



CORE

Public Health Functions for BC

**Model Core Program Paper:
Water Quality**

BC Health Authorities

**Population Health and Wellness
BC Ministry of Health**

August 2007

This Model Core Program Paper was prepared by a working group consisting of representatives of the BC Ministry of Health and BC's health authorities.

This paper is based upon a review of evidence and best practice, and as such may include practices that are not currently implemented throughout the public health system in BC. This is to be expected, as the purpose of the Core Public Health Functions process—consistent with the quality improvement approach widely adopted in private and public sector organizations across Canada—is to put in place a performance improvement process to move the public health system in BC towards evidence-based best practice. Where warranted, health authorities will develop public performance improvement plans with feasible performance targets and will develop and implement performance improvement strategies that move them towards best practice in the program component areas identified in this Model Program Paper.

This Model Program Paper should be read in conjunction with the accompanying review of evidence and best practice.

Model Core Program Paper approved by:

Core Functions Steering Committee (September 2007)

Population Health and Wellness, BC Ministry of Health (September 2007)

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EXECUTIVE SUMMARY

This paper identifies the core elements that are provided by British Columbia health authorities in the delivery of drinking water and recreational water quality programs. It is intended, as part of the BC Core Functions in Public Health, to reflect evidence-based practice and to support continuous performance improvement.

A Working Group of representatives from the Ministry of Health, BC Centre for Disease Control and the health authorities worked together in the development of this paper. They agreed that the program goal is to ensure that appropriate safeguards for drinking water and recreational water quality are in place to protect the health of the public in British Columbia. The objectives are:

- To prevent ill health, injury and death.
- To increase public awareness and understanding in order to reduce exposure to water contaminants.
- To ensure compliance with provincially legislated standards and/or recognized guidelines.

The Working Group determined that the main program components for delivery of an effective health authority water quality program are:

- Prevention.
- Advocacy.
- Public Education and Involvement.
- Regulatory Compliance.
- Program Surveillance and Evaluation.

“Better” or “promising” practices are identified, based on the literature and exemplary practices widely recommended by experts in the field. Recommended practices include:

- Approving plans and issuing construction/operating permits for drinking water systems, and encouraging the multiple-barrier approach and continuous quality improvement.
- Ensuring operators of drinking water systems and recreational water facilities¹ are competent.
- Advocating for improved legislation, regulation, policies, plans and procedures to enhance drinking water and recreational water analysis, risk assessment, safety, research, collaboration and compliance; this is done through program evaluation, proposals and presentations to decision-makers at all levels.

¹ Unless a specific term is required, the following general terms will be used for recreational water: **Recreational water facilities** includes pools, hot tubs, whirlpools, wading and spray pools that are operated for public or commercial use. **Natural recreational waters** includes any marine, estuarine or fresh water body of water, as well as any artificially constructed flow-through impoundment using untreated natural waters.

- Facilitating multi-sectoral watershed partnerships to develop and coordinate mapping and planning, in order to enhance and maintain water quality.
- Encouraging drinking water suppliers and operators of recreational water facilities to address key water issues and to upgrade their water systems, as necessary.
- Promoting the use of educational resources to highlight the importance of water quality, the value of water treatment, challenges of local water issues and effective interventions to reduce potential adverse health effects and to highlight safety issues related to recreational water facilities and natural recreational waters.
- Developing inventories and conducting risk assessments on drinking water systems and recreational water facilities to assist in categorizing risk levels, prioritizing monitoring and inspection schedules and allocating staff and other resources.
- Conducting inspections and investigations for drinking water systems, and recreational water facilities, including: initial inspections, routine inspections (at a frequency determined by a risk assessment), complaint inspections and follow-up inspections (to ensure compliance with remedial action).
- Ensuring compliance using a progressive enforcement approach, which includes education, persuasion, negotiated goal-setting, warnings and enforcement measures.
- Evaluating programs and outcomes to assess the trends, priorities and effectiveness of water quality management practices and interventions.

Key success factors highlight a range of strategies that ensure the successful implementation of an effective water quality program. These include: strong support from the Board and management; allocation of sufficient resources; well-trained and competent staff; a well-developed information system; and clear mechanisms for reporting and accountability.

As well, the Working Group identified a number of common tools and practices, and recommended that the following initiatives be developed through a collaborative process to be established and organized by the Ministry of Health in 2007:

- A common risk assessment tool for use across the province.
- Standardized inspection reports and a unified approach to data measurement to facilitate comparative analysis and consistency in reporting requirements by the Provincial Health Officer and other provincial agencies.
- Development of supplemental information resources for water suppliers (e.g., on multi-barrier treatment approaches, monitoring disinfectant residuals, etc.).
- Strategies for assisting and monitoring small water systems (serving under 500 individuals).
- Other collaborative initiatives that would enhance water quality practices across the province.

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Indicators and benchmarks for water quality programs are presented for each of the program components to provide a basis for ongoing performance review and evaluation. The indicators represent the activity of the health authorities and their partners, as well as monitoring results; there are no indicators of health outcomes, as little evidence is available on the burden of illness in relation to water quality.

In summary, this core program paper is viewed as a starting point by the Working Group, taking into account a considerable body of evidence supporting effective practice. It is anticipated that as the program moves forward, there will be an increased ability to identify illnesses and risk of illness from water-borne pathogens, and thus provide a basis for enhanced analysis and planning to support continuous program improvement.

1.0 OVERVIEW/SETTING THE CONTEXT

As demonstrated in recent Canadian reports, public health needs to be better structured and resourced, in order to improve the health of the population. The Framework for Core Functions in Public Health is a component of that renewal in British Columbia. It defines and describes the core public health activities of a comprehensive public health system. This policy framework was accepted in 2005 by the Ministry of Health and the health authorities.

Implementation of core functions will establish a performance improvement process for public health, developed in collaboration between the Ministry of Health, the health authorities and the public health field. This process will result in greater consistency of public health services across the province, increased capacity and quality of public health services and improved health of the population. To ensure collaboration and feasibility of implementation, the oversight of the development of the performance improvement process is managed by a Provincial Steering Committee, with membership representing all health authorities and the ministry.

What are core programs? They are long-term programs representing public health services that health authorities provide in a renewed and modern public health system. Core programs are organized to improve health; they can be assessed ultimately in terms of improved health and well-being and/or reductions in disease, disability and injury. In total, 21 programs have been identified as “core programs,” of which water quality is but one. Many of the programs are interconnected and thus require collaboration and coordination between them.

In a “model core program paper,” each program will have clear goals, measurable objectives and an evidentiary base that shows it can improve people’s health and prevent disease, disability and/or injury. Programs will be supported through the identification of best practices and national and international benchmarks (where such benchmarks exist). Each paper will be informed by an evidence paper, other key documents related to the program area and by key expert input obtained through a working group with representatives from each health authority and the Ministry of Health.

The Provincial Steering Committee has indicated that an approved model core program paper constitutes a model of good practice, while recognizing it will need to be modified to meet local context and needs. The performance measures identified are appropriate indicators of program performance that could be used in a performance improvement plan. The model core program paper is a resource to health authorities that they can use to develop their core program through a performance improvement planning process. While health authorities must deliver all core programs, how each is provided is the responsibility of the health authority, as are the performance improvement targets they set for themselves.

It is envisioned that the performance improvement process will be implemented over several years. During that time the process will contribute to and benefit from related initiatives in public health infrastructure, health information and surveillance systems, workforce competence assessment and development and research and evaluation at the regional, provincial and national levels. Over time, these improvement processes and related activities will improve the quality

and strengthen the capacity of public health programs, and this in turn will contribute to improving the health of the population.

1.1 An Introduction to This Paper

This model core program paper for water quality is one element in an overall public health performance improvement strategy developed by the Ministry of Health in collaboration with provincial health authorities and experts in the field of water quality. It builds on previous work from a number of sources.

In March 2005, the Ministry of Health released a document entitled *A Framework for Core Functions in Public Health*. This document was prepared in consultation with representatives of health authorities and experts in the field of public health. It identifies the core programs that must be provided by health authorities, including water quality, and the public health strategies that can be used to implement these core programs. It provides an overall framework for the development of this document.

Other documents that have informed this paper include:

- *Evidence Review. Water Quality (Drinking Water)* (April 2007), prepared for the Ministry of Health, Population Health and Wellness.
- *Evidence Review. Water Quality (Recreational Water)* (April 2007), prepared for the Ministry of Health, Population Health and Wellness.

These reviews identify risk to human health from water-borne contamination in BC and discuss options and interventions for managing these risks.

A Working Group for Water Quality, formed of experts on water quality from the Ministry of Health, BC Centre for Disease Control and the health authorities, was formed in June 2006. The group provided guidance and direction in the development of the model core program paper during meetings in June 2006 and March 2007, as well as through regular telephone and e-mail discussions.

1.2 Introduction to Water Quality

Water system managers and public health officials are trusted by the public to ensure that both drinking water and recreational water are of acceptable quality. Although disease outbreaks from contaminated water are not common occurrences, when they do occur, a large population may be seriously affected.

