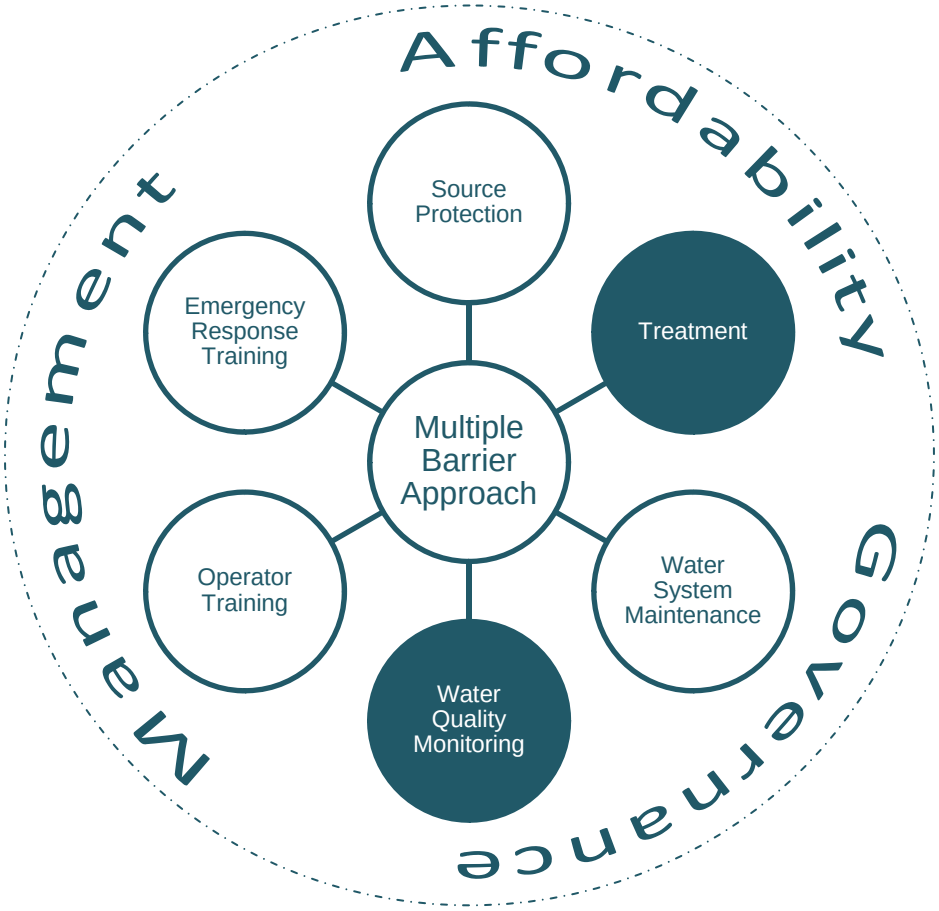
COMPREHENSIVE DRINKING WATER SOURCE-TO-TAP ASSESSMENT GUIDELINE

MODULE 5
AUDIT WATER QUALITY AND AVAILABILITY



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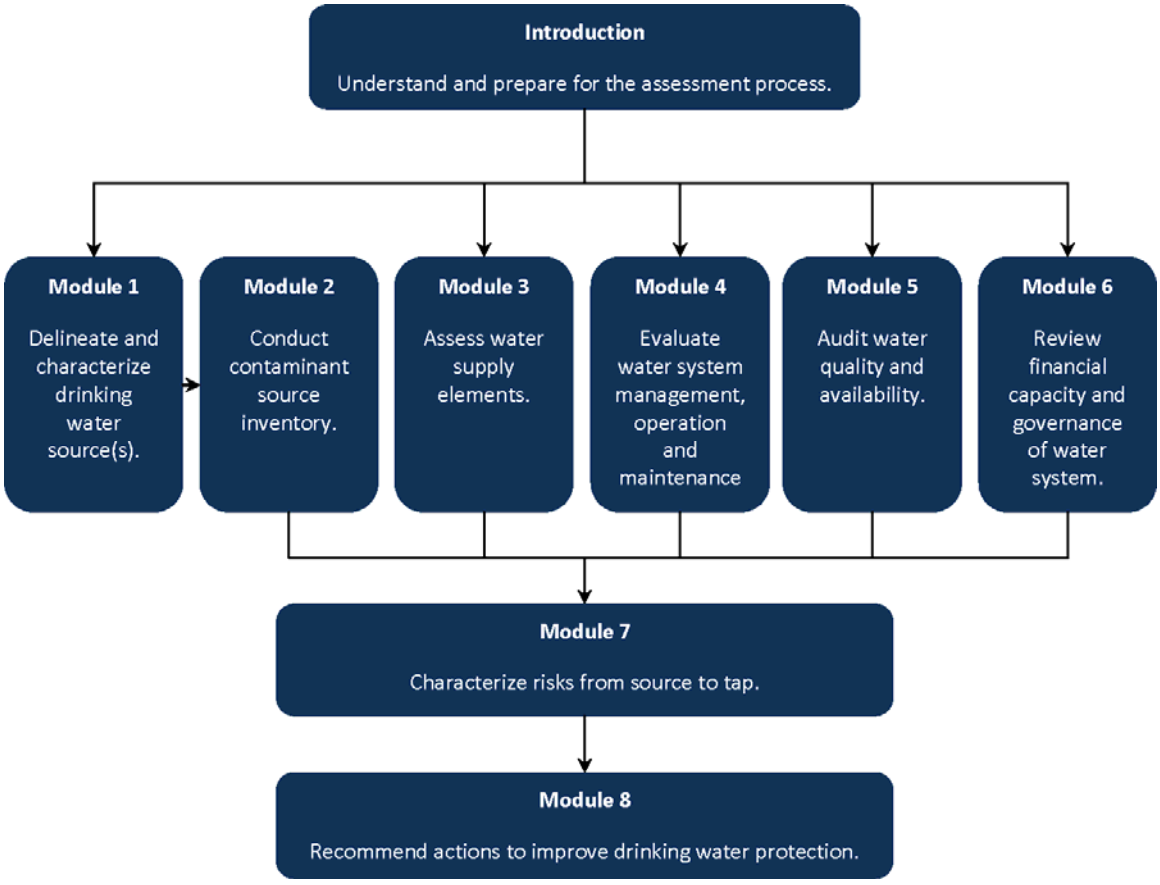
Ministry of Healthy Living and Sport

Comprehensive Drinking Water Source-to-Tap Assessment Guideline Process



Here are the steps in the source-to-tap assessment process, through the Introduction and eight modules. Note that the Introduction should be read prior to undertaking any assessment.

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1. INTRODUCTION

The success of a water system can be measured by its ability to provide adequate volumes of safe, palatable drinking water to all water users. Water monitoring and customer feedback are the primary ways that water suppliers determine if they are delivering a sufficient supply of safe drinking water. Module 5 of the source-to-tap assessment is an audit of present and historical tap water quality and quantity data. It is intended to evaluate the success of the water system in meeting this primary goal. Water monitoring is one of the barriers in the multiple barrier approach. It provides a check that water is potable and all other barriers are functioning well.

The water quality and quantity audit includes an analysis of historical water quality and quantity data, evaluation of treatment system effectiveness, investigation of customer satisfaction, evaluation of monitoring and reporting practices, and an assessment of the future sustainability of the water supply.

1.1. Hazard and Vulnerability Identification

Throughout the process of evaluating water supply elements in the source-to-tap system, assessors identify and describe hazards that pose a threat to drinking water safety or sustainability, and vulnerabilities in the multiple barrier system or other protective systems (e.g., security).

Hazards are recorded in the Hazard Identification Table (see Table 5-2), which is used to document hazards in a consistent way throughout the source-to-tap assessment process. Information on strengths and vulnerabilities in the drinking water supply system identified throughout the assessment is recorded, compiled from each module, and used to inform the multiple barrier system evaluation in Module 7 (Characterize risks from source to tap.).

1.2. Module 5 Assessment Team

A broad range of issues can exist in a water supply system from source to tap. As a result, comprehensive drinking water assessments require a multidisciplinary assessment team rather than a single assessor. Each module of the Comprehensive Drinking Water Source-to-Tap Assessment Guideline requires some specialized skills and a unique spectrum of knowledge related to water sources and systems.

