13

Water safety plans for small systems

Small, community-managed water supplies are found in both developed and developing countries worldwide. A wide range of technologies may be employed in such supplies, from relatively sophisticated treatment plants (sometimes of a ‘package’ nature) serving customers with in-house connections, to single point sources such as a tubewell or borehole fitted with a handpump. The common feature, however, of all such small water supplies is that operation and maintenance is performed by members of the community with limited specialist skills, who can commit only limited amounts of time and who frequently receive little or no financial remuneration or formal training. Furthermore, the range of available equipment to identify and rectify faults may be limited as is access to water quality testing equipment. There is often a significant degree of reliance on external bodies (usually an arm of local or national Government) to provide support for problems beyond the capacity of the community operator to resolve (for instance rehabilitation) and in providing general guidance.

13.1 PRIORITISING HAZARDS

The development of water safety plans for small systems should focus on the control of microbial quality and in particular pathogens derived from faecal contamination. Studies from both developed and developing countries highlight the vulnerability of small systems to microbial contamination (Gelinas 1997; Howard *et al*. 2003; Fewtrell *et al*. 1998). The risks of microbial contamination are more significant in shallow aquifers, which may show significant changes in quality in response to rainfall (Wright 1985; Barrett *et al*. 2000). Deeper aquifers tend to have better and more stable microbial quality. Where small systems include piped distribution with connections at a 'within-house level of service' feeding showers there is a risk from *Legionella*, although control strategies may require greater involvement by external bodies as this may be beyond the capacity of community operators to control.

Chemical hazards are most likely to result from either natural sources or agricultural pollution. Of the natural chemicals, arsenic and fluoride are likely to be the most significant problems facing small systems. Nitrate and pesticides may be found in areas of agriculture (and on-site sanitation in the case of nitrate) and lead may be problem in older distribution systems. Problems of chemical contamination may also be found with rainwater collection in areas with high air pollution or where chemicals leach from roofing material.

By preference, the assessment of risks posed by chemicals in water should be based on data derived from water quality tests performed on samples of water taken from water supplies before commissioning. However, it is unlikely that such data exist for all supplies and therefore risk assessment may be based on an incomplete set of data. The WHO document 'Chemical Safety of Drinking-water: assessing priorities for risk management' (Thompson *et al*. 2004) provides further guidance in how to identify chemicals likely to pose the greatest risk to health in a country or region or water supply employing a particular technology type. Although chemical quality in deeper groundwater is often stable, in shallow groundwater chemical quality may vary significantly with rainfall and seasonal fluctuations have been noted for arsenic and nitrate (Barrett *et al*. 2000).

The water safety plan should propose control measures for chemical hazards where possible. However, in most cases, the control of these hazards must be addressed at the design stage (for instance by setting appropriate intake depths) rather than operational controls. Monitoring is unlikely to be feasible by the operators of small systems and therefore any water quality testing will necessarily devolve to the surveillance agency. This further supports the need for the water safety plan to focus on microbial quality in smaller systems.

13.2 SMALL SYSTEM APPROACHES

The nature of small, community-managed water supplies means that the operators of the water supply are unlikely to have the necessary skills to develop system-specific water safety plans without outside assistance. Therefore, water safety plans must either be developed for the supply, or detailed guidance must be provided to ensure that local water safety plans can be developed. Two approaches are therefore envisaged to support small systems:

- development of *generic water safety plans* for particular technologies to be applied across a region or country; or,
- development of *guides* that support the local development of a water safety plan, with examples (model water safety plans) provided that may be modified according to local conditions.

Either approach may be applied in different situations depending on the resources available within communities. Both approaches may be used in a single country. In both developed and developing countries, very small water supplies serving relatively few households would be most likely to require the development of a generic water safety plan for the technology used. Appendix B provides examples of generic water safety plans that can be adapted to circumstances in different countries and/or regions. These could also function as model water safety plans.

In larger communities, including small towns, the capacity of communities to use guidance material to develop water safety plans may be much greater. The greater complexity of the supplies and wider range of hazardous environments that could occur will also make it desirable that water safety plans be tailored to the conditions in individual supplies.

In developing water safety plans for small systems, the implementation of the plans will be highly dependent on the training and resource material made available to operators. This is also likely to require ongoing support in maintaining the water safety plan and providing periodic updating. This is often a role that the surveillance agency will play, in addition to their role in independent assessment of water safety.