1.2.1 Drinking Water

On a global scale, water-borne infectious diseases remain one of the great scourges of humanity. While much less common in Canada, water-borne disease remains a potentially serious problem that can only be kept at bay by a high degree of vigilance over the quality of drinking water, as the example of Walkerton brings to our attention (Ministry of Health [MOH], 2005).

Exposure to water-borne contaminants may cause enteric illnesses, with symptoms such as diarrhea, abdominal cramps, weight loss, vomiting, chills, headache and fever (Rowe, 1998). Deaths have occurred from *E. coli* 0157:H7 in inadequately treated drinking water (O'Connor, 2002). *Toxoplasmosis* can have serious effects on the fetus, including fetal death and certain nervous system malfunctions (Bowie et al., 1997). Overall, the magnitude of endemic illness derived from the ingestion of contaminated drinking water is difficult to estimate due to underreporting and the challenges of establishing a causal link between water consumption and illness (MOH, Population Health and Wellness [PHW], 2007a).

One way of assessing the possible level of illness associated with drinking water is to examine the number of reported gastrointestinal illnesses. BC has the “highest rate of intestinal illness of all Canadian provinces and the second oldest water system infrastructure” (Drinking Water Review Panel, 2002). Approximately 75 per cent of the BC population receives their supply of drinking water from surface sources such as creeks, rivers, lakes, streams and reservoirs, which are particularly vulnerable to contamination from animals, farming and other industries. The remaining 25 per cent of the population receive drinking water from wells. Surface water normally requires disinfection to remove or inactivate pathogens, and is treated when necessary to remove physical and chemical contaminants that pose a health risk or interfere with the disinfection process. Groundwater is normally of a higher quality and usually requires less treatment.

The categories of contaminants in drinking water that pose a major health risk are microbiological and chemical. Microbiological pathogens in drinking water can be divided into three types: bacteria, viruses and parasitic protozoa. Pathogens include the bacteria *Campylobacter* and *Escherichia coli* (*E. coli*) as well as the protozoa *Cryptosporidium parvum* and *Giardia lamblia* (Drinking Water Review Panel, 2002). Protozoa pose the greatest risk to human health from water-borne contamination in BC as they are difficult to measure or monitor in water, and are somewhat resistant to treatment by chlorine disinfection (Drinking Water Review Panel, 2002).

Chemical contamination of drinking water is generally considered of lower significance; however, the burden of illness from exposure to chemical contaminants has not been assessed (Drinking Water Review Panel, 2002). Chemical contaminants include arsenic, nitrates and disinfection by-products. Arsenic, a natural element that is considered a human carcinogen, can occur at levels that pose health risks; this has happened in several parts of BC (the Sunshine Coast, Gulf Islands and the central Interior). Several studies suggest that nitrates, which can be present in heavily-farmed areas, may be linked to stomach cancer, colon cancer and bladder cancer, as well as to methemoglobinemia in infants (Provincial Health Officer [PHO], 2001).

Research evidence in the area of effective interventions directly associated with preventing illness from water-borne pathogens is limited; however, there is substantial evidence related to the improvement and protection of water quality. Well-established drinking water programs have been in effect in North America for over 100 years. Similarly, the burden of disease from unsafe water is difficult to estimate. However, in spite of limited current research evidence, considerable expertise has developed in the field over the years, and national and international drinking water guidelines now provide strong examples for exemplary practices. The *Guidelines for Canadian*

Drinking Water Quality provide standards related to contaminant levels, treatment, and analytical considerations (Federal-Provincial-Territorial Committee on Drinking Water [CDW], 2006).

An additional challenge is presented by the large number of drinking water systems in some health authorities, ranging from small private wells to large municipal systems. In rural and less populated areas of the province, the number of water systems and their geographic distances are significant. Small drinking water systems (serving fewer than 500 individuals) pose particular challenges in ensuring effective monitoring and regulatory oversight.

1.2.2 Recreational Water

The management and safety of recreational water is also a public health issue. Recreational water includes both treated water such as swimming pools, spas, hot tubs, natural spring facilities and wading pools, as well as untreated waters such as coastal and freshwater beaches.² Treated public and semi-private pools and spas are regulated by provincial legislation, while private, residential water environments are not regulated.

Despite clearly defined regulations and practices for pools and spas, serious injuries and illnesses still occur. The most widely studied diseases caused by unsafe recreational water include bacteria-associated gastro-intestinal illness, although viral and protozoan pathogens have, since the early 1990s, gained attention as an area of potential concern. Microbial hazards in treated recreational water are largely mitigated by the use of disinfection and filtration. However, chlorine-resistant protozoa and bacteria, such as *Legionella*, pose management challenges for the safe maintenance of pools and spa water.

A common risk factor is improper maintenance of facilities. Hazards can occur from the failure of pool operators to maintain safe operating practices, as well as from inappropriate bather behaviour, which creates risk (MOH, PHW, 2007b). Cases of drowning and injury occur each year from unsafe behaviours.

The safety of pools and spas impacts a significant number of British Columbians. In 2004, there were 208 public and semi-private pools in the province with average annual usage of 172,357 visits for each indoor pool, and 21,803 per outdoor pool (British Columbia Recreation and Parks Association, 2004, as cited in MOH, PHW, 2007b). The total number of annual visits to pools in BC has been estimated to be close to 30 million, implying 6 to 7 visits per year per-capita (MOH, PHW, 2007b).

The hazards present in coastal and freshwater beaches are complex. As source control or pathogen removal is not viable, the most feasible health protection strategy is preventing exposure through prevention of contamination, closure of designated beach sites, and/or public communication about risk levels. As active management of undesignated beach sites is not

² Unless a specific term is required, the following general terms will be used for recreational water: **Recreational water facilities** includes pools, hot tubs, whirlpools, wading and spray pools that are operated for public or commercial use. **Natural recreational waters** includes any marine, estuarine or fresh water body of water, as well as any artificially constructed flow-through impoundment using untreated natural waters.

feasible, public education, interest group participation and collaboration with other branches of government can assist in addressing risks.

The federal *Guidelines for Canadian Recreational Water Quality* (Federal-Provincial Working Group on Recreational Water Quality, 1992) is used as the basis for management of beaches throughout BC.

1.2.3 Other

An important consideration in implementing an effective drinking water and recreational water program is the need for collaboration with multiple sectors and levels of government that have a role in preventing and reducing water contamination, particularly in coordinating effective policies and strategies to reduce adverse health impacts. Successful interventions often depend upon effective advocacy and cooperation with and among a number of stakeholders.

In addition to water quality, it is also important to consider water quantity, as water conservation measures are necessary in many areas of the province. The sustainability of water supplies requires attention in long-term planning, so that drinking water and recreational water needs are met effectively.

It should be noted that liquid waste management is not part of the water quality core program—it is addressed under the core public health program for community environmental health.

2.0 SCOPE AND AUTHORITY FOR THE WATER QUALITY PROGRAM

In order to implement water quality programs, there must be clarity on quality standards as well as the respective roles and responsibilities of the Ministry of Health, the BC Centre for Disease Control, the health authorities and other ministries and levels of government involved in water quality.

2.1 National/International Roles and Responsibilities

The World Health Organization has established the *Guidelines for Drinking-Water Quality* (2004), which are the international reference point for drinking water quality regulation and standard-setting.

Similarly, Health Canada has taken an active role in developing water quality standards for Canada. The *Guidelines for Canadian Drinking Water Quality* (CDW, 2006), along with related supporting documents, are the primary guidelines used by medical health officers, public health inspectors, other health personnel, consultants and water system operators across the country. A Federal/Provincial/Territorial (FPT) Committee on Drinking Water plays a coordinating role in developing and approving the *Guidelines for Canadian Drinking Water Quality*; the committee also develops documents to guide water system operators in establishing a multi-barrier approach for drinking water protection, and to guide regulators in carrying out their responsibilities.

The federal government has also developed *Guidelines for Canadian Recreational Water Quality* (Federal-Provincial Working Group on Recreational Water Quality, 1992), which are used as a standard in Canada by inspectors, regulators and operators of treated and untreated recreational water sites.

The federal government is also responsible for water quality on federal lands and First Nations reserve lands.

2.2 Provincial Roles and Responsibilities

2.2.1 Ministry of Health Roles and Responsibilities

The Ministry of Health has three major roles and responsibilities:

- Providing overall stewardship of the health care system in British Columbia, including conducting strategic interventions with health authorities to ensure continuation of the delivery of efficient, appropriate, equitable and effective health services to British Columbians.
- Working with the health authorities to provide accountability to government, the public and the recipients of health services.
- Providing resources to health authorities to enable them to deliver health-related services to British Columbians.

At a provincial level, the Health Protection Branch, Population Health and Wellness, Ministry of Health, is responsible for strategic policies and legislation related to water quality, specifically:

- Advising the Minister on water quality issues, policies and legislation.
- Providing technical expertise and informational materials to the health authorities and other government agencies.
- Coordinating the development of plans and strategies with health authorities to improve drinking water and recreational water quality practices.
- Facilitating collaborative partnerships with other provincial ministries, the federal government and federal/provincial forums in order to protect water sources.

