

From Source to Tap

The multi-barrier approach to
safe drinking water

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Preface

This short position paper outlines the elements of a multi-barrier approach which would help ensure Canadian drinking water supplies are kept clean, safe and reliable for generations to come. The multi-barrier approach recognizes the inter-relationship of health and environmental issues, and encourages the integration of efforts to improve public health with those that also protect the natural environment.

This paper was prepared for a general audience (i.e., government, citizens, and interested stakeholders) to communicate the concept of a multi-barrier approach to drinking water protection. It builds on the experiences of Canadian jurisdictions and serves as a template for the strategic alignment of Canadian Water Quality Guidelines, best management practices, research and monitoring with an integrated source to tap approach to drinking water protection.

A comprehensive technical supporting document will be prepared in the coming months to provide detailed guidance to assist Canadian authorities in implementing the approach. This approach is not meant to be prescriptive but rather should be adapted to reflect the specific needs of a community with regards to providing safe drinking water.

These two documents will provide the basis for the on-going integration of health and environmental issues related to drinking water quality and should set the stage for increased collaboration and information-sharing among jurisdictions.

Acknowledgements

This paper was written as a collaborative effort between a working group of the Federal-Provincial-Territorial Committee on Drinking Water (which reports to the Federal-Provincial-Territorial Committee on Environmental and Occupational Health) and a working group of the Canadian Council of Ministers of Environment's Water Quality Task Group. Together, these groups represent the ministries of health and/or environment in every province and territory, as well as the departments of health and environment at the federal level.

For more information on water issues, please visit the following websites:

- Health Canada's water quality program: www.hc-sc.gc.ca/waterquality
- The Canadian Council of Ministers of Environment: www.ccme.ca

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Introduction

Recent outbreaks of waterborne disease in Walkerton, Ontario, and North Battleford, Saskatchewan, have heightened Canadian awareness of the fact that threats to water quality and quantity can have a profound impact on their health, the environment, and the economy.

In recognition of the above, it is imperative that drinking water be kept clean, safe and reliable. In order to do so, the components of the water supply system—from source protection to the treatment and distribution of drinking water to consumers—must be understood and managed as a whole.

The multi-barrier approach is...

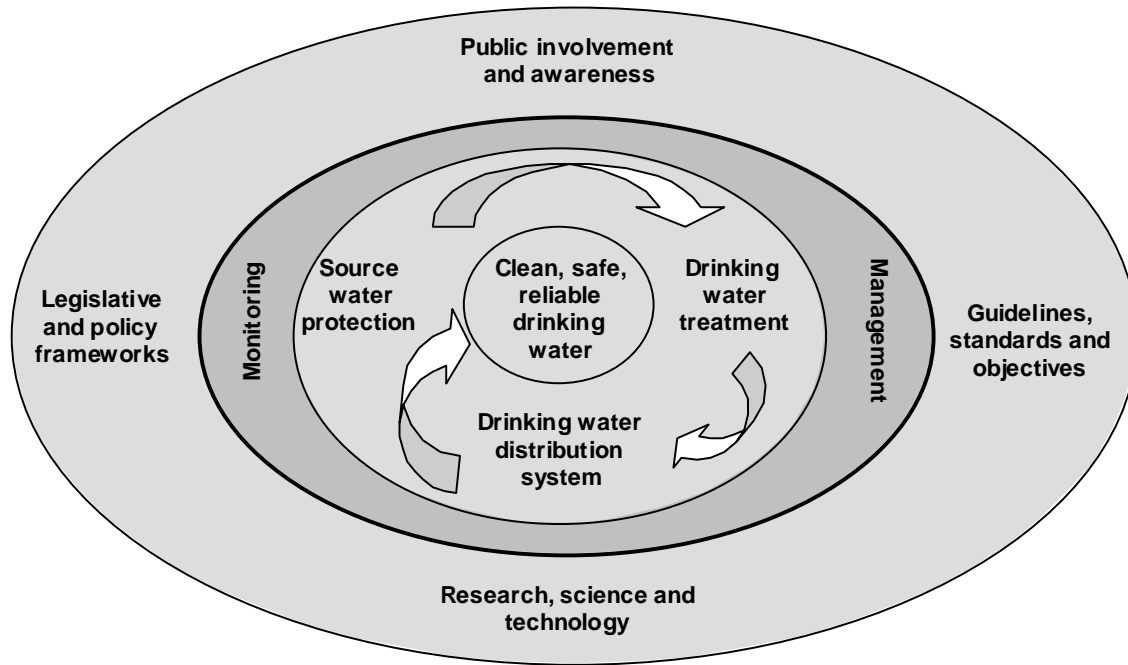
... an integrated system of procedures, processes and tools that collectively prevent or reduce the contamination of drinking water from source to tap in order to reduce risks to public health.

