Facilitator **handbook**

Water Safety Plans – Training package

World Health Organization

IWA | **International Water Association**

International Water Association (IWA)

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WSP Facilitator Handbook

Contents

Glossary of terms and abbreviations

Audit – review and evaluation of WSP practice

Catchment – drainage basin / watershed – a discrete area of land that has a common drainage system. A catchment includes both water bodies that convey the water and the land surface from which water drains into these bodies (Helmer & Hespanhol, 1997).

Compliance – adherence to set water quality / operational requirements

Control measure – any action or activity that can be used to prevent, eliminate or reduce to an acceptable level any water safety hazard

Control point – A step at which control can be applied to prevent, eliminate or reduce the risks of a water safety hazard

Corrective action – any action to be taken when critical limits are exceeded

Critical limit – a criterion that separates acceptability from unacceptability

HACCP (hazard analysis and critical control points) – a system that identifies, evaluates and controls hazards that are significant for food safety

Hazard – any agent (physical, chemical, biological or radiological) that can cause harm to public health

Hazardous event – any process that introduces hazards to, or fails to remove them from, the water supply

Implementation (of WSP) – putting a WSP into practice

Incident/near-miss – where loss of control has led to (or narrowly missed) a public health risk

IWA – International Water Association

Monitor – the act of conducting a planned sequence of observations or measurements of control parameters to assess whether the control point is under control or whether the water meets quality criteria

Multi-barrier approach – the concept of using more than one type of barrier or control measure in a water supply system (from catchment through abstraction, treatment, storage and distribution to the consumer) to minimize risks to the safety of the water supply

Operational monitoring – The act of conducting a planned sequence of observations or measurements of control parameters to assess whether a control measure is operating within design specifications

Operational step – a point, procedure, operation or stage in the water supply process

Organizational culture – attitudes, experiences, norms, beliefs and values of an organization

Point of use – point of consumption

Regulator – organization responsible for ensuring that the water supply meets specified statutory requirements

Risk – the likelihood of identified hazards causing harm to exposed populations in a specific time frame and the magnitude and/or consequences of that harm

Stakeholders – individuals or organizations that are influenced by, or influential to, the water supply

Supporting programmes – actions that are important in ensuring drinking-water safety but do not directly affect drinking-water quality (e.g. training and management practices)

Upgrade – improvement (to supply system)

Validation – investigative activity to identify the effectiveness of control measures. It provides the evidence that elements of the WSP can effectively meet the water quality targets.

Verification – the application of methods, procedures, tests and other evaluations to determine compliance with the WSP. Verification confirms that the water quality targets are being met and maintained and that the system as a whole is operating safely and the WSP is functioning effectively.

Water safety plan (WSP) – a comprehensive risk assessment and risk management approach that encompasses all steps in water supply, from catchment to consumer

WHO – World Health Organization

Part 1 – Introduction

This handbook is one third of a water safety plan (WSP) training package. It accompanies the WSP training workbook and WSP training PowerPoint presentations. The handbook is designed to be used by professional and non-professional trainers, who should have prior knowledge and understanding of WSPs, and who are facilitating WSP training based on the WSP manual of the International Water Association (IWA) and the World Health Organization (WHO) (Bartram et al., 2009). The training is targeted at all professionals involved in the management of drinking-water safety. The handbook is divided into three parts:

- Part 1 – Overview of the training approach, training structure and mode of training assessment
- Part 2 – Module learning material, which includes module objectives, delivery information, key points and exercises
- Part 3 – How the material can be adapted to different utility contexts

Objective of training

WSPs are a risk-based approach to most effectively protect drinking-water safety. WHO's 4th edition of the *Guidelines for drinking-water quality* (WHO, 2011) explicitly states the importance of WSPs, and the Bonn Charter (IWA, 2004) advocates the use of WSPs as the best way of ensuring good, safe drinking-water.

WSPs are now being adopted worldwide, but they are not always fully understood by all stakeholders. There are a number of key terms and concepts that are not always translated appropriately or are simply misunderstood. Face-to-face training is therefore considered to be an essential component of globally successful WSP implementation.

Training approach

In order to adequately convey the key concepts of WSPs, a variety of training techniques will be used:

- Instructive presentations – imparting information/theory
- Small group exercises – assimilating theory
- Case-study examples and/or a site visit – contextualizing key concepts
- Small group and large group feedback – deepening understanding of theory
- Energizer and review activities – informal review of theory
- Workbook – a comprehensive workbook to accompany module learning sessions
- Resources in the form of support documentation on data sticks – to include the WSP manual, presentation slides, workbook and the WSP quality assurance tool (WHO & IWA, 2012)

Theory sessions are the best method to relay technical information or core processes to all participants. They are a useful tool in this regard, but if used extensively or exclusively, they are limited in their success. Most people have a concentration span of less than 20 minutes, so it is essential that theory sessions have a high level of participation and are punctuated by other modes of training.

Small group work should be carried out regularly to enhance the learning of the theory sessions and ensure that the participants are able to assimilate the concepts. They also enable the facilitator to gauge participants' ability and adapt the learning material appropriately, if necessary. Furthermore, opportunities exist within small group work for discussions among participants as to how the theory concepts would work in their own organizations.

Where possible and appropriate, at least one, but preferably more than one, site visit should be inserted into the programme. This will be dependent on location, logistics and time available. If the training is taking place on-site at a water utility, for example, a variety of visits to catchment, laboratories, treatment plants, etc. may be easier to organize than if the training takes place at a remote training centre.

Site visits are extremely beneficial, as they will enable the key taught concepts to be contextualized and will have the most benefit if carried out later in the training workshop. Site visits also provide time for the participants to reflect on the material covered and to ask questions in an informal setting.

Feedback is vital for the facilitator to gauge participants' level of understanding and knowledge. Typical methods of capturing this involve the facilitator asking the participants to share key findings from a given exercise and then having a rapporteur to categorize any common themes. Feedback may also be given by peers (moderated by the facilitator) after any group presentation. This typically results in higher levels of participant motivation and attention during a session.

Workshop feedback is also important, and although this typically occurs at the end of the workshop, it is also valuable to have it part way through the workshop. Structured feedback at the midway point enables the findings to be fed into the remaining workshop time in order to improve any weak areas. "Happy sheets" are a common approach for workshop *validation*. It is also recommended that a workshop *evaluation* be carried out. Typically, these occur three months after the workshop and involve the participants completing a questionnaire that focuses on if, and to what extent, the workshop has fed into their work role. Examples of validation and evaluation sheets are given in Appendix A.

Discussions can be formalized or form part of the workshop as an informal component following on from any questions (which should be actively encouraged during any stage of the workshop). If the participants are withdrawn and appear disinterested, a well-facilitated discussion could revitalize the workshop. Discussions also enable the trainer to establish the participants' understanding in order to ensure that subsequent sessions are appropriately targeted with any necessary review.

Ideally, the facilitators should be WSP experts in their own right, but this may not always be possible. Therefore, the delivery and key concepts are made explicit throughout. In addition to this, a short section on training of facilitators is provided.

ADAPTING THE TRAINING MATERIAL

This material is not intended to be an off the shelf training package, but needs to be adapted to suit local needs (considering the national/regional drinking-water quality context, the attendees, the resources, time available to conduct the training, etc.). The training material should be updated to include national or regional examples (or case-studies) and to suit local interest (e.g. benefits could be different in different regions). Please refer to Part 3 of this handbook for further details.

Training structure

The structure of the training will vary according to participant numbers, available facilities and the facilitator's preferences. In order to have enough time to engage with each participant during group exercises and the theory sessions, it is suggested that the training be limited to 20 participants and presented by two facilitators. If participant numbers are greater than this, then more facilitators will be needed to ensure that the same time per participant is available. A facilitator:participant ratio of 1:10 is suitable. The material can be delivered over five days comfortably.

Room layout and facilities

Assuming a cohort of 20 participants, a suitable layout of the room is given in Figure 1. Ideally, the room should be on one level to enable participants and facilitators to move around freely. The room should have natural ventilation and light, but with blinds to enable the lighting conditions to be controlled and air-conditioning to maintain a suitable temperature.
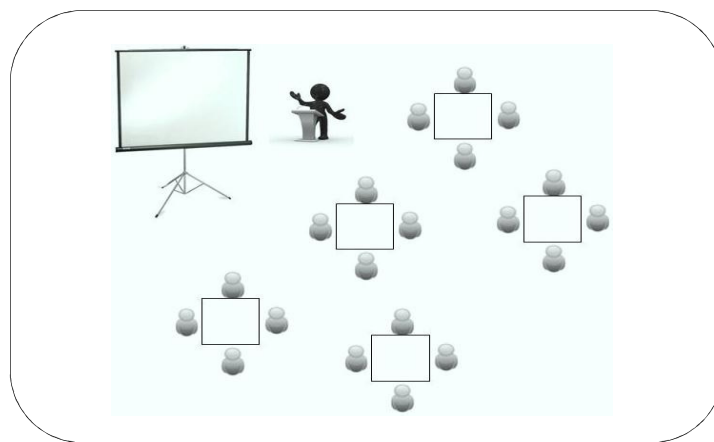
Figure 1 – Cabinet-style seating plan of room for WSP training

Timetables

In general, the training can be conducted over five days as follows:

- Day 1 – Introductory module, Modules 1 and 2
- Day 2 – Modules 3, 4 and 5
- Day 3 – Modules 6, 7 and 8
- Day 4 – Modules 9 and 10
- Day 5 – Modules 11 and 12

More detailed times are suggested in the example schedule provided in Appendix B. It is likely that the timing will vary from the example schedule; theory sessions may well take less than one hour, and exercises may take longer. The facilitator will need to adjust times of breaks and sessions and amend the schedule accordingly. As previously mentioned, it is crucial to also include at least one, but preferably more than one, site visit.

Introducing the workshop

At the start of the workshop, it is important to encourage the participants to become comfortable with their environment, the facilitators and the other participants. This short section lays out what is involved.

- Registration and refreshments (08:30–09:00)
- Welcome and introduction (09:00–09:30)
    - o Introduction by the facilitator(s)

- Housekeeping – location of fire exits, toilets, house rules, etc.
- Workshop delivery information – timetables, 12 modules, exercises & workbook, site visit(s), groups, energizer activities (icebreakers), etc.
- Group photograph of the participants (needed later for Module 9)

One common method used to warm up a workshop is to use "icebreakers". These are exercises that get participants to interact and share experiences to enable further conversations. The icebreaker suggested (Appendix C) should act as a good start for the workshop.

Energizer and review activities

At the start of each day and at the end of some days, it may be beneficial to have informal activities to revitalize the learning or simply act as a way of lightening the atmosphere. Nine activities of this sort have been developed and are detailed in Appendix C, including the icebreaker as described above. If you want to incorporate these activities into the training, you will have to add these exercises to your training schedule. The list below indicates when they may be of most use:

- Day 1 09:30 – "near-miss" icebreaker and "competence wheel Part I" (25 minutes)
- Day 1 17:00 – "share with a colleague" (15 minutes)
- Day 2 09:00 – "missing jigsaw" review of WSP team (15 minutes)
- Day 2 17:00 – "colour-coded questions" review (15 minutes)
- Day 3 09:00 – "spot the hazard" exercise (15 minutes)
- Day 4 09:00 – "support programmes" exercise (15 minutes)
- Day 4 17:00 – "competence wheel Part II" (15 minutes)
- Day 5 13:00 – "bingo quiz" review (15 minutes)

Training assessment

Assessment can be divided into two types: 1) the assessment of participants' understanding; and 2) the assessment of the workshop delivery and content.

The former can be conducted continuously throughout the workshop by the facilitators, through paying close attention to the individual participants' engagement in the workshop and in the group work in particular. This should provide the facilitator with an insight into their understanding and enable the facilitator to further explain any misunderstood concepts.

The latter can be achieved through the use of questionnaires. It is suggested that three questionnaires be carried out: the first part way through the workshop to capture the general feeling and motivation of participants, the second at the end of the workshop and the third three months later. The first and second questionnaires can take the form of validation "happy sheets", and the third is an evaluation questionnaire to note if concepts have resulted in changes in work practice. See Appendix A for example questionnaires.

Training of facilitators

The significance of a facilitator cannot be overplayed. Workshop success can, to a greater or lesser extent, be a function of how it is facilitated. This handbook provides much guidance on *what* to deliver and makes some clear suggestions as to *how* this might best be done. However, participants attending the workshop will differ from each other, and their interaction will also shape the workshop and ultimately the learning experience.

There are several qualities that a facilitator should try to develop in order to achieve the most from a group of participants, many of whom will not know each other. These are written below (in no particular order):

- **Introduction** – Facilitators should always remember to introduce themselves, not to sell themselves, but to instil confidence that they are qualified to provide the training.
- **Serve the participant** – Facilitating a workshop may be a huge achievement in a career, but it is important to remain grounded and keep the focus on the participants. The facilitator's role is to *facilitate learning*, not to *get through the material* or to *tell participants what to do.*

- **Respect and be respected** – Attending a workshop can be costly for participants, in terms of both time and money. Respect their desire to learn, and take care not to fabricate your expertise. No question should be dismissed as irrelevant or stupid.
- **Take charge as necessary** – There may be times when a facilitator needs to take charge. For example, in response to a disruptive participant, the facilitator could have a quiet word with the participant during break time to request an adjustment to their behaviour. Break time could be moved earlier if the problem needs urgent attention.
- **Encourage questions** – Any form of discussion, especially those developed through questions, should be actively encouraged. Participants are more likely to ask questions if they feel physically and socially comfortable, relaxed in the company of fellow participants and the facilitator. Therefore, the facilitator should work to build a rapport with participants as soon as possible. In addition to providing clarification and further details, questions will help facilitators gauge the level of understanding, which in turn will influence the material to be delivered.
- **Be responsive** – Participants' opinions and questions should not be seen as an unwelcomed interruption, but rather an opportunity to further explore common misperceptions and to offer any clarification as needed. Consider opening the question up to the workshop for an answer.
- **Responding to wrong answers** – During the workshop, questions are asked of the participants. If they answer incorrectly, it is first important to check whether the facilitator has understood the answer by rephrasing the response and asking if that is what was meant. At this point, the answer can be rephrased to be more accurate, but without deviating too much from the participant's answer. If their answer is still incorrect, then it is important not to simply dismiss the answer, but instead to try to identify why it was considered and then work from that point to give the correct answer. It is essential that the participants' views are respected at all times.
- **Honouring the answer** – The flipchart is used at many times during the workshop as a method to record discussions or feedback from exercises. When participants make comments, it is important not to paraphrase their comments, but instead to write them down as stated. This ensures that their meaning is not lost and also acts as a method of affirmation for the participants – that their opinions are worthy.
- **Deviate, but not too much** – The learning material supplied in this handbook should be a starting point only. The materials need to be complemented by first-hand experiences and nationally relevant, practical examples to emphasize key concepts. Sharing of such information can solidify the subject material for some learners, so interjecting the theory sessions with "real-life stories" should be encouraged. However, care should be taken not to deviate from the definitions and not to deviate too much from the exercises, as this can cause confusion among the participants.
- **Alternative delivery approaches** – This handbook has made suggestions as to how to deliver the material. If the facilitator prefers to "lecture", this does not mean that the workshop should be changed to be delivered in this manner. Each participant will have a different way of learning: some through images, others through individual thinking, listening, reading, group work, etc. The workshop needs to cover a broad range of styles so that each participant has an opportunity to learn in his or her preferred style.
- **Work with passion** – If the facilitator is keenly interested in the material being covered, it is likely to engage the participants more.
- **Be confident with the material** – Confidence will come as understanding of and familiarization with the material are formed. Prior preparation is therefore essential.
- **Stick to time** – The timetables suggested are simply guidelines, but it is important that breaks, lunch and the end of the day deadlines do not overrun unnecessarily. Additionally, appropriate arrangements for food and drinks are essential. Participants' learning is enhanced through regular breaks, and in order to prevent participants from becoming overtired or demoralized, it is important to end the day on time or earlier.
- **Help trainees appreciate time management** – Any overrun in time often comes from lengthy presentations by rapporteurs following group discussions. It should be made clear from the start that presentations are time-bound and people must learn how to present in the allotted time. Facilitators should be brutal but friendly and end presentations when the allotted time is up.
- **Collaborate with other facilitators** – It is suggested that two facilitators are needed to run a workshop of 20 participants. It is fundamental that the role that each facilitator has at each point in the day is known so as to avoid confusion and embarrassment. It is beneficial to establish the

strengths and weaknesses of each facilitator and work to the strengths during the different workshop components.

- **Prepare the material** – Many of the exercises require prior preparation such as photocopying. It is essential that this material is ready and organized to avoid delays. Other preparation that should be carried out before the participants arrive each day involves checking the working order of all electrical equipment.

Part 2 – Learning material

Part 2 of the handbook relates to the learning material associated with each module. Each module is organized by the learning objectives, material delivery, key concepts and exercises. Icons are used in the material delivery section, which are cross-referenced to the slides to act as prompts during the theory sessions. A key to the icons is given below.

Icon	Meaning
	Clock: timing of session
	Handshake: icebreaker activity
	Exclamation mark: emphasize a key point
	Question mark: ask participants a given question
	Drinking cup: break/lunch time
	People: group work/activity
	People with speech bubble: discussion time
	Glasses: review exercise/activity
	Book: refer to information provided in workbook
	Two people: work in pairs
	Flipchart: record information on a flipchart
	Play button: animated slide
	One person: individual work

The material delivery tables also include the activity or a brief description and other information defined (or determined) by the icons. This information may, for example, indicate the slide to which the activity relates or how long the activity might take, or even refer the facilitator to the WSP manual for additional guidance. For example, the following would tell the facilitator to ask a question on slide 8.

	Activity/description	Information
	Ask attendees why traditional ways of ensuring water quality are not enough (reactive, takes too long, not feasible to test all parameters, can't test all water, etc.).	Slide 8 Before 1st click

Unlike training that ends with a test, the learning objectives are not always measured. This simply reflects the nature of the training being offered, and these objectives should not be perceived as less important. However, the training does involve an assessment of participants' understanding, as described in the training assessment section on page 4 of the handbook.

The main exercise that accompanies each module is allocated one hour. Typically, this relates to approximately 30 minutes of group work and 30 minutes to discuss the exercise. The exercise is detailed in terms of its aim, description, timing, material needed and facilitation. Any templates or larger reference material may be documented as appendices at the back of this handbook.

WSP introduction (Module 0)

Learning objectives

Through active participation in and successful completion of the introductory module, each participant should be able to meet the following learning objectives:

- Explain that a WSP is a source to point-of-use risk management approach that exists within a wider framework for safe drinking-water.
- Explain why the traditional end-product monitoring approaches are insufficient for ensuring drinking-water safety.
- Elaborate on why the WSP approach was developed and why it is needed.
- Clearly communicate the WSP approach as outlined in the WHO/IWA WSP manual.