13.3 DEVELOPING GENERIC TECHNOLOGY WATER SAFETY PLANS

Generic technology water safety plans should be based on a thorough understanding of the hazards and risks that may threaten each type of technology. These may include, for example, lack of covers on wells allowing direct ingress of contaminated surface water, lack of drains that allow inundation of the wellhead, animal access close to the wellhead leading to the development of pathways into the source and faecal material close the source. For situations where there are many small supplies these cannot be tailored to each individual water supply, although it is possible to define a generalised list of hazardous events and associated risks for the settings in which such systems will be found.

The first stage in this process is to identify the range of technologies that exist within the country/region for which generic water safety plans will be developed. This may involve consideration of technologies installed by organisations other than a Government water supply agency (for instance by non governmental organizations). Variations in construction and design of the small systems should also be considered, as these may influence both the types of hazardous event that may occur and the risk (in particular the likelihood) associated with a hazardous event. For instance, contamination introduced by a bucket may occur in a well without handpump, but should not occur in a well with a handpump. Collecting information on the types of technology for which generic water safety plans will be developed would usually take the form of a detailed inventory of sources (Howard 2002; Lloyd and Helmer 1991).

The development of the generic technology water safety plans is usually best undertaken by a group of experts familiar with the technologies and the setting within the country. In Bangladesh a set of draft water safety plans were developed through convening a workshop of selected sector experts who went through the full process guided by facilitators familiar with water safety plans (APSU, 2005). The outputs from the workshop were a set of generic water safety plans for use by organisations undertaking the rolling-out of water safety plans to community-managed water supplies. The water safety plans themselves were not provided to the community, rather a set of simplified tools for community operators were developed to support action-orientated monitoring.

Water safety plans for can be based on the results of studies of water quality and sanitary inspection on a representative sample of water supplies throughout the country that reflect different climatic and hydrogeological conditions (Howard, 2003). Hazardous events that affect particular technologies, the likelihood of their occurrence and the impact of water quality can be assessed through simultaneous collection of sanitary inspection and water quality data. The process followed is also a form of validation of the protection barriers put in place around a small water source to secure water safety.

Sanitary inspection forms should be used to undertake the hazardous event assessment. These may initially identify a long list of questions to be asked regarding the security of the source, which through piloting and review of data may be reduced to key questions that apply for all sources of the same technology. The material shown in Appendix C provides examples of the types of forms that may be developed. These forms include a range of factors that can be broadly categorised into three groups (Howard 2002):

- Hazard factors – these are potential sources of faeces situated so that they may represent a risk to the water supply (an example being the location of a pit latrine in relation to the water source).
- Pathway factors – these are potential routes by which contamination may enter the water supply (examples include eroded backfill areas of protected springs, or leaking pipes).
- Indirect factors – these are factors that represent a lack of a control measure to prevent contamination (and therefore increase the likelihood of a hazard or pathway developing), but do not themselves represent either a hazard or a pathway. An example of this is a fence around the water source. The absence of a fence will not lead directly to contamination, but may allow animals or humans to gain access to the source and create either a hazard (through defecation) or a pathway (through causing damage to the source or its immediate surroundings).

In many cases the presence of multiple factors may be required in order for contamination to result, based on a source-pathway-receptor model that is commonly used to explain contamination. There are likely to be exceptions to this general rule, for instance where a particular hazard is the sole cause of the contamination (Lloyd and Bartram 1991). In such a case, while reductions in other risks may be desirable, they may potentially have limited impact on the quality of water (Howard 2002).

13.3.1 Designing the studies to develop water safety plans

Variability may be significant for both microbial and chemical quality. For instance, in rural areas peak microbial contamination may occur at the onset of a wet season, but then rapidly diminish as the reserves of faecal material are exhausted (Bartram 1999). In peri-urban areas, microbial contamination may occur in response to a rainfall event, but as the faecal reserve is not exhausted repeated peaks may be found (Howard *et al*. 2003).

Studies to support the development of water safety plans can be undertaken in several ways. Longitudinal studies require repeated sampling of the same sources over an extended period, with one year being a realistic minimum to gain a sufficient set of data to represent variation in quality. If these studies are undertaken then the collection of rainfall data is strongly advisable. Cross-sectional studies may also be used, which will typically involve single samples taken from a wider range of sources.

These have an advantage in that a much wider range of sources may be visited which may increase representivity in relation to the source characteristics, but will not provide information regarding seasonal fluctuations in quality. If data are also collected on rainfall then some indication of the impact of rainfall may be possible.

The final method is to review data available from routine monitoring programmes, whether in their entirety or a sample of results. This approach may provide a mixture of data from repeated sampling from the same sources with single samples taken from sources, which may add to the complexity of the analysis of the data.