Even though no approach will guarantee 100 per cent protection all of the time, it has been demonstrated that the most effective way to manage drinking water systems is to implement a multi-barrier approach (see sidebar). The goal of this approach is to reduce the risk of contamination of the drinking water, and to increase the feasibility and effectiveness of remedial control or preventative options. As a safeguard, it is important for contingency plans to be in place to respond to incidents as they arise, and for redundancies to be built into the system wherever feasible.

Figure 1 (below) depicts a multi-barrier approach to safe drinking water that contains three major elements. These elements are source water protection, drinking water treatment, and the drinking water distribution system. These elements are addressed in an integrated manner by using a system of procedures and tools, such as:

- Water quality monitoring and management of water supplies from source to tap
- Legislative and policy frameworks
- Public involvement and awareness
- Guidelines, standards and objectives
- Research
- The development of science and technology solutions

Figure 1: The Multi-Barrier Approach



Under the multi-barrier approach, all potential control barriers are identified along with their limitations. Limitations could include risks of pathogens or contaminants passing through the barrier. Individually, the barriers may be inadequate in removing or preventing contamination of drinking water, but together they offer greater assurance that the water will be fit to drink. This approach also helps ensure the long-term sustainability of water supply systems.

This document briefly discusses each element of the approach as a separate section, starting with the components in the outer ring of Figure 1 and moving towards the centre.

Legislative & policy frameworks

Overarching legislative and policy frameworks outline who is responsible for each aspect of the drinking water system and their specific responsibilities. These frameworks should be reviewed and revised as necessary. It is important that policies at all levels related to the quality of drinking water support public health goals.

In Canada, all levels of government have some responsibility for drinking water, whether direct or indirect. Because drinking water is considered a natural resource, the legislative responsibility for providing safe drinking water to the public generally falls under provincial or territorial jurisdiction. Each province and territory has adopted legislation to protect its source waters and to establish requirements to provide clean, safe and reliable drinking water to its citizens. The federal

government is responsible for drinking water under federal jurisdiction, such as on-board common carriers (e.g. ships, airplanes), in First Nations communities (shared responsibility), in military and other federal facilities, and in national parks.

All levels of government have policies and agreements in place which affect the quality of drinking water, ranging from land-use agreements in watersheds; to water quality monitoring, inspections, and operator certification; to purchasing policies for materials which come into contact with drinking water throughout the treatment and distribution chain. The federal government plays a leadership role in developing guidelines and conducting research into health based issues in collaboration with its partners in other jurisdictions.

Because of the complexity of water quality issues, and because public health is at stake, it is critical for all members of a drinking water program—whether elected officials (including municipal), regulators, scientific staff, utility operators, or others—to have appropriate levels of knowledge and understanding of the impact of their activities and decisions on the quality of the water. To this end, access to continuing education in this field is important.

It is imperative that all stakeholders—including government departments, industry, private sector companies, non-governmental organizations, and the public—work cooperatively without losing sight of the ultimate goal: the protection of public health.

Public involvement & awareness

As mentioned above, it is essential to maintain appropriate levels of partnership and communication among stakeholders. In addition, the public has expectations of government transparency and the availability of public health information. It is important that the public be aware that they can report concerns to the appropriate authority.