Material delivery

	Activity/description	Information
	Day 1:	10:00–11:30
	WSPs may have originated from more experienced, large-scale utilities, but WSP principles are transferable to any water supply system – big or small, old or new.	Slide 4
	Point out that "safe" is measured as an "improved" source, such as a well, but these are often fundamentally unsafe.	Slide 7
	Ask attendees why traditional ways of ensuring water safety are not enough (reactive, takes too long, not feasible to test all parameters, can't test all water, etc.).	Slide 8 Before 1st click
	Discuss the London cholera case-study (in workbook) and ask them what components most interest them. Record on flipchart.	Slide 9 <10 minutes
	Diagram is taken from the WHO *Guidelines for drinking-water quality* to show some of the various methods of transmission of harmful microorganisms – use to reinforce the need for WSPs.	Slide 10
	Highlight the five stages of WSP development.	Slide 12
	Many people are daunted by WSPs, believing them to require a totally fresh start to all components of water supply work. Stress that WSPs incorporate all features of good practice in water supply management and are incremental – involving gradual improvements.	Slide 14
	An effective WSP can reduce costs, as it will eliminate unnecessary monitoring and testing.	Slide 15
	The subsequent modules will deal with these requirements.	Slide 16
	Break	10:45–11:00 After slide 16
	Exercise – Water quality and health	Slide 17 20 minutes
	Provision of exercise answers and discussion	After exercise 10 minutes

Principles and features

- WSPs are based on risk management principles from other approaches, including HACCP (hazard analysis and critical control points) and the multi-barrier approach.
- The WSP approach is applicable to all types of water supply systems.
- End-point monitoring is still important in verifying drinking-water safety. However, a complementary approach is also needed to lower the risk of contaminants from entering drinking-water supplies in the first place to better protect consumers.
- WSPs involve preventive risk analysis and risk management from catchment to point of use.
- The public's health can be protected by knowing the supply system thoroughly, understanding utility staff roles, being aware of what problems may occur and taking action to control those problems to result in more consistent supplies of safe drinking-water.
- WSPs require an understanding that is beyond the "technical" aspects (e.g. managerial, training and incident response).
- WSP objectives are to:
  - Minimize contamination in source waters
  - Reduce or remove contamination by treatment
  - Prevent contamination during storage, distribution and handling.
- The development and implementation of WSPs are a continuous incremental process, with improvements made over time according to the significance of the risks, available resources, knowledge and as required. Some utilities may be more experienced in identifying and managing risks (i.e. risk "mature") than others, but each can improve, and should improve, continuously over time at a suitable pace.
- Multiple barriers (more than one control measure) should be put in place from the catchment to the point of use so that if one control measure is insufficient, other control measures are in place to minimize the risks to the safety of the water supply.
- WSPs should not be considered additional work; they provide a new way to do work more efficiently and effectively.
- There are five stages of a WSP (Figure 0.1):
  1. Preparation
  2. System assessment
  3. Monitoring
  4. Management and communication
  5. Feedback
- The WHO/IWA WSP manual describes a modular 11-step approach, on which this training package is based (Figure 0.1).

Benefits

- A key benefit of WSPs is that utility staff become more aware of their role in the provision of safe drinking-water.
- Other benefits may include cost savings (e.g. by reducing or eliminating any unnecessary monitoring and testing, reducing the need for treatment or improving maintenance), improved communication/ stakeholder relationships, regulatory compliance and management and operation of the utility.
- WSPs also provide an effective framework to better inform capital investment needs, thus ensuring that limited resources are used most effectively.
- Long-term implementation of WSPs will help to ensure the consistent delivery of safe drinking-water, resulting in reduced outbreaks and improved public health.

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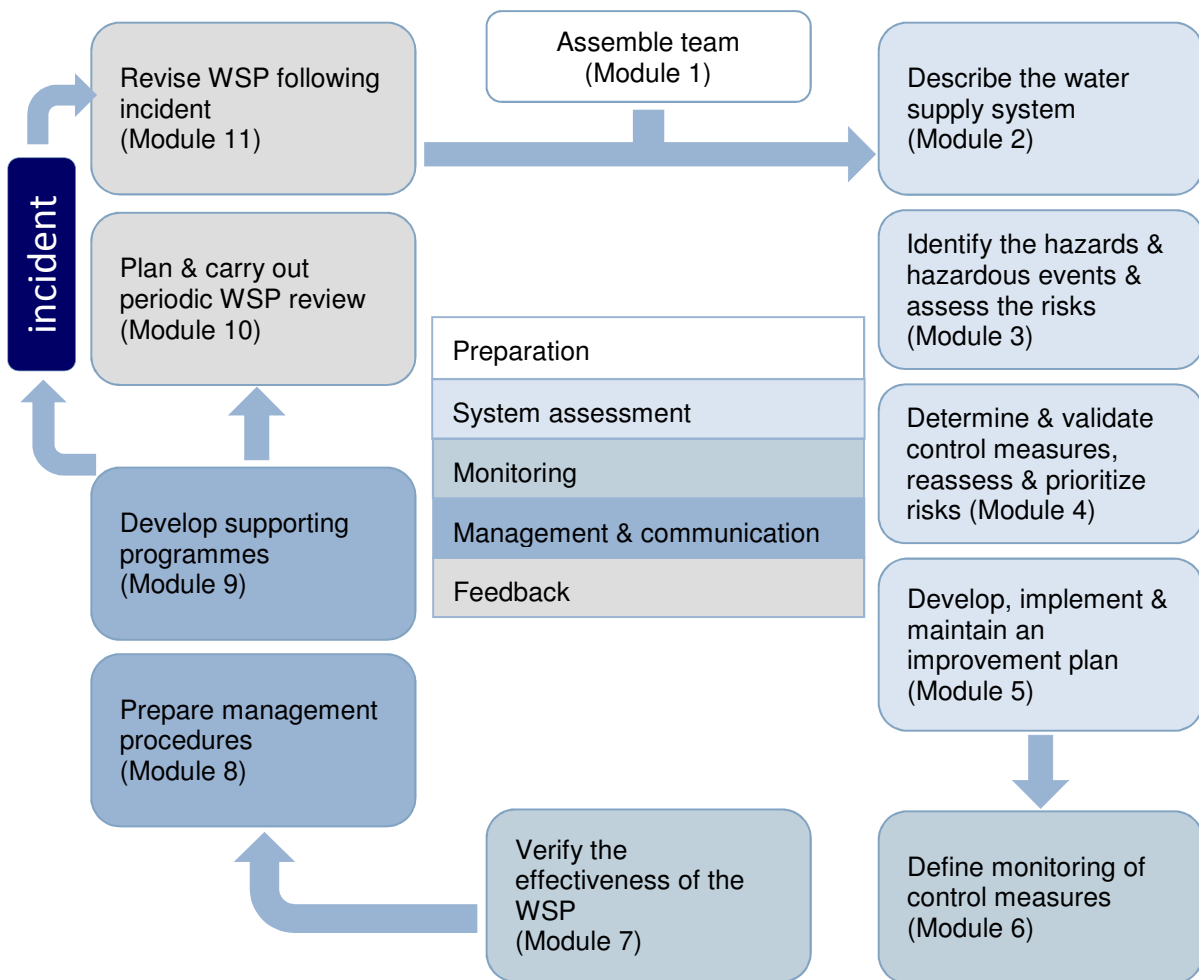
Figure 0.1 – WSP steps

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Key references:

- Bartram et al. (2009) *Water safety plan manual*
  http://www.wsportal.org/wspmanual
  http://www.who.int/water_sanitation_health/publication_9789241562638/en/index.html
- IWA (2004) *Bonn charter for safe drinking water*
  http://www.iwahq.org/cm
- WHO (2011) *Guidelines for drinking-water quality,* 4th edition
  http://www.who.int/water_sanitation_health/dwq/guidelines/en/index.html
- WHO/IWA (2012) Water safety plan quality assurance tool v1.3 (Excel tool and manual)
  http://www.wsportal.org/templates/ld_templates/layout_1367.aspx?ObjectId=20686&lang=eng
  http://www.who.int/water_sanitation_health/publications/wsp_qa_tool/en/index1.html
- WSPortal (tools and case-studies)
  http://www.wsportal.org

Exercise – Introductory module

Aim: To reinforce the public health role of suppliers and remind participants of what the potential health impacts would be within the population if treatment were to fail or were insufficient to remove such contamination, thus highlighting the need for an effective WSP.

Divide the participants into groups of four, each group sitting around one table. Ideally, the groups should be made up of participants from one utility or at least from the same country. This is so that they have a similar perspective of water supply systems. **These groups are to remain the same for the entire workshop unless the exercise specifies otherwise.**

Provide each group with a laminated version of the *incomplete* Table 0.1 (Appendix D) listing water quality parameters, potential health impacts and potential sources. The missing content is provided to the groups on a separate sheet. Following discussion, ask the groups to complete the table using wipe-off pens by matching up the information in the table with the missing content from the additional sheet. After the exercise, groups will rotate tables in order to "mark" each other's work as the facilitator provides the correct answers. The correct answers are provided in the *complete* Table 0.1 below.

Timing: Approximately 30 minutes

- 5 minutes to brief
- 15 minutes for the exercise
- 10 minutes to "mark" and discuss correct answers

Materials needed (per group)**:**

- Laminated "public health" Table 0.1 (Appendix D) and missing content list and one wipe-off pen

Table 0.1 – Water quality parameters, potential health impact and potential source *(complete table)*

Parameter	Potential health impact	Potential source (in water)
Escherichia coli	Diarrhoea	Faecal contamination (indicator for faecal contamination)
Shigella spp.	Dysentery	Faecal contamination
Vibrio cholerae	Cholera (severe diarrhoeal disease)	Faecal contamination
Cryptosporidium parvum	Diarrhoea	Faecal contamination
Giardia intestinalis	Diarrhoea and intestinal malabsorption	Faecal contamination (wide range of animal species)
Naegleria fowleri	Amoebic meningitis (via inhalation)	Occurs naturally, grows well at high temperatures
Legionella pneumophila	Pneumonia (via inhalation)	Occurs naturally and in certain human-made installations such as water cooling devices and spas
Fluoride	Too much: adverse changes in bone structure	Addition during treatment and naturally in the environment
Arsenic	Skin changes and cancers of the skin, lung and bladder (after long term exposure)	Volcanic rocks and sulfide mineral deposits
Lead	Adverse neurological effects	Old pipes and plumbing
Cyanobacterial toxins	Liver damage, neurotoxicity and possibly tumour promotion	Bacterial blooms in raw water

Module 1 – Assemble the WSP team

Learning objectives

Through active participation in and successful completion of Module 1, each participant should be able to meet the following learning objectives:

- Demonstrate clear understanding of the purpose of the WSP team and therefore who should be involved in WSP development and implementation.
- Explain why engagement of senior management from the outset is of vital importance.
- Evaluate the relative importance of all WSP stakeholders with regard to ensuring the delivery of safe drinking-water.
- Identify the expertise needed to design and implement an effective WSP with clearly assigned roles.

Material delivery

	Activity/description	Information
	Day 1:	13:00–15:00
	Why should you assemble a team? Do not necessarily answer, but ask so that participants have this in mind during the theory session.	Slide 1 (title)
	Question to workshop: Why do we need to engage senior management?	Slide 4 Before 1st click
	Point out the importance of engaging senior management from the outset.	Slide 4
	Ask participants if they are aware of any additional external support resources that may assist in WSP development; note on flipchart.	End of slide 6 <10 minutes
	Emphasize the importance of defining roles and responsibilities when the team/utility is large and confusion may exist.	Slide 7
	Ask participants how they could overcome the challenges listed. Note responses on flipchart.	Slide 9 <10 minutes
	Exercise – Assemble a team	Slide 11 25 minutes Exercise 25 minutes Report back
	Summary discussion	After exercise 5 minutes
	Break	14:45–15:00

Key points

- A WSP team should be formed to own and lead WSP development and implementation efforts and to advocate the approach to those connected with the safety of the water supply.
- A WSP team is largely made up of people from within the water utility, but, if required, external stakeholders and consultants may be approached for their expertise. The required expertise, including the need for external advisory input, should be identified early on.
- In order for WSPs to be implemented successfully, senior management buy-in is needed from the outset to support changes in work practices and provide financial and resource support.
- A team leader needs to be appointed to ensure focus.

- Members of the team must have appropriate authority to implement recommendations that result from the WSP.
- Team members should be skilled in risk management and collectively have knowledge of the entire supply chain. It is essential that the expertise needed is matched to a person responsible and that all roles are clearly defined.
- Key members will vary according to the context, but will likely include in-house operators, engineers, scientists, risk managers, technicians, external regulators, environmental agencies and landowners.
- Information about the WSP team members (e.g. name, job title, role within the WSP team and contact details) must be recorded and updated as necessary.
- The size of the team should depend on the size of the organization and complexity of the system (a small team is better than no team). For further information, see example/tool 1.3 in the WSP manual.
- Initial time input for WSP development and implementation may be high, but it will decrease over time as the WSP team becomes more familiar with the WSP process.
- Team development poses a number of challenges: finding skilled personnel, organizing the workload, identifying and engaging external stakeholders, keeping the team together and effective communication.

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Exercise – Module 1

Aim: To identify key competencies required for WSP teams and create a list of potential contacts.

After the theory session, ask participants to group together with other members of the same utility (if there are only single participants from each utility, then groups may discuss together, but prepare individual lists). Ask the groups to list an "ideal" WSP team from within their utility. On a flipchart, ask participants to write down job titles and names, if they know them, the expertise they will bring to the team, contact information and back-up contact details. Also ask participants to identify what expertise is missing and make suggestions of who they could ask to help source this expertise. Are there any external stakeholders that should be approached? Ask groups to nominate a rapporteur and someone to report back to the main group at the end of the exercise. Lists produced can be taken back and used as a starting point for recruiting potential WSP team members.

Timing: Approximately 1 hour

- 5 minutes to brief
- 25 minutes for the exercise
- 25 minutes to report back (5 minutes per group – remind groups of their time allocation and let them know that their presentations will be stopped at 5 minutes. Stress that these feedback sessions are also about learning how to present concisely to colleagues and management.)
- 5 minutes for summary discussions

Materials needed (per group)**:**

- Flipchart and pens

Exercise facilitation:

- The groups should note: name, affiliation, title, role in WSP, contact information and back-up contact. Also include whether or not they know the identified persons.
- Teams should include the following:
    - Appropriate authority to action any changes proposed in the WSP.
    - Knowledge of the whole supply chain.
    - Expertise in hazard identification and risk assessment.
    - A team leader.
    - Technical expertise and operational system-specific experience – and identify any gaps in knowledge/skills available.
    - Organizational authority to report through to the relevant controlling authorities such as the executive of an organization or community leader.
    - Understanding of water quality standards to be met.
    - Appreciation of the water quality needs of the users.
    - Understanding of the practical aspects of implementing WSPs in the appropriate operational context.
    - Understanding of the impact of proposed water quality controls on the environment.
    - Familiarity with training and awareness programmes.

Module 2 – Describe the water supply system

Learning objectives

Through active participation in and successful completion of Module 2, each participant should be able to meet the following learning objectives:

- Identify what factors need to be considered when describing a water supply system.
- Design and construct an interlinked flow diagram of system components (from source to point of use) for a known system.
- Formulate a list of common challenges encountered when describing a system.

Material delivery

	Activity/description	Information
	Day 1:	15:00–17:00
	Participants to describe components of a supply system according to: catchment; treatment; distribution; users. Record on flipchart.	Slide 4 Before 1st click <10 minutes
	What components does a utility not have direct control over (e.g. household components / catchment components)? For these components, what activities can utilities partake in to support water safety?	Slide 6
	Participants to suggest what other parameters might be measured with regard to water quality.	Slide 7
	Point out the importance of noting who and what the water is NOT intended for.	Slide 8
	Participants to suggest possible challenges that may be encountered when describing the system. Record on flipchart.	Slide 9 Before 1st click ~5 minutes
	Exercise – Describe known system	Slide 11 25 minutes Exercise 20 minutes Report to group
	Discussion and recap on Day 1. Activity	Appendix C 10 minutes
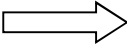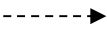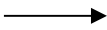
Key points

- Descriptions are specific to each system – generic descriptions can be used as a starting point only.
- It is important to confirm the accuracy of the system description through on-site checks and obtaining input from relevant staff/stakeholders.
- A detailed, accurate system description is essential for hazard identification and subsequent risk assessment to be carried out.
- The use and users need to be identified – these should also explicitly include who and what water is not suitable for.
- Many utilities will already hold a lot of relevant documentation. The system description may simply be a systematic review to ensure accuracy and completeness.
- The system needs to be described relative to the water quality standards required (which in turn are based on the local health-based targets).
- Identification of key staff involved with the supply of water also comes under system description.

Aim: To describe a water supply system known to participants and document as a flow diagram.

In groups of four (ideally from one utility or country), participants are to create a basic flow diagram of a water supply system known to them.

◯	Circle = Operational step
△	Triangle = Storage step
⇨	Block arrow = Transport step
✶	Star = Unknown part of system
▭	Banner = Refer to other documentation
- - - ▶	Dashed line arrow = Intermittent process
——▶	Full line arrow = Continuous process
BOLD/Blue	Bold/Blue = Utility control
UNBOLD/Red	Non-bold/Red = Outside of utility control

The flow diagram should be created using the symbols above (note that the first five symbols should be provided by the facilitator – see Appendix E). The system should be described from catchment to point of use, with notes made (star) where the system is unknown/not known in sufficient detail to the group. In these situations, the group should identify how this information will be obtained, including identification of relevant stakeholders to provide this information.

To supplement the diagram, reference should be made to other documentation (banner) that would provide more information, e.g. refer to the treatment works process flow diagram.

In addition, groups should list what they consider to be the important items when describing a system and make an attempt to plan where unknown information can be obtained.

Timing: Approximately 1 hour

- 5 minutes to brief (provide an example flow diagram using all symbols)
- 25 minutes to carry out exercise
- 10 minutes to critique
- 20 minutes (5 minutes per group) to provide feedback

Materials needed (per group)**:**

- Five of each symbol
- Thick pens (black, red and blue)
- Flipchart (to stick symbols to)
- Tacks

Exercise facilitation:

On completion, the groups rotate tables so that each group can critique another group's diagram with a view to feeding back any points of interest to the entire class.

Templates for the symbols are found in Appendix E for photocopying and reproduction.

Module 3 – Identify hazards and hazardous events and assess the risks

Learning objectives

Through active participation in and successful completion of Module 3, each participant should be able to meet the following learning objectives:

- Explain the stages and meaning of hazard identification and risk assessment.
- Undertake risk assessments of given hazards/hazardous events.
- Identify vulnerable areas or processes in a water supply system.
- Outline the common challenges associated with the use of risk assessment methods.