Collectively, the assessment team for Module 5 should have knowledge and experience related to:

- Drinking water quality monitoring systems and laboratory analysis including:
  - Operation, calibration and recording of continuous monitors.
  - Field sampling procedures and techniques.
  - Analytical procedures.
  - Quality assurance and quality control (QA/QC).
  - Data interpretation.

- Analyzing water volume and flow data and assessing the adequacy of a current water supply with the projected need for water in the future.
- Drinking water chemistry.
- Microbiology and microbes commonly found in drinking water.
- Public health issues related to drinking water.
- Legislation relating to drinking water, surface water, groundwater.
- Risk assessment and risk management.

2. ASSESSMENT COMPONENTS

2.1. Analyze Raw and Finished Water Quality Trends

The primary objective for water suppliers is to provide sufficient quantities of potable water to their consumers. Regular monitoring of key water quality indicators affecting public health (see Box 5-1) is the best method of determining if that objective has been met.

2.1.1. Conduct a Trend Analysis of Water Quality Data

Review the status and trends in water quality for key public health indicators (Box 5-1). Review concentrations of water constituents related to health and how they fluctuate over time. How do they compare to the guidelines, objectives, and standards (see Box 5-2) in place?

Are temporal (within a year and between years) or spatial patterns evident? When conducting a trend analysis of water quality data, it is important to identify when analytical techniques changed or alterations of the water system (especially treatment processes) occurred, so that any corresponding water quality changes can be accounted for. If water quality problems are observed or reported, identify the nature of the concern, frequency and severity, and possible causes, as well as recommended solutions to minimize problems.

Box 5-1. Common Water Quality Indicators for Public Health

- Microbiology
  - Coliform bacteria (total, fecal, *E. coli*)
  - Giardia, cryptosporidium, and viruses
  - Heterotrophic plate counts (HPC)
- Turbidity
- General water chemistry
- Algal counts
- Organic matter
- Colour
- pH
- Nitrate
- Arsenic
- Disinfection residuals
- Disinfection byproducts
- Other water quality characteristics related to public health where there is a reasonable possibility of exceeding a guideline or standard. (This could be based on land uses or contaminant sources identified in Step 2.)
- Chemicals used in treatment processes with potential to impact water quality (e.g., flocculants, water softeners, fluoride, chemicals for pH adjustment)

See Canadian Guidelines for Drinking Water Quality Supporting Documents (http://www.health.gov.sk.ca/water-guidelines-water-quality) about the occurrence/ health effects of water constituents.

2.1.2. Review Historical Water Quality Results to Identify Exceedances in the Guidelines for Canadian Drinking Water Quality

Review historical water quality laboratory results to identify elevated concentrations of contaminants or exceedances of water quality standards in the *Drinking Water Protection Regulation*, Guidelines for Canadian Drinking Water Quality. Microbiological analyses should be reviewed for the previous two years. At a minimum, the two most recent physical/chemical analyses should be examined.

Box 5-2. Definitions of Water Quality Benchmarks (CCME, 2004)

Guidelines: nonlegally enforceable benchmarks against which to assess water quality

Objectives: values based upon guidelines that incorporate site-specific consideration of chemical, physical and biological factors, and established for the protection of water users (e.g., drinking water, aquatic life, recreation)

Standards: legally enforceable water quality limits, referenced in legislation, for the protection of human and ecosystem health

If chemical sampling has not been performed within the past five years, obtain water samples for analysis by an approved laboratory for parameters defined in the operating permit or identified by the drinking water officer. Site-specific water quality issues such as arsenic and radon in groundwater should be considerations when selecting constituents for analysis.

Interviews with the water supplier can provide important information about water quality trends, past water quality problems, or incidents to supplement the empirical monitoring data.

2.2. Determine if Current Treatment Type and Practices are Effective

Evaluating the effectiveness of treatment processes in addressing source water quality issues is a critical component of assessing drinking water quality. For example, if high turbidity is a problem in the source water, do treatment processes effectively reduce turbidity to acceptable levels in finished water? Are disinfection processes providing sufficient pathogen removal rates?