Analysis of the data from the studies is important in understanding the relative importance of different hazardous events and in the interactions between risk factors that lead to contamination occurring. This allows both the identification of specific control measures and also provides a greater insight into how different possible hazardous events may occur. Statistical analysis may be based on simple assessments of frequency of reporting of sanitary risks (Cronin et al, 2002) or through the use of contingency tables and logistic regression (Howard et al, 2003).

References:

APSU, 2005 'Support to implementation of water safety plans, www.apsu-bd.org

Cronin A, Breslin N, Taylor RG and Pedley S, 2002, Assessing the risks to groundwater quality from on-site sanitation and poor sanitary well completion, in 'Eocsan- closing the loop', Proceedings of the Second International conference of Ecological Sanitation, Lubeck, Germany, April 2003.

Howard G, Pedley, S, Barrett M, Nalubega M & Johal K. (2003). Risk factors contributing to microbiological contamination of shallow groundwater in Kampala, Uganda. Water Research, 37(14): 3421-3429.

13.1: Contingency table analysis of water quality and sanitary inspection data (adapted from Howard *et al*. 2003)

Variable	Faecal streptococci >0 cfu/100ml			Thermotolerant coliforms >10 cfu/100ml		
	Odds ratio	p	95% CI	Odds ratio	p	95% CI
Faulty masonry	1.913	0.008	1.185-3.087	1.506	0.075	0.960-2.363
Backfill area eroded	2.276	0.001	1.381-3.749	2.762	<0.001	1.716-4.445
Collection area floods	0.966	0.890	0.591-1.579	0.603	0.035	0.377-0.964
Fence absent or faulty	5.175	0.052	0.987-27.138	3.496	0.138	0.668-18.303
Animal access <10m	2.010	0.488	0.279-14.471	1.366	0.756	0.190-9.826
Surface water uphill	3.655	<0.001	2.054-6.507	3.933	<0.001	2.316-6.680
Diversion ditch faulty	1.114	0.679	0.667-1.862	1.324	0.263	0.810-2.163
Other pollution uphill	2.040	0.259	0.577-7.210	5.728	0.029	1.196-27.429
Latrine <30m uphill of spring	1.229	0.455	0.715-2.113	1.759	0.036	1.038-2.979
Latrine <50m uphill of spring	0.862	0.547	0.532-1.397	0.738	0.198	0.465-1.171
High population density	2.889	<0.001	1.780-4.688	4.708	<0.001	3.899-7.644
Waste <10m uphill of spring	0.144	0.150	0.875-2.380	2.557	<0.001	1.560-4.189
Waste <20m uphill of spring	1.340	0.231	0.830-2.163	3.085	<0.001	1.923-4.950
Waste <30m uphill of spring	0.842	0.590	0.451-1.573	1.896	0.031	1.059-3.397
Rainfall within previous 5 days	2.284	0.009	1.225-4.259	4.097	<0.001	2.096-8.008
Rainfall within previous 2 days	3.285	<0.001	2.014-5.357	3.827	<0.001	2.385-6.139
Rainfall with previous day	2.583	0.001	1.473-4.529	2.115	0.004	1.276-3.506

Table 13.2: Generic water safety plan for protected spring not connected to a piped network

Hazardous event	Cause	Risk	Control measure	Critical limits		Monitoring			Corrective action	Verification
				Target	Action	What	When	Who		
Contam. able to recharge spring in backfill area	Backfill area becomes eroded	Mod/ major	Effective spring protection measures maintained	Area has grass cover; fence and diversion ditch in good condition No surface water uphill	Fence is broken Diversion ditch is damaged Surface water pools develop	Sanitary inspection	Monthly	CO	Repair fencing and ditches; drain surface water. Re-lay grass. Rehabilitate protective measures	Sanitary inspection and analysis of: *E.coli* and faecal streptococci
Contamination in spring box or outlet	Spring box or retaining wall in poor condition, inund^{n} from ww	Mod/ major to mod	Maintain protection and drainage works	Masonry in good condition; ww ditch clear and in good condition	Masonry deteriorated; ww ditch blocked	Sanitary inspection	Monthly	CO	Repair masonry and covers; clear ditch	Sanitary inspection and analysis of: *E.coli* and faecal streptococci
Contam. surface water causes rapid recharge	Surface water is allowed to form pools uphill and leads to rapid recharge of pollutants and limited atten^{n}	Mod to un/ major	Establish set-back distance based on travel time; drainage	No surface water, solid waste dumps uphill Faecal disposal methods available	Surface water close to springs Low sanitation coverage Poor solid waste removal Springs show rapid response in flow and quality to rainfall	Sanitary inspection Colour change response to rainfall	Monthly/ seasonally	CO	Drain surface water pools uphill of springs, promote improved sanitation and solid waste disposal	Sanitary inspection and analysis of:*E.coli* and faecal streptococci