Drinking water programs can involve the public and increase awareness of drinking water quality issues by:

- Informing the public about its impact on source water quality and about available pollution mitigation measures.
- Informing the public about health risks and providing educational materials on issues such as water disinfection, guidelines, conservation issues, and costs of providing service.
- Making monitoring results or summaries available and relaying information about what the authority is doing to address the risks.
- Issuing regular reports about drinking water systems, including improvements and areas that need further attention.

- Incorporating public consultations into decision-making processes that have an effect on public health, such as the development of new guidelines and regulations.

Providing additional information to owners of private drinking water systems (groundwater or surface water) is very important as they are responsible for regularly testing the quality of their water. Owners need to know what to do in case of microbiological or chemical contamination of their drinking water. Well-owners need to know how to maintain their wells and how to arrange to decommission wells that are no longer safe or needed.

All landowners should be encouraged through community awareness programs to implement best management practices such as protecting stream banks, providing buffer strips, and subsidizing tree planting and fencing works.

Guidelines, standards & objectives

Guidelines, standards and objectives provide utility managers and system owners with drinking water quality targets to strive to achieve within their systems. These targets are closely linked to monitoring results, as the latter tell utility managers and system owners how close they are to meeting targets and help them make decisions about their water system. In some jurisdictions, meeting these targets is mandatory.

Because raw water (including ground and surface waters) may support a variety of beneficial uses, such as aquatic life and agriculture, a number of guidelines¹ have been developed to protect these uses; these guidelines may help protect or enhance the quality of water used as a source for drinking water even though they are not specifically developed for this reason.

Since it is prudent to protect raw water supplies to ensure they are maintained as good sources of drinking water, these guidelines, and those developed for source waters, may be used as benchmarks to develop protection measures or corrective actions in watersheds and around wells and to measure the success of management practices. Watershed management encompasses both regulatory and non-regulatory strategies. The success of watershed management is based on agreed-upon, achievable, environmental quality objectives.

The development and implementation of source water quality guidelines not already in place would add a new dimension to source protection efforts and would complement the multi-barrier approach.

¹ The guideline values for other beneficial uses are posted on the website of the Canadian Council of Ministers of Environment (www.ccme.ca)
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For drinking water, the *Guidelines for Canadian Drinking Water Quality*² set out the basic parameters all water systems should strive for in order to deliver the cleanest, safest, and most reliable drinking water to consumers. These guidelines apply to water destined for human consumption and are developed for select physical, chemical, microbiological, and radiological parameters. The most important guidelines deal with microbiological quality and help ensure the risk of exposure to disease-causing organisms in drinking water is minimized.

Research, science & technology

Research, disease surveillance, and associated science and technology development serve core functions in the multi-barrier approach. Like other elements, all levels of government—in collaboration with universities, institutes, the water industry and other research networks—should be involved in this function. For example, there is a growing need to better integrate existing and future water quality monitoring (source and drinking) with waterborne disease surveillance. This integration is requisite to a full understanding of the relationship between source water quality, drinking water quality, and the ultimate health outcomes and benefits of a multi-barrier approach.

Management

The successful management of the drinking water supply from source to tap requires the commitment and co-operation of a wide array of stakeholders representing a variety of fields (e.g. health, environment, agriculture, industry, waste management). It also requires qualified personnel to run the various aspects of the system.

Standard operating procedures should be followed to ensure treatment and distribution systems are operating at optimum levels. Operator certification programs are one example, as these provide treatment plant and distribution system operators with appropriate levels of education, experience, and knowledge to allow them to competently operate the type of plant or system in which they are working.

That said, regardless of how well operated a drinking water system may be, unexpected incidents may occur. Contingency procedures are important as they are an effective means to cover off any number of incidents such as the loss of source water, major main breaks, vandalism, treatment plant failure, and deliberate chemical or microbiological contamination of the distribution system or reservoirs. Also important are management plans dealing with potential sources of contamination within the watershed area that may affect drinking water quality and emergency plans which include clear procedures for communicating with appropriate authorities and the public and for remediating the situation.

