2. GUIDELINE REQUIREMENTS

The quality of drinking-water may be controlled through a combination of protection of water sources, control of treatment processes and management of the distribution and handling of water.

2.1. Guidelines for safe water

The Guidelines outline a preventive management Framework for Safe Drinking-water that comprise five key components:

1. Health based targets based on critical evaluation of health concerns (Chapter 3);
2. System assessment to determine whether the water supply chain (from source through treatment to the point of consumption) as a whole can deliver water of a quality that meets the above targets (Chapter 4.1);
3. Operational monitoring of the control measures in the supply chain which are of particular importance in securing drinking-water safety (Chapter 4.2);
4. Management plans documenting the system assessment and monitoring; and describing actions to be taken in normal operation and incident conditions; including upgrade and improvement documentation and communication (Chapter 4.3);
5. A system of independent surveillance that verifies that the above are operating properly (Chapter 5).

In support of the Framework for Safe Drinking-water, the guidelines provide a range of supporting information to assist in the development of Water Safety Plans, including microbial aspects (Chapter 7), chemical aspects (Chapter 8), radiological aspects (Chapter 9) and aesthetic aspects (Chapter 10). Figure 2.1 provides an overview of the interrelationship of the individual Chapters in the development of drinking-water safety.

There is a wide range of microbial and chemical constituents of drinking-water that can cause adverse human health effects. The detection of these constituents in both raw water and water delivered to consumers is often slow, complex and costly, which limits early warning capability and affordability. Reliance on water quality determination alone is insufficient to protect public health. As it is neither physically nor economically feasible to test for all drinking-water quality parameters equally, monitoring effort and resources should be carefully planned and directed at significant or key characteristics.

Some characteristics not related to health, such as those with significant aesthetic impacts, may also be of importance. Where water has unacceptable aesthetic characteristics (e.g. taste and odour), further investigation may be required to determine whether there are problems with significance for health.

The management plans developed by water suppliers are best termed a Water Safety Plan (WSP). A WSP comprises system assessment and design, operational monitoring, and management plans including documentation and communication. The plans should address all aspects of the water supply and focus on the control of water production, treatment and delivery of drinking-water. The control of microbial and chemical quality of drinking-water requires the development of WSPs which, when implemented, provide the basis for system protection and process control to ensure that numbers of pathogens and concentrations of chemical present a negligible risk to public health.
Many drinking-water supplies provide adequate, safe, drinking-water in the absence of formalised WSPs. A major benefit of developing and implementing a WSP for these supplies is the systematic and detailed assessment and prioritisation of hazards and the operational monitoring of barriers or control measures. This process ensures that safe water is continually supplied and that contingency plans are in place to respond to system failures or hazardous events.

Figure 2.1  Structure of the Guidelines for Drinking-water Quality
2.1.1. Health-based targets

Health-based targets provide the basis for the application of the Guidelines to all types of water supply. Constituents of drinking-water may cause adverse health effects from either single (e.g. microbial pathogens) or long-term exposures (e.g. non-threshold genotoxic chemicals) or longer-term or multiple exposures (in the case of chemicals which have a threshold of effect). Due to the range of constituents in water, their mode of action, and nature of fluctuations of concentrations in drinking-water, there are four principal types of health-based targets used as the final requirement for safety of drinking-water all based on Health outcome targets:

1. Health outcome targets: In some circumstances, especially where there is a measurable burden of disease, a significant proportion of which is water-related/water-borne, reducing exposure through drinking-water has the potential to appreciably reduce overall risks of disease. In such circumstances it is possible to establish a health-based target in terms of a quantifiable reduction in the overall level of disease. This is most applicable where adverse effects soon follow exposure and are readily and reliably monitored and where changes in exposure can also be monitored readily and reliably. This type of health outcome targets is therefore primarily applicable to some microbial hazards in developing countries and chemical hazards with clearly-defined health effects largely attributable to water (e.g. fluoride). In other circumstances health-based targets may be the basis for evaluation of results of quantitative risk assessment models. In these cases, health outcomes are estimated based on information concerning exposure and dose-response relationships. The results may be employed directly, as a basis to define water quality targets or provide the basis for development of performance and safety targets. Such an approach is currently of limited applicability in practice because of limitations in the available data and models. Specific attention must be given to short term fluctuations in water quality that may be sporadic in nature but may be determining for overall health risks or even the cause of outbreaks.