Hazardous event	Cause	Risk	Control measure	Critical limits		Monitoring			Corrective action	Verification
				Target	Action	What	When	Who		
Ingress of animal faeces	Animal husbandry uphill and close to the spring Animal damage to backfill area	Mod/ mod	Set-back distance to Control animal husbandry; good fencing	No kraals or sheds in set-back distance; fence in good condition	Animal husbandry found within controlled area Fencing damaged or absent	Sanitary inspection	Monthly	CO	Remove animal sheds or kraals from uphill of spring or move to safe distance Repair or erect fences	Sanitary inspection *E.coli*, faecal streptococci, bacteriophages, nitrate
Leaching of microbial contaminants into aquifer	Leaching of faecal material from sanitation, solid waste, drains	Mod/ mod	Provide adequate set-back distances defined on travel time	No sources of faecal material within set-back distance	Latrines/ sewers built or solid waste dumps within separation distance	Inspection by community	Monthly	CO	Move pollutant sources, improve sanitation design, reduce sewer leakage	Sanitary inspection *E.coli*, faecal streptococci, bacteriophages, nitrate, chloride, tracer studies
Leaching of chemicals into groundwater	Leaching of chemicals from landfills, waste dumps, discharges to ground	Mod/ minor	Provide adequate set-back distances defined on travel time	No sources of chemicals within set-back distance	Pollutant discharges within set-back distance	Inspection by community	Monthly	CO	Move pollutant sources, improve pollution containment	Inspection Analysis of chemical composition of pollution Analysis of water quality

Contam. – contamination; Mod – moderate; Un – unlikely; inund^{n} – inundation; atten^{n} – attenuation ; ww – wastewater; CO – community operator

13.3.2 Implementing a system of support for generic technology water safety plans

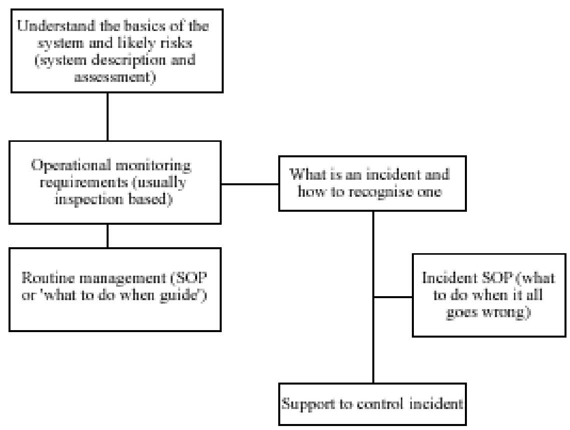
Once the generic technology water safety plans have been developed, the water safety plan team will need to develop a strategy for rolling-out implementation of the water safety plans at a source level. This will require the development and testing of simple monitoring and operational tools for community operators, development of training materials and a programme of ongoing support and surveillance. These tools should be piloted in a small number of communities, evaluated and refined before trying to roll-out a programme across a country.

Responsibility for ensuring water safety and implementing a water safety plan in a community-managed supply resides with the operator of the supply who, by using tools for monitoring and maintaining control measures, should have the skills and resources to ensure that the relevant generic technology water safety plan can be applied. Ensuring that the operators have adequate skills and capacity to perform this role is a critical aspect of the effective implementation of a water safety plan. This requires that the tools developed for community operators are easy to use and provide the operator with information for each control measure, such as:

- what the control measure is and how it prevents or reduces contamination;
- how the performance of the control measure is measured and what monitoring tools should be used;
- how often monitoring should be undertaken and how information will be recorded;
- to identify when the control measure has exceeded a critical limit; and
- to apply the appropriate corrective action when a critical limit has been exceeded.

Performing these tasks successfully requires that the operator is provided with the appropriate technical training and materials as shown in Figure 13.1.

It is also important that operators are aware of the agency to contact should a problem be noted that is beyond their immediate capacity to correct. In addition to operator training, training should also be provided to a water management committee to enable them to monitor the performance of the operator. This should include development of simple reporting formats between the operator and the management committee and establishing agreed targets and milestones. Where an operator is deemed to consistently fail to provide the level of performance expected or is no longer available to carry out the tasks required, the committee should have a means by which to bring this to the attention of the support or surveillance agency. This may result in identifying and training a new operator. As the maintenance of water safety requires ongoing interventions ongoing training of the operator, by an external agency, is likely to be required. Thus the surveillance or support agency may wish to develop local training units or contract reputable third party organisations to support ongoing skills development and training provision.