Material delivery

	Activity/description	Information
	Day 2:	09:00–11:00
	Review exercise on Module 1 – Identify which roles are missing from the WSP team jigsaw.	5 minutes Appendix C
	Animated slide – click on arrows to access photographs. *Slide should be prepared using local photos.*	Slide 3
	Emphasize that once hazards and hazardous events are identified, the WSP should be updated to record the hazards, hazardous events and risks.	Slide 3
	Ask participants to name some generic hazardous events that are found within each stage of a supply system.	Slide 5 WSP manual examples/tools 3.1–3.4
	Ask participants how they would be able to determine what might go wrong.	Slide 7 Before 1st click
	Emphasize that semiquantitative assessment alone may be limited, as it may reduce or elevate certain hazards (see case-studies in WSP manual for reasons); therefore, a qualitative assessment may also be useful to ensure that risks are appropriately prioritized.	Slide 8 WSP manual, case-studies 1 and 2, field experience 3.2
	This matrix is an example only. It is arguably better to tailor the mode of assessment to local contexts, although the matrix adopted by a utility should be applied consistently from system to system and from source to point of use.	Slide 10
	In groups, using the example of algal blooms in a reservoir, assess the risk and give a score. Remember to record the rationale for the risk assessment score.	Slide 11 Before 1st click
	It is important to define the likelihood and consequence definitions prior to the risk assessment, to avoid subjective assessments and to enable consistency. Documenting the rationale for the risk assessment scores will also help to facilitate consistency in assessments.	Slide 12
	Exercise – Risk score the three given hazardous events (third to be provided by facilitator). *Adjust examples to local situation as needed.*	Slide 13 25 minutes
	Break	11:00–11:15

- In practical terms, this module is carried out concurrently with Modules 4 (determine and validate control measures, reassess and prioritize the risks) and 5 (develop, implement and maintain an improvement/upgrade plan). It forms part of the system assessment, which first identifies potential hazards/hazardous events, then assesses their risk level, reviews the controls in place to mitigate the risks and finally reassesses the risks and confirms that the controls are working and that water quality targets are being met.
- Definitions:
  - Hazard – any agent (physical, chemical, biological or radiological) that can cause harm to public health
  - Hazardous event – any process that introduces hazards to, or fails to remove them from, the water supply
  - Risk – the likelihood of identified hazards causing harm to exposed populations in a specific time frame and the magnitude and/or consequences of that harm.
- Hazard identification and risk assessment should be based on a review of the system description (including the flow diagram) as well as on site visits and review of other pieces of information (e.g. historical and predictive information).
- Risks must be assessed based on an understanding of the effectiveness of control measures to mitigate the risks (residual risks) – this is discussed in the next module. However, it may also be worth assessing the risks if the controls were not in place (raw risks), as described in this module.
- It is essential that the risk matrix used is tailored to the local context. For example, detailed definitions for the severity and likelihood categories should be developed based on the local context. The risk matrix score that identifies significant risks should also be defined. There is no one way to conduct the risk assessment. Regardless of the methodology that is adopted, it is important to be consistent in the assessment approach (e.g. the likelihood and severity scoring criteria) to enable meaningful prioritization of the risks.

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Exercise – Module 3

Aim: To assign raw risk scores for three given hazardous events and appreciate how difficult it is to be consistent in such assessments

With participants in the same groups as for Module 2, ask them to assess the risks for three given hazardous events. Two examples are provided in this handbook (which should be adjusted to local situations; see material delivery section for more details) and the participants' workbook, but a third, local example should be developed by the facilitator. Note that "answers" are included on page 20 of the handbook.

It is expected that the groups will have different scores, despite being given the same information. On completion of their scoring, ask the groups to present their feedback to the workshop. On a flipchart, record the different scores and note any reasons for higher/lower scores, emphasizing that the allocation of scores is one of the main challenges for Module 3. A key point worth noting to the participants is that the risk matrix scoring is best not taken literally, and that both quantitative and qualitative approaches are needed to make a sensible assessment. Highlight the need for assigning a higher score for uncertain situations where sufficient information is not available to justify the likelihood and severity scores.

The exercise can be concluded by giving summary handouts of the case-studies from which these examples of hazardous events are taken (Appendix F).

Timing: Approximately 1 hour

- 5 minutes to brief
- 25 minutes to carry out exercise
- 20 minutes (5 minutes per group) for feedback
- 10 minutes for class discussion/facilitator to emphasize key findings

Materials needed (per group)**:**

- Information on the three hazardous events (information included in workbook without "answers")
- Example risk matrix (included in workbook)
- Flipcharts and pens

Exercise facilitation:

Prior to the exercise:

1. Read through the two example case-studies found in Appendix F so that help can be provided to the participants during the exercise, if required. Determine whether the examples are relevant to the local context of the participants, and change the examples if this is not the case.
2. Create the third, locally relevant example of a hazardous event to which the participants can assign a risk score.
3. Work through at least one of the examples, describing the typical risk score that might be given based on the likelihood and consequence, and the reason for this choice. This can be distributed after the exercise.
4. Include the following headers on the flipcharts: hazardous event, hazard, likelihood, severity, basis for risk assessment and risk score.

Example matrix for risk assessment

		Severity or Consequence				
		Insignificant or no impact - Rating: 1	Minor compliance impact - Rating: 2	Moderate aesthetic impact - Rating: 3	Major regulatory impact - Rating: 4	Catastrophic public health impact - Rating: 5
Likelihood or frequency	Almost certain / Once a day - Rating: 5	5	10	15	20	25
	Likely / Once a week - Rating: 4	4	8	12	16	20
	Moderate / Once a month - Rating: 3	3	6	9	12	15
	Unlikely / Once a year - Rating: 2	2	4	6	8	10
	Rare / Once every 5 years - Rating: 1	1	2	3	4	5
Risk score		<6	6-9		10-15	>15
Risk rating		Low	Medium		High	Very high

Example 1	Failure to disinfect
Hazardous event	Failure of chlorine dosing pump, resulting in microbial pathogens not being removed
Hazard	Microbial pathogens
Likelihood of hazardous event	If there are no controls in place (e.g. no alarms, standby chlorinators, no routine maintenance), what is the likelihood of contamination from chlorinator failure? Based on records, a chlorine dosing pump failure once every two weeks. Likelihood score of 3 or 4 is expected based on the frequency of chlorine dosing pump failure.
Severity or consequence	Severity score of 5 is expected based on the health consequences of microbial pathogens.
Raw risk score	3×5 or $4 \times 5 = 15$–20

Example 2	Water main breaks (bursts)
Hazardous event	Water main breaks and ingress of pathogens and soil into water main during repair
Hazard	Physical, chemical and microbial contamination
Likelihood of hazardous event	If there are no controls in place (e.g. no flushing after the repair, no procedure for repairing the main), what is the likelihood of contamination during the repair of water main? Water main breaks occur at least once a week in a distribution system, and it is reasonable to expect contamination of the main if flushing is not carried out after repair. Likelihood score 4 is expected based on the frequency of water main breaks.
Severity or consequence	Severity score of 5 is expected based on the health consequences of microbial pathogens.
Raw risk score	$4 \times 5 = 20$

Module 4 – Determine and validate control measures, reassess and prioritize the risks

Learning objectives

Through active participation in and successful completion of Module 4, each participant should be able to meet the following learning objectives:

- Understand the terms control measure and validation.
- Identify typical control measures for all stages of a water supply system.
- In given examples, assess which measures are used to control certain hazards.
- Explain the processes involved in validating control measures.
- Discuss the challenges of prioritizing risks.

Material delivery

	Activity/description	Information
	Day 2:	11:15–14:15
	Ask participants to individually write down all the control measures they can think of on post-it notes. Stick notes on appropriate flipchart pages representing stages of a water supply system (catchment, treatment, distribution and user). Facilitator then summarizes and provides feedback.	Slide 6 10–15 minutes
	Emphasize the four activities of Module 4. Write on flipchart for regular viewing.	Slide 7
	Emphasize the definition of validation. Use local examples to help.	Slide 8
	Give different examples of how a control measure can be validated based on the bullet points included in the slide (e.g. catchment sanitary surveys can be carried out to validate buffer distances and fencing in a catchment to ensure minimal risk of microbial pathogens entering a water intake).	Slide 9
	Why is it important to assess risks with and without control measures in place? Record answers on flipchart.	Slide 10 5 minutes
	Discussion: How can you assess the effectiveness of catchment control measures (validation)? Record key discussion points on flipchart.	Slide 13 <10 minutes
	Lunch	12:15–13:15
	Exercise **Part 1:** Relate hazardous events and respective control measures. **Part 2:** Describe how to validate certain control measures. **Part 3:** Reassess risks for the three hazardous events after considering the effect of control measures. **Part 4:** Demonstrate the process of risk prioritization by ranking the risks from the highest to lowest. Highlight that this can be undertaken only on completion of risk assessment from catchment to the consumer.	Slide 14 30 minutes

Key points

- Remind participants that in practical terms, this module is carried out concurrently with Modules 3 and 5, forming part of the system assessment.
- Definitions:
  - Control measure – any action or activity that can be used to prevent, eliminate or reduce to an acceptable level any water safety hazard
  - Validation – investigative activity to identify the effectiveness of control measures. It obtains the evidence that elements of the WSP can effectively meet the water quality targets.
- Module 4 contains four activities: identification of control measures, validation, reassessment of risks and prioritization of risks.
- In order to understand what inadequately controlled risks exist in the water supply system, risks must be assessed with a consideration of existing control measures and their effectiveness. It is essential that inadequately controlled risks are prioritized to facilitate development and implementation of improvement/upgrade plans. These plans are further discussed in the next module.
- Major challenges include:
  - Assessing control measure effectiveness (validation)
  - Uncertainty in prioritizing risks due to lack of knowledge and/or data to assess risks
  - Inconsistent risk assessment methodologies.

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Exercise – Module 4

Part 1 – Aim: To link hazardous events with control measures to mitigate risks.

With participants in groups of four, ask them to match up cards of hazardous events with suitable control measures. The cards are to be made available to each group. If there are five groups, five duplicates of each hazardous event and control measure will be needed. The example hazardous events and associated control measures are detailed in Table 4.1.

Highlight the importance of listing "current" control measures. With participants in the same groups, ask them to identify possible control measures for the hazardous events listed below (and described further in Module 3):

1. Failure to disinfect due to chlorine dosing pump failure at the chlorination step
2. Contamination during repair of main breaks in the distribution system
3. Locally relevant example (facilitator should create example)

Once Part 1 is completed, do a quick (5 minutes) check that each group assigned the same control measures to the associated hazardous event. Discuss any differences.

Part 2 – Aim: To promote deeper thinking about how control measures are validated.

With participants in the same groups, ask them to describe how the control measures included on the cards would be validated. Any mention of verification at this stage should be avoided. If someone mentions it, the correct response would be to park the question until Module 7 and make it clear that verification relates to the success of the WSP as a whole in relation to water quality targets.

Table 4.1 also outlines associated methods of validation, but these should *not* be made available as cards.

Part 3 – Aim: Reassess risks for the three hazardous events after considering the effect of control measures. Highlight how the likelihood and severity scores will change depending on the strength and effectiveness of control measures. With participants in the same groups, ask them to reassess the likelihood and severity by considering the implementation of control measures. In general, the likelihood score will be reduced depending on the effectiveness and robustness of the control measures. The severity score in most cases will remain the same. Note that "answers" are included on page 24.

In the feedback session of Part 3, if there is time, ask the groups how each control measure would be validated.

Part 4 – Aim: Demonstrate the process of risk prioritization.

Explain how to prioritize the risks by ranking the risk scores from highest to lowest. Explain that the objective is to separate the significant risks (critical risks) for developing operational monitoring programmes as explained in Module 6 and to identify and prioritize improvement activities (Module 5). The facilitator is strongly encouraged to demonstrate risk prioritization using a real-life risk assessment table from a water utility.

Timing: approximately 1 hour

- 5 minutes to brief
- 5 minutes to carry out Part 1
- 5 minutes for feedback from Part 1
- 5 minutes to carry out Part 2
- 10 minutes for feedback from Part 2
- 15 minutes to carry out Part 3
- 10 minutes for feedback from Part 3
- 5 minutes to carry out Part 4

Materials needed (per group)**:**

- Cards for control measures and hazards/hazardous events
- Flipcharts and pens (for Part 3)

Exercise facilitation:

Prior to the exercise:

1. Create cards of hazardous events and control measures, ensuring that the number duplicated matches the number of groups in the workshop.
2. Create a local example of a hazardous event and make copies to distribute to the groups.
3. Include the following headers on the flipcharts: hazardous event, hazard, control measure, likelihood, severity, basis for risk assessment and risk score.

Example 1	Failure to disinfect
Hazardous event	Failure of chlorine dosing pump, resulting in microbial pathogens not being removed
Hazard	Microbial contamination
Control measure	List current control measures based on participants' knowledge of their chlorinator operations
Validation of control measures	Describe effectiveness of control measures e.g. Historical dosing pump/chlorinator inspection records e.g. Historical treated water chlorine data (daily, hourly, etc. at the dosing point), records of chlorine analyser telemetry alarm failures
Likelihood of hazardous event	The likelihood score should be reduced to 2 or 3, depending on the strength of the implementation of the control measures; e.g. well-maintained chlorination system with online chlorine analysers and alarms connected to a telemetry system may reduce the likelihood score to 2
Severity or consequence	Severity score remains the same compared with the raw risk
Residual risk score	2 × 5 or 3 × 5 = 10–15

Example 2	Water main breaks (bursts)
Hazardous event	Water main breaks and ingress of pathogens and soil into water mains during repair
Hazard	Physical, chemical and microbial
Control measure	List current control measures based on participants' knowledge of their burst main repair practices
Validation of control measures	Describe effectiveness of control measures e.g. Historical burst main records, customer illness and discoloured water complaint analysis e.g. Special field investigations to assess effectiveness of mains repair procedures
Likelihood of contamination	The likelihood score should be reduced to 1–3 depending on the effectiveness of the burst main repair process
Severity or consequence	Severity score remains the same compared with the raw risk
Residual risk score	1 × 5 or 2 × 5 or 3 × 5 = 5–15

Table 4.1 – Example hazardous events, hazards, associated control measures and possible methods of validation

Hazardous event(s)	Hazards	Control measures	Possible validation
Runoff from animal farms to source water	Microbial contaminants	Controlled grazing in the catchment – fencing of catchment areas	Historical microbial source water quality data Sanitary survey results for buffer distances Historical catchment inspection results
Rubbish dumping in source water	Physical, chemical and microbial contaminants	Availability of bins/rubbish collection Customer education and awareness programme Security fencing/routine patrols Signage	Historical sanitary inspection records
Algal blooms in open reservoirs	Physical and microbial contaminants Odour	Reservoir aeration Powdered or granular activated carbon dosing at the treatment plant Selective withdrawal from multi-level intake structure Alternative supply	Historical algae monitoring data (catchment and after treatment) Historical data on algal blooms
Interruption of power supply causing failure of disinfection	Microbial contaminants	Power failure alarm Equipment maintenance programme Plant shutdown protocols Generator backup supply Distribution system flushing Boiled water notification protocols	Equipment maintenance and replacement records Backup power supply testing and maintenance records Historical records of power failure Historical plant shutdown incident records
Recontamination of treated water at distribution system closed storages	Physical, chemical and microbial contaminants	Locked cover on storage tank Vermin screening over vent piping Storage reservoir maintenance programme	Historical *E. coli* (faecal coliforms) monitoring data Historical reservoir inspection reports Historical incident records Historical maintenance reports
Industrial contaminants polluting source water	Chemical contaminants	Enforced industrial effluent standards	Collaboration with regulator or enforcement agency to obtain historical reports on effluent discharge
Blocked abstraction screen	Physical contaminants	Regular cleaning	Inspection logs and cross-reference to any reported blockage incidents to establish that cleaning is working
High levels of natural organic matter in source water	Disinfection by-products	Treatment to remove natural organic matter (disinfection should not be compromised in attempting to control disinfection by-products)	Historical disinfection by-products indicator test results or consistent reduction in disinfection by-products under range of operating conditions.

Module 5 – Develop, implement and maintain an improvement/upgrade plan

Learning objectives

Through active participation in and successful completion of Module 5, each participant should be able to meet the following learning objectives:

- Explain why an improvement/upgrade plan is required and what four activities are involved.
- Identify the factors that need to be considered when elevating the WSP cause to senior managers for financial investment of improvements/upgrades.
- Explain the challenges in developing/implementing and maintaining an improvement/upgrade plan.

Material delivery

	Activity/description	Information
	Day 2:	14:15–16:30
	Ask participants to call out reasons why they think an improvement/upgrade plan is needed. Record answers on flipchart.	Title slide 5 minutes
	An improvement/upgrade plan is necessary when any uncontrolled risk has been identified in order for work to progress according to priority needs and to maximize effectiveness of limited resources.	Slide 3
	New control measures may introduce new risks. E.g. chlorination as a control measure introduces a risk associated with storing gas cylinders.	Slide 5
	Any plan will need to be updated. It is an iterative process.	Slide 6
	Part 1: In workbooks, review the example plan (taken from WSP manual, page 54). In groups, invent a further "action" and complete the rest of the table, creating an improvement/upgrade plan relating to that action. Part 2: What other factors need to be considered when developing an improvement/upgrade plan?	Slide 7 Part 2: Appendix G 10 minutes
	What challenges may be encountered when trying to develop an improvement/upgrade plan?	Slide 8 Before 1st click
	Break	15:15–15:30
	Exercise – Part 1: Health awareness campaign Part 2: Draft proposal for funding	Slide 10 30 minutes
	Participants to answer colour-coded questions relating to the Modules 0–5	At end of session Appendix C

Key points

- Remind participants that in practical terms this module is carried out concurrently with Modules 3 and 4, forming part of the system assessment.
- An improvement/upgrade plan is needed if previous WSP steps have revealed that existing controls are not effective or are absent. This plan will prioritize the work that needs to be done.
- An improvement/upgrade plan can include short-, medium- and long-term programmes and should be implemented based on the significance of the risk and available resources.

- Each improvement or upgrade must be owned by a person for its implementation.
- Capital investment may be needed to upgrade parts of the supply system.
- The WSP should provide evidence for the need of an upgrade, resulting in proactive investment planning.
- Introducing new controls may introduce new risks, hence the need to review the WSP accordingly.
- Improvements/upgrades should involve monitoring and reviews.

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Part 1 – Aim: For participants to consider what methods and content of communication would be most suitable in a given context to raise awareness of water quality and health issues.

Tell participants that evidence gathered from household surveys has shown a lack of knowledge about safe water storage and the links between water quality, hygiene and health. With participants in **new** groups of four, ask them to briefly outline a health awareness campaign for an area that is familiar to at least one member of the group. The outline should include advice both on content and on methods of communication (e.g. information on bills, the press and media).

Ask participants to present their outline on a flipchart, verbally feeding back to the workshop once completed.

Part 2 – Aim: To promote deeper thinking among the participants for how WSPs may be used to aid proactive financial investment; and to encourage discussion about the important factors that need to be considered when trying to secure funding.

With participants in the same groups of four as in Part 1 of this exercise, ask them to consider an upgrade that might be applicable in a supply system familiar to at least one of them. With reference to this upgrade, ask participants to draft an investment planning proposal to their utility finance strategy team. Ask the groups to consider:

- Who would be the first person they would contact to get the issues raised?
- What internal management procedure would they need to follow to ensure that ideas for new capital investment are heard?
- What typical challenges might be encountered?
- What evidence might be needed to support any case for increased capital expenditure?
- Would extra training or research be required?

Once completed, ask participants to present their proposal on a flipchart, verbally feeding back to the workshop.

Timing: Approximately 1 hour

- 5 minutes to brief
- 10 minutes to carry out Part 1
- 10 minutes to provide feedback from Part 1
- 20 minutes to carry out Part 2
- 15 minutes for feedback on Part 2

Materials needed (per group)**:**

- Flipchart and pens

Exercise facilitation:

Prior to the exercise, clearly think through Parts 1 and 2 so as to be able to advise groups as necessary. If groups are not able to think of any example upgrades, the following list may help:

- Installation and validation of ultraviolet treatment for *Cryptosporidium*
- Installation of new chlorinator to main water supply source
- Operator training on chlorine dosing and monitoring
- Replacement of ageing water mains.

Module 6 – Define monitoring of the control measures

Learning objectives

Through active participation in and successful completion of Module 6, each participant should be able to meet the following learning objectives:

- Evaluate the importance of monitoring as a way of protecting the public's health.
- Develop a best-practice monitoring programme for their organization.
- Take the action required following any abnormal monitoring result.