2.2.2 Provincial Health Officer's Roles and Responsibilities

In addition, the Provincial Health Officer (PHO) has an oversight role both directly and through the mandated role of the drinking water officers, and is responsible for ensuring accountability in fulfilling the legal requirements for water quality. The PHO monitors the government and health authorities for compliance with legislation.

2.2.3 Provincial Health Services Authority Roles and Responsibilities

The Provincial Health Services Authority is responsible for ensuring that high-quality specialized services and programs are coordinated and delivered within the regional health authorities. With respect to water quality, its role includes surveillance, knowledge transfer, and research. The BC Centre for Disease Control has gradually evolved and developed its services in this area. It provides support, expertise, and laboratory analysis for the Ministry of Health and health authorities, including:

- Conducting research on BC water quality issues.
- Providing technical guidance.
- Leading quality assurance working groups.
- Conducting epidemiological surveys.
- Interpreting a portion of microbiological samples.
- Advising the Provincial Health Officer on microbiological laboratories.
- Developing public awareness materials on water issues.

2.2.4 Other Provincial Ministries/Agencies Roles and Responsibilities

The Ministry of Environment is responsible for the overall management of water resources and watersheds within the province. The Ministry of Community Services administers a federal/provincial infrastructure program that funds the building of water treatment plants. Other ministries, including the Ministry of Forests and Range, and the Ministry of Agriculture and Lands, also have a role in land-use planning and water protection. Interministry coordination of water resource planning has resulted in regional protocols to ensure good communication and collaboration among field staff of the various ministries. A Memorandum of Understanding

among provincial ministries and health authorities has clarified the commitment to a collaborative approach, and established regional drinking water teams coordinated by health authority drinking water officers.

The Environmental Operators Certification Program (EOCP) is the accrediting and certification body for operators of BC water distribution systems, water treatment systems, wastewater collection, wastewater treatment, small water systems and small wastewater systems. Training is provided through the British Columbia Water and Waste Association, as well as through a number of post-secondary institutions (e.g., British Columbia Institute of Technology, Thompson Rivers University, Camosun College) and the private sector.

2.3 Health Authority Roles and Responsibilities

The role of health authorities overall is to identify and assess the health needs in the region, to deliver health services (excluding physician services and BC Pharmacare) to British Columbians in an efficient, appropriate, equitable and effective manner, and to monitor and evaluate the services which it provides.

In the area of water quality, medical health officers in the health authorities are responsible for drinking water and recreational water quality. For drinking water, public health inspectors/professional engineers act under written delegation from the medical health officer. The recreational water program is carried out by public health inspectors/engineers who have direct authority from legislation (and under certain circumstances also act under written delegation from medical health officers). The role of the health authorities in water quality is to:

- Administer the *Drinking Water Protection Act* and the *Health Act*.
- Identify appropriate prevention, maintenance and quality improvement measures that are necessary for water suppliers/pool owners to undertake.
- Approve permits for drinking water systems, and permits for recreational water facilities.
- Advocate with government and community partners to increase the safety and protection of water supplies on a local and regional level.
- Educate the public to raise awareness about safe water and water quality risks.
- Conduct program surveillance and compliance measures, including monitoring, inspection, investigation and enforcement.

2.4 Local Roles and Responsibilities

Local governments have direct responsibility for the development and operation of their drinking water systems. In some cases, such as White Rock and Port Hardy, the municipality contracts with a private utility to operate the water system. In rural areas there are a variety of approaches, particularly with small water systems (serving under 500 individual during any 24-hour period); for example, a local improvement area may manage a small water system for the area; private

individuals (over 5 people) may incorporate as a “water user community”; private utilities may provide services to new subdivisions; or other agencies or individuals may be water suppliers. Local governments also have responsibility for municipally-operated swimming pools and wading pools. Other community groups and organizations may be involved in providing access to recreational water facilities. Public beaches are managed by local or regional authorities.

2.5 Legislation and Policy Direction

The overall legislative and policy direction for a water quality program is derived from:

- The following acts and regulations: *Health Act* (Sanitary Regulations; Swimming Pool, Spray Pool and Wading Pool Regulations), *Drinking Water Protection Act* (Drinking Water Protection Regulation); *Water Act* (Groundwater Protection Regulation) ; *Water Utility Act*; *Water Protection Act*; *Local Services Act* (Subdivision Regulations); *Environmental Management Act*, and *Forest and Range Practices Act*.
- *The Drinking Water Officer’s Guide* and the *Action Plan for Safe Drinking Water in British Columbia*.
- The *Guidelines for Canadian Drinking Water Quality* (the primary guideline for determining water quality in British Columbia).
- The *Guidelines for Canadian Recreational Water Quality*.
- *A Framework for Core Functions in Public Health* (March 2005).
- Specific policies/priorities that may be established by the health authority, the Ministry of Health or the provincial government.

3.0 PRINCIPLES

The following principles³ can guide the direction of policies, procedures and operating practices for the water quality program:

- The safety of drinking water is a public health issue.
- Collaboration with water suppliers, operators of recreational water facilities, municipalities, other provincial ministries and agencies, the federal government, non-government organizations and members of the public.
- Advocacy for effective water quality initiatives.
- A focus on prevention, protection and education.
- A culture of continuous quality improvement.
- Assessment of risks and response to community priorities in a timely manner.
- Enforcement of provincial legislation and regulations.
- Evaluation to support measurable, innovative and effective strategies.

4.0 GOALS AND OBJECTIVES

The goal of the drinking water and recreational water quality program is to ensure that appropriate safeguards for water quality are in place to protect the health of the public in British Columbia. The specific objectives for achieving this goal are:

- To prevent ill health, injury and death.
- To increase public awareness and understanding in order to reduce exposure to water contaminants.
- To ensure compliance with provincially legislated standards and/or recognized guidelines.

³ More specific principles related to safe drinking water may be found in the Cabinet-approved *Action Plan for Safe Drinking Water in British Columbia* (Ministry of Health, 2002).

5.0 MAIN COMPONENTS AND SUPPORTING EVIDENCE

5.1 Introduction

The major program components for a drinking and recreational water quality program are:

- Prevention.
- Advocacy.
- Public Education and Involvement.
- Regulatory Compliance.
- Program Surveillance and Evaluation.

Drinking water suppliers at the local level have the primary responsibility for supplying safe water to their communities. The operators of recreational facilities and managers of beach facilities have similar responsibilities with respect to water quality and safety features. The role of the health authorities is to ensure that water suppliers and pool owners comply with provincial legislation, that the public have notification about adverse beach water quality and that responsible parties (campsite owners, local or provincial governments) manage safety hazards at beaches. This role is carried out through the strategies described in the following sections under each of the program components.

5.2 Prevention

Prevention initiatives involve advising and informing water suppliers, other regulators, industries (e.g., logging, mining, waste management) and the public of effective practices and regulatory requirements. This includes:

Drinking Water:

- Receiving information from water suppliers and reviewing permit applications during the planning stages of new drinking water systems and upgrades to existing systems, encouraging implementation of a multi-barrier approach.
- Advocating with water suppliers to establish reliable, sustainable drinking water systems that will be appropriate in the long-term.
- Approving plans and issuing construction/operating permits for drinking water systems, encouraging continuous quality improvement.
- Ensuring that drinking water system operators are competent (i.e., that operators have the required legislated qualifications).

Recreational Water:

- Receiving and reviewing information from operators of recreational water facilities on planning new facilities and maintaining safe water quality.

- Approving plans and issuing operating permits.
- Ensuring that operators of recreational water facilities are competent (i.e., pool and spa operators, engineers and designers are encouraged to obtain appropriate training, including BC PoolSafe).

The literature strongly supports the use of a multi-barrier system as the key preventive approach for effectively managing drinking water quality (MOH, PHW, 2007a). Rather than rely on only one barrier or a fragmented approach, six potential stages of protective interventions should be utilized rather than relying on only one barrier or a fragmented approach. These stages are: source water protection, water treatment, the distribution system, ongoing monitoring, at-home strategies and public education. A failure at any one of these stages could result in negative health outcomes from water-borne disease (MOH, PHW, 2007a).

The United States Centers for Disease Control and Prevention reported that among the seven outbreaks associated with community water systems in 2000–2001, one (14.3 per cent) was caused by contaminated, untreated groundwater, one (14.3 per cent) was related to a treatment deficiency and four (57.1 per cent) were related to problems in the water distribution system (Blackburn, et al., 2004). A review of outbreaks in the United States between 1991 and 1998 reported 36 per cent associated with distribution system deficiencies, 19 per cent with inadequately treated water, 17 per cent with inadequately treated surface water, 17 per cent from undetermined causes, and 11 per cent from inadequate control of chemical feed (Craun, Nwachuku, Calderon, & Craun, 2002). Considering that distribution system problems accounted for 36 per cent, prevention measures should take into the account the research on BC water infrastructure, which demonstrates that the average age of many of the water systems is beyond their expected operating life (McGill University, 1996).