SOP – standard operating procedure

Figure 13.1: Community operator requirements for water safety plan implementation

The first component of the water safety plan is a simplified guide to the technology that should provide the operator with a basic description of the technology, how it works, how it prevents or reduces contamination and what problems could occur that would result in contamination. This guide should provide the operator with a good understanding of their system and how their activities are important in controlling risks. The use of illustrations is likely to be important in all circumstances and in particular for operators of very small systems in developing countries.

Community operators will also need simple tools for monitoring of the control measures and actions to be taken when the control measures are no longer in compliance with critical limits. Monitoring of the control measures can largely be achieved through regular sanitary inspection. This should use approaches that are closely linked to actions to be taken as a result of monitoring data indicating that a critical limit is being exceeded. Either pictorial or written forms may be appropriate depending upon the level of literacy. In both cases, however, it should be clear what is action is expected when the monitoring indicates a loss of control measure compliance. Example forms are shown in Tables 13.3 and 13.4.

Table 13.3 Community checklist for monitoring a protected spring

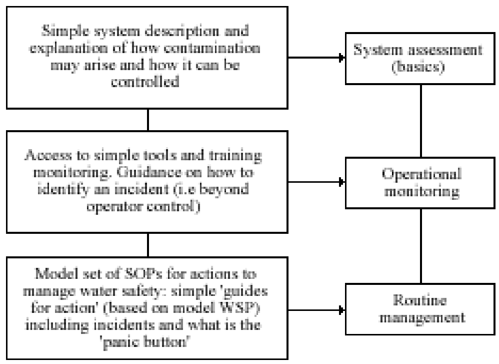
Checklist	No	Yes	Action
Does the water in the spring change colour after heavy rain?			
Have the local public health department tested your spring recently?			
Were you told the result and given any advice?			
Did you act on the advice?			
Is the retaining wall showing any signs of damage?			
Does the retaining wall need repair – what is this and can you do it yourself?			
If you cannot do it, is there anyone in your community who can do this repair?			
How much will the repair cost (think about labour as well as material)?			
Does the uphill diversion ditch need cleaning?			
When was it last cleaned?			
Is the drainage ditch below the spring blocked or need clearing?			
Does the fence need any repairs?			

In some circumstances it may be more appropriate to use pictorial approaches to illustrate what constitutes good and bad practice regarding water safety management. The latter can draw on examples from the Participatory Health and Sanitation Transformation (PHAST) approach to hygiene, which contains examples of the types of materials and their use in relation to water source management (WHO 1996b). The approach adopted should be based on the needs and capacity of the communities that will use the generic water safety plan within the country.

Table 13.4 Checklist for operation and maintenance of a protected spring

Activity	Dry season	Wet season		Action limits
		Routine	After heavy rainfall	
Clear uphill diversion ditch	At least once per month	At least once per week	Always inspect	Clean if ditch contains mud or silt
Clear drainage ditch from outlets	At least once per month	At least once per week	Always inspect	Clean if ditch contains mud or silt
Slashing grass inside fence	At least once per dry season	At least once per month		Cut grass once it exceeds mid-shin height
Make sure steps are clean and not broken	At least once per week	At least once per week	Always inspect	Clean and repair when dirty or showing signs of breaking
Clear rubbish away from area around spring, particularly uphill	At least once per week	At least once per week	Always inspect	Dispose of rubbish properly
Keep paths and grassed areas above springs clear of rubbish	At least once per month	At least once per month		Clear paths and dispose of rubbish properly
Trim hedge once it reaches a height of 4 feet	Do not trim in the dry season	As soon as hedge reaches 4 feet in height		Trim hedge
Carry out regular inspections of the spring and note any faults	At least twice per week	Daily	Always inspect	Record faults and identify actions to be taken

The materials and tools required by operators to implement a generic water safety plan are summarised in Figure 13.2 below.



SOP – standard operating procedure
WSP – water safety plan

Figure 13.2: Providing the information to the operator

13.3.3 Developing supporting programmes

A programme of support and surveillance will need to be developed to aid implementation of the generic water safety plan. It is important that these programmes reflect the capacity of the surveillance agency and are piloted to ensure the long-term applicability. The stages and requirements to achieve this are outlined in Figure 13.3.

Pilot trials of the water safety plans should be undertaken in a number of communities to evaluate their effectiveness and to identify modifications required. The pilot should run for at least 12 months and be evaluated to ensure the monitoring tools have been used and appropriate actions taken. The evaluation should also include an assessment of the feasibility of the supporting programmes.