2. Water quality targets (WQTs) are established for individual drinking-water constituents which represent a health risk from long-term exposure and where fluctuations in concentration are small or occur over long periods. They are typically expressed as Guideline Values (concentrations) of the substances of concern.

3. Performance and safety targets: control measures employed as part of the drinking-water management system for constituents where short-term exposure represents a public health risk, or where large fluctuation in numbers or concentration occur over short periods of time with significant health implications. They are typically expressed in terms of required reductions of the substance of concern or effectiveness in preventing contamination.

4. Directly specified requirements: National regulatory agencies may establish targets for specific actions for smaller municipal and community water supplier. Such targets may identify specific permissable devices or process for given situations and generic drinking water system types.

Different health-based targets are concerned with controlling different types of hazards and different types of supply as outlined in table 3.2.
It is important that health-based targets, defined by the relevant health authority, are realistic under local operating conditions and are set to protect and improve public health.

Health-based targets provide information with which to evaluate the adequacy of existing installations, assist in identifying the level and type of inspection and analytical verifications appropriate and underpin the development of water safety plans.

The overall package of appropriate measures will vary between countries and localities. In order that they are relevant and supportive, representative scenarios should be developed, including description of assumptions, management options, control measures and indicator systems for verification where appropriate. These should be supported by general guidance regarding the identification of national, regional or local priorities and regarding progressive implementation that would be of special, but not unique, relevance to less industrially developed countries, thereby helping to ensure that best use is made of limited resources.

(Health-based Targets are considered in more detail in Chapter 3)

2.1.2. System assessment and design

Assessment of the drinking-water system is one of the components of a Water Safety Plan and is equally applicable to large utilities with piped distribution systems, and piped and non-piped community supplies, including handpumps, and individual domestic supplies. Assessment can be of existing infrastructure or of plans for new or upgrading supplies. As drinking-water quality varies throughout the system, the assessment should aim to determine whether the final quality of water delivered to the consumer is able to routinely meet established health-based targets. Understanding source quality and changes through the system requires expert input. The assessment of systems should be reviewed periodically.

The assessment needs to take into consideration the behaviour of selected constituents, or groups of constituents which may influence water quality. Having identified and documented actual and potential hazards, including potentially hazardous events and scenarios that may affect the water quality, the level of risk for each hazard can then be estimated and ranked, based on the likelihood and severity of the consequences.

Validation is an element of assessment. It is undertaken to ensure that the information supporting the plan is correct and is concerned with the assessment of the scientific and technical inputs into the WSP. Evidence to support the WSP can come from a wide variety of sources. This will include the scientific literature, trade associations, regulation and legislation departments, historical data, professional bodies, or supplier knowledge.

If the system is theoretically capable of meeting the health-based targets, the WSP is the management tool that will assist in actually meeting the health-based targets and should be developed following the steps outlined in the subsequent sections. If the system is unlikely to be capable of meeting the water quality targets, a programme of upgrading (which may include capital investment or training) should be initiated to ensure that the supply will meet the targets. In the interim every effort should be made to supply water of the highest achievable quality. Where a significant risk to public health exists additional measures may be appropriate.

(Assessment and Design is considered in more detail in Chapter 4.1, see also WHO, “upgrading water treatment”)

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2.1.3. Monitoring

Monitoring is the conduct of planned observations or measurements to assess whether the components of a water supply are operating properly. Control measures (CMs) are steps in the water supply at which contamination is prevented, reduced or eliminated. These include, for example, the plinth surrounding a well, and filters and disinfection infrastructure on piped systems. If collectively operating properly they would ensure that water quality targets are met.

It is possible to set limits for control measures, monitor those limits and take corrective action in response to a detected deviation before the water becomes unsafe. For example, the plinth surrounding a hand-pump is complete and not damaged, the turbidity of water following filtration is below a certain value, or chlorine residual at the far point of the distribution system is above agreed values.