Assess the effectiveness of treatment processes in achieving source water quality objectives. The following questions are provided as guidance in this assessment process:

- Are treatment goals being achieved (such as those specified in the operating permit)?
- Is tap water achieving standards established in the operating permit? Does tap water meet the Guidelines for Canadian Drinking Water Quality?
- Are treatment processes adequate for worst-case scenarios in water quality?
- Do changes in source water quality ever impede treatment processes?
- Are disinfection processes providing sufficient pathogen removal rates?
- Are chlorine residual levels in the distribution system within an acceptable range, as specified in the operating permit or according to World Health Organization (WHO) guidelines[1]?

[1] WHO guidelines specify, "For effective disinfection, there should be a residual concentration of free chlorine of ≥0.5 mg/litre after at least 30 min contact time at pH <8.0." (WHO Guidelines for Drinking Water

- Other questions as appropriate for a specific water treatment system.

2.3. Ascertain if the Water Supply is Sufficient to Meet Present and Future Water Demands

The chief concern for water quantity is whether or not there is enough water to supply consumer demand, both at present and in the future. A number of factors can influence the availability of sufficient volumes of water, including source water capacity (determined by source type, climate, other water users and the protection of ecological values); customer population and demand; and, in some cases, storage reservoir capacity.

Table 5-1 identifies the supply- and demand-side elements that influence water availability. Water quantity can also pose a threat due to impaired water quality when volumes are not sufficient. For example, when lakes and open reservoirs experience low water levels, temperatures increase and algal blooms can result, affecting water taste and odour, and, potentially, its potability if toxic blue-green algae are present.

If the source supply is inadequate, a water supplier can use water conservation measures through demand-side management or obtain an additional water supply through supply-side management. "Demand management is a comprehensive, integrated and long-term approach that seeks to improve overall productivity of water use and deliver water services matched to the needs of end users (Brandes and Ferguson, 2004)." Demand management, reduces overall water consumption through regulatory, education and incentive programs.

Table 5-1. Supply-Side and Demand-Side Factors Influencing Water Availability and Sustainability

Supply-Side Factors	Demand-Side Factors

• Primary and backup water source(s)
  o Type
  o Capacity/volume
  o Climatic influences
  o Other water users
• Storage capacity
• Pumping capacity
• Flow/pipe capacity
	• Consumer population
	• Per capita demand
	• Connection types
	• Water pricing, incentives
	• Demand timing

Evaluate whether or not the water supply is sufficient to meet present and future projected water demand. Some key questions to ask are listed below in three categories: supply-side factors, demand-side factors, and questions that integrate both supply- and demand-side

Quality. Annex 4: Chemical Summary Tables. http://www.who.int/water_sanitation_health/dwq/en/gdwq3_ann4tab.pdf)

elements. Information sources include interviews with the water supplier and key staff, pump and meter data, source water and storage volume measurements.

Supply-Side Assessment

- What is the maximum licensed water demand?
- Does the water source experience seasonal or occasional quantity issues such as low stream flows or a declining groundwater level? If yes, is the cause known?
- Are there backup water sources in place? Is the water supplier proactive in ensuring that there is an adequate supply of water or developing new sources? Are source water acquisitions planned?
- Does the purveyor know the long-term plans or needs of major industrial, commercial, or irrigation users?
- Does the purveyor understand the competing uses for water? Does the water supplier understand his/her legal rights to water?
    - What are the other demands on the water source (e.g., other users, need to maintain fish flows)?
    - Do you know who the users are and understand their long-term needs and plans?
- What types and magnitude of climate change impacts are projected for water availability in the region?

Demand-Side Assessment

- Is unaccounted-for water monitored and analyzed regularly? What is the proportion of unaccounted-for water loss in the system?
- Are water conservation programs in place (e.g., public education, watering restrictions, rebate programs for low flow fixtures)?
- What is the projected population change for the water service area over the next 10 years? Will system demand be growing, declining or remaining stable over that time? Is the water supplier planning for growth?

Integrated Assessment

- What are the present and future projected demands compared with water licence volumes (where applicable), available water source volumes, and storage capacity?
- Is source capacity higher than peak day demand by an adequate margin (determined and justified using professional judgment)? Are there times when demand exceeds supply or the reservoir level drops below its balancing storage level?
- Can peak water demand be supplied without pumping at peak capacity for extended periods?
- Is reservoir capacity a limiting factor in providing sufficient water volumes to meet demand?