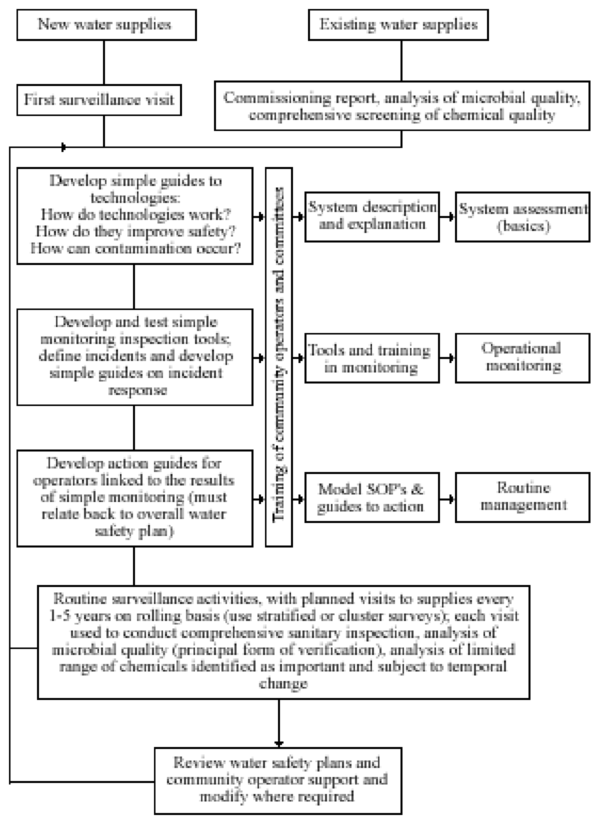


Figure 13.3: Implementing the water safety plan roll-out

Implementing a generic technology water safety plan includes several key elements. These include the development of training and supporting materials that will enable the community operator and other key members of the community (for instance water committee) to operate the water safety plan, undertake the required monitoring and understand how the data will be used. The development of a monitoring programme by the community will require training for the community water supply operators.

13.3.4 Progressive expansion

The progressive rolling-out of the water safety plans requires careful planning and will almost certainly have to address the two different situations of new supplies being developed and application of water safety plans to existing water supplies. It is recommended that programmes be developed for both situations, with training and support to water safety plan development in all new supplies that are developed and a programme to provide training and support to implement water safety plans in existing supplies prepared.

A water safety plan should be developed for all new supplies with appropriate training, tools and documentation provided to operators before the supply is commissioned. This should be supported by testing of samples of water taken from the source as part of a commissioning report. The selection of chemicals to be included should be based on an assessment of the natural chemicals and pollutants likely to be present, based on the geology, climate and land-use. Further guidance is available in Thompson *et al*. (2004) for inclusion in drinking-water quality monitoring programmes.

The existing supplies are likely to represent a larger group than the new supplies and thus the programme will need to consider the most effective approach to developing appropriate water safety plans and associated support programmes. This will be most effectively done through the progressive rolling-out across the country/region.

The roll-out of generic water safety plans could be integrated into the development of a regional surveillance programme. In terms of planning, it is important that the rolling-out takes into account the capacity of the surveillance agency and water supply agency/authority to provide ongoing support to communities. Experience from a number of countries has shown that to have an impact on the quality of small water supplies, surveillance programmes must be directly linked to interventions (Bartram 1999; Moore 1999). Therefore investment to support water safety plans should be linked to investment in order to support development of surveillance at local levels.

13.3.5 Verification for generic technology water safety plans

Responsibility for the verification for generic technology water safety plans should not be undertaken by the community operator, although they should participate in the process. The verification of performance will primarily be carried out by the surveillance agency as part of their routine activities. Verification should focus attention on the overall microbial quality of the drinking-water and will also include testing of those chemicals previously identified as locally or regionally important. Although it will be expected that the principal faecal indicator organisms used will be *E.coli* or thermotolerant coliforms, a limited number of analyses of other organisms such as faecal streptococci and bacteriophages may also be included. Such analyses would be expected to be performed on a smaller number of supplies and form specific targeted assessments rather than broader routine surveillance.

It is unlikely that verification will occur at every small supply on a frequent basis as the costs involved in regular visits and testing are prohibitive in most countries. Therefore, verification should be designed as a means of assessing the performance of the generic technology water safety plan as applied across a number of water supplies rather than assessing the performance of its application on individual supplies. If this approach is adopted then only a sample of supplies using the generic water safety plan need to be visited each year. It would be expected, however, that each supply would be visited regularly, for instance once every three to five years.