² All values and supporting documentation for the *Guidelines for Canadian Drinking Water Quality* are posted on Health Canada's water quality website (www.hc-sc.gc.ca/waterquality).
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Monitoring

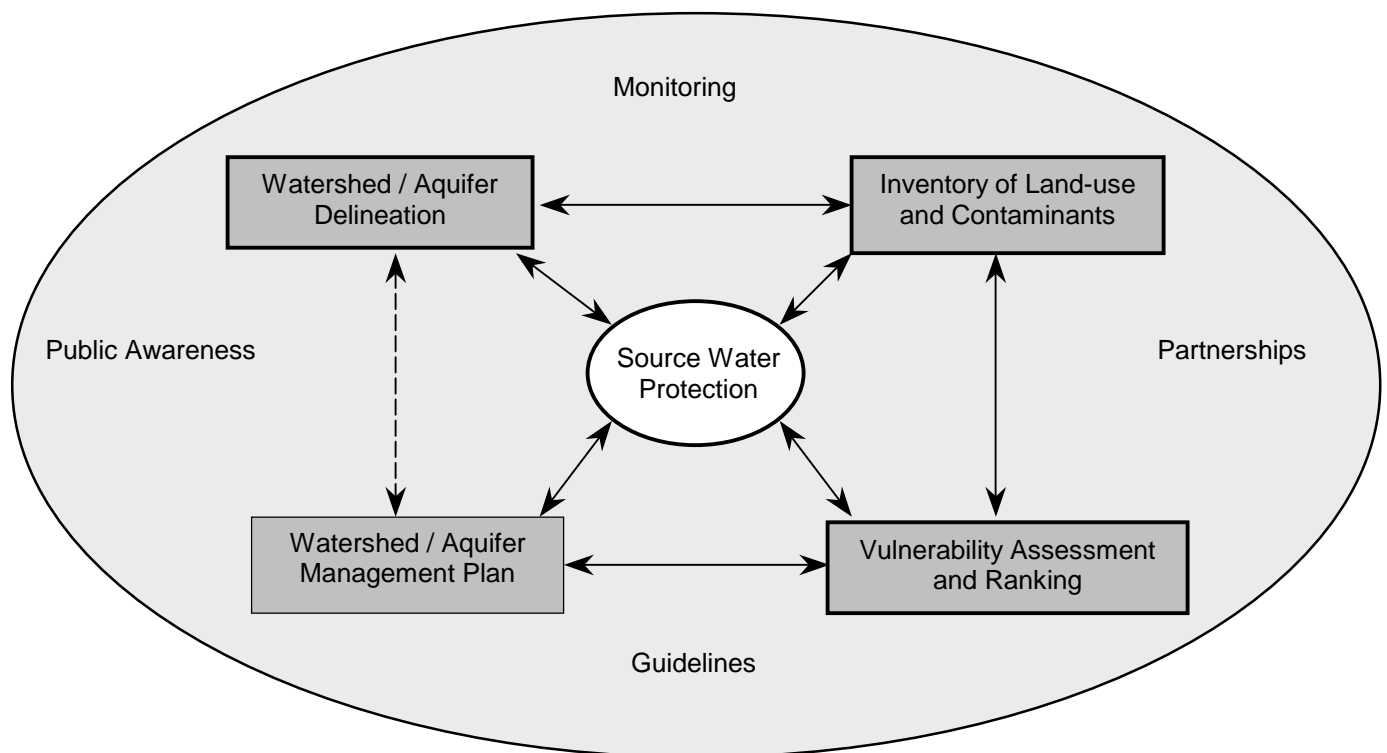
Water quality monitoring takes place throughout the system for a number of reasons. Use of accredited laboratories better ensures sampling test results are accurate.