The frequency of monitoring varies with the nature of the CM. For example, checking plinth integrity monthly-yearly, turbidity monitored on-line or very frequently, and disinfection residual at multiple points daily or continuous on-line. If monitoring shows that a limit has been exceeded, then there is the potential for water to be, or to become, unsafe. The objective is timely monitoring of CMs, with a logically based sampling plan, to prevent the delivery of potentially unsafe water.

In most cases, monitoring will be based on simple and rapid observations or tests, such as turbidity or structural integrity, rather than complex microbial or chemical tests. The complex tests are generally applied as part of validation and verification activities (discussed in 2.1.3 and below respectively) rather than in monitoring.

In order to have confidence that the chain of supply is not only operating properly, but to confirm that water quality is being maintained and achieved, it is necessary to carry out verification as outlined in section 2.2.

(The use of indicator bacteria in monitoring of water quality is discussed elsewhere in a WHO and OECD text on water testing indicators and monitoring is considered in more detail in Chapter 4.2)

2.1.4. Management plans, documentation and communication

The development of a management plan for the drinking-water supply is important to ensure the sustainable supply of safe drinking-water and are components of a Water Safety Plan.

A management plan outlines requirements in both normal operation and during ‘incidents’ where a loss of control of the system may occur. The management plan should also outline procedures and other supportive measures required to ensure optimal operation of the drinking-water system. Targets, assessment and monitoring as outlined in preceding sections provide information necessary to develop a management plan.

As the management of some aspects of the water supply system often falls outside the responsibility of a single agency, it is essential that the accountabilities and responsibilities of the various agencies involved be defined in order to coordinate their planning and management activities. Appropriate mechanisms and documentation should therefore be established for stakeholder commitment and involvement. This may include establishing working groups, committees or task forces, with appropriate representatives, and
development of partnership agreements, including signed memoranda of understanding (see also section 1.2).

Documentation of the WSP pertinent to all aspects of drinking-water quality management is essential. Documents should describe activities that are undertaken and how procedures are performed. They should also include detailed information on:
- assessment of the water supply system (including flow diagrams, potential hazards);
- control measures and monitoring plan
- routine operation and management procedures
- incident and emergency response plans
- supporting measures
  - training programs
  - research and development
  - procedures for evaluating results and reporting
  - performance evaluations, audits and reviewers
  - communication protocols
  - community consultation

Documentation and records systems should be kept as simple and focused as possible. The level of detail in the documentation of procedures should be sufficient to provide assurance of operational control when coupled with a suitably qualified and competent operator.

Mechanisms should be established to periodically review and, where necessary, revise documents to reflect changing circumstances. Documents should be assembled in a manner that will enable any necessary modifications to be made easily. A document control system should be developed to ensure that current versions are in use and obsolete documents are discarded.

Appropriate documentation and reporting of an incidents/emergencies should also be established. The organisation should learn as much as possible from an incident to improve preparedness and planning for future incidents. Review of an incident may indicate necessary amendments to existing protocols.

Effective communication to increase community awareness and knowledge of drinking-water quality issues and the various areas of responsibility is essential. Communication helps consumers to understand and contribute to decisions about the service provided by a drinking-water supplier or land-use constraints imposed in catchment areas. A thorough understanding of the diversity of views held by individuals or groups in the community is necessary to satisfy community expectations. (Documentation and Communication is considered in more detail in Section 4.5)

2.1.5. Surveillance

The surveillance agency is responsible for an independent (external) and periodic audit of all aspects of safety, whereas the water supplier is responsible at all times for regular quality control, and for monitoring and ensuring good operating practice.

Surveillance contributes to the protection of public health by promoting improvement of the quality, quantity, accessibility, affordability, and continuity of water supplies.
Surveillance requires a systematic programme of surveys that may include analysis, sanitary inspection, and auditing of WSPs.

Sanitary inspection should cover the whole of the water-supply system including sources, transmission infrastructure, treatment plants, storage reservoirs, and distribution systems.
Key characteristics related to health include:

- microbiological indicator organisms
- disinfectant residuals
- any health-related characteristic that can be reasonably expected to exceed the guideline value, even if occasionally, such as turbidity or particle count
- potential contaminants, including disinfection byproducts identified in chemical analysis (or assessment) of the water supply system and hazard identification.