People play a critical role in many water treatment system failures. Many of the failures indicate inadequate training of operators, designers, managers, regulators and/or health professionals (Hrudey & Hrudey, 2004). Studies in the United States have indicated that the highest recreational water hazard is the deficiency in accreditation and knowledge of semi-private and spa operators in maintaining proper water chemistry. Wading pools were found to have the greatest source of recreational water quality infractions (Centers for Disease Control and Prevention, 2003).

5.3 Advocacy

In the area of water quality, advocacy includes:

Drinking Water:

- Advocating for improved legislation, regulations, policies, plans and procedures to enhance drinking water analysis, risk assessment, research, collaboration and compliance; this is done through program evaluation, proposals and presentations to decision-makers at all levels (industry, local, regional, provincial and federal).

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- Promoting the development and dissemination of risk information/education materials for drinking water suppliers by federal, provincial, local and industry-related agencies.
- Coordinating, with multi-sectoral watershed partners, a collaborative, proactive approach to planning and implementing watershed protection.
- Advocating for improved water source protection by water suppliers, other ministries, industrial and farming sectors in the region.
- Providing leadership and scientific expertise to urge drinking water suppliers to address key water issues such as safeguarding future supplies, and to upgrade their water systems as necessary (e.g., advocating for the amalgamation or elimination of non-financially viable small systems).
- Encouraging funding support for improved water quality.

Recreational Water:

- Advocating for improved legislation, regulations, policies, plans and procedures to enhance recreational water analysis, risk assessment, safety and research; this is done through program evaluation, proposals and presentations to decision-makers at all levels (industry, local, regional, provincial and federal).
- Promoting the development and dissemination of risk information/education materials for operators of recreational water facilities by federal, provincial, local and industry-related agencies.
- Advocating for improved water source protection by managers of beaches and owners of surrounding farms and industries.
- Providing leadership and scientific expertise to urge operators of recreational water facilities to address key water issues and upgrade their facilities as necessary.

As described in *A Framework for Core Functions in Public Health*, public health leaders at the regional and local level have an advocacy role on behalf of the public to provide advice to their communities on matters of public health, to report on the health of their communities, and to play a leadership role in initiatives that address the determinants of health in their communities (MOH, 2005).

As well, the World Health Organization's *Ottawa Charter on Health Promotion* (1986) highlights the importance of promoting healthy public policies, creating supportive environments, developing personal skills and strengthening community action in key public health areas.

5.4 Public Education and Involvement

Health authorities have a role in improving the level of public education, knowledge and involvement in water quality. This could include:

Drinking Water:

- Educating water suppliers about advisory, assessment, approval, inspection and investigation processes.
- Promoting public education resources and other tools highlighting the value of water, the importance of water treatment and how to deal with unsafe water.
- Targeting educational materials to specific drinking water quality issues that are of special concern to a neighbourhood, community or sector.
- Developing marketing campaigns, when necessary, to build public involvement and support for water quality interventions that may be required (in partnership, as appropriate, with the Ministry of Health, other health authorities and other sectors).
- Monitoring public advisories and notices issued by water suppliers, as well as working with them as they communicate drinking water risks and publicize steps that are necessary to minimize the risk.

Recreational Water:

- Educating operators of recreational water facilities about advisory, assessment, approval, inspection and investigation processes.
- Encouraging the use of educational resources (e.g., materials, websites, etc.) for operators of private pools, spas and wading pools, to ensure they are aware of risk factors, safeguards and effective maintenance procedures.
- Promoting public education resources on safety issues related to recreational water facilities and natural recreational waters.
- Monitoring public advisories and notices issued by managers of public beaches, as well as working with them as they communicate risks and publicize steps that are necessary to minimize the risk.

Public education and public involvement is repeatedly supported, both in the literature and guidelines of many jurisdictions, as an important element in effective community decision-making. The WHO explains that “experience has shown the necessity of recognizing the important roles of many different stakeholders in ensuring drinking water safety” (WHO, 1986). The Australian Guidelines note that decisions made by a drinking water supplier and the regulatory authorities must be aligned with the needs and expectations of consumers; “discussions should include the establishment of levels of service, costs, existing water quality problems, and the options for protection and improvement of drinking water quality, including constraints on land use and changes in treatment infrastructure” (Australian Government, 2004).

When water is unsafe, public information becomes a key factor in minimizing risk. Although compliance with boil water advisories is not consistently high, public information is considered to be a vital barrier to water-borne epidemics, as it reduces exposure to contaminated water by encouraging consumers to adopt precautionary behaviour during water quality emergencies (Casman, Fischhoff, Palmgren, Small, & Wu, 2000). The BC Provincial Health Officer has recommended that automatic boil water advisories be triggered when monitoring indicates elevated levels of certain parameters, and that established emergency plans define the processes involved (PHO, 2001).

5.5 Regulatory Compliance

Health authorities have a major role in ensuring compliance with provincially legislated standards for water quality, and beyond these standards, determining what constitutes acceptable levels and criteria for safe water in their region. Initiatives include:

Drinking Water:

- Developing inventories and conducting risk assessments on drinking water systems in order to analyze trends and needs, prioritize schedules for enforcing legislative compliance and assign program resources.
- Monitoring, assessing and interpreting regular reports and surveys provided by drinking water suppliers. In addition, there may be a direct role in testing and assessment as circumstances require (e.g., program audit purposes).
- Ensuring that operators of drinking water systems have appropriate processes in place to monitor their treatment train.
- Conducting inspections and investigations as follows:
 - Initial inspections, conducted during the planning stages of new or modified water systems.
 - Routine inspections of drinking water systems, conducted on a frequency rate determined by risk level (high-risk water systems will require higher frequency than low-risk systems). The drinking water officer should: assess compliance; review treatment methods and practices; review emergency response and contingency plans; review monitoring and other records; determine identifiable threats, deficiencies, cross-connection controls, risk-assessment ratings, status of continuous improvement plans, etc.
 - Complaint investigations conducted in a timely manner, when there is reason to suspect a problem (e.g., findings from routine inspections, laboratory reports, complaints, requests from other agencies, etc.), to assess threats and assemble evidence to take remedial action as appropriate.
 - Follow-up action targeted to ensure compliance with remedial action, which is necessary to address serious violations identified in inspections and investigations.

- Ensuring compliance:
 - Education, persuasion, negotiated collaborative goal-setting (within reasonable time-frames), remedial action and warnings.
 - Progressive enforcement as required, including: obtaining voluntary compliance, ticketing, issuing orders for public notice, closure and/or obtaining a court order (injunction).
 - In situations that pose an imminent risk, a court order (injunction) may be sought as an early remedy in the event that the water supplier does not voluntarily take the actions that the drinking water officer deems necessary.

Recreational Water:

- Monitoring, assessing and interpreting regular reports and surveys provided by operators of treated recreational water facilities.
- Testing and assessing the water quality of beaches, particularly during high-risk periods, or ensuring that such processes are otherwise in place.
- Conducting inspections and investigations as follows:
 - Initial inspections, conducted during the planning stages of new or modified recreational water facilities.
 - Routine inspections of recreational water facilities based on a frequency rate determined by risk levels.
 - Complaint investigations of recreational water facilities, conducted in a timely manner (e.g., findings from routine inspections, laboratory reports, complaints, requests from other agencies, etc.), to assess threats and assemble evidence to take remedial action as appropriate.
 - Follow-up action targeted to ensure compliance with remedial action, which is necessary to address serious violations identified in inspections and investigations.
- Ensuring compliance:
 - Education, persuasion, negotiated goal-setting (within reasonable time-frames), remedial action and warnings.
 - Progressive enforcement as required, including: obtaining voluntary compliance, ticketing, issuing orders for public notice, closure, and/or obtaining a court order (injunction).

Monitoring is highlighted in the literature as a fundamental need in ensuring that water quality is safe for consumption and for recreational uses. With respect to drinking water, continuous real-time monitoring through the measurement of turbidity has been employed in cities such as

Kamloops. After the cryptosporidiosis outbreak in Kamloops in 1996, the city added turbidity advisories. The action resulted in a reduced rate of enteric illness within the population. Also, testing of chemical and radiological parameters can be useful for assessing the health risks from drinking water (MOH, PHW, 2007a).

The Canadian, WHO, Australian and New Zealand guidelines recommend that risk assessment be used as a key feature in a preventive management framework for safe drinking water. For example, the WHO recommends:

a system-wide assessment of risk from catchment to consumer, and prioritization of risk; identification and monitoring of the most effective control points to reduce identified risks; and a system of independent surveillance that verifies that the above are operating properly (WHO, 2004).

The Canadian *From Source to Tap: Guidance on the Multi-Barrier Approach to Safe Drinking Water* (CDW & Canadian Council of Ministers of the Environment, 2004) emphasizes the multi-barrier approach as fundamental to an effective management system, along with a risk management process to identify hazards, assess risks, manage risks and communicate risks. New Zealand requires that water suppliers prepare Public Health Risk Management Plans for drinking water using: risk analysis, risk reduction, readiness, response (based on contingency planning) and recovery (return to normal with planning to reduce a recurrence (New Zealand Ministry of Health, 2005).