Source water monitoring provides useful information on the water supply when selecting a source for drinking water. Data collected also influences the design of the treatment solution as it helps determine what type of treatment is needed. Once treatment is in place, on-going monitoring at the intake allows plant operators to modify treatment if water quality fluctuates. Monitoring in other parts of the treatment plant ensures treatment is working properly and that water leaving the plant is safe for human consumption. Compliance monitoring in the distribution system ensures any problems that arise can be dealt with as quickly and efficiently as possible, thus ensuring that water reaching consumers is clean, safe and reliable.

Source water protection & management

In any drinking water system, protecting source water is a critical step towards avoiding drinking water contamination. Source water protection (see Figure 2) based on watershed management involves a coordinated approach among stakeholders to develop short- and long-term plans to prevent, minimize, or control potential sources of pollution or enhance water quality where necessary. Source water includes surface waters, aquifers or groundwater recharge areas.

Figure 2: Components of Source Water Protection



In addition to reducing public health risks, effective watershed management minimizes operating costs and reduces the degree of drinking water treatment required, the quantity of chemicals used during treatment, and the creation of treatment by-products.

Drinking water treatment

Water treatment is key to both the multi-barrier approach and to protecting public health. The safety of Canada's drinking water is largely due to the introduction of disinfection at the start of the 20th century which eradicated serious and life-threatening diseases such as cholera and typhoid fever. That said, the safety of Canada's drinking water supplies is still challenged by microbiological pathogens and chemical substances found in source waters.

In order to safeguard public health, it is important that treatment systems be designed and constructed based on the results of source water assessments. They should be regularly reviewed and upgraded as necessary. Items to consider in designing effective treatment systems include the treatment processes required, treatment components (including redundancies), equipment design, chemicals used, treatment efficiency, and monitoring procedures. In assessing these components, potential hazards and their causes should be identified along with their associated health risks so priorities for risk management can be established.

Comprehensive, scientifically defensible, and achievable performance standards—based on recognized principles—are essential to ensuring the effectiveness and reliability of treatment technologies. Decision-makers must balance the need or desire to use the latest technologies against economic realities. Public health goals should be at the forefront of any treatment-related decision.

Criteria for the design and operation of the treatment system should be established to ensure public health protection objectives are met. Alternative approaches may be used if these have been demonstrated to be equivalent or better ways of achieving the same objectives.

Only certified products (such as chemicals, plumbing materials or water treatment devices) that meet recognized health-based performance standards should be used during treatment and distribution. For consumers who use treatment devices in their homes, the proper selection, operation and maintenance of off-the-shelf products is important to reducing the risk of illness.

Drinking water distribution systems

The distribution system is the final physical barrier in the multi-barrier approach. After treated drinking water leaves the treatment plant, its quality must be maintained throughout the distribution system. Diligence

is required on the part of the system operator to ensure sufficient disinfectant is present at all points throughout the distribution system in order to adequately protect public health. Because it has been shown that a significant number of outbreaks are caused by breakdowns in the distribution system, authorities are encouraged to put active cross-connection control programs in place.

Treated water reservoirs and distribution systems should be designed, constructed, reviewed and upgraded as necessary, to take the following into account: all local or provincial bylaws, best management practices, and regulations; prevention of access by wildlife and unauthorized personnel; system capacity; emergency water storage; contact time required for disinfection; minimization or elimination of dead ends, and cross-connection controls.

Future directions

The provision of drinking water is made up of multiple stages or processes. A multi-barrier approach to the protection, production and distribution of drinking water takes local conditions and challenges into account while offering an integrated system of procedures, processes and tools to reduce the risk of, or prevent, contamination. To be effective, its implementation requires the commitment and co-operation of a wide range of stakeholders—from elected officials and government employees, to members of the water industry and the public.

The successful use of similar approaches elsewhere in the world validates the endorsement of a national multi-barrier approach. In fact, in some international and provincial jurisdictions, similar approaches have already been incorporated into legislation to protect water supplies from source to tap.

A comprehensive supporting document, to be developed over the coming months, will provide more details about the multi-barrier approach and offer guidance to Canadian authorities on how it could be implemented in Canadian communities.