within the system, any improvements etc</td>
<td>Information memos on latest updates; staff meetings</td>
</tr>
<tr>
<td>Customer Complaints</td>
<td>A mechanism for logging of customer complaints and action taken to address the complaints</td>
<td>Customer complaints center</td>
</tr>
<tr>
<td>Legal Aspects</td>
<td>Ensure that the water supply is meeting any legal compliance requirements</td>
<td>Monitoring compliance against drinking water quality standards</td>
</tr>
<tr>
<td>Contingency / Emergency Plan</td>
<td>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.</td>
<td>Major contamination or disruption to the water supply due to natural disasters or a chemical spill affecting the source water</td>
</tr>
</tbody>
</table>

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* and * Development of new programmes*.

Table 14: Examples of Supporting Programmes for ensuring 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 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 practice 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.
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 daily 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.
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

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.

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.

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 +/− 0.2°C. 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 salmonella 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 than 400nm 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).
References


Appendix 1
Drinking water safety plan - Template

Drinking water safety plan for Matai urban water supply
This document was prepared by: John Dollar (Consultant)

Date: 11 / 11 / 08
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: 678900
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, Matai

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

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
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

<table>
<thead>
<tr>
<th>Likelihood Score</th>
<th>Possible Descriptions</th>
<th>Risk Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Almost Certain</td>
<td>Very common event, occurs on a regular basis</td>
<td>5</td>
</tr>
<tr>
<td>Likely</td>
<td>The event has happened before and can probably occur again</td>
<td>4</td>
</tr>
<tr>
<td>Possible</td>
<td>The event could happen</td>
<td>3</td>
</tr>
<tr>
<td>Unlikely</td>
<td>The event may not happen</td>
<td>2</td>
</tr>
<tr>
<td>Rare</td>
<td>Very uncommon event – probably will never occur</td>
<td>1</td>
</tr>
</tbody>
</table>
### Catchment

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

### Treatment

<table>
<thead>
<tr>
<th>Hazard</th>
<th>Cause / Hazard Event</th>
<th>Control measure / barrier</th>
<th>Likelihood</th>
<th>Consequence</th>
<th>Priority</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microbial contamination</td>
<td>2.0 Insufficient disinfection</td>
<td>Hourly FAC measurements at clear water well</td>
<td>Likely</td>
<td>Major</td>
<td>High</td>
</tr>
<tr>
<td>Chemical Contamination</td>
<td>2.1 Fluoride overdosing</td>
<td>Trained staff</td>
<td>Unlikely</td>
<td>Major</td>
<td>Medium</td>
</tr>
<tr>
<td></td>
<td>2.2 Power outage shuts plant down</td>
<td>None</td>
<td>Possible</td>
<td>Major</td>
<td>High</td>
</tr>
</tbody>
</table>

### Storage & Distribution

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

### 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.

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

<table>
<thead>
<tr>
<th>What to monitor</th>
<th>Operational Limit</th>
<th>Critical Limit</th>
<th>Monitoring</th>
<th>Contingency / Emergency Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turbidity</td>
<td>&lt; 1.0 NTU</td>
<td>&gt; 1.0 NTU</td>
<td>Daily</td>
<td>SOP # 5.6 Joe Blue CEP # 2.1</td>
</tr>
<tr>
<td>FAC</td>
<td>0.2 – 0.5/ mg/L</td>
<td>&lt; 0.2 or &gt; 0.5/ mg/L</td>
<td>Daily</td>
<td>SOP # 5.3 Joe Blue CEP # 2.2</td>
</tr>
<tr>
<td>E-coli</td>
<td>&lt; 1.0</td>
<td>&gt; 1.0</td>
<td>Daily</td>
<td>SOP # 5.1 Joe Blue CEP # 2.3</td>
</tr>
</tbody>
</table>

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**

- Turbidity meter at intake records raw water turbidity
- Turbidity value exceeds Maximum Acceptable Value
- **Yes**: Operate as normal
- **No**: Turbidity value greater than 10.0 NTU
- **Yes**: Shut down intake. Give out “reduce water use” notice
- **No**: Reduce flow into the plant and adjust coagulant dose

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”.

<table>
<thead>
<tr>
<th>Hazard</th>
<th>Cause / Hazard Event</th>
<th>Control measure / barrier</th>
<th>Likelihood</th>
<th>Consequence</th>
<th>Priority</th>
<th>Corrective Action</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**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”.

<table>
<thead>
<tr>
<th>Hazard</th>
<th>Cause / Hazard Event</th>
<th>Control measure / barrier</th>
<th>Likelihood</th>
<th>Consequence</th>
<th>Priority</th>
<th>Corrective Action</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


### 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”.

<table>
<thead>
<tr>
<th>Hazard</th>
<th>Cause / Hazard Event</th>
<th>Control measure / barrier</th>
<th>Likelihood</th>
<th>Consequence</th>
<th>Priority</th>
<th>Corrective Action</th>
</tr>
</thead>
</table>

### 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”.

<table>
<thead>
<tr>
<th>Hazard</th>
<th>Cause / Hazard Event</th>
<th>Control measure / barrier</th>
<th>Likelihood</th>
<th>Consequence</th>
<th>Priority</th>
<th>Corrective Action</th>
</tr>
</thead>
</table>
**Appendix 3**
Improvement schedule - Template

**Supplies 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.

<table>
<thead>
<tr>
<th>Improvement</th>
<th>Responsibility</th>
<th>Resources Needed</th>
<th>Timeframe</th>
<th>Progress</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Appendix 4**
Monitoring plan - Template

**Supplies 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”.

<table>
<thead>
<tr>
<th>Monitoring Parameter</th>
<th>Operational Limit</th>
<th>Trigger Limit</th>
<th>Who</th>
<th>When</th>
<th>How</th>
<th>Action to be taken if trigger limit is breached</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

**Appendix 3**
Improvement schedule - Template

**Supplies 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.

<table>
<thead>
<tr>
<th>Improvement</th>
<th>Responsibility</th>
<th>Resources Needed</th>
<th>Timeframe</th>
<th>Progress</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

**Appendix 4**
Monitoring plan - Template

**Supplies 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”.

<table>
<thead>
<tr>
<th>Monitoring Parameter</th>
<th>Operational Limit</th>
<th>Trigger Limit</th>
<th>Who</th>
<th>When</th>
<th>How</th>
<th>Action to be taken if trigger limit is breached</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
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.

<table>
<thead>
<tr>
<th>Date</th>
<th>Component Inspected</th>
<th>Description of Problem (if any)</th>
<th>Requires Action? Please specify what action is needed, if any</th>
<th>Action completed? Signed off by a supervisor / manager</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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)

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

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.
Appendix 8 continued...

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 1 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 10.1.

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.

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.

Appendix 8 continued...

9.0 Procedure

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 1 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 10.1.

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.

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.
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 ($\Delta$Temperature):

$$\Delta \text{Temperature (°C)} = \text{EC T} - \text{Ref T}$$

where $\text{Ref T}$ = Reference Thermometer reading (°C)

$\text{EC T}$ = EC Meter Built-In Temperature Sensor reading (°C)

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

---

### CEP # 1.0

**Highly turbid raw water**

1. **Turbidity meter at intake** records raw water turbidity

2. **Turbidity value exceeds Maximum Acceptable Value**
   - No: Operate as normal
   - Yes: Proceed to the next step.

3. **Turbidity value greater than 10.0 NTU**
   - No: Reduce flow into the plant and adjust coagulant dose.
   - Yes: Shut down intake. Give out "reduce water use" notice.

---