For recreational water, the WHO *Guidelines for Safe Recreational Water Environments* (Volumes 1 and 2) recommends four major types of compliance measures that comprise a comprehensive program including: regulations, guidelines and enforcement; technological and engineering measures; education and public involvement; and public health advice and interventions (MOH, PHW, 2007b). It is further noted that safe untreated recreational water can be “achieved via the coordination of national or provincial environmental legislation, provincial sanitation and sewer regulations, local building and urban design policies...All of these separate bodies ideally should work in conjunction with each other” (MOH, PHW, 2007b).

There is also evidence that “infrequent inspections (less than 3 per year) by health officials is not sufficient to ensure that pools are consistently compliant with regulations and that public health protection is not compromised” (MOH, PHW, 2007b). Similarly, the WHO’s minimum sampling recommendations are for fecal indicator sampling weekly at public pools and monthly at semi-public pools (WHO, 2000).

5.6 Program Surveillance and Evaluation

Surveillance assists in identifying trends and priorities in water quality practices, while evaluation enables assessment of program effectiveness. These activities include:

- Gathering, assessing and reporting statistical information to reflect long-term drinking water quality results and trends.
- Gathering, assessing and reporting recreational water quality patterns and trends.

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- Data sharing in support of advocacy initiatives with water suppliers/operators of recreational water facilities and with the public to improve and protect water quality.
- Evaluating the regulatory oversight program.
- Collaborating with other health authorities, the Ministry of Health, Provincial Health Officer and other groups as appropriate to establish consistent, congruent statistical indicators (i.e., well aligned datasets that are congruent but not necessarily identical, recognizing a range of goals and needs).

6.0 BEST PRACTICES

Often, there is no one “best practice” that is agreed upon; rather, there are practices that may have been successful in other settings and should be considered by health authorities. The terms “promising practices” or “better practices” are often preferred to reflect the evolving and developmental nature of performance improvement.

Some “promising practices” are recommended consistently by professional experts, and have already been identified in this paper, as follows:

Drinking Water:

- Approving plans and issuing construction/operating permits for drinking water systems, and encouraging the multiple-barrier approach and continuous quality improvement.
- Ensuring operators of drinking water systems are competent.
- Advocating for improved legislation, regulation, policies, plans and practices to enhance drinking water systems, research evidence, collaboration and compliance; this would be done through proposals and presentations to decision-makers at all levels.
- Facilitating multi-sectoral watershed partnerships to develop and coordinate mapping and planning.
- Encouraging drinking water suppliers to address key water issues and to upgrade their water systems, as necessary.
- Promoting the use of educational resources to highlight the importance of water quality, the value of water treatment, challenges of local water issues and effective interventions to reduce potential adverse health effects.
- Developing inventories and conducting risk assessments on drinking water systems to assist in categorizing risk levels, prioritizing monitoring and inspection schedules and allocating staff and other resources.
- Conducting inspections and investigations, including: initial inspections, routine inspections (at a frequency determined by a risk assessment), complaint inspections and follow-up inspections (to ensure compliance with remedial action).
- Ensuring compliance using a progressive enforcement approach, which includes education, persuasion, negotiated goal-setting, warnings and enforcement measures.
- Evaluating programs and outcomes to assess the trends, priorities and effectiveness of water quality management practices and interventions.

Recreational Water:

- Ensuring operators of recreational water facilities are competent.

- Advocating for improved legislation, regulation, policies, plans and practices to enhance recreational water facilities, research evidence, and compliance.
- Encouraging operators of recreational water facilities to address key water issues and to upgrade their facilities, as necessary.
- Promoting the use of educational resources to highlight safety issues related to recreational water facilities and natural recreational waters.
- Developing inventories and conducting risk assessment on recreational facilities to assist in categorizing risk levels, prioritizing schedules, and allocating staff and other resources.
- Conducting inspections and investigations, including: initial inspections, routine inspections (at a frequency determined by a risk assessment), complaint inspections and follow-up inspections (to ensure compliance with remedial action).
- Ensuring compliance using a progressive enforcement approach, which includes education, persuasion, negotiated goal-setting, warnings and enforcement measures.
- Evaluating programs and outcomes to assess the trends, priorities and effectiveness of water quality management practices and interventions.

The evidence reviews on water quality (referenced in section 1.1) reflect an absence of substantial evidence on drinking water interventions. Although national and international guidelines and standard technical and engineering controls may be considered exemplary practices, there are few specific evidence-based “best” practices available at this time. However, there are a number of emerging initiatives that appear to enhance the management of water quality. These include:

- Development of preventive water quality management frameworks utilizing a risk management system from source to tap (MOH, PHW, 2007a).
- The use of real-time monitoring of water treatment to provide the earliest warning of treatment failure so that actions can be immediately taken to protect consumers (MOH, PHW, 2007a).
- A commitment to research on drinking water quality and technical challenges to ensure response to future emerging pathogens, and the analysis of human immunity to pathogens (MOH, PHW, 2007a).

7.0 INDICATORS, BENCHMARKS AND PERFORMANCE TARGETS

7.1 Introduction

It is important to define what one means by the terms *indicators*, *benchmarks* and *performance targets*. An indicator is a measurement (usually numerical) of a factor that constitutes an important reflection of some aspect of a given program or service. Indicators need to be standardized in some manner so that they can be compared across different organizational entities such as health regions. Benchmarks are usually numerical representations. However, they are reflective of “best” practices. They represent performance that health authorities should strive to emulate. Benchmarks are determined by: reviewing the literature; reviewing the best practice experience in other jurisdictions; or by determining “consensus” opinion of leading experts and practitioners in the field. Performance targets are locally determined targets that represent a realistic and achievable improvement in performance for a local health authority.

This section presents a number of key indicators or performance measures for a water quality program. Suggested benchmarks can apply across the province, while other benchmarks may need to be modified to account for key variables such as the level of arsenic in different areas, geographic size or population density of the health authority. As there are several agencies (Ministry of Health, Health Protection Branch, Provincial Health Officer, and BC Centre for Disease Control) that have a role in monitoring and surveillance of water quality in addition to health authorities, it is recommended that the core program performance measures be consistent with other provincial measures and indicators on water quality.

One can develop indicators related to the inputs, activities, outputs and outcomes (immediate, intermediate or final) of each of the respective components of the water quality program. Thus, it is not necessary to only have outcome-related indicators and benchmarks. Furthermore, indicators need to be understood within a broader context. For example, a low per-capita cost for a specific function could reflect the efficiency and effectiveness of the function, or it could reflect a function that is under-resourced. It is recognized that water quality programs are complex; it may be difficult to link interventions with direct human health outcomes, particularly as initiatives involve multiple factors and multiple sectors, which all play a role in determining outcomes. In general, it is best to consider a number of indicators, taken together, before formulating a view on the performance in this area. Indicators and benchmarks work best as flags to indicate a variance from accepted norms and standards. Further investigation is usually required to determine the causes of any given variance from such norms or standards.

A health authority could determine its performance targets by assessing its current (and perhaps historical), level of performance; then, based on consideration of local factors (e.g., capacity, resources, new technology, staff training, etc.), it could establish a realistic performance target. This performance target would be consistent with the goal of performance improvement, but would be “doable” within a reasonable period of time. Initially, health authorities will set performance targets for a number of indicators. However, over time, and particularly if consistent data collection methods and definitions are applied, it would be realistic for health authorities to share information related to their targets and then develop a consensus approach to

determine provincial benchmarks for these indicators. In other words, locally developed performance targets, over time, could lead to the development of provincial benchmarks.

7.2 Indicators for the Water Quality Program

As there is an absence of information and knowledge linking water quality with health problems and illness, the indicators represent the activity of the health authorities and their partners, as well as water monitoring results; there are no indicators on health outcomes as little information is available on the burden of illness related to water quality. It is anticipated that as the program moves forward there will be an increased ability to identify adverse health effects and health risks from water-borne pathogens, and thus provide a basis for enhanced analysis and planning to support continuous program improvement.

The indicators listed below are considered to be interim indicators, as the Drinking Water Leadership Council plans to review the indicators on an annual basis.

Some of the indicators may not be under the control or influence of health authorities; nevertheless, it is important information for the health authorities to collect.

Those indicators and benchmarks for water quality programs that are under the control and influence of health authorities provide a basis for ongoing performance review and evaluation. In many cases, the baseline data will need to be established to provide a basis for future comparative analysis. In these cases, benchmarks are currently not available but will be determined over time between the Ministry of Health and the health authorities. In other instances, it may be more appropriate to establish local or regional performance targets.

7.3 Indicators for the Drinking Water Quality Program

Table 1: Drinking Water Quality Program Indicators (Outcome Indicators)

Indicator	Definition/Description	Benchmark
1.1 Adverse bacteriological monitoring results.	a) Percentage of systems with <i>E. coli</i> detected in the distribution system. b) Percentage of health authority population served by systems with <i>E. coli</i> detected in the distribution system.	No benchmarks available.
1.2 Adverse chemical constituents.	a) Number of health authority systems that provide drinking water containing: <ul style="list-style-type: none"> • Levels of arsenic or nitrate at levels that exceed the <i>Guidelines for Canadian Drinking Water Quality</i>. • Levels of disinfection by-products that exceed the <i>Guidelines for Canadian Drinking Water Quality</i>. b) Number of health authority systems that provide drinking water containing levels of arsenic above the “essentially negligible” health risk level.	No benchmarks available.