The knowledge base on waterborne disease is underpinned by effective and ongoing public health surveillance. Public health surveillance of waterborne disease, undertaken by the health authority, provides a basis for policy decisions and the evaluation of the efficacy of water safety plans and the appropriateness of health based targets. It is an essential component of the verification of drinking water safety. In this context, safety can be assessed by routine surveillance and epidemiological investigations. Routine surveillance includes:

- ongoing monitoring of reportable diseases, many of which can be caused by waterborne pathogens;
- outbreak detection;
- long term trend analysis;
- geographic and demographic analysis; and
- feedback to water authorities.

Surveillance can be enhanced in a variety of ways to identify possible outbreaks in response to suspicion about unusual disease incidence or following deterioration of water quality. Epidemiological investigations include:

- outbreak investigations;
- intervention studies to evaluate treatment options; and
- case-control or cohort studies to evaluate the role of water as a risk factor in disease.

However, public health surveillance cannot be relied upon to provide information in a timely manner to enable short term operational response to control waterborne disease. Limitations include:

- outbreaks of non-reportable disease;
- time delay between exposure and illness;
- time delay between illness and reporting;
- low level of reporting; and
- difficulties in identifying causative pathogen and sources.

(Surveillance is considered in more detail in Chapter 5)

2.2 Verification

Drinking-water safety is secured by application of a Water Safety Plan (WSP) as described in Chapter 4. These are based on assessment of water quality from catchment to consumer and includes monitoring the efficiency of control measures using appropriately selected physico-chemical determinants and microorganisms. In addition to this “process monitoring”, a final verification of quality employing a “catch all” parameter is required.

Verification is the use of methods, procedures or tests in addition to those used in process monitoring to determine if the WSP is in compliance with the stated objectives outlined by the water quality targets and/or whether the WSP needs modification and revalidation.
2.2.1 Verification of Microbial Quality

For microbial quality, verification is likely to include some microbiological testing. In most cases will involve the analysis of faecal indicator micro-organisms, but in some countries this may include assessment of pathogen densities also.

Approaches to verification could include testing of source water, influents and effluents of unit processes, treatment end-point product and distribution systems. Conventional faecal indicator bacteria such as *E. coli* serves as the primary indicator for verification purposes, but at times and under certain circumstances it may be desirable to include more resistant microorganisms such as bacteriophages, bacterial spores. Such circumstances could include the use of source water known to be contaminated with enteric viruses and parasites or high levels of viral and parasitic diseases in the community. Verification may be undertaken by the supplier, surveillance agencies or a combination of the two. The minimum overall frequency of such testing should never be less than that outlined in Section 7.7.3.

Water quality varies rapidly and all systems are subject to occasional failure. Results of analytical testing must be interpreted taking this into account and absolute compliance is rarely achievable in the long term. Since incremental improvement and prioritizing action in systems presenting greatest overall risk to public health are important, there are advantages in adopting a grading scheme for the relative safety of supplies (See Chapter 4). More sophisticated grading schemes may be of particular use in community supplies where the frequency of testing is low and reliance on analytical results is particularly inappropriate. Such schemes will typically take account of both analytical findings and sanitary inspection through approaches such as those presented in Section 5.5.2.

2.2.2 Verification of chemical water quality

Assessment of the adequacy of the chemical quality of drinking-water relies on comparison of the results of water quality analysis with Guideline Values.

For most chemicals leading to adverse effects after long periods of exposures and arising from water sources, the quality of water in supply is determined by chemical analysis and compared directly with tables of drinking-water guidelines or national drinking-water standards derived from the Guidelines.

For additives, i.e., chemicals deriving primarily from materials and chemicals used in the production and distribution of drinking-water, emphasis is placed on the direct control of additives, rather than control of water in distribution. In controlling drinking-water additives, testing procedures typically assess the contribution of the additive to drinking-water and take account of variations over time in deriving a value which can be compared with the Guideline Values. (See Section 8.10)

Some hazardous chemicals that occur in drinking-water are of concern because of effects arising from single exposures or sequences of exposures over a short period. Where the concentration of the chemical of interest varies widely, even a series of analytical results may fail to fully identify and describe the public health risk, for example nitrate which is associated with methaemoglobinaemia in bottle fed infants. In controlling such hazards, attention must be given to both knowledge of causal factors such as fertiliser use in

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agriculture and trends in detected concentrations since these will indicate whether a significant problem may arise in the future. Other hazards may arise intermittently, often associated with seasonal activity or seasonal conditions. Once example is the occurrence of blooms of toxic cyanobacteria in surface water.
There are a number of general principles surrounding guideline values.