13.4 GUIDES TO AID LOCAL DEVELOPMENT OF WATER SAFETY PLANS

For many smaller communities (including where utilities operate a small town supply), there may be a lack of capacity to undertake the development of a system-specific water safety plan without external support, but where applying a generic technology water safety plan would not be appropriate. This may be because the system is relatively complex and there may be significant variation in the hazardous events that could affect supplies. These situations would typically apply in larger communities with a well-defined management structure, with more than one operator who may receive partial remuneration and commonly where some form of piped distribution system exists.

In such situations, the development of a water safety plan can be tailored to the situation found in the supply but based on a set of generic materials that provide guidance in developing the water safety plan. To support the local development of water safety plans for small systems, a number of supporting materials are required. These will typically include guidance notes, for instance in the form of flow charts and decision-trees for different components of water supplies. Demonstration materials or example plans may be required to provide users with a clearer idea of what is contained within a water safety plan and how they are structured and used. These should provide the local water safety plan team with information regarding the type of hazardous events that may occur and examples of potential control measures with associated monitoring, critical limits and means of verification. The model water safety plans included in the Appendix illustrate the type of an example material that could be provided, in addition to guides to support local water safety plan development. In developing guides on the preparation of the water safety plans, a national team of experts with extensive experience of small water supplies should be established to develop both the guides and model water safety plans.

The first stage in developing the guides and model water safety plans is to decide what types of supply will be targeted. Implementation is likely to be easier to plan and manage if a clear distinction is drawn between the types of water supply or community where generic technology water safety plans should be used and those that will be expected to develop system-specific water safety plans using guides and model water safety plans. Clear criteria should be established, for instance in relation to technology type, management arrangements and population size. Some possible criteria are as follows:

- treatment is applied within the water supply (including where only terminal disinfection is used routinely);
- the water supply has a piped distribution system that serves more than a few public taps;
- the population served by the individual supply exceeds 1000 people;
- the supply has more than one operator, who receive some payment for services provided; and,
- there is distinct management body with a constitution.

In order to achieve the local development of water safety plans for small systems, the operators will need a range of information as outlined in Figure 13.4.

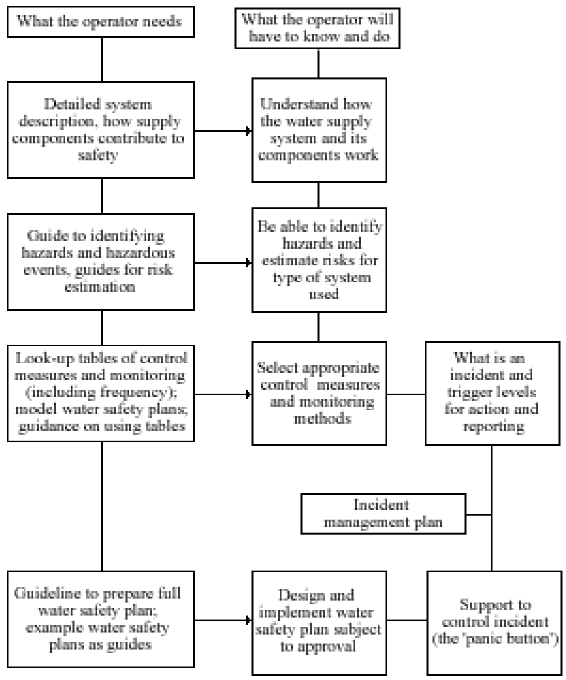


Figure 13.4: Supporting guided water safety plan development and implementation

13.4.1 Preparing the support material

Developing descriptions of water supplies and their components is the first stage of this process. These descriptions should be more extensive than those developed for the generic water safety plan materials and be in the form of simple booklets covering the scientific and engineering principles of each component of the system. This should include discussion of how the different parts of the system act to control risks by ensuring that hazards are reduced, eliminated or excluded from the water supply. The descriptions can be ‘modular’ to allow operators to develop a set of materials dealing with their own system. The modules should cover source protection, water treatment and distribution.

Material should also be developed to support operators in undertaking hazard identification (primarily in terms of hazardous events), risk assessment, identifying control measures with associated critical limits and monitoring. These guides should provide the user with clear guidance regarding how to identify a potential hazardous event and to determine the risk of that event occurring. Guidance should also be provided to the users about appropriate monitoring for each control measure, which is likely to be a mixture of inspection methods and physico-chemical tests. This guidance is best provided in a series of look-up tables including, for instance, a number of potential control measures and the appropriate monitoring approach. The information included in the model water safety plans in the Appendix could be used as a starting point to develop these look-up tables.