Table 2: Indicators of Drinking Water System Operations (Process Indicators)

Indicator	Definition/Description	Benchmark
2.1 Water system risk levels.	a) Percentage of water systems that are rated by the health authority as being: <ul style="list-style-type: none"> • High risk.* • Medium risk. • Low risk. b) Percentage of health authority population served by systems rated by the health authority as being: <ul style="list-style-type: none"> • High risk. • Medium risk. • Low risk. 	A risk assessment tool will be developed and verified by the Drinking Water Leadership Council.
2.2 Level of operator training.	a) Percentage of health authority water suppliers who have trained staff consistent with Environmental Operators Certification Program criteria. b) Percentage of small systems that have operators with training acceptable to the drinking water officer.	No benchmarks available
2.3 Microbial treatment.	a) Percentage of systems using surface or GUDI** sources that provide water treated to the following levels: <ul style="list-style-type: none"> • 4-log reduction of viruses. • 3-log reduction of <i>Giardia</i>. • 3-log reduction of <i>Cryptosporidium</i>. b) Percentage of health authority population served by systems using surface or GUDI sources that provide water treated to the following levels: <ul style="list-style-type: none"> • 4-log reduction of viruses. • 3-log reduction of <i>Giardia</i>. • 3-log reduction of <i>Cryptosporidium</i>. 	Further discussion and development of process-monitoring indicators will be undertaken by the Drinking Water Leadership Council to include measurement of turbidity and chlorine residuals.
2.4 Annual report to users.	Percentage of systems that provide an annual report to their users.	No benchmark available.
2.5 Responses to critical hazards.	a) Number of health authority systems with identified serious violations. b) Percentage of serious violations corrected within the allotted time period.	A list of serious violations is currently being drafted by the Drinking Water Leadership Council for use by the health authorities.

Notes:

* Risk in this context refers to the comparative, inherent risk of the water system as determined by the “Internet Risk Assessment Tool” developed by the Drinking Water Leadership Council. This tool’s primary purpose is to assist in assigning frequency of inspections/assessments of the water system, based on the comparative “risk” of the system and its components.

** GUDI: Groundwater Under the Direct Influence of surface water.

Table 3: Indicators of Drinking Water Regulatory Compliance (Process Indicators)

Indicator	Definition/Description	Benchmark
3.1 Patterns in health authority inspections, reviews, and reports on regulatory compliance of water systems.	a) Percentage of health authority water systems inspected/reviewed in accordance with the frequency established by a risk assessment. b) Health authority provides an annual public report that identifies non-compliance issues and related priority regulatory interventions. (Yes/No)	No benchmarks available. Yes

7.4 Indicators for the Recreational Water Quality Program

Table 4: Indicators of Recreational Water Facility Operations (Process Indicators)

Indicator	Definition/Description	Benchmark
4.1 Prevention policies/practices – treated recreational water facilities.	a) Percentage of facilities with an active system for monitoring and recording pool chemical parameters. b) Percentage of staff at each facility who have attended a pool operation and maintenance course. c) Percentage of facilities with written procedures on: <ul style="list-style-type: none"> • Incidents related to physical, chemical and biological/microbiological hazards. • Reporting of incidents. • Public complaints. • Fecal accidents. • Disease outbreak response. • Staff training. 	No benchmarks available.
4.2 Prevention policies/practices – untreated recreational water.	a) Percentage of public beaches meeting the recommended water sampling frequency. b) Percentage of public beaches with an active system for monitoring safety and sanitary conditions.	No benchmarks available.

Table 5: Indicators of Recreational Water Regulatory Compliance (Process Indicators)

Indicator	Definition/Description	Benchmark
5.1 Inspection/monitoring and level of treated recreational water quality.	a) Percentage of health authority facilities meeting the inspection frequency (defined by risk categorization). b) Percentage of facilities that are assessed as: <ul style="list-style-type: none"> • High risk.* • Medium risk. • Low risk. c) Percentage of serious violations corrected on follow-up inspections. d) Percentage of complaints followed up within designated response time. e) Health authority has a comprehensive, progressive enforcement guideline for treated water.	No benchmarks available.
5.2 Inspection/monitoring and level of untreated recreational water quality.	a) Percentage of samples exceeding the 30 day log mean average of 200 fecal coliforms per 100 ml. b) Number of health-related closure days for marine and freshwater recreational areas.	No benchmarks available.

Indicators for surveillance and monitoring have been included in the above tables.

8.0 EXTERNAL CAPACITY AND SUPPORT REQUIREMENTS

8.1 Key Success Factors/System Strategies

The previous sections outlined the main components and best practices that health authorities could include in their water quality program. However, it must be emphasized that successful implementation of an effective water quality program will also depend on having in place key success factors/system strategies. They include:

- Strong support from the Board and management of the health authorities regarding the importance of the water quality program in their regions and the role it plays in protecting the health of the population.
- Allocation by the health authorities of sufficient resources to meet the priority needs identified in their health improvement plans.
- Well-trained and competent staff with the necessary policies and equipment to carry out their work efficiently.
- An information system that provides staff with appropriate support, and provides management with the information it needs to drive good policy and decisions.
- High-quality and competent management of the water quality program, including monitoring of performance measures.
- Clear mechanisms of reporting and accountability to the health authority and external bodies.

The Working Group emphasized the importance of a number of additional strategies that are necessary to strengthen and develop the current management and oversight of water systems. These would aid in priority-setting by the health authorities and enhance the effectiveness of existing water quality programs. Collaborative development of these strategies would be required by health authorities and the Ministry of Health, with technical support from the BC Centre for Disease Control. It was recommended that the Ministry of Health, in consultation with health authorities, establish a collaborative process and develop a workplan in 2007 to address these strategies. These strategies include:

- A risk assessment tool, developed through ongoing research and best practices, for use across the province for risk assessment and prioritization. It would enable and support: analysis of key issues and trends; improved surveillance of health risks and health outcomes; comparisons across the province; and improved research, evaluation and planning on province-wide water systems.
- Consideration of the principles of the Hazard Analysis and Critical Control Point (HACCP) system, and adoption of “critical risk factors” in reviewing and assessing water quality and water systems.
- Standardized inspection reports, noting critical hazards, which could be used by health authorities for comparative purposes (including the sharing of information). It could also provide consistent information for the Health Protection Branch (Ministry of Health), the

Provincial Health Officer and the BC Centre for Disease Control, and enable improved analysis and research.

- A congruent, consistent approach to provincial measures and indicators to overcome current difficulties in overlapping data needs from several agencies (e.g., indicators need to be well-aligned [congruent] with the reporting requirements of the Provincial Health Officer, but not necessarily identical, recognizing there are different goals and needs of each agency).
- Supplemental information materials for water suppliers that articulates and clarifies expectations to assist them in planning improved source protection, water treatment and water distribution systems, including:
 - Multiple-barrier treatment for drinking water protection, including source water protection, water treatment, the distribution system, ongoing monitoring, at-home strategies and public education.
 - The importance of monitoring residuals and other indicators.
 - Corrosion issues and the need for corrosion control (water on the coast is very acidic).
 - Research evidence and other technical information related to BC water systems.⁴
- An education plan to strengthen the knowledge of health authority staff and water suppliers.
- Strategies for assisting and monitoring small water systems (serving fewer than 500 individuals), including Point of Entry and Point of Use systems.
- An enhanced collaborative decision-making mechanism that includes representatives from the health authorities and the Ministry of Health (as well as other experts), who have authority and accountability to build consensus and agreement on a number of water quality issues and projects (e.g., a consistent risk assessment tool).
- Clarification of the role of BC Centre of Disease Control, recognizing the need for centralized surveillance of water systems, water-borne illness outbreaks trends/patterns in water quality.

8.2 Intersectoral Collaboration and Integration/Coordination

As noted earlier, a water quality program does not exist in isolation and will not achieve optimum efficiency or effectiveness unless it works collaboratively with other key partners involved with water quality. Intersectoral collaboration and coordination on the local and regional levels is essential to ensuring the active participation of those that can contribute to water quality.

⁴ New drinking water legislation and regulations focus on outcomes, rather than prescriptive directives. Informational materials would support water suppliers in planning effective performance improvement measures.

On the provincial level, the key linkages are the Ministry of Health and the BC Centre for Disease Control. Other important linkages are with the Ministry of Environment and the Ministry of Community Services. At the regional and local level, it is essential to link with local government, local networks and agencies involved in water quality, and ensure that there are linkages between environmental issues and health concerns.