(a) A guideline value represents the concentration of a constituent that does not result in any significant risk to the health of the consumer over a lifetime of consumption. A few guidelines for chemical contaminants are set on the basis of particular high-risk groups, e.g. lead, nitrate, therefore these guidelines are also protective of the general population over a lifetime.

(b) When a guideline value is exceeded, it does not necessarily mean that this will result in adverse health effects, therefore deviations above the guideline values, either in the short or long term do not necessarily mean that the water is unsuitable for consumption. The amount by which, and the period for which, any guideline value can be exceeded without affecting public health depends upon the specific substance involved. However, it should be a signal:

(i) to investigate the cause with a view to taking remedial action as necessary;
(ii) to consult with, and seek advice from, the authority responsible for public health. It is recommended that when a guideline value is exceeded, the surveillance agency (usually the authority responsible for public health) should be consulted for advice on suitable action, taking into account the intake of the substance from sources other than drinking-water (for chemical constituents), the toxicity of the substance, the likelihood and nature of any adverse effects, the practicability of remedial measures, and similar factors.

The use of the Guidelines in emergencies is considered in more detail in section 6.3. Unless there are appropriate alternative supplies available, maintenance of adequate quantities of water is a high priority.

(c) Although the Guidelines describe a quality of water that is acceptable for lifelong consumption, the establishment of these Guidelines including guideline values should not be regarded as implying that the quality of drinking-water maybe degraded to the recommended level. Indeed, a continuous effort should be made to maintain drinking-water quality at the highest possible level.

(d) The principle of prevention of contamination is an important and fundamental part of maintaining high drinking-water quality.

(e) In the case of radioactive substances, screening values for gross alpha and gross beta activity are given, based on a reference level of dose.

It is important that recommended guideline values are both practical and feasible to implement as well as protective of public health. Guideline values are not normally set at concentrations lower than the detection limits achievable under routine laboratory operating conditions. Moreover, guideline values are established taking into account available techniques for controlling, removing or reducing the concentration of the contaminant to the desired level.

In some instances, provisional guideline values have been set for contaminants for which there is some uncertainty exists in available information, or calculated guideline values are not practically achievable.

2.3 Adapting Guidelines to National and Regional Circumstances
2.3.1 Laws, Regulations and Standards

National drinking-water laws and standards are intended to ensure that the consumer enjoys safe potable water, not to shut down deficient water supplies.

Effective control of drinking-water quality depends ideally on the existence of adequate legislation, standards, and codes, and their enforcement. The precise nature of the legislation in each country will depend on national, constitutional, and other considerations. It will generally outline the responsibility and authority of a number of agencies and describe the relationship between them as well as establish basic policy principles (e.g. water supplied for drinking-water should be safe). This would normally embody different approaches towards situations where formal responsibility for drinking-water quality is assigned to a defined entity and towards situations where community management prevails.

Legislation should make provision for the establishment and amendment of drinking-water quality standards and guidelines, as well as for the establishment of regulations for the development and protection of drinking-water sources, and the treatment, maintenance, and distribution of safe drinking-water.

Legislation should establish the legal functions and responsibilities of the water-supply agency and would generally specify that the water-supply agency is legally responsible at all times for the quality of the water sold and/or supplied to the consumer and for the proper supervision, inspection, maintenance, and safe operation of the water-supply system. It is the water-supply agency which actually provides water to the public - the “consumer” - usually on a commercial basis, and which should, as the supplier or vendor of the finished product, be legally responsible for its quality and safety from a public health point of view. In addition, the agency is responsible for providing continuous and effective quality assurance and quality control of water supplies, including inspection, supervision, preventive maintenance, routine testing of water quality, and remedial actions as required. However, the supplier is normally responsible for the quality of the water only up to a defined point in the distribution system, and not for any deterioration of water quality within the household as a result of poor plumbing or unsatisfactory storage tanks.