Material delivery

	Activity/description	Information
	Day 3:	09:00–11:00
	Energizer activity – "spot the hazards/hazardous events"	Appendix C & PowerPoint
	What other things (besides "what" to monitor) need to be detailed in any effective monitoring programme?	Slide 4 Before 1st click
	Emphasize that the person analysing the results needs to be aware of any critical limits and know who to contact to implement any required corrective action.	Slide 5
	Exercise: In addition to the challenges listed, in pairs, write down on a flipchart sheet as many other challenges as you can think of in 3 minutes. Pass challenges on to another pair, then consider what actions may be suitable to mitigate the challenges listed.	Slide 7 10 minutes
	Exercise: Walkerton case-study	Slide 8 45 minutes
	Break	11:00–11:15

Key points

- Definitions
  - Operational monitoring – the act of conducting a planned sequence of observations or measurements of control parameters to assess whether a control measure is operating within design specifications
  - Critical limit – a criterion that separates acceptability from unacceptability
  - Corrective actions – any action to be taken when critical limits are exceeded
- The purpose of operational monitoring is to demonstrate that control measures continue to work.
- Operational monitoring should include corrective actions, which are the actions that should be taken when the results of monitoring show that the critical limit is exceeded.
- Procedures need to be in place on how to monitor these control measures, including information related to critical limits and corrective actions.
- Monitoring programmes need to include: what, how, when, where, who.
- Persons responsible for monitoring, analysing and receiving results need to be identified.

- The person receiving the results needs to have sufficient power to enable immediate action to take place if the results exceed critical limits.
- Operational monitoring may already be ingrained within a utility's working practice. WSPs may highlight areas where monitoring is not needed, as well as areas where more is needed.
- Monitoring itself is not enough; operators need to understand the importance of their role so that tragedies such as Walkerton can be avoided in the future. Monitoring and corrective actions form the control loop to ensure that unsafe drinking-water will not be consumed.

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Aim: To emphasize the ease with which a tragedy can unfold, and to assess the steps that are necessary to mitigate such events.

With participants in groups of four, ask them to review the material provided on the Walkerton water tragedy (Appendix H) and highlight what went wrong in respect to the monitoring of control measures. Ask groups to:

1. Prepare a timeline of events and indicate the opportunities for intervention that could have prevented or reduced the scope of the outbreak.
2. Identify what actions the operators of this facility should have taken that could have prevented or reduced this outbreak.
3. Identify who was to blame.

Note: Question 3 is deliberately phrased to be somewhat contentious so as to encourage deeper thinking into the subject of blame. To support the discussion, the WSP manual lists a typical challenge in Module 11 as focusing and acting on the positive lessons learnt rather than apportioning blame.

Provide each group with a flipchart for them to record their discussion. At the end of the exercise, ask the groups to rotate tables to review another group's flipchart discussion notes.

Following the peer review, ask participants to present feedback to the whole workshop. At the front on another flipchart, have the above three questions written, and then ask for answers from the floor. It is expected that there will be agreement with regard to the first two questions of the exercise. The subject of blame should be discussed when answering the third question. After, the discussion can be steered towards the Walkerton case itself and the importance of defining and adhering to agreed monitoring of control measures.

Timing: Approximately 1 hour

- 5 minutes to brief
- 15 minutes to read through the case material
- 15 minutes to discuss and answer the three questions
- 15 minutes to review and critique
- 10 minutes for feedback and discussion

Materials needed (per group)**:**

- Flipchart and pens
- Walkerton case-study synopsis

Exercise facilitation:

Prior to the exercise, review the Walkerton case material thoroughly. Consider the following:

- Chlorine residual should have been measured daily (regulation). It was not, and at times data were fabricated.
- If the chlorine residual had been monitored as required, the problem would have been apparent.
- When the heavy rain fell, it should have alarmed operators to be more vigilant – to monitor more, check chlorine residual, increase dose as necessary and shut off Well 5, knowing its vulnerability.
- Operators and foreman had not been properly trained and so did not fully understand the supply system, its vulnerabilities and the potential impact on public health.
- Within the first 24 hours of measuring a drop in chlorine residual (which was not monitored)
  - The system should have been dosed with chlorine.
  - The mains should have been flushed.

- The health authority and regulator should have been contacted.
- Joint agreement should have been reached on a boil water advisory based on water quality measurements.
- Ineffective regulation, inadequate catchment protection, water treatment and monitoring, and poor system management all contributed to the tragedy.

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Module 7 – Verify the effectiveness of the WSP

Learning objectives

Through active participation in and successful completion of Module 7, each participant should be able to meet the following learning objectives:

- Understand the purpose of verification and describe the three key actions of verification.
- Understand the difference between operational monitoring and compliance monitoring and between validation and verification.
- Design an effective programme for verifying a WSP.

Material delivery

	Activity/description	Information
	Day 3:	11:15–14:15
	Emphasize that all three activities are required for thorough verification.	Slide 4
	Ask participants to suggest what things an auditor would need to know / what information an auditor should obtain in order to accurately assess a WSP. Record answers on flipchart.	Slide 4 WSP manual tools 7.3 & 7.4 10 minutes
	Operational monitoring provides an indication that treatment is effective and assesses whether a control measure is operating within design specifications. *Compliance monitoring* assesses adherence to set water quality / operational requirements. *Verification* confirms that treatment is effective. *Validation* is investigative activity to identify the effectiveness of control measures. It provides the evidence that elements of the WSP can effectively meet the water quality targets.	Slide 6
	Discuss in groups any indirect or direct experiences they have had of missing or incorrect verification data. What are the main reasons for this failing? Provide feedback to workshop and record on flipchart.	Slide 8 10 minutes
	Lunch	12:15–13:15
	Exercise: Plan a verification programme	Slide 9 30 minutes

Key points

- Definitions
  - o Verification – the application of methods, procedures, tests and other evaluations to determine compliance with WSP. Verification confirms that the water quality targets are being met and

maintained and that the system as a whole is operating safely and the WSP is functioning effectively. It is made up of three activities:

1. Compliance monitoring – for example, the use of *E. coli* measurements. Does the water quality meet the set targets?
2. Internal and/or external auditing – to assess the practical implementation of WSPs and compliance. Auditors need a detailed knowledge of the system to be able to identify any possible fraudulent data, often needing to witness procedures in person.
3. Consumer satisfaction – are users happy with the service and trust that the water is safe?

o Validation – investigative activity to identify the effectiveness of control measures. It obtains the evidence that elements of the WSP can effectively meet the water quality targets
o Operational monitoring – the act of conducting a planned sequence of observations or measurements of control parameters to assess whether a control measure is operating within design specifications

- Verification is necessary to ensure that the WSP is used in practice, that the WSP is working and that the water quality meets the set targets. It is made up of three activities, as described above.
- External auditing is increasingly becoming a regulatory requirement for utilities. Where it is not a regulatory requirement, external auditing, for the purpose of accreditation, is increasingly being requested and is encouraged to support continuous improvement of the WSP.
- Auditing can highlight weak areas in operation and signpost where further investment (e.g. training) is needed.
- Key challenges to verifying a WSP include: lack of capable auditors, lack of qualified laboratories, lack of resources, no consumer feedback and inaccurate documentation.

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Exercise – Module 7

Aim: To consider all elements involved in the development of a verification programme.

Part 1: Divide the workshop into two groups. Ask one group to consider what should be audited during verification, e.g. water quality compliance. Ask the other group to devise a checklist of factors to consider when establishing a verification programme, e.g. frequency and duration. Allow 10 minutes for this exercise, and then ask for verbal feedback to the workshop. Write on a flipchart the agreed factors to consider during verification and what should be audited.

Example factors to consider when designing a verification programme (refer to WSP manual tool 7.2, which is specific for compliance monitoring):

- Regulatory requirements of verification
- Personnel – for monitoring , analysing water quality data, auditing
- Frequency and duration
- Communication protocol of audit – within utility and to regulator
- What should be audited

Examples of what should be audited (refer to WSP manual tool 7.4):

- Operational practice (e.g. implementation of identified improvements and operational procedures, including corrective actions)
- Water quality compliance (microbial and chemical testing)
- Protocol adherence (e.g. communication protocols)
- Review of hazards/hazardous events, control measures and their monitoring
- Corrective actions in place
- Consumer satisfaction

Part 2: Rearrange the workshop back to the original groups of four (established in Module 0). Using the agreed audit and verification factors (from flipchart) as a starting point, ask the groups to develop an outline verification programme in the context of a supply system known to at least one group participant. Allow 20 minutes for this exercise. After completion, ask each group to provide feedback to the workshop focusing on what challenges they encountered and what additional factors they considered to be important for a verification programme. Note these on a flipchart.

Timing: Approximately 1 hour

- 5 minutes to brief
- 10 minutes for Part 1
- 10 minutes to provide feedback and to brief Part 2
- 20 minutes for Part 2
- 15 minutes to provide feedback and discussion

Materials needed (per group)**:**

- Flipchart and pens

Exercise facilitation:

Prior to the exercise, review the WSP manual, specifically tools 7.1–7.4. Be familiar with what should be audited and what factors should be considered in a verification programme.

Module 8 – Prepare management procedures

Learning objectives

Through active participation in and successful completion of Module 8, each participant should be able to meet the following learning objectives:

- Explain management procedures during different operating conditions.
- Emphasize the importance of organizational culture and management style when reporting near-misses.
- Design management procedure components for a given case-study supply system.

Material delivery

	Activity/description	Information
	Day 3:	14:15–16.30
	Emphasize that management procedures are necessary during normal operation, incident conditions, as well as emergencies	Slide 4
	In two large groups. Ask Group 1 to identify management procedures for 1) facility operations, 2) disinfection, 3) surface source water abstraction and 4) groundwater abstraction, or any other four categories they want. Ask Group 2 to write a generic checklist of corrective action procedures that should be followed after an incident, e.g. location of backup equipment.	Slide 5 10 minutes WSP manual tools 8.1 & 8.2
	In small groups: what organizational factors (management style, communication, etc.) would best promote an environment where near-misses are reported and learnt from? How might this be cultivated within your utility?	Slide 7 10 minutes
	Break	15:15–15:30
	Exercise: Outline management procedures – Walkerton	Slide 12 25 minutes

Key points

- Management procedures
    - o Standard operating procedures define the actions to be taken during normal operational conditions and should detail the steps to follow in specific "incident" situations (corrective actions) where loss of control of the system may occur.
    - o Emergency management procedures to be followed during unforeseen (emergency) situations should also be documented.
- The procedures should be written by experienced staff and updated as necessary.
- Near-misses as well as actual incidents should be recorded.
- The outputs of preparing management procedures include:
    1. Standard operating procedures:
        - o Procedures during normal operation, principally operational monitoring with defined responsibilities
        - o Procedures for corrective actions following incidents, including defined responsibilities and location of any needed backup equipment

2. Emergency management procedures, which include responsibilities and alternative water supplies
3. Communication protocols with consumers, the water supplier, health authorities, regulator and environmental agencies during normal and incident conditions
4. Documentation – a programme to review and revise documentation regularly and following incidents, emergencies and near-misses

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Aim: For participants to consider how to design management procedures for a given case-study.

Note: Only certain components of management procedures are covered in the given example.

Using the Walkerton case material, with participants in groups of four, ask them to draft a document of management procedures that address the following points:

1. What water quality parameters and control measures should have been monitored as standard to support the supply of safe water?
2. What should the response actions have been when the analysed water samples showed microbial contamination and when the chlorine residual measurements were <0.5 mg/l?
3. Explain what communication protocols should have been in place and identify who needed to be contacted, about what and when?
4. Identify who should have been responsible for coordinating emergency measures, including the provision of emergency water, the boil water advisory and the re-establishment of safe drinking-water.

Provide each group with four flipchart pages for them to record their discussion and to enable feedback to the workshop. Ask groups to be as specific as possible. For example, ask them to name people (positions) or organizations, to specify frequency of monitoring, etc.

Timing: Approximately 1 hour

- 5 minutes to brief
- 5 minutes to re-read the case material
- 20 minutes to discuss and answer the four points
- 25 minutes to provide feedback to class (5 minutes per group)
- 5 minutes for further discussion

Materials needed (per group)**:**

- Flipchart and pens

Exercise facilitation:

Prior to the exercise, review the Walkerton case material thoroughly.

The following key points are worth addressing during the feedback discussion if they are not covered by the participants during the exercise:

- Microbial water quality and chlorine residual measurements should have been taken with increased frequency following the heavy rainfall, as it should have been apparent that the risk of well contamination was heightened.
- Sample collection protocols should also be included in the standard operating procedures – how to collect, volume to collect, how to label, etc.
- It is important to have staff who are trained and appreciate potential risks to a shallow water supply and the subsequent health impacts.

Module 9 – Develop supporting programmes

Learning objectives

Through active participation in and successful completion of Module 9, each participant should be able to meet the following learning objectives:

- Assess the relative importance of supporting programmes in the wider context of WSPs and the delivery of safe drinking-water.
- Explain what constitutes effective supporting programmes.
- Examine the role that organizational culture has on WSP implementation success.

Material delivery

	Activity/description	Information
	Day 4:	09:00–11:00
	Activity: Supporting programmes brainstorm	Before slides 10 minutes Appendix C
	Supporting programmes help you do your job well and thus help protect the public's health.	Slide 3
	Cultivating a suitable organizational culture can have a significant impact on WSP success.	Slide 4
	Supporting programmes can make the difference between WSP success or failure, as often the sustainability depends not on following a step-by-step approach but on developing the right support for people in roles of responsibility.	Slide 6
	Ask participants to give examples (real or theoretical) where having support (training, etc.) could indirectly lead to improved water safety (e.g. training of Walkerton operators may have led to faster responses and a more honest conduct). What other supporting programmes do they have at their utilities, in addition to the ones listed during the brainstorm session? Record discussion on flipchart.	Slide 8 15 minutes
	Exercise: Culture quotes	Slide 9 25 minutes Appendix I
	Break	11:00–11:15

Key points

- Definitions
  - Supporting programmes – actions that are important in ensuring drinking-water safety but do not directly affect drinking-water quality (e.g. training and management practices)
- Supporting programmes can support the development of people's skills and knowledge, commitment to the WSP approach and capacity to manage systems to deliver safe water.
- Supporting programmes are designed to "help you do a good job", and they can range from research and development and individual training through to upgrading of equipment and operating hygienically.
- A less considered, but very important supporting programme deals with the cultivation of a WSP organizational culture.

- When developing supporting programmes, you first need to review what is needed and then revise any existing programmes and develop new ones as needed.
- Success factors:
    - WSPs are not just a step-by-step process guaranteeing safe water.
    - Personal accountability and responsibility are essential components.
    - Broader stakeholder engagement is vital.
    - Organizational commitment is fundamental.
- A major challenge for this module is that of resourcing. Supporting programmes can be considered by some as non-essential or of lesser importance.
- Another major challenge is to cultivate a culture of fair blame with avenues to encourage open communication so that near-misses or incidents are reported and actively learnt from.

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Exercise – Module 9

Aim: For participants to evaluate the way in which organizational culture can present itself and its impact on WSP implementation.

In groups of four, participants should review the quotations provided (five per group) from various case-studies conducted with water utilities trying to implement WSPs. All quotations are different, i.e. there are 25 in total. Ask the participants:

- What assumptions can be made from each quotation?
- Are they positive or negative?
- Of those that are negative
    - How might this hinder WSP development (hint – look at what kind of person is quoted; if they are senior management, then they might not provide the necessary resources; if they are an operational worker, they might not implement the plan; etc.)?
    - How might this be overcome?
- Of those that are positive
    - How might this aid WSP implementation?
    - How could this enthusiasm be harnessed?

Timing: Approximately 1 hour

- 5 minutes to brief
- 25 minutes to evaluate quotations
- 25 minutes to provide feedback to class (5 minutes per group)
- 5 minutes for further discussion

Materials needed (per group)**:**

- Refer to Appendix B in workbook (Appendix I in handbook)
- Focus on set of five quotations per group (different quotes)

Exercise facilitation:

- Prior to the exercise, review the quotations thoroughly.
- Photocopy the quotations, and cut out each quotation on a separate piece of paper.

Module 10 – Plan and carry out periodic review of the WSP

Learning objectives

Through active participation in and successful completion of Module 10, each participant should be able to meet the following learning objectives:

- Explain when and what to review in the WSP.
- Mitigate against some common challenges in reviewing the WSP.
- Explain clearly the benefits of an up-to-date WSP.

Material delivery

	Activity/description	Information
	Day 4:	11:15–14:15

	Consider the following (one subject per group, i.e. four groups)
	   1. When do you review a WSP?
	   2. What do you review in a WSP?
	   3. What are the main challenges in reviewing?
	   4. What are the main benefits of keeping a WSP up to date?
	Provide feedback to workshop using flipcharts. Ask the workshop participants how they might mitigate the challenges presented.
		Slide 4
		(Slides 5–8 are summary slides to be shown after exercise feedback)
		10 minutes
		WSP manual tool 10.2

	Lunch	12:15–13:15
	Exercise: Checklist for WSP review; review of Modules 1–10	Slide 9 30 minutes Appendix J

Key points

- The WSP team should reconvene at agreed periods to review the WSP.
- A continually updated WSP provides confidence to operational staff and external stakeholders that the best possible activities are in place to protect the public's health. The periodic review is a way to ensure that the WSP will be continually updated.
- The review should include updating for new risks – although this should also be done immediately after a new risk is identified.
- It is important to review all aspects of the WSP and amend as necessary. This includes accounting for the following: changes in the water supply system, improvement programmes, revised procedures, staff changes and stakeholder contact details.
- It is challenging to a) reconvene the team, as people's diaries are often full, b) retain institutional memory when staff change, c) maintain enthusiasm once WSP is implemented, d) ensure continual support for the WSP, e) keep records of all changes and f) keep in contact with stakeholders.

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Exercise – Module 10

Part 1 – Aim: For participants to be aware of the main factors to consider when conducting a WSP review.

Ask all participants to call out to the facilitator what agenda items there might be at a WSP review meeting and how often the meeting should take place. Record the discussion on a flipchart.

Example agenda items

- Last meeting's review & minutes
- Contact details/roles of all stakeholders
- Changes in supply chain (catchment through to point of use)
- Review of operational monitoring results (any trends?)
- Review any revision of regulatory requirements related to water supply
- Validation of new controls
- Review outputs from WSP verification, including audit reports
- Review effectiveness of communication (internal and external)
- De-brief of training and other supporting programmes
- De-brief of progress in improvement programme implementation
- Date of next meeting

Part 2 – Aim: To review material from Modules 1–10 and be given the opportunity to address unanswered questions.

In groups of four, participants review the copied case-study material (Appendix J – copied from the WSP manual) and highlight any areas of uncertainty. Each participant writes at least one question relating to that case-study or module and places it in the question box.

Once the questions have been submitted, pass the box around the workshop and ask participants to attempt to answer the question they pull from the box. Intervention from the facilitator may be required to clarify certain points. It is important that the participants are not made aware beforehand that they will be answering the questions, as there is a chance that they will only ask "easy" questions so that they can be perceived to give the "right" answers.

Timing: Approximately 1 hour

- 5 minutes to brief
- 10 minutes for Part 1
- 20 minutes to read and write questions (Part 2)
- 25 minutes to answer questions

Materials needed:

- Slips of paper and pens to write down questions
- Question box
- Case-studies from WSP manual (Appendix J)

Exercise facilitation:

- Prior to the exercise, review the case-study material thoroughly.
- Photocopy and cut out each case-study snapshot.
- Make a question box.
- Review Modules 1–10 to aid with the answering of the questions.

Module 11 – Revise the WSP following an incident

Learning objectives

Through active participation in and successful completion of Module 11, each participant should be able to meet the following learning objectives:

- Identify in what circumstances and for what benefit a WSP review is needed (identify why a WSP review is needed following emergencies, incidents and near-misses).
- Explain the need for a fair blame culture.
- Evaluate how a WSP might be modified following an incident, emergency or near-miss.