Evaluate whether or not the water supply will be sufficient to furnish water demand over the projected future (at least 10 years). Identify the key limiting factors for water availability.

2.4. Evaluate the Adequacy of the Current Monitoring and Reporting Program

The purpose of assessing a water monitoring program is to determine if it is serving the needs of the water supply system, providing sufficient useful data at appropriate frequencies and locations. This portion of the assessment considers the collection, analysis, storage and reporting of water quality and quantity data for the water supply system. It includes compliance monitoring and operational monitoring.

Compliance monitoring evaluates conformity with standards or the Guidelines for Canadian Drinking Water Quality. Operational monitoring checks water quality indicators to measure the performance of the water supply system.

Do the water supplier and operators understand their monitoring requirements and have a schedule in place to ensure compliance?

Evaluate the adequacy of the drinking water monitoring program components including:

- Monitoring locations:
  - Are there sampling points throughout the distribution system and in different distribution zones, at exit points from water storage, near water main size changes, and at far ends of the distribution system (CCME, 2004)?
- Parameters analyzed, frequency:
  - Parameters specified in the operating permit.
  - Source water contaminants of concern.
  - Parameters selected based on water system characteristic.
  - Parameters selected based on treatment type.
  - Sampling equipment and methods:
  - According to *Standard Methods for the Examination of Water and Wastewater* (see Recommended Resources).
- Data analysis and interpretation methods.
- Documentation, storage and backup of monitoring results.
- Reporting practices considering the terms and conditions outlined in the operating permit:
  - Under the *Drinking Water Protection Act*, water suppliers are required to report water quality results to the local health authority as specified in the terms and conditions of the operating permit, and annually to the public. Examine whether the water supply system is meeting its current water quality reporting requirements.
  - Are there protocols in place for responding to poor water quality results? How are water quality results summarized and reported to water system decision makers and consumers?

- QA/QC system:
  - An essential part of a credible, finished water quality monitoring program is having a quality assurance and quality control (QA/QC) system in place in which documented and consistent methods are used for sampling and analysis; trained personnel conduct sampling and analysis; equipment is maintained and properly calibrated; and results and any observations or deviations from protocol are recorded. Evaluate the adequacy of the QA/QC program for finished water quality monitoring based on the components listed above (or other meaningful criteria).
- Laboratory services.
  - Is an accredited laboratory used to analyze water quality? Check that the laboratory is accredited to analyze the required water parameters at the concentrations at which they typically occur in drinking water. How are laboratory results communicated between the lab and the water supplier? What is the lag time between the lab sending and the water supplier receiving results?

2.5. Evaluate Customer Vulnerability and Satisfaction

One key indicator of the success of a water supply system is the number of customer complaints in a year. The water quality audit should include an evaluation of customer complaints regarding water quality or low water pressure as a measure of customer satisfaction with drinking water quality. Customers usually describe water as good if its quality is consistent, and free of suspended solids and objectionable tastes and odours.

Evaluate records of customer complaints, recording the kinds of complaints (e.g., chlorine content, colour, odour and lack of water) and their frequency and location in the system to identify any relevant patterns. E.g., frequent customer complaints on a dead end main may indicate the need for more flushing or looping of the pipe back into another part of the distribution system. Assess how customer complaints are handled by water system personnel, noting suggestions for improvement.

Some people are more susceptible to waterborne illness than others, including infants, the elderly, and immunosuppressed individuals. Water suppliers should be aware of the locations of facilities serving vulnerable populations, such as hospitals, nursing homes, daycares, schools, etc. Does the water supplier know to what vulnerable populations it supplies water? Does the water system's emergency response plan consider vulnerable populations in its responses?