Legal and organizational arrangements aimed at ensuring compliance with the legislation, standards, or codes of practice for drinking-water quality will normally provide for the establishment of an independent surveillance agency as outlined in chapter 5. The legislation should define the duties, obligations, and powers of the water-surveillance agency. The surveillance agency should preferably be represented at national level, and should operate at central, provincial (departmental/regional), and local (district) levels. The surveillance agency should be given the necessary powers to administer and enforce laws, regulations, standards, and codes concerned with water quality. It should also be able to delegate those powers to other specified agencies such as municipal councils, local health departments, regional authorities, and qualified, government-authorized private testing services.

Its responsibilities should include the surveillance of water quality to ensure water delivered to the consumer, either through piped distribution systems or smaller non-piped water supplies, meets supply service standards, approving sources of drinking-water, and surveying the provision of drinking-water to the population as a whole. There needs to be a high level of knowledge, training and understanding in such an agency in order that water supply does not suffer from inappropriate regulatory action.
Implementation of programmes to provide safe drinking-water should not be delayed because of a lack of appropriate legislation. Even where legally binding guidelines or standards for drinking-water have yet to be promulgated it may be possible to encourage, and even enforce, the supply of safe drinking-water through educational efforts or commercial, contractual arrangements between consumer and supplier (e.g. based on civil law) or through interim measures including health, food or welfare legislation for example.

The drinking-water quality legislation may provide for interim standards, permitted deviations and exemptions as part of a national or regional policy, rather than as a result of local initiatives and self-interest. This can take the form of temporary exemptions for certain communities or areas for defined periods of time.

2.4.2 Setting National Standards

The authority to establish and revise drinking-water standards, codes of practice, and other technical regulations should be delegated to the appropriate government minister - preferably the minister of health - who is responsible for ensuring the quality of water supplies and the protection of public health. The authority to establish and enforce quality standards and regulations may be vested in a ministry other than that usually responsible for public and/or environmental health. Consideration should then be given to requiring that water-quality standards are promulgated only after approval by the public health or environmental health authority so as to ensure their conformity with health-protection principles.

The basic water legislation should not specify sampling frequencies but should give the administration the power to establish a list of parameters to be measured and the frequency and location of such measurements.

Standards and codes should specify the quality of the water to be supplied to the consumer, the practices to be followed in selecting and developing water sources and in treatment processes and distribution systems, and procedures for approving water systems in terms of water quality.

Setting national standards ideally involves both the quality of the water itself and the quality of service and ‘target setting’ as well as enforcement action and the quality of infrastructure and systems. For example, they should clearly define protection zones around water sources, minimum standard specifications and minimum standard operating systems, hygienic practice in construction and minimum standards for health protection. Some countries include these details in a ‘sanitary code’ or ‘code of good practice,’. It is preferable to include in regulations the requirement to consult with supply agencies and professional bodies, for example, since doing so makes more likely the effective implementation of drinking-water controls.

Where consecutive agencies manage water, for example a drinking-water wholesaler, municipal water-supply agency or a local water-distribution company, each agency should carry legal responsibility for the quality of the water arising from its actions.

In developing national drinking-water standards based on these guidelines, it will be necessary to take account of a variety of environmental, socio-cultural, economic, dietary, and other conditions affecting potential exposure. This may lead to national standards that differ appreciably from the guideline values. A programme based on modest but realistic goals
including fewer water-quality parameters of priority health concern but at attainable levels consistent with providing a reasonable degree of public health protection may achieve more than an over ambitious one, especially if targets are upgraded on a regular basis.

Short- and medium-term targets should be set so that the most significant risks to human health are controlled first.

The costs associated with water quality surveillance and control must also be taken into account in developing national standards. For guidance on these issues, the reader should refer to other more comprehensive publications (see Bibliography).

To ensure that standards are acceptable to consumers, communities served should be involved in the standards setting process, together with the major water users, the national regulations, adjusted as necessary, should be applicable to all water suppliers. Public health agencies are often closer to the community than those responsible for its water supply. At local level, they also interact with other sectors, e.g. education, and their combined action is essential to ensure active community involvement.