Material delivery

	Activity/description	Information
	Day 4:	14:15–16:30
	Emphasize that there must be action after an incident, emergency or near-miss. Lessons should be learnt and changes made to reduce the likelihood of it happening again or ensuring a better response in the future.	Slide 3
	The "action" could be simply to inform operators of the cause of the incident and to review the incident to determine if the best possible response occurred. This feedback is important, as it will elevate morale and ensure that vigilance is maintained.	Slide 4
	Near-misses are important to monitor and record because they may be symptomatic of something more serious. They also provide an opportunity to learn, correct procedures, etc.	Slide 5
	In groups, discuss (through their direct or indirect experience): • When blame happened. • Why can blame be bad? • When can blame be good? Provide feedback to workshop verbally. This can relate to situations outside of work.	Slide 6 <10 minutes
	Break	15:15–15:30
	Exercise: *Cryptosporidium* outbreak	Slide 9 35 minutes
	Activity: Part II competence wheel	After exercise Appendix C

Key points

- After an incident, emergency or near-miss, the WSP must be reviewed. The cause of the incident should be determined and then revisions to the WSP made.
- The WSP should be reviewed after an incident, emergency or near-miss regardless of whether a new hazard/hazardous event was identified.
- Reviewing the WSP should reduce the likelihood of the incident being repeated and determine whether the actual response was the best possible.
- After an incident, it can be difficult to establish what the chain of events was, and who was responsible.
- The main benefit of reviewing the WSP after an incident is better protection of the public's health, i.e. you must learn from the incident, not just record it.

Aim: To evaluate an incident (*Cryptosporidium* outbreak) and modify an existing WSP in order to reduce the likelihood of a recurrence.

With participants in groups of four, ask them to review the WSP based on the reported incident. Furthermore, ask participants to update the WSP, including suggestions for future improvements (short, medium and long term), including treatment investments to reduce the risk of the incident recurring.

Case-study: There has been a *Cryptosporidium* outbreak in the local community that was attributable to contamination of the drinking-water supply. The source is a river abstraction that goes straight to treatment with no raw water storage. Treatment includes coagulation, clarification, sand filtration and chlorine disinfection. The filter backwash is recycled to the head of the works.

Following investigation of the incident, poorly maintained septic tanks were found in the catchment, as well as farm animals gaining access to the river. There are a number of licensed discharges from sewage works several kilometres upstream of the intake that are operated by another organization. Prior to the incident, there had been a period of heavy rain.

A simplified version of the catchment and treatment sections of the (flawed) WSP is provided (Table 11.1), which was produced before the outbreak occurred (note: not all the detail is included). The WSP uses a standard 5 × 5 risk scoring matrix.

Following the exercise, ask the groups to rotate and review another group's modifications.

Timing: Approximately 1 hour

- 5 minutes to brief
- 35 minutes for exercise
- 20 minutes to provide feedback and discuss

Materials needed (per group)**:**

- Case-study material
- Flipchart and pens
- Laminated Table 11.1 and wipe-off pens

Exercise facilitation:

- Prior to the exercise, review the *Cryptosporidium* outbreak case-study material thoroughly.
- Photocopy case-study material.
- Laminate the incomplete table (Table 11.1).
- A list of possible modifications is given below:
    - Re-scoring of risk.
    - Monitoring the water treatment works' (WTW) final and/or raw water for *Cryptosporidium*.
    - Removing recycling of backwash water.
    - Working with farmers to ensure that fences are maintained.
    - Consider on-site raw water storage (longer term/higher cost).
    - Consider additional treatment. such as ultraviolet and membrane filtration (longer term/higher cost).
    - Septic tank inspection (may need to work with government).
    - Develop relationship with sewage operators (consider an alarm/early warning system – if discharges overflow in periods of high rainfall, then alert system so that WTW may shut down).
    - Research studies, e.g. modelling to see how long the WTW would need to shut down for if untreated sewage were to enter the water supply at the sewage works.

- o Educate catchment stakeholders on impacts that their activities have on drinking-water quality.
- o Somewhere in the WSP, the likelihood and consequence justification should be documented.
- o Worth mentioning that filtration can be an effective barrier to *Cryptosporidium.*
- o Turbidity can be used in operational monitoring for *Cryptosporidium* removal.
- o The explanation in the table can be amended to include *Cryptosporidium*. This may impact the risk assessment.

Table 11.1 – Flawed WSP excerpts for catchment and treatment (pre-*Cryptosporidium* incident)

Note there are possible improvements that can be made.

Hazardous events	Explanation	Controls	Monitoring	Risk			Improvement plan	Exercise aid
				L	C	S		
Contamination from septic tanks within the catchment	Several properties that do not have mains sewage have been identified within a kilometre of the WTW intake.	Septic tank licensing rules by local government that specify distance from water courses and depth; plus cleaning schedules.	Monitoring of treated water for indicator organisms (*E. coli*).	2	4	8	No direct control over catchment, so no improvements possible.	Rules are in place, but the government department is unable to police adherence to the rules over time. Is the water company really powerless in the catchment?
Untreated discharge from sewage works upstream of intake	Sewage works is operated by another organization; in times of heavy loading, may overflow into river.	Sewage works is subject to regulations and has licensed discharges.	Agreement was set up 5 years ago with sewage operator to notify WTW if overflow occurs.	2	5	10	No improvement needed because of agreement.	The water supplier still had not confirmed that the sewage works follows the agreement and assumes that it will be notified if necessary.
Failure of coagulation	Failure of coagulation stage leading to ineffective filtration stage, production of disinfection by-products at later stages.	Routine maintenance schedules; shut down works; back up coagulant pumps.	Online monitoring of turbidity.	1	4	4	Review maintenance schedules.	
Failure of disinfection	Failure of disinfection stage leading to bacteriological breakthrough; pumps have failed in past, but automatic switch to backup.	Alarms when chlorine drops; backup chlorine pumps; shut down works.	Online monitoring of chlorine.	3	4	12	Pumps are old, request new equipment.	

L = likelihood, C = consequence, S = score, WTW = water treatment works

Table 11.1 (continued) – Flawed WSP excerpt for catchment and treatment (pre-*Cryptosporidium* incident)

Hazardous events	Explanation	Controls	Monitoring	Risk			Improvement plan	Exercise aid
				L	C	S		
Failure of filtration	Failure of filtration stage leading to ineffective removal of organics and production of disinfection by-products.	Routine maintenance and cleaning schedules; shut down works; backup filters.	Online monitoring of turbidity.	1	4	4	Review maintenance schedules.	
Cryptosporidium entering WTW	Unlikely – see catchment section. Not had a problem with this in the past.	Coagulation and filtration suitable for low-risk situations.	Monthly raw water monitoring.	1	4	4	N/A	Are they right to consider this as a low-risk area?
Faecal contamination from farm animals within the catchment entering WTW	Dairy and sheep farming upstream; however, livestock are fenced off at least 1 m from the water course.	Fencing off of livestock from water course.	Annual visual inspection of the catchment by WTW operators.	2	4	8	No direct control over catchment, so no improvements possible.	Since the last visual inspection, animals have breached the fence. Farmer is unaware of this and also unaware of the potential consequences.
Faecal contamination entering WTW	Unlikely to occur – see catchment section. Regulations are in place regarding septic tanks/sewage works and farms. However, there is no raw water storage.	Treatment to remove microbial pathogens if the event did happen; chlorine disinfection.	Monthly raw water monitoring.	1	4	4	N/A	Are they right to consider this as a low-risk area?

L = likelihood, C = consequence, S = score, WTW = water treatment works

WSP quality assurance tool (Module 12)

Learning objectives

Through active participation in and successful completion of Module 12, each participant should be able to meet the following learning objectives:

- Explain why WSP benefits are realized only through sustained effort and continuous improvement.
- Evaluate the benefits that use of the WSP quality assurance (QA) tool can bring, who can use the tool and when it can be used.
- Demonstrate an ability to use the tool to support and assess WSP implementation.

Material delivery

	Activity/description	Information
	Day 5:	09:00–12:00
	Ask participants what additional benefits they think the tool could bring.	Slide 4 Before 1st click
	Tool can be used at all stages: initially, it acts as a guide so that no WSP element is overlooked; then to monitor progress and in continual review and potentially for benchmarking.	Slides 5–6
	Macros should be enabled. Ask participants to open the tool and enable macros. Offer help.	Slide 10
	Animations on button clicks highlight the four sections of the tool: 1. Main menu page, 2. About the tool page, 3. Assessment page and 4. Assessment results.	Slide 11
	Emphasize that too much focus should not be placed on the final scores achieved. Additionally, the entire WSP team needs to be involved in the scoring process to ensure accuracy of the assessments.	Slide 21
	Animations on button clicks that will highlight: - **Rationale/comments field** – explain the importance of the comment fields. See the key points section for details. - **Create new assessment** – therefore multiple assessments can be made - **Create a new question** – tool is intended to be adaptable, and therefore two types of question can be added, an assessment type that is added to the cumulative score and a non-assessment type.	Slide 23
	Ask participants to create a new "assessment"-style question within the tool and save their work to the desktop.	Slide 24
	New assessments can be used to compare performance over time or between different supply systems.	Slide 25
	Demonstration of QA tool (participants can follow on laptops) Stress that the demonstration is purely to show how the Excel tool works. In actual use, each question + guidance should be read and understood prior to scoring, and often there may be discussions among the WSP team members before a score is agreed upon.	After slide 28 20 minutes
	Break	10:45–11:00
	Exercise: Using the WSP QA tool	Slide 29 50 minutes

- The WSP quality assurance tool is an Excel-based tool, which enables systematic evaluations of WSP development and implementation. Use of the tool will help to identify areas for improvement, thereby facilitating WSP implementation efforts.
- The tool can be used at all stages of WSP development and implementation to compare systems and to track progress over time.
- The tool will not identify what actions should be taken, only where improvement is needed.
- The tool is divided into four sections: 1. Main menu page, 2. Introduction page, 3. Assessment page and 4. Assessment results page.
- To fully understand each question in the assessment section, the scoring definitions as well as the information included in the guidance section should be read. Often the accompanying guidance note will contain further details that should be considered in assessment against a WSP step.
- For self-assessment purposes, it is important for the entire WSP team to contribute to the assessment process for accurate interpretation of questions and scores.
- It is important not to place too much emphasis on the exact scores obtained. The purpose of the scoring process is to help identify where improvements should be targeted.
- It is important to use the comments/rationale field to:
  o justify why a particular score was given
  o explain the users' interpretation of a question if unsure of terminology used or meaning of question
  o explain why a question was not answered
  o document evidence for a particular answer.
- When creating a new question, two types of question can be added, an assessment type that is added to the cumulative score and a non-assessment type. The user can use the comments field to insert guidance and references. This space should also be used to include definitions for the 0–4 grading scale if an assessment-type question has been selected. The text of new questions will be listed in a different coloured font to distinguish them from standard questions.
- New assessments can be added to enable assessment of WSP progress over time and to compare WSP performance between different water supply systems.
- Summary tables and graphs can be generated in the assessment results page. These summaries are useful when communicating WSP progress with senior management and when trying to justify the additional resources needed to improve the WSP process. Results can be exported into a different Excel file, MS Word and PowerPoint.

QA tool demonstration

Appendix K gives details of a fictional WSP that can be used to enter into the WSP QA tool as an example for the participants. The facilitator will enter the assessment information into the QA tool so that the participants are familiar with how it is used before undertaking the main exercise. Ask participants to follow the demonstration while looking at the tool on laptops.

Additional things to demonstrate:

- Create a new assessment, and enter new date in Table 1 or new name in Table 2 (return to Table 1 in order to create a new assessment).
- Create a new "assessment"-style question, and define scoring criteria in the comments field.
- View tables and graphs – click the "view results" button, then select either summary tables or summary graphs, followed by results by WSP step or results by component.
- Export summary tables and graphs to Excel, and save to the desktop.
- Add rationales for scoring and comments for some answers.
- Save after completing each table.
- Change language of the tool.

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Exercise – Module 12

Aim: For participants to navigate around the WSP QA tool so that they will be familiar with it when using it to guide and assess WSPs in their own utility.

Ask participants to work through the tool in pairs or as individuals (depending on number of computers available), following the guidance shown below (also found within the participant workbook):

- Open the tool and enable macros (note that this activity should have been conducted as part of slides 9–10).
- Complete the assessment for participants' utilities – estimate values if the answers are not known (this exercise is intended not to assess the utility, but rather for participants to become familiar with the tool). If it is not possible to complete the assessment using details from the participant's utility, refer to the fictional example in Appendix K.
- Create a new "assessment"-style question that is relevant to your utility in any table between 3 and 12. Note that this activity was also conducted as part of slide 24, and another "assessment"-style question should be created during this exercise.
- What references are suggested for question 3.1? (hint: ensure that "show guidance" is checked).
- How was 4.1 assessed? Did you consider the below points in your assessment (hint: ensure that the guidance information as well as the definition for a score of 4 have been fully reviewed)?
    - o Does the system description include all the sources, abstraction points, treatment sites, treatment streams, service reservoirs, pumping stations, area of supply and connections to other water supply systems?
    - o Is the flow diagram / system schematic sufficiently detailed to identify where the system is vulnerable to hazards and where existing controls are sited?
    - o Is there information regarding the users and uses of the water?
    - o Is there information on the water quality targets?
    - o Is the flow diagram / system schematic dated?
- Enter the following information:
    - o 5.1a = 4; 5.1b = 0; 5.1c = 1; and 5.1d = 2
    - o 5.2a = 1; 5.2b = 0; 5.2c = 0; and 5.2d = 4
    - o Why is the assessment cell for question 5.2b dark grey?
    - o Why is the assessment cell for question 5.2d red?
- View summary tables for general information results.
- Export summary graphs for WSP steps into MS Word and save to the desktop.

Timing: Approximately 1 hour

- 5 minutes to brief
- 50 minutes to use the tool
- 20 minutes to feed back and discuss. Allow participants to ask questions and provide comments. To stimulate discussions, the facilitator may ask the group the following questions:
    - o Was the tool easy to use?
    - o Were there any questions that were difficult to understand?
    - o If the participants worked in pairs, ask the groups if there was some disagreement in deciding on scores for the assessment questions. Stress the importance of involving the entire WSP team in the assessment process to ensure the accuracy of answers. Experience has shown that it is common for team members to interpret questions differently and to disagree on scores, but through discussions, agreement can be reached.

Materials needed (per group)**:**

- Computer
- WSP QA tool

Exercise facilitation:

- Supply details in Appendix K if participants are unable to use real data.

Site visit

In order to contextualize key taught concepts, it is strongly recommended that participants partake in a site visit. Prior to the workshop, the facilitator will need to organize and obtain permission for a visit to a local water supply system (ideally from catchment to distribution) to view control measures and other aspects of the WSP (e.g. how critical limits are addressed, water supply improvements being made, etc.) first hand. Preferably, personnel (manager, operator, etc.) from the water supplier will provide a guided tour of the facilities.

If a WSP has been developed, it would be beneficial to arrange for the WSP team leader to give a short talk about the WSP process, including challenges and benefits of the WSP. Time should also be allowed for a few questions, and the facilitator should ensure that questions are focused on key concepts learnt. It may additionally be useful to meet with regulators (particularly in countries where WSPs are required by regulation), water supply offices (to view WSP documentation), local health centres and consumers. The facilitator will need to establish what the most suitable site visit would entail.

Part 3 – Adapting the training material

The material presented in this handbook has been developed with a workshop of approximately 20 participants in mind, delivered by two facilitators with prior knowledge and understanding of WSPs, although possibly with no prior experience with training.

It is probable that from one workshop to another there will be variations in:

- Local context
- Number of participants
- Resources available (room, electrical appliances, etc.)
- Number and expertise of facilitators
- Expertise of participants
- Type of water supply systems.

This section provides some general suggestions as to how the material can be adapted to address these variations.

Local context: The material includes a number of examples, case-studies and photos that you as the trainer should update to reflect local circumstances. It is therefore crucial to go through all the material and update as needed.

Adaptation of the PowerPoint slides: There are times when the facilitator is required to enter data or change slides in the presentations. For example, in Module 3, a third hazardous event needs to be drafted for the exercise, while in Module 9, a photograph of the workshop participants needs to be inserted. To fit the local context, the following slides may also need to be updated: Module 0, slide 9, and Module 3, slides 4, 13, 14 and 15.

Besides these specific examples, the slides are ready to use. However, it should be worth noting that Modules 9–11 are very summary-like in style because they cover smaller aspects of WSP design. Therefore, it may be worth considering not training through the use of PowerPoint for these modules.

Adaptation of the workbook/handbook: Since the examples and case-studies presented in the training package are mostly focused on the developed world, there may be a need to prepare local examples and case-studies to better suit the context.

Number of participants: The material can easily be adapted to cater to larger numbers, simply by having more facilitators. In this case, the facilitators would be expected to manage group feedback more succinctly (e.g. rather than feeding back all ideas, each group feeds back the top three ideas). An alternative is to increase the small group sizes, but only to a maximum of six. If the workshop runs with only a few participants (4–10), the facilitator would have to consider adapting some of the delivery methods – for example, working in pairs instead of in small groups. Also, many of the exercises for small groups may need to be changed to "all participants". Therefore, if there was an element of learning from another group in the original material, this would need to be removed and potentially changed to a discussion after the exercise, with the facilitator taking more of a lead role to ensure that all topics are covered. With a smaller number of participants, it is possible that the workshop may be slightly shortened because feedback from group activities may not take as long. However, this may not have a significant impact and is unlikely to reduce the length of the workshop by more than 3 hours.

Resources available: It is assumed that there will be a room, reliable electricity, computer, projector and screen, paper and pens, tables, photocopier, flipcharts and numerous laptops (one per two participants for Module 12) available. If, however, such resources are not available, then alternative arrangements need to be made. An alternative to flipchart and pens (which are useless when working outside in windy conditions) is the Ketso kit (see www.ketso.com). Other adaptations include using large printouts of slides or acetates instead of PowerPoint if a computer or projector is not available. Module 12 relies heavily on the use of computers, as it is a computer-based tool. If computers are not available for every two participants, then sharing those available will be necessary. In order for participants to get some learning from the module, it is essential that the computer operator alternates so that each participant has a turn.

Number and expertise of facilitators: Ideally, professional trainers with WSP experience are used as facilitators for the workshops. However, it is expected that in many situations, this will not be possible. Therefore, it may be suitable to have one facilitator with WSP expertise (but who is not a professional trainer) and have the other familiar with expertise in training. If external expertise is required, it may be worth contacting the local water utility, national water association, university or other local organizations to assist.

Expertise of participants: Participants may vary from officers who have designed and implemented a WSP through to managers or operators who have never heard of a WSP. The level of expertise can be gauged early in the workshop through questions, an initial questionnaire on workshop expectations, ice breakers where jobs are discussed and reviewing participants' competence wheels (Day 1 activity – Appendix C). If it is found that several participants have a lot of WSP experience, consider calling on them for examples when needed and split them among the workshop so that no one small group is made up of the "experts".

Type of water supply systems: This should not influence the workshop material greatly if the initial small groups are formed according to the recommendations – i.e. have groups formed either from the same utility or from the same country. However, whenever possible, refer to local examples of water quality issues and WSP implementation.