8.3 Assessment and Evaluation of the Water Quality Program

It will be important for health authorities to review their existing information and monitoring systems with respect to their ability to measure and monitor performance indicators. It will be necessary to:

- Establish new policies and procedures for some activities to ensure that the necessary records are kept.
- Acquire additional software to facilitate the process of recording and monitoring data (consistency and compatibility among the health authorities with respect to reporting systems are desirable).
- Plan regular survey or sampling projects, either individually or in partnership with other health authorities, or with the Ministry of Health, to assess performance on certain indicators. For example, the level of knowledge about water quality among the public will likely only be available by conducting a survey to gather baseline data, and repeating the survey at a later date to determine any differences over time. Such surveys may be conducted by each region or be developed as joint projects.

Health authorities will also need to consider the impact of program monitoring and evaluation on their staffing resources. Expertise will be needed in the fields of program monitoring, program analysis and program evaluation to ensure effective implementation and assessment of the core functions improvement process.

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APPENDIX 1: THE EVIDENCE BASE FOR A MODEL CORE PROGRAM FOR DRINKING WATER QUALITY

Taken from: *Evidence Review. Water Quality (Drinking Water)* (April 2007), prepared for the Ministry of Health, Population Health and Wellness.

This evidence review is split into two parts: Part I discusses the effectiveness of interventions to reduce illness from drinking water. Part II looks at best practices in the management of drinking water quality.

Part I

Providing clean drinking water is a top priority for public health officials. Water system managers and public health officials are trusted by the public to ensure that drinking water provided is free of disease-causing contaminants. Maximizing health protection in a cost-effective manner requires that public health decisions concerning drinking water management are based upon sound scientific data. This review was conducted to assess the evidence behind drinking water-related interventions.

A literature search on drinking water interventions was conducted using several online databases. To be included in the review, the studies had to focus on interventions and their effects on health. Several exclusion criteria were identified. Due to the small number of intervention studies identified in the database searches, the grey literature was also searched for drinking water interventions.

Using the multi-barrier approach to safe drinking water, six potential stages of interventions were identified, including source water protection, water treatment, distribution system, monitoring, at-home strategies and public education. A total of five intervention studies were retrieved and reviewed for this report. All intervention studies retrieved involved at-home treatment of tap water. The lack of data for the other intervention stages is discussed.

No published studies were identified that examined the effectiveness of interventions at the source water or distribution system stages. Although there are several mentions of interventions used to increase source water quality in the grey literature, pre- and post-intervention rates of enteric disease are not reported. Without this data, it is not possible to evaluate the effectiveness of these interventions for health protection.

Approximately three-quarters of British Columbians receive their supply of drinking water from surface sources such as creeks, rivers, lakes, streams and reservoirs. Due to the high vulnerability of surface water to contamination from wildlife and human activity, source water protection is an essential step in the provision of clean drinking water.

The outbreaks of *Cryptosporidium* in multiple cities in BC in 1996 resulted in the implementation of various water treatment interventions. For those cities that employed routine disinfection prior to the outbreaks, added measures succeeded in reducing rates of intestinal

disease. The additional actions taken included added filtration, issuance of turbidity advisories and increased disinfection.

Boil water advisories are often issued as part of the multi-barrier approach to safe drinking water when tap water has been shown to be unfit for consumption. However, the data indicates that public health officials should not rely on boil water advisories as a means of protecting the population against drinking water-related disease, as compliance with advisories can be low.

With the exception of at-home devices, there were no scientific studies found that examined the effectiveness of interventions on reducing enteric illness. There is some evidence from reviews of experience in BC communities that shows improvements to drinking water treatment is associated with a reduction in enteric illness. Despite the lack of formal studies identified in a search of recent literature, disinfection of drinking water is well accepted as an effective means of reducing water-borne illness. Although the grey literature may contain information that could assist public health officials in making drinking water-related decisions, this information is not easily obtainable. A coordinated effort is needed to ensure that further research on drinking water is available to interested individuals and agencies.

Part II

While much progress has been made in the quality of drinking water through water disinfection and other measures in developed countries, the risk of water-borne diseases remains a potentially serious problem that can only be kept a bay by a high degree of vigilance. Between 1980 and 2004, BC had one of the highest reported number of water-borne disease outbreaks in Canada: 29 confirmed outbreaks that affected tens of thousand of British Columbians.

This evidence review discusses the contaminants in BC water supplies that present health concerns. For example, the bacteria *Campylobacter* was responsible for at least four disease outbreaks since 1990; a number of other bacteria, such as *E. coli*, cyanobacteria and *Salmonella* are of concern because of their potential for serious impact on human health. The parasite *Giardia* was responsible for thirteen outbreaks since 1980, and the parasite *Cryptosporidium* for three outbreaks since 1995.

An overview of the status of drinking water legislation, standards and guidelines in leading international jurisdictions is provided to provide a context and comparison for safe drinking water practices in BC. The regulatory approaches adopted by the federal government as well the European Union, United Kingdom, United States, Australia and New Zealand, are discussed. Recently released recommendations and guidance from the World Health Organization and International Water Association highlight the importance of a management framework and comprehensive water safety planning, in particular risk assessment and risk management. The emphasis on these measures is reflected strongly in mandated legislation in New Zealand (currently in draft form), and guidelines recently established by Australia.

A multi-barrier approach is a fundamental “best practice”, which is repeatedly recommended in the literature by experts in the field, and reflected in recent years in the statutes and guidelines of many jurisdictions considered to be leaders in the field. A multi-barrier system is an integrated

approach to reducing the risk of contamination at key points in the water supply system, including: source water protection, treatment measures and the distribution system.

Source water protection involves: developing and implementing a watershed management plan that delineates controls to protect surface water and groundwater sources from contaminants; planning regulations to ensure the enforcement of protection from potentially polluting activities; and promoting awareness in the community about the importance of water quality.

Treatment measures include an adequate level of disinfection as an essential element for most water systems to achieve the necessary level of microbial risk reduction. In addition, depending on the quality of local supplies, filtration processes may also be required, particularly in areas that experience frequent turbidity in source waters. A range of treatment options and technologies are available to effectively reduce contaminants based on local requirements (although different technologies are noted, this review does not examine their relative effectiveness). A “best practice” for treatment has been developed by the Interior Health Region, as an expansion of recommendations in the *Guidelines for Canadian Drinking Water Quality*. Interior Health Region requires water suppliers to provide details on how they plan to achieve the “4-3-2-1-0” objectives as part of a continuing performance improvement plan. The “4-3-2-1-0” objectives are:

- 4 log (99.99 per cent) inactivation of viruses.
- 3 log (99.9 per cent) removal or inactivation of *Giardia* and *Cryptosporidium*.
- 2 treatment processes for surface water (e.g., filtration and disinfection).
- 1 NTU⁵ of turbidity, or less, with a target of 0.1 NTU.
- 0 total and fecal coliforms and *E. coli*.

Water transmission and distribution mains are a vital component of a safe water supply system. Good engineering practices are required with respect to pipe sizing, material, layout and burial. Cross-connection control and disinfection is also important to protect against contamination.

Operational monitoring is a key protective function for each stage of the multi-barrier system. As well, operator awareness and training is an important best practice in ensuring safe drinking water. As noted in the *Report of the Walkerton Inquiry* (O’Connor, 2002), “ultimately the safety of drinking water is protected by effective management systems and operating practices, run by skilled and well-trained staff.”

Additional preventive measures are highlighted in the literature and practices of other jurisdictions. These include the importance of public education and consultation, as well as strengthened research and evaluation strategies. A major challenge for many jurisdictions is safeguarding water supplies for small communities and rural populations. Approaches taken in other jurisdictions are noted for information and consideration.

⁵ nephelometric turbidity unit.

APPENDIX 2: THE EVIDENCE BASE FOR A MODEL CORE PROGRAM FOR RECREATIONAL WATER QUALITY

Taken from: *Evidence Review. Water Quality (Recreational Water)* (April 2007), prepared for the Ministry of Health, Population Health and Wellness.

Water is used in our society for many purposes, including transport, drinking, bathing, as a receptacle or transport mechanism for wastes, as a source of food, for therapeutic purposes, and—of particular relevance to this paper—recreation. Our society enjoys a high level of leisure time for recreational activities as never before, and the use of water in this role has evolved (i.e., jet skis, etc.) and increased. Along with the obvious and plentiful benefits that people derive in their use of water for recreation, are potential health hazards. As the types of recreation and features of the site where the activities occur are highly varied, so are the hazards and the associated risks. This evidence paper summarizes the body of literature and statistics available regarding these health hazards and their management as they pertain to British Columbia.

Section 1 provides definitions of the recreational water environments to be used herein. These distinctions are important as the literature reviewed, including various World Health Organization reports (1999; 2000; 2003), consistently present treated and untreated (natural) recreational water in separate papers, reports or books. The mandate of this paper, however, requires the combination of both diverse subject areas into one document. All efforts have been made to maintain clarity as to which environment is being discussed. Section 2 establishes the scope of this document and notes those topics that have been excluded.

Section 3 presents the evidence and literature regarding a variety of microbiological, chemical and physical hazards that may be encountered in recreational water environments. Microbiological and chemical hazards encountered in both environments are addressed separately, reflecting the treatment of these topics in the common literature. Statistics and findings presented for physical hazards apply or refer to pool/spa and beach environments unless otherwise indicated. Where possible, an effort has been made to estimate the burden of recreational water-related diseases, specific to the recreational water environment in BC.