As with the development of the generic technology water safety plans, the guidance material (including model water safety plans) should be developed by a national team of experts with detailed knowledge of the types of supply that will be covered and the types of hazardous events and control measures that will be effective.

It is important that in developing the model water safety plans, that the risk of hazardous events is based, wherever possible, on analysis of water quality and sanitary inspection data, potentially through failure analysis or through the development of statistical models. The model water safety plans should be based on analysis of representative data and should ensure that weighting of the likelihood of the event occurring reflects data from the field. As with the approach to developing the generic water safety plans, such analysis can be based on data derived from specific assessments designed to be representative. Data previously collected should also be analysed to provide a longer-term perspective on risks that may arise.

The model water safety plans should be similar in format to the expected structure of a water safety plan and provide the user with a comprehensive list of likely hazardous events, control measures and means of monitoring. In approaches used in New Zealand, potential hazardous events and control measures are listed for water supplies, with local operators expected to identify those hazardous events and controls that can be put into place in their supply (NZMOH 2001). It would also be possible to provide a full model water safety plan to users and encourage operators to select those that are of relevance to their system. It is important, however, to ensure that users do not simply copy the model water safety plan but use these in conjunction with the advice within the guides to develop their own water safety plan.

13.4.2 Developing and testing the guides

The guidance material may take a number of forms including manuals, videos, audio-visual material and web-based guides. The guides should provide sufficient information to allow users to follow the process and should refer to model water safety plans. The guides should be structured so that the user is taken through all the stages of the establishment and implementation of a water safety plan. The use of decision-trees and flow-charts is particularly helpful and the guides should provide questions to prompt the user to identify information needs and how to acquire this information. The guides should assist the user in making key decisions, for instance regarding the selection of particular control measures or the frequency of monitoring or verification that will be required.

The team developing the guidance material should include water quality specialists but will also be likely to benefit from participation from professionals within the knowledge transfer sector. The success of the guides may rest, to a significant extent, on the degree to which the guides are user-friendly and use a language and approach that is comprehensible to the target audience.

Before embarking on a programme of guided water safety plan development, the materials within the guides and model water safety plans should be piloted and evaluated. Where additional training is to be provided to operators this should also be piloted and evaluated to ensure that the materials prepared will result in effective water safety plans being developed.

13.4.3 Approval of the water safety plan

The water safety plans developed based on guidance material should undergo a formal approval process. This will require that an external assessor (either the surveillance agency or accredited third party organisation) review the water safety plan and water supply to ensure that there are no omissions and that the water safety plan in its entirety will provide assurance of safety. Such a process requires a detailed assessment of the catchment and source, an audit of the treatment works and field assessment of the distribution systems. Where the water safety plan in deemed to be inadequate for a particular supply, the assessor should identify deficiencies in the plan and make recommendations for improvements. If there is a persistent failure by the community water supply managers to develop an appropriate water safety plan, the surveillance agency should have the right to impose a water safety plan on the supply managers.

13.4.4 Verification

Where the process of establishing a water safety plan is being guided in the fashion outlined above, how verification is undertaken should be carefully considered. In some situations it may be possible for the system operators to undertake some verification using low-cost analytical equipment. This would primarily focus on the analysis of water quality, with principal focus on *E.coli* or thermotolerant coliforms and chemical hazards of concern. Verification programmes will need to be undertaken regularly and the surveillance agency should support and approve local verification programmes.

In this situation, the surveillance agency will still be required to conduct additional analysis of the water quality, including assessments of a wider range of indicator organisms and chemicals, and undertake audits of the systems. In other cases, primary responsibility for verification may devolve to the surveillance agency as in the case of the technology generic water safety plans. Whether verification is performed by both the operator and surveillance agency or surveillance agency alone, the primary objective of verification is the performance of the water safety plan for individual supplies, with broader lesson-learning a secondary objective.

13.4.5 Progressive expansion

The use of the guides for the development of water safety plans is likely to require progressive expansion, although it can be expected to be quicker than for generic water safety plans as the requirements on supporting bodies may be more limited and greater use can be made of a range of audio-visual tools to support development. Guided water safety plans should be prepared and supported for all new supplies constructed and training provided to operators before they take up their responsibilities.

For existing supplies, the roll-out may be more progressive and could be integrated with the surveillance programme or other means of support to smaller water supplies. It is likely that progressive rolling-out of the programme can be achieved relatively quickly and should follow either administrative boundaries or supply types – for instance, small towns supplies first followed by increasingly smaller communities.