Essential resources

Bartram J et al. (2009). *Water safety plan manual: step-by-step risk management for drinking-water suppliers*. Geneva, World Health Organization.
http://www.wsportal.org/wspmanual
http://www.who.int/water_sanitation_health/publication_9789241562638/en/index.html

Helmer R, Hespanhol I, eds (1997). *Water pollution control—a guide to the use of water quality management principles.* London, E & FN Spon. Published on behalf of the United Nations Environment Programme, Water Supply and Sanitation Collaborative Council and World Health Organization.
http://www.who.int/water_sanitation_health/resourcesquality/wpcbegin.pdf

Water Safety Portal
http://www.wsportal.org

WHO (2011). *Guidelines for drinking-water quality*, 4th ed. Geneva, World Health Organization.
http://www.who.int/water_sanitation_health/dwq/guidelines/en/index.html

WHO (2012). Water safety plan quality assurance tool v1.3 (Excel tool and manual)
http://www.wsportal.org/templates/ld_templates/layout_1367.aspx?ObjectId=20686&lang=eng
http://www.who.int/water_sanitation_health/publications/wsp_qa_tool/en/index.html

WHO Lexicon
http://apps.who.int/thelexicon/entry.php

Acknowledgements

Appendix A

Example evaluation and validation sheets

Example validation ("happy sheet") questions

To be completed at the midway point and at the end of the workshop

1. Course date
2. Your name
3. What were your objectives before attending the workshop?
4. Did you meet the objectives fully?
5. Please rate the course under the following headings (1 = low/poor; 5 = high/excellent)
   - Course content
   - Pace of course
   - Theory sessions
   - Exercises
   - Workbook
   - Learning methods
   - Facilitators
   - Facilities
   - Administration
6. What, if anything, would you change about the workshop?
7. What will you do differently as a result of attending the workshop?
8. Do you have any other comments you wish to make (e.g. how the workshop could be improved)?
9. Finally, if one of your friends asked you to tell them one benefit of attending the workshop, what would you say?

Example evaluation survey questions

To be completed three months after workshop

1. Course date
2. Your name
3. Describe the improved practice that is taking place as a result of attending the WSP training workshop. Please give evidence.
4. What were the most useful aspects of the workshop?
5. What further actions, if any, have you decided to take forward as a result of the training?
6. What has been the impact on your day-to-day practices?
7. [For operators] What further support would you like?
8. [For management] What additional areas of development would be most useful for you?
9. Have you noticed any benefits from attending this workshop?
10. What further development activities have you undertaken?

Appendix B

Suggested schedules and timetables for a five-day workshop

This schedule needs to be adapted according to number of days available, location, energizers, site visits, review activities/happy sheets and break times.

Day 1	
09:00–09:30	Registration
09:30–10:00	Welcome
10:00–10:45	Introductory module
10:45–11:00	Break
11:00–11:30	Water quality and health exercise
11:30–13:00	Lunch
13:00–14:00	Module 1
14:00–14:45	Assemble team exercise
14:45–15:00	Break
15:00–16:00	Module 2
16:00–17:00	System description exercise

Day 2	
09:00–10:00	Module 3
10:00–11:00	Risk scoring exercise
11:00–11:15	Break
11:15–12:15	Module 4
12:15–13:15	Lunch
13:15–14:15	Control measures and reassessment of risks exercise
14:15–15:15	Module 5
15:15–15:30	Break
15:30–16:30	Health awareness exercise
16:30–17:00	Review of day

Day 3	
09:00–10:00	Module 6
10:00–11:00	Walkerton disaster exercise
11:00–11:15	Break
11:15–12:15	Module 7
12:15–13:15	Lunch
13:15–14:15	Verification exercise
14:15–15:15	Module 8
15:15–15:30	Break
15:30–16:30	Incident exercise
16:30–17:00	Review of day

Day 4	
09:00–10:00	Module 9
10:00–11:00	Culture exercise
11:00–11:15	Break
11:15–12:15	Module 10
12:15–13:15	Lunch
13:15–14:15	Review Modules 1–10
14:15–15:15	Module 11
15:15–15:30	Break
15:30–16:30	WSP review exercise
16:30–17:00	Review of day

Day 5	
09:00–10:00	Module 12
10:00–10:45	QA tool demonstration
10:45–11:00	Break
11:00–12:00	QA tool exercise
12:00–13:00	Lunch
13:00–17:00	Site visit

Appendix C

Energizer and review activities

These activities act as a way of stimulating learning or interaction among the participants. Most are designed as review exercises to revise key points from the WSP modules. It is recommended that these activities be carried out at the start of each day to energize the workshop and at the end of each day to review the material in a light-hearted manner.

Day 1, 09:30 – "Near-misses", icebreaker and "competence wheel" Part I (25 minutes)

Part 1 – (20 minutes) Near-misses With participants in groups of four, ask them to discuss what direct or indirect knowledge or experience they have of drinking-water-related incidents. These could include near-misses where a potential incident was avoided or examples of situations where a failure resulted in a boil water advisory. It is important to get the groups talking as much as possible. To promote this interaction, it is essential that the facilitator partake in each group's discussion, moving around the room until the allocated time (10 minutes) has ended. Questions that might be useful to ask during this discussion include: What went wrong? How is that hazard normally managed? How was the problem identified? What should have happened to mitigate the incident? Did anybody drink the unsafe water? Were there any fatalities or reported illnesses?

The facilitator will need to capture the discussions (10 minutes) by use of a flipchart and ask participants to call out some key points. These real "case-studies" can be used throughout the rest of the workshop to contextualize a point being made within any set module.

Part 2 – (5 minutes) Competence wheel Ask participants to individually score their agreement with the six statements (A–F) below, which are also included in participants' workbooks. Stress that these are for their own use only, and it is expected that scoring will be low at this point in the workshop.

- A.   I have a thorough understanding of what is involved in WSP design and implementation.
- B.   I know where most of the hazards are in the water supply system where I work.
- C.   I have a thorough understanding of the complexities of risk assessment and know of the two main approaches.
- D.   I know how a WSP is used to steer financial investments within the utility where I work.
- E.   I know what a control measure is and how it is used, monitored and validated.
- F.   I know when a WSP should be reviewed and amended.

For each question, assign a score between 0 and 3:

- 0 = No understanding and/or not heard of
- 1 = Little understanding and/or could not apply in practice
- 2 = Good understanding and/or could apply in practice
- 3 = Complete understanding and/or have applied in practice and/or could train others

Once this has been completed, ask participants to complete the spider diagram in their workbook. For example, if Participant Jones scored the following: A – 1, B – 1, C – 0, D – 0, E – 1, F – 2, his diagram would look like this:
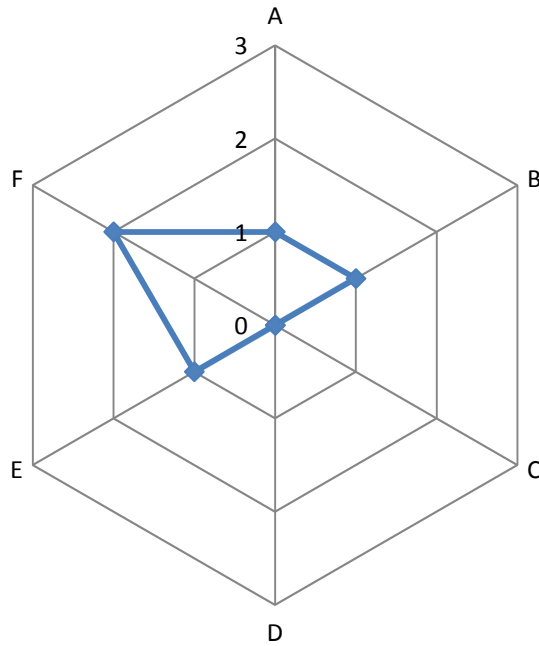
Day 1, 17:00 – "Share with colleague" review

Ask participants to consider what elements of the day's learning they would share with a colleague; what interested them, what was new, what was very important, etc. After allowing for a few minutes of thought, ask the participants to call out their "answers" and record them for your own reflection (this will aid further teaching sessions).

Day 2, 09:00 – "Missing jigsaw" review of WSP team

This exercise acts as a review to Module 1 – Assemble the WSP team. With participants in groups of four, ask them to complete the jigsaw puzzle below as quickly as possible. Retain one piece of each jigsaw puzzle (this should be the same piece for each group so as to avoid getting the answers from another group). Ask the groups who is missing from the WSP team. Record the discussion on a flipchart.

Note: Preparation, in the form of copying and cutting out the appropriate number of jigsaw puzzles, will be required.
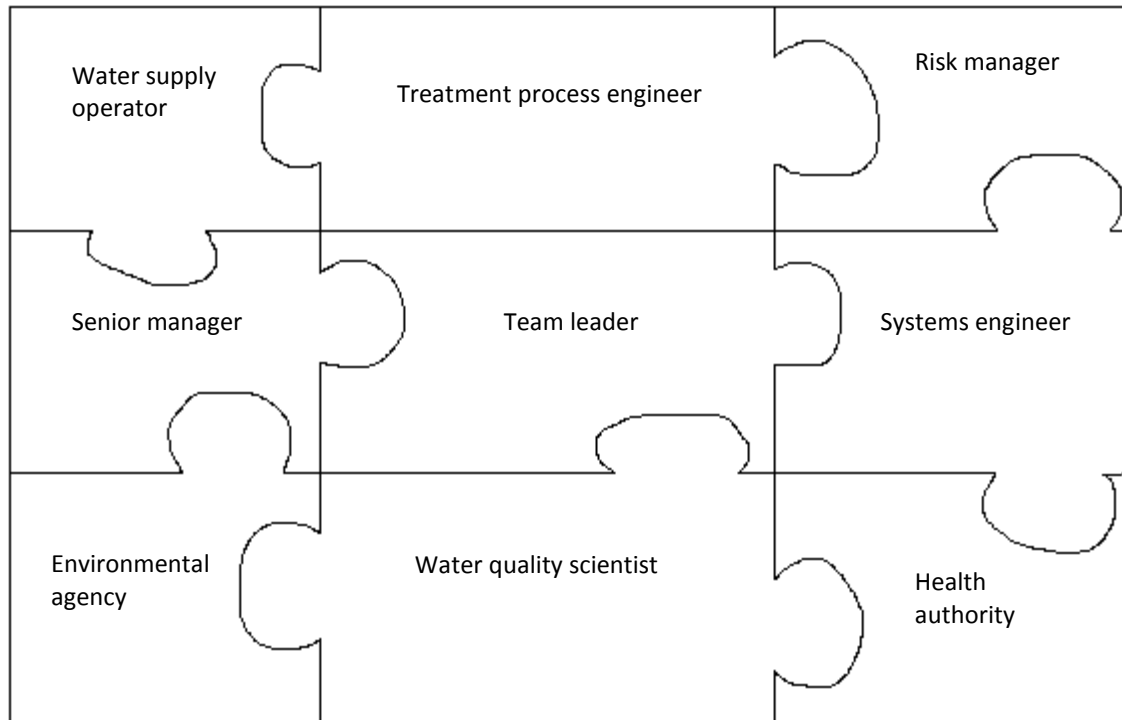
Day 2, 17:00 – "Colour-coded questions" review

This exercise acts as a review to Modules 0–5. The principal activity is questions and answers. The number of questions asked will relate to the number of participants, so approximately 20 questions covering the 6 modules are required. Each module is assigned a colour that relates to an individually wrapped coloured sweet. Put all the sweets in a box and pass them around the room. Ask participants to save the sweet. Once all the sweets are distributed, ask, for example, a "yellow" (Module 2) question. Anyone with a yellow sweet can attempt to answer the question – on a first-come basis. When the participant has answered the question (correctly or incorrectly), he or she can eat the sweet. If the answer is incorrect or ambiguous, then promote a discussion among all the participants. Repeat the questions until each participant has attempted to answer one question. Example questions are provided below.

1. What is a WSP?
2. Why are WSPs needed?
3. What are the five stages of a WSP?
4. What is the main aim of a WSP?

Module 1

1. Identify three skills that are required on the WSP team for effective WSP implementation and management (e.g. technical knowledge of treatment operations).
2. Identify what five pieces of information about each team member should be documented (e.g. name).
3. What external stakeholders might be part of the WSP team?
4. What is a potential disadvantage of giving the development of WSPs to the supplier's "water quality officer" only?

Module 2

1. Why is it essential that the system description accurately reflects the current conditions?
2. What should be described in the system description?
3. What three methods might be used to gather information to describe the system?
4. Who will read/use the supply system description? Why?

Module 3

1. When assessing hazards, hazardous events and risks, what is important to know – besides what could go wrong?
2. What can be done to overcome the disadvantage that a risk assessment provides only a "point in time" picture of the system?
3. What are some common challenges associated with risk scoring?
4. How would you calculate the risk of a certain hazard/hazardous event?

Module 4

1. What is a control measure?
2. Why is it important that control measures should be validated at their point in the supply system, rather than in isolation?
3. What common methods might be used to validate control measures (e.g. pilot studies)?
4. What typical control measures are associated with catchment management?

Module 5

1. Why are improvement/upgrade plans needed?
2. Identify three things that should be considered when developing an improvement/upgrade plan.
3. How might improvements/upgrades be classified as short, medium or long term?
4. What is a typical challenge associated with developing/implementing and maintaining an improvement/upgrade plan?

Note: Make sure you have the same number of coloured sweets per coloured question.

Day 3, 09:00 – "Spot the hazard" exercise

This exercise relates to Module 3 but should promote a wider thinking among participants, because the hazards/hazardous events do not relate solely to piped water supplies. There are 10 slides showing scenes from a large urban area in southern Nigeria.

In this city, there are three main water supplies:

1. Municipal piped supply (intermittent, river abstraction)
2. Hand-dug wells (semi-protected)
3. Sachet water (vendors)

The photographs refer to the first two supplies. Neither of the two supplies is microbially safe, and there are many hazards in the system. However, the WSP approach can be applied to all types of water supply, and this exercise is designed to broaden the thinking of the participants. The intention is for participants to look at these images in groups of four and discuss the potential hazards/hazardous events.

- Slide 1 – the environment
- Slide 2 – tributary to main surface water source (used by municipality)
- Slide 3 – pipes (low pressure due to intermittent supply) running through highly polluted river and open drains
- Slide 4 – main tributary to surface water source
- Slide 5 – hand-dug well with drawer
- Slide 6 – unlined well – potential for ingress from contaminants near surface water
- Slide 7 – proximity to neighbours' burial site
- Slide 8 – proximity to shared toilets
- Slide 9 – cracked apron (left) and toilet, grave, sewage outflow, chicken all in close proximity to well (right)
- Slide 10 – "groundwater" well – proximity to river

Note: The slides are available electronically. It will be necessary to copy the slides as hand-outs for each group.

Day 4, 09:00 – "Supporting programmes" exercise

Module 9 (to follow) is about supporting programmes. Before the theory session, ask participants to brainstorm, in their groups, a few supporting programmes from their water supply company that already exist in each of the following areas:

- **Hygiene and sanitation:** e.g. hygiene procedures
- **Training**: e.g. WSP training, competency requirements, induction training, complaints training
- **Research and development:** e.g. understanding potential hazards, research into better indicators of contamination (research could be external but funded by the supplier)
- **Equipment upgrade and maintenance:** e.g. calibration schedules; self-calibrating equipment
- **Culture:** e.g. customer complaints procedures

Ask participants to explicitly state how these may support an effective WSP, and record the discussion on a flipchart. Allow 10 minutes for brainstorming and 5 minutes for feedback.

Note: The examples are supplied for the benefit of the facilitator and should not be given to the participants.

Day 4, 17:00 – "Competence wheel" Part II

This forms Part II of this exercise, first introduced on Day 1. The aim of this exercise is to record how participants' knowledge and understanding of WSPs have increased during the workshop. Ask participants to score (0–3) the same six statements (A–F) and record the results on the blank spider diagram in their workbook.

Day 5, 13:00 – "Bingo quiz" review (en route to site visit)

Bingo is a popular game played in many countries. Balls with numbers on them are randomly selected and called out. Players have a Bingo score-card with randomized 5 × 5 numbers. If the ball number called out corresponds to a number on the Bingo score-card, then the number is crossed off the score-card. When a full line of five numbers is crossed off on a Bingo card, the card-holder shouts out "BINGO!" and is given a prize. This exercise is an adaptation of the game Bingo.

Each participant is given a Bingo score-card. Ten questions are written on individual pieces of paper, and a number is written on the back of each. The questions are folded up and placed in a box. A participant is asked to pick out a piece of paper from the box, and the question is read out. When the question is correctly answered (by anyone from the workshop), then its number (written on the back of the question) is read out. Participants with that number on the score-card mark off the number. The exercise is repeated until all the questions are read out or someone calls "BINGO!" (whichever comes first). A small prize (e.g. sweets, memory stick) could be given to the winner. Below are 10 example easy questions. It is suggested that these be adapted based on the facilitator's understanding of the participants' strengths and weaknesses.

- **Number 21** – In one sentence, describe what a WSP is.
- **Number 49** – Why is developing an appropriate WSP culture within the utility important?
- **Number 27** – Under what circumstances should WSPs be reviewed?
- **Number 20** – What are the 11 steps of WSP development and implementation?
- **Number 54** – How can a WSP save a water utility money?
- **Number 16** – What are the main challenges of WSPs?
- **Number 58** – Name three example supporting programmes for WSPs
- **Number 18** – Effective monitoring relies on answering five questions – what are they?
- **Number 50** – Name four common hazardous events that can occur during the "treatment" of water.
- **Number 17** – What are the main risks associated with not having a thorough understanding of the supply system?

Note: This exercise has been manipulated so that the numbers 16, 17, 18, 20 and 27 will win Bingo for one card. It is therefore essential that the numbers given on both the score-cards and questions are used as given and that if the workshop contains fewer than 20 people, the Bingo-winning score-card is handed to a participant and not left out. Preparation, in the form of copying and cutting out the Bingo score-cards, will also be required.