3. ASSESSMENT DOCUMENTATION AND REPORTING

3.1. Assessment Report

The assessment report should include, at a minimum, the following components:

- Summary of trends in important water quality constituents, with a focus on those that are elevated:

  - Graphical and/or tabular presentations of the water quality and quantity audit. Any exceedances, elevated concentrations of contaminants, or water volume concerns should be clearly identified.
- Discussion of known or theoretical causes of water quality concerns.
- Description of past outbreaks, water quality problems or boil water advisories.
- Evaluation of treatment/disinfection process effectiveness.
- Summary of trends in water availability and demand (graphs and figures are helpful).
- Description of the key limiting factors for water availability.
- Evaluation of whether or not the water supply will be sufficient to furnish water demand over the projected future (at least 10 years).
- Discussion of the adequacy of the monitoring and reporting program.
- Summary of consumer complaints.
- Evaluation of how customer complaints are handled by water system personnel.
- Identification of vulnerable populations or facilities supplied by the water system.
- Completed hazard identification table for Module 5 (see Table 5-1 for an example).

3.2. Hazard Identification Table

Drinking water hazards identified in Module 5 should be entered into the hazard identification table. See Table 5-2 for an example.

Table 5-2. Sample Module 5 Hazard Identification Table

Hazard No.	Drinking Water Hazard	Possible Effects	Existing Preventative Measures	Associated Barrier(s)
5-1	Disinfectant residual frequently too low.	Low disinfection residual in the distribution system exposes consumers to possible bacterial growth in the pipes and from contamination within the system.	None identified	Treatment
5-2	Occasional customer complaints of low pressure at the tap	Low pressure in the distribution system can lead to back flow at cross-connections, allowing nonpotable water into the distribution system.	None identified	Water monitoring

APPENDIX 5A:
MODULE 5 ASSESSMENT AT A GLANCE

Components	Recommended Methods	Scope	Documentation and Reporting
1. Analyze raw and finished water quality trends.	• Review historical water quality results to identify exceedances in the Guidelines for Canadian Drinking Water Quality. • Conduct a trend analysis of water quality data. • Send water samples for analysis by an accredited laboratory when physical and chemical analysis has not been performed for the past five years or more. • Interview water supplier and key staff about: o Observations of water quality. o Past incidents/water quality problems.	• Water quality indicators of public health (see Box 5-1) and any other constituents of concern	• Produce a summary of trends in important water quality constituents, with a focus on those that are elevated or exceed standards or guidelines. • Discuss known or theoretical causes of water quality concerns. • Describe past outbreaks, water quality problems or boil water advisories. • Identify as a hazard or vulnerability any practice, process, situation (or absence of one) that could put the safety of water at risk.
2. Verify if current treatment processes are adequate.	• Evaluate the effectiveness of treatment of the source water: o Are treatment goals being achieved? o Is the treatment plant meeting performance criteria from the operating permit? o Is tap water achieving standards? o Do changes in source water quality	• Primary and backup treatment and disinfection systems	• Evaluate the effectiveness of the treatment/ disinfection process. • Identify as a hazard or vulnerability any practice, process, situation (or absence of one) that could put the safety of water at risk.

Components	Recommended Methods	Scope	Documentation and Reporting
	ever impede treatment processes? o Are disinfection processes providing sufficient pathogen removal rates? o Are chlorine residual levels in the distribution system within an acceptable range?		
3. Ascertain if the current water supply is sufficient to meet present and future water demands.	• Supply-Side assessment • Demand-Side assessment • Integrated assessment	• Present and future water supply and demand • Supply-Side elements influencing water availability: o Primary and backup water source(s): – Type – Capacity/ volume – Climatic influences – Other water users o Storage capacity o Pumping capacity o Flow/pipe capacity • Demand-Side elements influencing water availability: o Consumer population o Per capita demand o Connection types o Water pricing, incentives o Demand timing	• Summarize trends in water availability and demand (graphs and figures are helpful). • Identify the key limiting factors for water availability. • Evaluate whether or not the water supply will be sufficient to furnish water demand over the projected future (at least 10 years). • Identify as a hazard or vulnerability any practice, process, situation (or absence of one) that could put the safety of water at risk.