2.4.3 Other Regulatory Aspects

Other normative and regulatory functions belong to such ministries as those responsible for public works, housing, natural resources, or the environment, which are concerned with the design of water-supply and waste-disposal systems, equipment standards, plumbing codes and rules, water allocation, protection and conservation, and waste collection, treatment, and disposal.

2.4 Identifying priority water quality parameters

These Guidelines cover a large number of constituents in drinking-water in order to meet the varied needs of countries world-wide. There are a large number of constituents that may potentially occur in water. Generally, only very few will be of concern under any given circumstance. It is essential that the national regulatory agency and local water authorities determine the relevance of constituents in local drinking-water systems. This will ensure efforts and costs can be directed to those constituents that are of public health relevance.

Guidelines are established for potentially hazardous water constituents and provide a basis for assessing drinking-water quality. It is recognised that different parameters may require different priorities for management to ensure public health. In general the progression of priority is such that:

1. Ensure an adequate supply of microbiologically safe water
2. Manage key inorganic contaminants known to cause adverse health effects in humans
3. Maintain acceptability of drinking-water quality to prevent consumers seeking other potentially less microbiologically safe supplies
4. Address other chemical contaminants

Priority setting should be undertaken on the basis of a systematic assessment. The fundamental principle is that the assessment should be a collaborative effort. All relevant agencies should be involved, as much of the necessary information may be available in existing documentation from various sources, from previous studies or from a number of
agencies. It may require the formation of a broad based inter-agency committee including authorities such as health, water resources, water supply, environment, agriculture and geological/mining to establish a mechanism for sharing information and reaching consensus on drinking-water quality issues.

Sources of information that should be considered to determine priorities include catchment type (protected, unprotected), geology, topography, agricultural land use, industrial activities, and sanitary surveys, records of previous monitoring, inspections, and local, and community knowledge. The wider the range of data sources used, the more useful the results of the process will be. In many situations, authorities or consumers may have already identified a number of drinking-water quality problems, particularly where they cause obvious health effects or aesthetic problems. These existing problems would normally be assigned a high priority.

2.5.1 Assessing microbial priorities

The most common and widespread health risk associated with drinking-water is microbial contamination, the consequences of which are such that its control must always be of paramount importance. It may be impossible to attain the targets population-wide in the short or medium term and it is therefore necessary to ensure that priority is given to improving and developing water supplies to populations at greatest public health risk.

Microbial contamination of large systems has the potential to affect a large number of people through potentially large outbreaks of water-borne disease. Improvement of quality in such systems is therefore a priority. Nevertheless, the majority (around 80%) of the global population without access to improved water supply is rural. Similarly small and community supplies in most countries contribute disproportionately to overall water quality concerns. Identifying local and national priories should take factors such as these into account.

Health-based targets for microbial contaminants are discussed in section 3.2, and a comprehensive consideration of microbial aspects of water quality is considered in Chapter 7.
2.5.2 Assessing chemical priorities

The selection of chemicals for consideration in the Guidelines for Drinking-water Quality takes into account the frequency and concentration that the chemical is detected in drinking-water, and/or those for which member states have specifically requested guidance because of a range of concerns. Guideline values are developed for those chemicals considered to be potentially hazardous to human health and occur significantly at concentrations of concern for public health.

Not all of the chemicals with Guideline Values will be present in all water supplies or indeed all countries. If they do exist, they may not be found at levels of concern. Conversely, some chemicals without guideline values or not addressed in the Guidelines may nevertheless be of legitimate local concern under special circumstances.

Risk management efforts and resources should give priority to those chemicals in water systems that pose a risk to human health, or to those with significant aesthetic impacts.

Only a few chemicals have been shown to cause widespread actual health effects in humans as a consequence of exposure through drinking-water. These should be addressed in all circumstances in priority setting and include fluoride, arsenic, nitrate and lead. In some cases, assessment will indicate that no risk of significant exposure exists at national, regional or system level. However, the scale of health effects associated with these chemicals indicates that they should be considered under all circumstances.

Drinking-water may only be a minor contributor to the overall intake of a particular chemical, and controlling the levels in drinking-water, may have little impact on overall exposure for some chemicals, despite potentially considerable expense. Drinking-water risk management strategies should therefore not be considered in isolation from other potential sources of human exposure to chemicals in the environment.