BINGO				
3	20	42	53	70
13	24	33	55	68
14	22	Free Space	56	69
12	18	37	49	75
6	26	40	57	63

BINGO				
7	27	35	56	65
10	22	42	46	63
14	23	Free Space	48	68
15	26	33	51	74
6	20	44	57	70

BINGO				
11	27	39	59	66
12	21	33	56	72
14	19	Free Space	60	65
8	23	44	55	69
6	28	35	51	74

BINGO				
13	22	38	57	69
4	23	45	53	63
12	28	Free Space	54	68
3	17	34	56	62
14	18	39	55	61

BINGO				
8	22	42	54	75
2	25	44	56	68
3	26	Free Space	58	69
4	23	36	49	72
10	28	37	60	63

BINGO				
11	26	43	55	62
5	25	35	52	68
7	21	Free Space	47	63
4	19	44	54	75
12	24	34	53	66

BINGO

8	18	37	57	66
2	28	42	55	65
6	25	Free Space	50	67
14	24	38	52	71
11	23	39	49	62

BINGO

14	19	41	53	65
4	20	38	46	74
5	29	Free Space	54	70
1	21	39	51	72
2	30	40	58	62

BINGO				
10	22	42	55	71
13	17	40	58	74
6	27	Free Space	49	73
14	25	35	56	66
8	23	39	48	72

BINGO				
7	18	36	59	62
3	29	34	57	69
4	30	Free Space	56	65
8	25	32	52	72
13	24	38	49	68

BINGO

B	I	N	G	O
12	24	31	49	66
11	25	32	52	74
5	19	Free Space	53	63
4	22	43	55	67
13	26	33	50	69

BINGO

B	I	N	G	O
9	16	38	55	66
14	18	35	49	65
12	27	Free Space	53	64
13	17	39	47	63
11	20	45	59	71

B	I	N	G	O
14	26	44	57	75
13	16	37	47	71
11	22	Free Space	56	69
12	29	39	49	70
6	23	31	54	65

B	I	N	G	O
3	29	39	52	72
9	21	36	48	64
5	26	Free Space	55	70
14	27	32	56	71
8	19	35	59	63

BINGO				
12	21	40	53	71
6	29	35	57	62
7	17	Free Space	55	61
3	25	44	58	65
8	16	41	54	75

BINGO				
9	26	42	53	64
11	17	40	51	70
13	24	Free Space	50	72
3	29	41	56	67
12	16	43	52	66

Appendix D

Incomplete Table 0.1 for Introductory Module exercise

Parameter	Potential health impact	Potential source (in water)
	Diarrhoea	Faecal contamination (indicator for faecal contamination)
Shigella spp.		
Vibrio cholerae		
	Diarrhoea	Faecal contamination
Giardia intestinalis		Faecal contamination (wide range of animal species)
Naegleria fowleri	Amoebic meningitis via inhalation	
	Pneumonia (via inhalation)	
Fluoride		
Trihalomethanes (THMs)		
	Adverse neurological effects	Old pipes and plumbing
Cyanobacterial toxins		Bacterial blooms in raw water
Aluminium		

Possible answers:

- Lead
- *Escherichia coli*
- Dysentery
- Faecal contamination
- Diarrhoea and intestinal malabsorption
- Occurs naturally, grows well at high temperatures
- *Legionella pneumophila*
- Too much: adverse changes in bone structure
- Disinfection by-products
- *Cryptosporidium parvum*
- Liver damage, neurotoxicity and possibly tumour promotion
- Used in treatment
- Cholera (severe diarrhoeal disease)
- Addition during treatment and naturally in the environment
- Potential link to Alzheimer disease
- Uncertain, possibly carcinogenic
- Occurs naturally and in certain human-made installations such as water cooling devices and spas
- Faecal contamination

Appendix E

Templates for Module 2
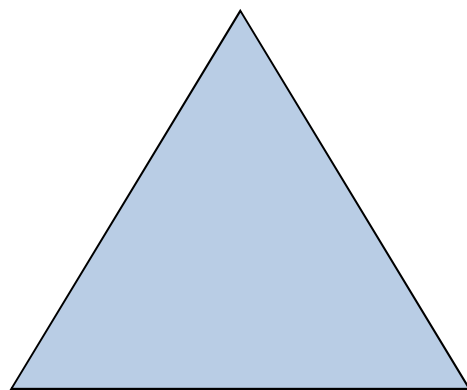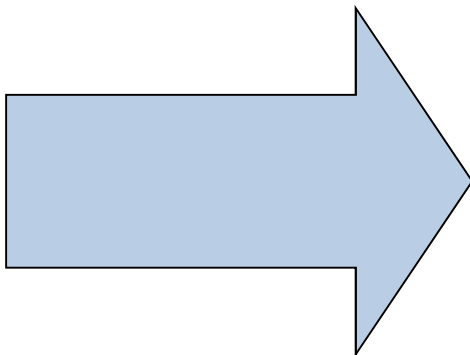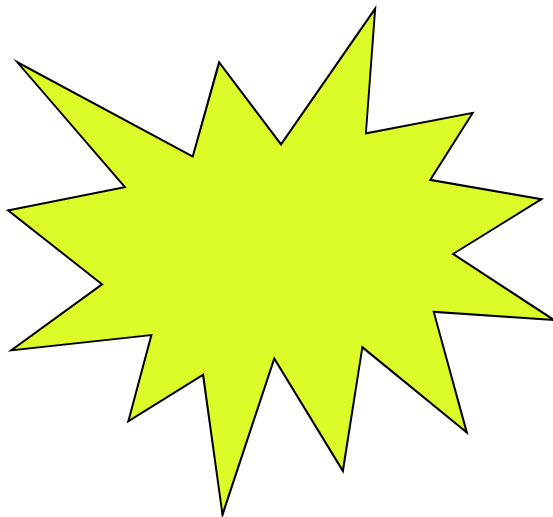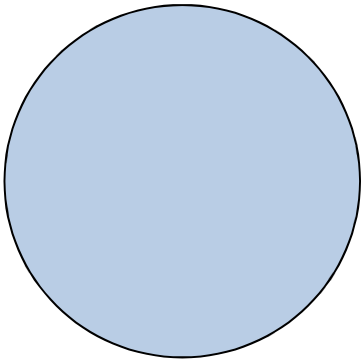
Appendix F

Hazard identification and risk assessment – Module 3 and Module 4

Case-study 1 – Disinfection failures

Chlorination is the most commonly used process for disinfection and/or oxidation in drinking-water treatment. Chlorine inactivates microorganisms harmful to human health. Chlorination is achieved using liquefied chlorine gas, sodium hypochlorite solution or calcium hypochlorite granules. Injection of chlorine solution via a dosing system into a water main (which extracts untreated raw water from the source) is a common and cost-effective method adopted by water utilities in many developing nations. Whereas well-controlled injection systems have online controls based on flow and residuals after minimum contact time, injection systems in many developing countries have a fixed injection rate.

Mechanical failure of chlorine dosing pumps due to various reasons (e.g. clogging of dosing lines, power failure and pump mechanical failure) is a common cause of disinfection failure. The frequency or likelihood of these failures varies widely from daily in poorly designed/maintained systems to once a year in well-controlled situations. Factors affecting the dosing pump performance are effectiveness of design, construction, operational controls and maintenance programmes. Untreated and unsafe water will be supplied to customers (relates to severity of consequence) if such failures are not immediately detected and corrective actions are not implemented; this is further described in Module 6. There are numerous examples of disinfection plant failures around the world to demonstrate that consequences can vary from minor illnesses to disease outbreaks and loss of life, depending on specific local circumstances.

Hazard – is microbial pathogens, including viable infective bacteria and viruses (Note that chlorine disinfection has limitations against protozoa and some viruses)

Hazardous event – failure to remove harmful microorganisms due to failure of chlorine (disinfectant) dosing caused by a dosing pump breakdown

Factors to consider in assessing likelihood and severity (risk assessment) – availability of standby dosing pumps, presence of operator, degree of control of inlet water flow and quality, duration of failure, source water quality, downstream customer population, proximity of downstream customers

Likelihood – answer the questions, "how often does the dosing pump break down?", "how did we know each time this occurred?", "did we keep records of every failure event?", "what is the process of recording such failure?". Based on the information available, answer the question, "what is the likelihood of contamination during a dosing pump failure?".

Severity – answer the question, "what is the severity or consequence of pathogens entering the water distribution system and reaching customers?". Consider the questions, "can it create an outbreak?", "can this event make our customers sick?", "will this water reach customers downstream, and how quickly?" in justifying your severity score.

Control measures – list "current" methods practised for controlling/minimizing the failure of chlorine dosing system. Do not consider any "future" controls. If there are none, state "this risk is currently uncontrolled".

Validation of controls – answer the question, **"**what proof is available to demonstrate that the control measures listed will be effective in preventing the disinfection failure?". Historical performance data for chlorinator operations, including residual chlorine alarms, manual dosing records and dosing pump maintenance records, are typical information used in validation.

Typical control measures and validation (proof that the controls will be effective)

Control measure	Sources of validation information
Automatic residual chlorine trim and flow-paced dosing system Automated (or manual) adjustment of dosage to a predetermined set point using a chlorine analyser (or as a result of manual monitoring at the chlorinator at a defined frequency) Automated alarms for free residual chlorine, pH, flow, turbidity will trigger notification and plant shutdown in the event the chlorine levels drop below a set value	Frequency of failures using telemetry records of alarms or manual records Frequency of failures using historical manual chlorine residual monitoring and inspection records Historical microbial water quality data Historical free residual chlorine data
Routine maintenance of dosing systems	Historical maintenance records Frequency of failures using historical manual chlorine residual monitoring and inspection records
Uninterrupted power supply using standby generators	Historical inspection, maintenance and failure records for standby generators Frequency of failures using historical manual chlorine residual monitoring and inspection records

Case-study 2 – Water main breaks

Water main breaks (bursts) in the distribution system occur in almost all water supply systems due to asset failure. Main breaks can introduce contaminants into already treated and safe water due to loss of pressure in the water main. Contaminants, including soil, dirty water, harmful microorganisms and chemicals in surrounding ground, may enter the water main during the repair process. Contaminants must be completely removed prior to turning on the water supply to customers.

Hazard – is microbial pathogens, including viable infective bacteria, viruses and protozoa, physical (colour, turbidity from soils) and chemical (petrochemicals, heavy metals in surrounding contaminated soils) parameters (specific parameters depend on local context)

Hazardous event – ingress of pathogens and soil during a main break and repair

Factors to consider in assessing likelihood and severity – ability to isolate the area, ability to flush the water main after repair, training of work crews on water quality impacts, work crew practices, availability of valves and hydrants for flushing

Likelihood – answer the questions, "how often do water mains break?", "how did we know each time this occurred?", "did we keep records of every failure event?", "what is the process of recording such failure?". Based on the information available, answer the question, "what is the likelihood of contamination of the water distribution system due to the repair work?".

Severity – answer the question, "what is the severity or consequence if pathogens enter the water distribution and reach some customers?". Consider the questions, "can it create an outbreak?", "can it cause discoloured water at the customer end?", "can this event make our customers sick?", "will this water reach customers downstream, and how quickly?" in justifying your severity score.

Control measures – list "current" methods practised to prevent contamination after a repair of a water main break. Do not consider any "future" controls. If there are none, state "this risk is currently uncontrolled".

Validation of controls – answer the question, "what proof is available to demonstrate that the control measures listed will be effective in preventing contaminated water reaching customers?". Historical performance data, such as recording of main breaks and confirmation of flushing, customer complaints after main breaks and routine water quality results, are typical information used in validation.

Typical control measures and validation (proof that the controls will be effective)

Control measure	Sources of validation information
Procedure for water mains repairs, including; ➢ flushing of water mains in the area affected by the shutdown ➢ isolation of minimum length of the main ➢ separate crews for water and sewerage repairs ➢ material selection ➢ disinfection of water main prior to turning on the supply	Historical water quality monitoring data after main breaks and repairs Past field audit reports Historical customer complaint records Industry standards or codes of practice Historical chlorine measurement data after main breaks and repair

Appendix G

Module 5 – Example checklist of issues to consider when developing an improvement/upgrade plan (from example/tool 5.1 of the WSP manual)

1. Options for mitigating risk
2. Responsibility for improvement programmes (process owner)
3. Financing
4. Capital works
5. Training
6. Enhanced operational procedures
7. Community consultation programmes
8. Research and development
9. Developing incident protocols
10. Communication and reporting

Appendix H

Walkerton water tragedy – Module 6 exercise

- Walkerton (population 5000), Ontario, Canada.
- Incident: Breakthrough of *E. coli* O157:H7 and *Campylobacter* bacteria into drinking-water supply.
- Outcomes: 7 deaths, 2300 cases of illness (27 with potentially lifelong implications); hundreds of millions of dollars in compensation and investigation expenses. Two people jailed.

In 2000, Walkerton's water supply came from three wells, named Well 5, Well 6 and Well 7 (Table A). Typically, Well 7 was used, as this had the capacity to serve the entire town and was a deeper well than either Well 6 or Well 5.

Table A – Description of Wells 5, 6 and 7 – Walkerton, 2000

Well	Location	Depth (m)	Casing depth (m)	Overburden depth (m)	Water supply	Capacity (Ml/d)
5	Edge of town near farmland	15	5	2.5	water supply zones from 5.5 – 7.4 m depth	1.8
6	3 km west of town	72	12.2	6.1	50% from ~19 m depth	1.5
7	~3.5 km west/northwest of town	76.2	13.7	6.1	100% from below 42 m, 50% from ~70 m depth	4.4 (120% of town's needs)

Studies revealed that there was a hydraulic pathway linking Wells 6 and 7. Both were disinfected by gas chlorination. Well 5 was disinfected by hypochlorite solution.

From 8 to 12 May, Walkerton experienced about 134 mm of rainfall (1 in 60 year event), with 70 mm falling on 12 May. The result of the heavy rainfall was flooding in the Walkerton area. Flooding was seen near Well 5 on the evening of 12 May.

The General Manager (GM) of Walkerton Public Utilities (PUC) was away from 5 to 14 May. The Foreman was therefore responsible for the operation of the water supply at this time. On 3 May, the chlorinator for Well 7 broke down, and for 6 days, the town received unchlorinated water from Well 7, which was against the provincial treatment requirements. The chlorinator on Well 7 was not replaced until 19 May. From 9 to 15 May, the water supply for the town was switched to Wells 5 and 6, with Well 5 as the primary source.

On 13 May, according to the daily operating sheets, the Foreman performed checks on pumping flow rates and chlorine usage and measured the chlorine residual in the water entering the distribution system. He recorded a daily chlorine residual measurement of 0.75 mg/l for treated water from Well 5 on 13 May and again for 14 and 15 May. A subsequent inquiry concluded that these operating sheet entries were fictitious.

On 15 May, the GM returned and turned on Well 7, despite the chlorinator still being broken. Well 7 supplied the town until 20 May. Well 5 was shut off at 1:15 pm on 15 May, making the unchlorinated Well 7 supply the only source of water for Walkerton during the week of 15 May.

Samples were typically submitted once per week. On 1 May, the sample volumes were too small for analysis, and there was a labelling discrepancy. On 8 May, no samples were submitted. Raw and treated water samples

were taken on 15 May from Well 7, the distribution system and a mains construction site on Highway 9. The four samples were sent for analysis, but were submitted incorrectly.

On 17 May, the laboratory called the water utility and faxed the GM to inform him of the presence of *E. coli* in the highway and distribution samples. The Walkerton ones "didn't look good either".

The tests conducted on three of the four samples submitted (not Well 7 treated) indicated only a presence or absence of indicator bacteria. Only the sample labelled "Well 7 treated" was analysed to enable a bacterial count to be determined. However, in this case, the sample was so contaminated that it produced an overgrown plate with bacterial colonies too numerous to count. The subsequent inquiry concluded that this sample was most likely mislabelled and was more likely representative of the water from Well 5. The laboratory did not fax the results to the Ministry of the Environment (MOE) or Ministry of Health (MOH) as was "expected" (note, not required). The GM advised the consultant for the Highway 9 project that their samples had failed so they would need to rechlorinate, flush and resample to complete the project.

On Thursday, 18 May, the first signs of illness were becoming evident in the health-care system. Two children were admitted to the hospital in Owen Sound, 65 km from Walkerton, both with bloody diarrhoea. The attending paediatrician noted that both children were from Walkerton. Bloody diarrhoea is a notable symptom for serious gastrointestinal infection, particularly infection with *E. coli* O157:H7. Accordingly, the paediatrician submitted stool samples from these children to evaluate that diagnosis.

By Friday, 19 May, the outbreak was evident at many levels. Thirty-three children were now absent from Walkerton schools with stomach pain, diarrhoea and nausea. Several residents of retirement homes and long-term care facilities also developed diarrhoea. A Walkerton physician had examined 12 or 13 patients suffering from diarrhoea.

The hospital paediatrician in Owen Sound notified the responsible public health agency for Walkerton (based in Owen Sound) of the emerging problems on 19 May. A Walkerton school administrator also called the public health inspector at the Walkerton office of the Health Unit to report the number of children absent and stated that she suspected the town's water supply was the source of the problem.

In contrast, the Health Unit officials suspected a foodborne basis for the outbreak, by far the most common cause of such diseases. Nonetheless, the Health Unit called the GM in the early afternoon of 19 May. By the time he called, the chlorinator had been installed on Well 7 so that it was supplying chlorinated water to Walkerton's distribution system. The GM advised him that "everything's okay", despite having been faxed the adverse microbial results from the Highway 9 project, the distribution system *and* the sample labelled Well 7 treated two days earlier.

Later that afternoon (19 May), an administrator of the Health Unit based in Owen Sound also called the GM asking whether anything unusual had happened in the water system. The GM mentioned that there was a water mains construction under way, but made no mention of the adverse bacteriological results or of operating Well 7 from 3 to 9 May and from 15 to 19 May without a chlorinator.

The reassurances about the water's safety from PUC's GM kept the Health Unit staff pursuing a foodborne cause of the outbreak. Meanwhile, the GM increased the chlorination level at Well 7 and began to flush the distribution system until 22 May.

By Saturday, 20 May, the outbreak was straining the Walkerton hospital, with more than 120 calls from concerned residents, more than half of whom complained of bloody diarrhoea. After the Owen Sound hospital determined that a stool sample was presumptive positive for *E. coli* O157:H7, the Health Unit notified other hospitals in the region.

On Saturday, the Health Unit contacted the PUC GM again to determine the current chlorine residual levels in the water and to receive reassurance that the water system would be monitored over the weekend. The GM assured the Health Unit that there were measurable levels of chlorine residual in the distribution system, leading health officials to believe that the water system was secure.

Early on Saturday afternoon, the Health Unit (Owen Sound) contacted the local Medical Officer of Health who had been out of town during the onset of the outbreak, to advise him of the emerging outbreak. By that time,

several people in Walkerton were reporting bloody diarrhoea, and 10 stool samples had been submitted for pathogen confirmation.

A concerned PUC employee began to suspect something was wrong with Walkerton's water. He had learnt that the samples from the Highway 9 project had failed testing and phoned the MOE (Ontario) anonymously to report his concerns and provide a contact number at PUC for the MOE to call about the Walkerton water system. In the early afternoon of Saturday, 20 May, a MOE employee who received the anonymous call phoned the GM to find out if there were problems with the system. The MOE employee was reassured that any problems with bacteriological results had been limited to the Highway 9 mains replacement project some weeks earlier. Later that evening, the concerned PUC employee followed up his call with the MOE, and eventually the MOE agreed to contact the local MOE office (in Owen Sound) to look into the matter further.

The outbreak continued to expand. By Sunday, 21 May, there were more than 140 calls to the Walkerton hospital, and two more patients were admitted to the Owen Sound hospital. A local radio station interviewed the local Medical Officer of Health on Sunday morning and subsequently reported on the noon news that drinking-water contamination was an unlikely source of this outbreak, but with little else to go on, a boil water advisory was issued at 1:30 pm. This notice was provided only to the local AM and FM radio stations; additional publicity by the television station or by direct door-to-door notification was not pursued.

The Health Unit established a strategic outbreak team to deal with the emergency. Local public institutions were to be notified about the boil water advisory. By that evening (21 May), the Health Unit had notified provincial health officials of the outbreak and requested the assistance of major hospitals in London and Toronto in treating Walkerton residents and the assistance of Health Canada in conducting an epidemiological investigation.

By Monday, 22 May, the Health Unit had received reports of 90–100 cases of *E. coli* infection, and the first victim died. The regional MOE official in Owen Sound had been notified the previous evening about the outbreak but did not initiate a MOE investigation, even after being advised about the large number of cases of *E. coli* infection and that the Health Unit suspected the Walkerton water system. Only after being contacted later that day by the local Medical Officer, who stressed the urgency of the situation, did the regional MOE initiate an investigation by sending an environmental officer to Walkerton to meet first with the Health Unit and then with PUC's GM. The environmental officer was asked to obtain any microbiological test results from PUC for the previous two weeks. The GM did not tell the officer about the adverse bacteriological results for 15 May, but did provide him with a number of documents, including the 17 May laboratory report. When the officer reviewed the report, he did not report the alarming evidence of water contamination to his supervisor, because he believed that the boil water advisory had eliminated any urgency.

In the meantime, the Health Unit was continuing its research, suggesting that the most likely date of contamination was between 12 and 14 May and revealing that cases were distributed across the area served by the Walkerton water distribution system. By that evening, the Health Unit was convinced that this was a waterborne outbreak, even though it had not yet been provided with the adverse results for 15 May.