Components	Recommended Methods	Scope	Documentation and Reporting
4. Evaluate the adequacy of the current monitoring and reporting program. (4. continued)	• Assess adequacy of: o Monitoring locations o Sampling frequency o Parameters analyzed o Sampling equipment and methods o Data analysis and interpretation methods o Documentation, storage and backup of monitoring results o Reporting practices considering the terms and conditions outlined in the operating permit o QA/QC system o Laboratory services	• Collection, analysis, storage and reporting of water quality and quantity data for the water supply system • Compliance monitoring and operational monitoring	• Discuss the adequacy of the monitoring and reporting program. • Identify as a hazard or vulnerability any practice, process, situation (or absence of one) that could put the safety of water at risk.
5. Evaluate customer vulnerability and satisfaction with water.	• Evaluate records of customer complaints regarding water quality or water pressure and identify patterns in their: o Nature o Frequency o Locations • Identify how customer complaints are handled by water system personnel. • Identify vulnerable populations or facilities supplied by the water system.	• Available records of customer complaints • Vulnerable populations or facilities supplied by the water system	• Produce a summary of consumer complaints. • Evaluate how customer complaints are handled by water system personnel. • Identify vulnerable populations or facilities supplied by the water system. • Identify as a hazard or vulnerability any practice, process, situation (or absence of one) that could put the safety of water at risk.

APPENDIX 5B: RECOMMENDED RESOURCES

Drinking Water Quality Guidelines and Information

Health Canada. Federal–Provincial–Territorial Committee on Drinking Water. 2002. *Summary of Guidelines for Canadian Drinking Water Quality*. Ottawa, Ontario: Health Canada. http://www.health.gov.sk.ca/water-guidelines-water-quality

Health Canada. Federal–Provincial–Territorial Committee on Drinking Water. various. *Guidelines for Canadian Drinking Water Quality—Technical Documents*. Ottawa, Ontario: Health Canada. http://www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/index-eng.php#tech_doc

Ministry of Environment. Groundwater Quality Fact Sheets. http://www.env.gov.bc.ca/wsd/plan_protect_sustain/groundwater/library/ground_fact_sheets/.

National Water Research Institute. 2001. *Threats to Sources of Drinking Water and Aquatic Ecosystems Health in Canada*. NWRI Scientific Assessment Report Series No. 1. Environment Canada. http://www.ec.gc.ca/INRE-NWRI/235D11EB-1442-4531-871F-A7BA6EC8C541/threats-eprint.pdf.

Distribution System Water Quality Monitoring

British Columbia Water and Waste Association (BCWWA). 2004. *Chorine Disinfection and Monitoring*. http://www.bcwwa.org/BMP/index.php

British Columbia Water and Waste Association (BCWWA). 2004. *Turbidity Monitoring and Reporting*. http://www.bcwwa.org/BMP/index.php

National Guide to Sustainable Municipal Infrastructure (InfraGuide). 2003. *Water Quality in Distribution Systems.* http://gmf.fcm.ca/files/Infraguide/Potable_Water/Monitor_water_quality_distr_syst_727k.pdf

National Guide to Sustainable Municipal Infrastructure (InfraGuide). 2004. *Monitoring Water Quality in the Distribution System.* http://gmf.fcm.ca/files/Infraguide/Potable_Water/Monitor_water_quality_distr_syst_433k.pdf

Source Water Quality Monitoring

Cavanagh, N., R.N. Nordin, L.W. Pommen and L.G. Swain. 1998. *Guidelines for Designing and Implementing a Water Quality Monitoring Program in British Columbia*. Field Test Edition. Resources Inventory Committee. http://srmwww.gov.bc.ca/risc/pubs/aquatic/design/index.htm.

Cavanagh, N., R.N. Nordin, L.W. Pommen and L.G. Swain. 1998. *Guidelines for Interpreting Water Quality Data*. Field Test Edition. Resources Inventory Committee. http://srmwww.gov.bc.ca/risc/pubs/aquatic/interp/index.htm.

Water Quantity

Brandes, O. and K. Ferguson. 2004. *The Future in Every Drop: The benefits, barriers and practice of urban water demand management in Canada*. The Polis Project on Ecological Governance, University of Victoria. http://www.poliswaterproject.org/publication/25

National Guide to Sustainable Municipal Infrastructure (InfraGuide). 2003. *Water Use and Loss in Water Distribution Systems.* http://gmf.fcm.ca/files/Infraguide/Potable_Water/Water_Use_Loss_distrib_syst.pdf

National Guide to Sustainable Municipal Infrastructure (InfraGuide). 2003. *Establishing a Metering Plan to Account for Water Use and Loss.* http://gmf.fcm.ca/files/Infraguide/Potable_Water/establish_metering_plan_account.pdfS