This process of “short-listing” chemicals of concern may initially be a simple classification of high and low risk to identify broad issues. This may be refined using data from more detailed assessments and analysis, and may take into consideration rare events, variability, and uncertainty.

Guidance is provided in [cross-reference Assessing Priority Chemicals publication] on how to undertake prioritisation of chemicals in drinking-water. This guidance assists in taking account of:

- The probability of exposure (including the period of exposure) the consumer to the chemical,
- The concentration of that chemical that is likely to give rise to health effects (see also Chapter 8), and
- The evidence of health effects or exposure arising through drinking-water, as opposed to other sources and relative ease of control of the different sources of exposure.
Definitions of Terms

Drinking-water quality typically varies progressively from source to consumer. Increments may represent improvement (during treatment for example) or deterioration (through contamination or regrowth).

**Health-based targets** are an essential component of the drinking water safety framework which should be established by a senior authority responsible for health in consultation with others including water suppliers and affected communities. They should take account of the overall public health situation and contribution of drinking water quality to disease due to water-borne microbes and chemicals, as a part of overall water and health policy. They must also take account of the importance of ensuring access to water especially amongst the unserved. Health based targets may take four basic forms:

- **Health outcome targets**: for instance based on information on the impact of tested interventions on the health of real populations are ideal but rarely available. More common are health outcome targets based on defined levels of tolerable risk either absolute or fractions of total disease burden and are preferably based on epidemiological evidence of alternatively risk assessment studies.
- **Water quality targets**: the definition of acceptable water quality in relation to the concentration of specified hazards (specific chemicals or microbes);
- **Performance targets** (for example for removal of microbes, based on source water quality) or
- **Treatment targets**: direct specification of acceptable technologies for specific circumstances

A **water safety plan** comprises as a minimum the three essential actions which are the responsibility of the supplier in order that drinking water is safe. These are: a **system assessment**, **effective monitoring** and **management**.

The purpose of a **system assessment** is to determine whether a system has control measures in place which would ensure that the health-based targets are consistently met. It involves understanding the characteristics of the drinking water system, what hazards may arise, how these create risks and the processes and practices that affect drinking water quality.

**Validation** is an investigative activity to identify the effectiveness of a control measure. It is typically an intensive activity when a system is initially constructed or rehabilitated. It provides information on reliably achievable quality improvement or maintenance to be used in system assessment in preference to assumed values and also the operational criteria required to ensure that the control measure contributes to effective control of hazards.

**Monitoring** comprises operational monitoring and usually also verification

**Control measures** are those steps in supply which directly affect water quality and which collectively ensure that water consistently meets health-based targets. They are actions, activities and processes applied to prevent or minimise hazards from occurring or reduce them.

**Operational monitoring** should therefore address, as a minimum, all control measures as defined above. The performance of a control measure should be assessed at an appropriate periodicity - which may vary widely, e.g. from on line control of residual chlorine to quarterly verification of the integrity of the plinth surrounding a well.

Many actions are important in ensuring water safety but do not directly affect water quality and are therefore not control measures. These include for example staff training, research and development. These are referred to as **supporting programmes**.

In addition to operational monitoring of the performance of the individual components of a supply system it is necessary to undertake final ‘verification’ for reassurance that the system as a whole is operating safely. Verification may be undertaken by the supplier or by an independent authority or a combination of these, depending on the administrative regime in a given country. It can include testing for faecal indicator organisms, pathogens and hazardous chemicals.

Effective **Management** implies definition of requirements of normal operational situations and in incident situations where a loss of control of the system may occur. Management plans should be documented and outline procedures, supporting programmes and communication required to ensure safe operation of the system.

**Surveillance** is the continuous and vigilant public health assessment and overview of the safety and
Surveillance contributes to the protection of public health by promoting improvements of the quality, quantity, coverage affordability and continuity of water supplies. It takes a population-wide approach and is not restricted to piped or formal water supply systems. It should be undertaken by an entity independent of the supplier because of the conflict of interests that otherwise arise. It may be implemented through an audit-based approach, through assuming direct responsibility for all or some of verification testing and/or a combination of these.