On Tuesday, 23 May, the second victim died. The Health Unit also received bacteriological results from water samples it had taken around Walkerton, which had evidence of coliforms. When the Health Unit presented these to the GM, he finally admitted to the adverse water quality results from 15 May (reported on 17 May).

Ultimately, 5 more deaths, 27 cases (median age of 4) of haemolytic-uraemic syndrome, a life-threatening kidney condition that may subsequently require kidney transplantation, and 2300 cases of gastrointestinal illness were attributed to the consumption of Walkerton water. The Ontario Clean Water Agency took over operation of Walkerton's water system. The boil water advisory was lifted on 5 December.

Note: As illness emerged in the community, the GM and Foreman of PUC remained convinced that water was not to blame, and they continued to drink the water. In the past, they had often consumed Well 5 water before chlorination, because they did not recognize the danger of pathogen contamination.

Appendix I

Quotations for Module 9 exercise

"Top management is OK, as long as it doesn't interrupt whatever the operations people are doing. Whatever they are doing now is quite OK with regards to water quality, we don't have a high number of violations or anything so to have WSP is OK as long as it doesn't give too much burden at the end of the day, to the people who are doing the work." **Water quality manager**	
"Basically one of the obstacles that we face is people. I don't want to name names, but when we do new things like WSP, it's like crossing borders." **WSP team member**	
"When it comes to implementing initiatives like this, some of the people are actually quite challenging and some of these people can be at top management level." **WSP team member**	
"I have some idea of the WSP, I have been to some of the talks but I'm not sure what the actual objective is, because to me we have been doing it already, so I'm not sure what is the expected outcome of the WSP." **Water treatment works manager**	
"Here we have no control over the catchment, it is being taken care of by another authority. We only take care from the intake up to the customer, so how can we do a catchment to consumer WSP?" **Water treatment works manager**	
"Well the challenge in implementing any programme in this company, which we have a few like six sigma, ISO, lots of things, lots of different departments so I think with trying to implement another programme, you come up against objections." **Source unknown**	
"Yes, but not in detail. It's more in the quality department. We haven't been involved really at the moment, we are still in the early stage. We just have our own initiatives like I mentioned are our efforts to maintain water quality." **Water treatment works manager**	
"I was partially involved in the WSP but I can't remember the details. They didn't give us that much information at the time that I can	

remember. I really don't remember that much about it." **Water treatment works operator**	
"We got really busy all of a sudden and the WSP got forgotten, the frills of doing extra stuff…. It was purely a manpower issue." **CEO**	
"I'm not even sure we've really talked about a WSP but if someone had to give you a reason why we haven't implemented it, I think we would say, well what would we gain from doing that? I think department managers have got a good enough handle on what the risks are already." **Water quality manager**	
"I think the main problem is that all the members of the team have their routine work as well." **WSP team member**	
"You must aim for 100%, in water quality I believe that compliance must be 100%, it should be 100% because you cannot say that it's OK if one person in 1000 gets sick because of our water. Nobody should get sick." **CEO**	
"The thing about the water industry is you cannot rest, you rest and that is when you get into trouble, so it's about being on your toes all the time, what we provided yesterday is of no consequence tomorrow, we have to always constantly try." **Executive manager**	
"Well we have our standard operating procedures, we have trained staff, very good monitoring, should something come up we have engineered backup systems in place." **Source unknown**	
"I went to the conference and got all charged up. At the conference, it was the first time I had been exposed to WSPs and it looked like a really good idea." **CEO**	
"But I think the most important is that people know the system, because sometimes you go to companies and people say OK, I work in this department, in this area and I just know what I do, I don't care what the other people do. The WSPs involve all employees so it's very important to create a team spirit." **WSP team member**	
"It's difficult sometimes because we would have discussions and people would say 'oh we never had that' (never experienced the event in the past). So it's good that we have never had a major event, but it can happen, so we need to be sure that when it happens we have	

the appropriate barriers and know how to act." **WSP team member**	
"We impose stricter guidelines on ourselves, because you would never want to go through that reporting process for a violation. That causes a lot of red tape, disciplinaries and fines etc." **Water treatment works operator**	
"The standard has been changing over the years. What was normal say 25 years ago is substandard now. And quite frankly it's a good thing! The more you improve it the smoother things run." **Water quality manager**	
"We want to be the preferred water solution company in this country, number one in the country, recognized within the region." **WSP team member**	
"Our mission? We are looking at cost effectiveness, cost efficiency." **Water treatment works operator**	
"We don't like dry taps and one of the things we take very seriously here is connection hours. If we have a break then we shut down the areas that are immediately impacted but we'll reroute our system to make sure as many people are with water as possible. We minimize down time and do that extremely well." **CEO**	
"One of our drivers is to gain the confidence of the public, and probably so they can justify the bill, people want to know what they are getting for their money." **WSP team member**	
"It's cheaper to work with quality – there are several people that don't understand that and don't want to understand that." **WSP team member**	
"They (highly publicized water quality incidents) definitely changed the way we all worked. You know, we've gone to courses, we've gone to seminars. The knowledge is more there now, we've got to protect our water here, water is very precious." **Water treatment works operator**	

Appendix J

Case-study extracts from WSP manual – Module 10 exercise

Module 1

The second purpose of the team was to provide the political support and authority necessary to enable implementation of the recommendations that followed from the WSP. To this end, a Steering Committee comprising senior officials of the water utility, the Ministry of Health, and the regional Environmental Protection Agencies was formed to oversee and support the activities of the Task Force. Engaging senior officials from the start of the project proved essential for generating support to carry out tasks that required managerial or political authority, such as establishing water quality standards, introducing regulatory requirements, and dedicating financial or personnel resources.

***

One or more stakeholders usually contributed to the WSP efforts. [...] However, the involvement of these external stakeholders and contractors was usually limited to review and workshop participation. Sometimes professional facilitators were contracted to help support the development of the plans, acting as coaches or mentors and providing technical support to the WSP coordinator, and general support to run workshops and help complete documentation.

Module 2

The WSP team found the flow diagram to be a useful tool for describing the system and referred to it frequently throughout the WSP development process. Rather than using the standard engineering flow diagram symbols, the team opted for an alternative schematic to represent the water supply system in an intuitive way because these were seen to be more easily interpreted and user friendly.

***

A key component of the system description is an assessment of the current quality of treated and delivered water. Water quality testing and a review of monitoring records collected by the water utility and the health department showed that finished water was consistently not meeting water quality standards, revealing discrepancies between perceived and actual water quality. These discrepancies were particularly important to consider when evaluating the effectiveness of existing control measures and in assessing the risk presented by the identified hazards (Module 4). For example, if the belief that chlorination at the water treatment plant was sufficient to maintain water quality throughout the distribution network had not been disproven through a current water quality assessment, increased chlorine dosing would not have been identified as a critical corrective action to prevent microbial contamination. Because subsequent steps of the WSP rely and build upon information gathered in the system description, it was important that the system description accurately reflected current conditions.

Module 3

The semi-quantitative approach was relatively easy to apply [....] and was very familiar to most industry professionals. However, there was always difficulty forming agreement on risks. In particular, it was common for the same stated risk to have more than one connotation: a low likelihood of a severe consequence and a high likelihood of a minor consequence. For instance, the risk of dirty water contamination was both likely but minor (sporadic dirty water complaints with no health implications are quite common) and rare but severe (major dirty water events that compromise disinfection are serious but not common). Therefore, it was necessary to set out very clearly what each risk was.

***

Initially a semi-quantitative approach [...] was employed. Considerable confusion and disagreement arose, however, over some hazards that did not always lend themselves to quantitative ranking and led to time-

consuming discussions of hypothetical situations. In many cases, assignment of severity and likelihood was inconsistent. [...] Participants also found it difficult to exclude consideration of existing control measures when assessing risk, further contributing to frustration in the preliminary ranking process. WSP team members found that the resulting rankings did not reflect priorities and therefore decided to switch to a more intuitive approach and to delay priority ranking of risks until after control measures had been considered....

***

It was noticeable that many WSPs did not identify consumers or consumer organizations as WSP stakeholders. Hazard identification and risk assessment of consumer premises was a weak area in most WSPs and it is true that there is a limit to what water companies can achieve although they do have powers of inspection. Water storage within premises is common [...] and is a source of hazards but is an area where water companies have little control. A good example of co-operation within the water industry was an education package for consumers setting out what they can do to protect the safety of their water supplies in areas such as hygiene, plumbing and preventing back syphonage. Companies were aware that this is an area that requires handling carefully as there is a danger of scaring consumers away from drinking tap water.

Module 4

There were significant uncertainties in estimating the effectiveness and value of some catchment and distribution system controls. There was often a reluctance to rely on catchment controls due to difficulties with measuring and enforcing controls in practice. There was also difficulty in having confidence as to the effectiveness of catchment controls, other than total exclusion of people, agriculture, industry and development, which was practiced in some catchments. In general, if activities were allowed in the catchments, it was assumed that treatment was required regardless of the way that the activities were managed.

***

In preparing the system description, the WSP team found that there were standards and protocols that were not always carried out as indicated. For example, chlorination was described as part of the standard operations for the water treatment plant; but at the time of the WSP development, a chlorinator had not yet been connected. Routine water quality monitoring was carried out as indicated, but there was no system of review or communication of results. Thus, even though control measures were indicated, they were shown to be minimally or not effective.

Module 5

Most WSPs identified the need for capital works to improve the reliability of systems and address vulnerabilities. Generally the [...] water supplies were able, under normal circumstances, to provide safe water, so most capital upgrades were aimed at reducing risks of process failures and improving overall system reliability. One of the major benefits of a WSP was that the identified capital improvements, using the evidence obtained through the WSP as the driver, had a very high probability of being funded and given a priority. Prior to the use of WSPs there was often less clarity as to the real priority needs of the water quality investments. [...] In the past there was more reliance on reacting only to the adverse events that actually occurred. Therefore, the WSP has helped to drive more proactive, preventive water quality planning.

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Several of the hazards identified through the household survey and the monitoring records led to a lack of chlorine residual in the distribution system. The risk associated with this was high and therefore corrective actions to optimize chlorine dosing were ranked among the highest priorities. The insufficient chlorine was associated with a lack of operator knowledge about appropriate dosing, a lack of routine monitoring of chlorine in the distribution system, a lack of communication of monitoring results to operators [...]. Corrective actions were proposed to address each of these contributing factors: a training programme for plant operators was developed [...]; a schedule was developed and sites were selected for routine monitoring along the distribution system [...]; a protocol for communicating monitoring results to plant operators was developed

[…]; and water quality test results were presented to address misperceptions about the safety of water sources […].

<p style="text-align:center">***</p>

Operational monitoring of treatment processes was usually fully instrumented using on-line calibrated instruments linked to a computer system. Alarm levels were typically set to provide an early warning as well as an emergency trigger. Alarms usually called system operators to attend the plant and often started automated processes to stop supplying water into the treated water storage. In practice, the automated monitoring systems required a lot of work due to problems with selecting reliable instruments and reliable control systems. However, most utilities persevered until the systems were sufficiently reliable and are continuing to improve these systems into the future as their WSPs mature. Most systems were designed to have multiple triggers to avoid ever supplying untreated water.

Module 6

Insufficient water pressure within the distribution system caused by leaky pipes and unauthorized connections led to inconsistent water service and the introduction of microbial and chemical contamination. Maintaining water pressure was therefore identified as a critical control measure. Pressure gauges were installed at strategic points along the distribution network, an operator monitoring and recording plan was established, and monitoring records were reviewed monthly by utility managers. This system of increased operator awareness and supervisory oversight improved accountability and adherence to protocol and ensured that operators were better informed of pressure conditions that required immediate corrective action.

Module 7

When the utility's water quality monitoring records were collected and reviewed to assess the current state of the piped water supply […], it became clear that the utility's protocol for testing, recording and reporting finished water quality was not consistently followed by operators. Lapses in data collection were common and the body of data that did exist had never been systematically compiled and reviewed to ensure compliance with water quality standards and to inform operational decisions. Additionally, the majority of samples had been processed at a remote laboratory and the results were never reported back to operators, denying them important feedback on plant operations.

<p style="text-align:center">***</p>

Generally, verification of the effectiveness of the WSP approach is through compliance with regulatory requirements for drinking-water quality, treatment and use of chemicals and materials. The regulator of drinking-water quality is also the WSP external auditor. It does not anticipate normally auditing a company's WSPs in their entirety but particular elements of the WSP will feature in its other audits including compliance assessment, sample audit trails, incident investigations, site inspections, consumer complaints and stakeholder liaison.

Module 8

In general, the […] water supply industry is fairly informal with limited formal procedures and documentation. Therefore, most WSPs include some associated additional documentation. The lack of formality partly reflects the long careers and extensive experience of most water supply operators, making written procedures less important than the body of experience and hands-on training. In general, the procedures that have been developed for the WSPs are concise statements of what is required to be achieved rather than detailed procedures for how to achieve those objectives. Generally, there is a reliance on training and operator experience and discretion rather than on following documented procedures. However, where large parts of utility operations are outsourced to contractors, most authorities have developed detailed procedures against which contractor activity can be measured and assessed.

<p style="text-align:center">***</p>

Operational guidance took the form of verbal instruction from supervisors and was often incomplete and poorly understood. The lack of thorough, clearly defined operating procedures was recognized as a major

barrier to safe water provision and was also believed to adversely impact engagement and morale among utility personnel. Considerable time and energy were therefore invested in the development of SOPs [standard operating procedures].

Module 9

The utility did not have a formal operator training programme and poorly trained operators were considered among the highest-priority threats to water quality. Training had not been offered in many years and considerable operator turnover had taken place since. Further, past training sessions had been conducted by external experts and in-house capacity had not been developed to address future training needs. The WSP team therefore developed an operator training programme with a focus on sustainability.

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This area [developing support programmes] was not a significant challenge for water companies as they already had good supporting programmes such as training programmes, hygiene procedures, ISO [International Organization for Standardization] quality systems, accredited laboratories with internal and external quality control programmes and company and collaborative industry research and development. The challenge was to consider and include such supporting programmes as part of the WSP.

Module 10

[The] utilities maintain their WSPs as "living documents" that are subject to ongoing change to capture improvements. Most WSPs are in fact version-controlled by having an intranet-based electronic version live on the web rather than a hard copy version. The WSPs typically undergo a major revision every couple of years with ad hoc revisions usually scheduled to coincide with audits or other milestones or major asset changes.

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Companies that had many paper-based WSPs were challenged by the workload requirements to keep them up to date particularly where many improvements had been identified and implemented. Keeping the WSP initiative embedded in company operations was likely to be a challenge before the WSP risk assessment and risk management approach was made a regulatory requirement.

Appendix K

Data for use with the WSP quality assurance tool – Module 12

Remember – while demonstrating the tool, use your own discretion to:
- Create a new assessment, and enter new date in Table 1 or new name in Table 2 (return to Table 1 in order to create a new assessment).
- Create a new "assessment"-style question, and define scoring criteria in the comments field.
- View tables and graphs – click the "view results" button, then select either summary tables or summary graphs, followed by results by WSP step or results by component.
- Add rationales for scoring or comments for some answers.
- Save after completing each table.

Entry page
Name of water supplier: Use any fictional name that you like (or just use "test")
Country where water supplier is located: Use the country in which you are giving the demonstration

Table 1: General information on supplier
1.1 = 300,000
1.2 = 300,000
1.3 = 15
1.4a = 4
1.4b = 1
1.5a = 30,000
1.5b = 10,000 (This will be the supply system described in the rest of the assessment)
1.6 = 100
1.7 = 5
1.8 = 2
1.9 = Tick any that you wish
1.10 = No
1.11 = N/A

Table 2: General information on water supply system
Name of the water supply system: Use any fictional name that you like (or just use "test system")
2.1a Shared responsibility; **2.1b** Full responsibility; **2.1c** Full responsibility; **2.1d** Full responsibility; **2.1e** No responsibility
2.2 = 10,000
2.3 = 10,000
2.4 = 4000
2.5 = 1
2.6 = 1300
2.7 = 35%
2.8 = 4

Table 3: WSP team
3.1 = 3; **3.2 =** 3; **3.3 =** 3; **3.4 =** 2; **3.5 =** 2

Table 4: System sescription
4.1 = 2; **4.2 =** 1

Table 5: Hazard identification and risk assessment
5.1a = 4; **5.1b =** 0; **5.1c =** 1; **5.1d =** 2
5.2a = 1; **5.2b =** 0; **5.2c =** 0; **5.2d =** 2
5.3a = 5; **5.3b =** 0; **5.3c =** 2; **5.3d =** 3
5.4a = 1; **5.4b =** 0; **5.4c =** 0; **5.4d =** 1
5.5a = 1; **5.5b =** 2; **5.5c =** 2; **5.5d =** 1

5.6a = 0; **5.6b** = 1; **5.6c** = 3; **5.6d** = 3
5.7a = 3; **5.7b** = 3; **5.7c** = 1; **5.7d** = 2
5.8a = 1**; 5.8b** = 10; **5.8c** = 3; **5.8d** = 3
5.9 = 2
5.10a = 0; **5.10b** = 1; **5.10c** = 1; **5.10d** = 0

Table 6: Control measures and validation

6.1a = 2; **6.1b** = 2; **6.1c** = 0; **6.1d** = 2
6.2 = 10
6.3 = 3
6.4a = 2; **6.4b** = 0; **6.4c** = 0; **6.4d** = 1
6.5a = 1; **6.5b** = 0; **6.5c** = 0; **6.5d** =1
6.6a = 1; **6.6b** = 0; **6.6c** = 0; **6.6d** = 1
6.7 = 10
6.8 = 2

Table 7: Improvement plan

7.1a = 0; **7.1b** = 2; **7.1c** = 3; **7.1d** = 0
7.2a = 0; **7.2b** = 2; **7.2c** = 2; **7.2d** = 0
7.3a = 0; **7.3b** = 0; **7.3c** = 3; **7.3d** = 0
7.4a = 0; **7.4b** = 1; **7.4c** = 3; **7.4d** = 0
7.5a = 0; **7.5b** = 1; **7.5c** = 1; **7.5d** = 0

Table 8: Operational monitoring

8.1a = 1; **8.1b** = 1; **8.1c** = 0; **8.1d** = 2
8.2a = 3; **8.2b** = 0; **8.2c** = 0; **8.2d** = 3
8.3a = 1; **8.3b** = 2; **8.3c** = 1; **8.3d** = 0
8.4a = 3; **8.4b** = 1; **8.4c** = 2; **8.4d** = 0
8.5 = 5
8.6 = 500
8.7 = 500
8.8 = 500
8.9 = 500
8.10 = 490
8.11 = 480

Table 9: Verification

9.1 = 3
9.2 = 3
9.3 = 2
9.4 = 3
9.5 = 2
9.6 = 3
9.7 = 3
9.8 = 2
9.9 = 10
9.10a, b, c, d = 500
9.11a, b, c, d = 500
9.12a, b, c, d = 500
9.13a, b, c, d = 500
9.14a = 499
9.14b = 490
9.14c = 498
9.14d = 490
9.15a = 496
9.15b = 500
9.15c = 495

9.15d = 490

Table 10: Management procedures
10.1a = 3; **10.1b** = 1; **10.1c** = 2; **10.1d** = 2
10.2a = 1; **10.2b =** 1; **10.2c =** 2; **10.2d =** 1
10.3 = 1

Table 11: Supporting programmes
11.1 = 3
11.2 = 1

Table 12: Review of the WSP
12.1–12.5 N/A (as this supply system is in development)