Prüss-Üstün, Mathers, Corvalan, and Woodward (2003) define the burden of disease as a quantitative figure that represents the amount of disease (or the "health gap") at a defined population level. The standard measure used by the WHO to represent the burden is the disability-adjusted life-year (DALY) (Prüss-Üstün et al., 2003; Kay, Prüss, & Corvalan, 2000); however, data and time constraints prevented the preparation of BC-specific DALY estimates for this paper. Where possible and nationally relevant, estimates on DALY from other sources for recreational water incidents or diseases have been included. Otherwise, the burden of disease is reported as cases, incidence rates or economic costs, or qualitatively as ranges from negligible to high. For some hazards, the estimation of the recreational water burden of disease was not possible due to prohibitive uncertainty regarding the evidence of an exposure-risk relationship in a recreational water environment (Kay et al. 2000; Prüss & Havelaar, 2001).

Section 4 is a point form, tabular summary of the potential health hazards, contributing factors, and options that have been identified in the literature as being effective in preventing or reducing the possibility of a negative outcome. The mitigation options in this table are comprised of standards, suggestions for research, technical options and public awareness campaigns, among other risk management strategies.

Section 5 presents programs and interventions that draw upon or are comprised of mitigation options highlighted in Section 4. A significant portion of this section refers to the comprehensive recreational water management documents recently published by the World Health Organization and the United States Environmental Protection Agency. Where available, BC-specific examples are highlighted and comparisons are made with respect to the WHO's suggestions. Given the breadth of the topic, not all management aspects are addressed. Additional information on any of the specific topics can be found within the documents and papers cited in the reference section of this review.

APPENDIX 3: PROGRAM SCHEMATIC – MODEL CORE PROGRAM FOR WATER QUALITY

Objectives: To prevent ill health, injury and death.
 To increase public awareness and understanding, in order to reduce exposure to water contaminants.
 To ensure compliance with provincially legislated standards and/or recognized guidelines.

Main Components	Implementation Objectives (Best Practices)	Outputs	Linking Constructs	Short-term Outcomes	Long-term Outcomes
<p>Prevention</p>	<p>Drinking Water</p> <ul style="list-style-type: none"> • Receive information from water suppliers and review permit applications during the planning stages of new drinking water systems and upgrades to existing systems, encouraging implementation of a multi-barrier system. • Advocate with water suppliers to establish reliable, sustainable drinking water systems that will be appropriate in the long-term. • Approve plans and issue construction/operating permits for drinking water systems, encouraging continuous quality improvement plans. • Ensure that drinking water system operators are competent (i.e., that operators have the required legislated qualifications). <p>Recreational Water</p> <ul style="list-style-type: none"> • Receive and review information from operators of recreational water facilities on planning new facilities and maintaining safe water quality. • Approve plans and issue operating permits. • Ensure that operators of recreational water facilities are competent (i.e., pool and spa operators, engineers and designers are encouraged to obtain appropriate training, including BCPoolSafe). 	<ul style="list-style-type: none"> • Meetings with water suppliers/communities. • Application reviews. • Approved plans. 	<ul style="list-style-type: none"> • Implementation of plans. • Increased willingness to implement multi-barrier approach and continuous quality improvement plans. 	<ul style="list-style-type: none"> • Increased adoption of multi-barrier approach and continuous quality improvement plans. 	<p>Improved safeguards to protect water quality in BC</p>

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Main Components	Implementation Objectives (Best Practices)	Outputs	Linking Constructs	Short-term Outcomes	Long-term Outcomes
Advocacy	<p>Drinking Water</p> <ul style="list-style-type: none"> • Advocate for improved legislation, regulations, policies, plans and procedures to enhance drinking water analysis, risk assessment, research, collaboration and compliance. • Promote development and dissemination of risk information/education materials for drinking water providers, by federal, provincial, local and industry-related agencies. • Coordinate, with multi-sectoral watershed partners, a collaborative, proactive approach to planning and implementing watershed protection. • Advocate for improved water source protection by water supplies, other ministries, industrial and farming sectors in the region. • Provide leadership and scientific expertise to urge drinking water suppliers to address key water issues and to upgrade their water systems as necessary. • Encourage funding support for improved water quality. <p>Recreational Water</p> <ul style="list-style-type: none"> • Advocate for improved legislation, regulations, policies, plans and procedures to enhance recreational water analysis, risk assessment, safety and research. • Promote the development and dissemination of risk information/education materials by federal, provincial, local and industry-related agencies. • Advocate for improved water source protection by managers of beaches and owners of surrounding farms and industries. • Provide leadership and scientific expertise to urge operators of recreational water facilities to address key water issues and upgrade their facilities as necessary. 	<ul style="list-style-type: none"> • Proactive proposals. • Presentations. • Meetings with regional/provincial partners, and local governments. 	<ul style="list-style-type: none"> • Increased ability to address local water issues. • Increased coordination among partners. 	<ul style="list-style-type: none"> • Improved plans to upgrade local water quality. • Enhanced source water protection. 	

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Main Components	Implementation Objectives (Best Practices)	Outputs	Linking Constructs	Short-term Outcomes	Long-term Outcomes
Public Education and Involvement	<p>Drinking Water</p> <ul style="list-style-type: none"> Educate water suppliers about advisory, assessment, approval, inspection and investigation processes. Promote public education resources and other tools highlighting the value of water, the importance of water treatment and how to deal with unsafe water. Target educational materials to specific drinking water quality issues that are of special concern to a neighbourhood, community or sector. Develop marketing campaigns, when necessary, to build public involvement and support for water quality interventions that may be required. Monitor public advisories and notices issued by water suppliers, as well as working with them as they communicate drinking water risks and publicize steps that are necessary to minimize the risk. <p>Recreational Water</p> <ul style="list-style-type: none"> Educate operators of recreational water facilities about advisory, assessment, approval, inspection and investigation processes. Encourage the use of educational resources for operators of private pools, spas, and wading pools, to ensure they are aware of risk factors, safeguards and effective maintenance procedures. Promote public education resources on safety issues related to recreational water facilities and natural recreational waters. Monitor public advisories and notices issued by managers of public beaches, as well as working with them as they communicate risks and publicize steps that are necessary to minimize the risk. 	<ul style="list-style-type: none"> Information and educational materials. Education/training meetings. Public service announcements. 	<ul style="list-style-type: none"> Increased knowledge about local water quality issues and needs. Increased willingness to engage in effective action for improving water quality. 	<ul style="list-style-type: none"> Increased public awareness and support for effective water quality initiatives. 	

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Main Components	Implementation Objectives (Best Practices)	Outputs	Linking Constructs	Short-term Outcomes	Long-term Outcomes
Regulatory Compliance	<p>Drinking Water</p> <ul style="list-style-type: none"> Develop inventories and conduct risk assessments on drinking water systems in order to analyze trends and needs, prioritize schedules for enforcing legislative compliance and assign program resources. Monitor, assess and interpret regular reports and surveys provided by drinking water suppliers. Ensure that operators of drinking water systems have appropriate processes in place to monitor their treatment train. Conduct inspections and investigations for drinking water systems: initial inspections; routine inspections (at a frequency based on risk level); complaint investigations (in a timely manner); follow-up inspections (to ensure compliance with remedial action). Ensure compliance through: education; persuasion; negotiated goal-setting, remedial action, warnings and enforcement measures. <p>Recreational Water</p> <ul style="list-style-type: none"> Monitor, assess and interpret regular reports and surveys provided by operators of treated recreational water facilities. Test and assess the water quality of beaches, particularly during high-risk periods, or ensure that such processes are otherwise in place. Conduct inspections and investigations for recreational water facilities: initial inspections; routine inspections (at a frequency based on risk level); complaint investigations (in a timely manner); follow-up inspections (to ensure compliance with remedial action). Ensure compliance through: education; persuasion; negotiated goal-setting, remedial action, warnings and enforcement measures. 	<ul style="list-style-type: none"> Inventories. Risk assessments. Monitoring, inspections, and investigations based on risk level. Compliance and enforcement actions as necessary. 	<ul style="list-style-type: none"> Improved responsiveness to high risk water supplies. 	<ul style="list-style-type: none"> Timely response to high risk water issues. Effective correction action plans to ensure compliance. 	Improved population health
Program Surveillance and Evaluation	<ul style="list-style-type: none"> Gather, assess and report statistical information to reflect long-term drinking water quality results and trends. Gather, assess and report recreational water quality patterns and trends. Evaluate the regulatory oversight program. Collaborate with other health authorities, the Ministry of Health, Provincial Health Officer and other groups as appropriate to establish consistent, congruent statistical indicators. Data sharing in support of advocacy initiatives with water suppliers/pool operators and with the public to improve and protect water quality 	<ul style="list-style-type: none"> Remedial measures identified/implemented. Analysis of water quality trends. Evaluation framework. 	Analysis and assessment of programs, trends.	Improved decision-making to enhance program effectiveness.	