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Standards for Micro Waterworks Systems

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Contents

Foreword

Waterworks systems of all sizes are found throughout Alberta. Regulatory oversight for these systems is shared between two departments: Alberta Environment and Parks (AEP) and Alberta Health (AH), depending on the source water type and characteristics, as well as the size, ownership, and use of the waterworks system. Alberta Health Services (AHS) oversees waterworks systems regulated by AH.

Most municipal systems are regulated under the *Environmental Protection and Enhancement Act* (EPEA), the Potable Water Regulation (PWR) and the *Standards and Guidelines for Municipal Waterworks, Wastewater and Storm Drainage Systems* (the Municipal Standards). The Municipal Standards require municipal waterworks systems to have treatment process redundancies to ensure continuous production of safe drinking water with complex distribution systems and large populations.

Micro waterworks systems need a more size and risk proportionate set of design, performance, operational, monitoring and reporting requirements that are effective at providing safe drinking water and enable them to safeguard public health.

Micro waterworks systems require a '*real-time*' operational control and response model, that allows for an immediate treatment system shut-down and alternate on-demand drinking water supply, when a critical treatment step is outside performance criteria, or when the treatment system fails.

Purpose

The *Standards for Micro Waterworks Systems* (the Micro Standards) outline both the minimum treatment and operational requirements and provide guidance and best practices that are relevant to micro waterworks systems regulated by the department.

For the purposes of continuous improvement, the Micro Standards will be reviewed and updated, as appropriate, from time to time.

Definitions / Abbreviations

AO: Aesthetic Objectives

AEP: Alberta Environment and Parks

ANSI: American National Standards Institute

APEGA: Association of Professional Engineers and Geoscientists of Alberta

AWWA: American Water Works Association

DWSP: Drinking Water Safety Plan

E. coli: Escherichia coli

EPEA: *Environmental Protection and Enhancement Act*

GCDWQ: Guidelines for Canadian Drinking Water Quality

GWUDI: Groundwater under the direct influence of surface water

HAA: The total of monochloroacetic acid, dichloroacetic acid, trichloroacetic acid, monobromoacetic acid and dibromoacetic acid

MAC: Maximum Acceptable Concentration

NH3-N: Ammonia nitrogen

NSF: National Sanitation Foundation International

NTU: Nephelometric Turbidity Unit

POE : Point of Entry

POU: Point of Use

QA/QC: Quality Assurance/Quality Control

TOC: Total Organic Carbon

TTHM: Total Trihalomethanes refers to the total of chloroform, bromodichloromethane, dibromo-chloromethane and bromoform

USEPA: United States Environmental Protection Agency

UV: Ultraviolet

WHO: World Health Organization

Average daily design flow: The product of the following:

- design population of the facility, and
- the greatest annual average per capita daily flow which is estimated to occur during the design life of the facility.

Co-op: An organization formed by the individual lot owners served by a waterworks system, wastewater system or storm drainage system.

Groundwater: All water under the surface of the ground.

Maximum daily design flow (water): Maximum three consecutive day average of past- recorded flows, times the design population of the facility. If past records are not available, then 1.8 to 2.0 times the average daily design flow.

Maximum hourly design flow (water): 2.0 to 5.0 times the maximum daily design flow depending on the design population.

Micro Waterworks: is a waterworks system in accordance with the Regulations

(i) that uses:

(A) a surface water source as the source of its water supply, and has a maximum daily demand design flow of less than or equal to 0.25 L/s, or

(B) a groundwater other than high quality groundwater as the source of its water supply, and a maximum daily demand design flow of less than or equal to 0.5 L/s, **AND**

(ii) that:

(A) uses a pre-engineered water treatment system,

(B) that utilizes an automatic shut-off prior to the clearwell if water is outside of equipment manufacturers specifications, and

(C) provides an alternative supply of potable water when the water treatment system is shut down.

Municipal Standards: *Standards and Guidelines for Municipal Waterworks*, *Wastewater and Storm Drainage Systems, Part 1*

Owners: Owners of the waterworks systems as defined in the regulations.

Peak demand design flow (water): The maximum daily design flow plus the fire flow.

Potable water: As defined in the EPEA. Other domestic purposes in the EPEA definition include water used for personal hygiene, e.g., bathing, showering, washing, etc.

Surface water: Water in a watercourse.

Watercourse: As defined in the EPEA.

1. Guiding Principles for Drinking Water Safety

Source water for waterworks systems varies in quality and needs to be assessed for the presence of pathogenic microorganisms and to identify naturally occurring minerals and trace metals. Source water can also become contaminated from anthropogenic activities. If any parameter is found in the source water at a higher level than is considered acceptable, it may be unsafe to use. Regardless of the size of the waterworks system, owners and operators are responsible for assessing the source water, identifying any concerns and supplying water that is safe to drink and fit for domestic use.

Assessment of the drinking water supply system is an essential prerequisite for subsequent steps in which effective strategies for managing hazards are planned and implemented. This includes understanding the characteristics of the micro waterworks system, what hazards may arise, how these hazards create risks, and the processes and practices that affect drinking water quality. To effectively manage drinking water system risks, owners and operators should work to understand the unique risks associated with their own waterworks systems.

Regardless of the treatment and monitoring technology used, the following principles are important to all owners, and operators of a micro waterworks system:

- Protection of water sources and treatment is of paramount importance and are not to be compromised;
- Waterworks systems require installation and maintenance of robust multiple barriers appropriate to the level of potential contamination facing the raw water supply;
- Ongoing awareness of any sudden or extreme change in water quality/flow or environmental conditions (e.g., extreme rainfall, flooding, or drought) that might impact drinking water treatment is essential;
- Adverse monitoring signals are responded to quickly and effectively; and
- Consumer complaints about water quality are taken seriously.

2. Scope

The Micro Standards apply to waterworks systems that meet the definition of a micro waterworks under the Activities Designation Regulation.

Micro waterworks system owners and operators are responsible for understanding and complying with all legislative and regulatory requirements and for producing and consistently delivering an adequate supply of safe drinking water to consumers. This includes maintaining water quality in the piping network or water distribution system up to service connections.

2.1 IMPLEMENTATION

The requirement to meet the Micro Standards is established through the Potable Water Regulation of the *Environmental Protection and Enhancement Act* (EPEA). The Micro Standards are to be used in conjunction with the code of practice specific to micro waterworks systems.

2.1.1 Existing

Existing micro waterworks system owners will receive written notice from AEP that they will potentially be regulated under a code of practice and subject to the Micro Standards going forward.

2.1.2 New Systems

The Micro Standards applies to all future micro waterworks systems as outlined by the Potable Water Regulation coming into force.

3. System Installation Requirements

In this Standard, the term “must” indicates a requirement, while terms such as “should,” or “recommend” indicate a recommended or best management practice.

This section outlines the minimum requirements for the installation of a micro waterworks system.

3.1 SOURCE WATER CHARACTERIZATION

3.1.1. Baseline Testing

Micro waterworks systems must conduct raw water quality baseline testing, in accordance with Table 1, to characterize source water quality.

A thorough evaluation of the raw water must be completed to identify potential risks and determine the appropriate treatment units and processes.

TABLE 1: RAW WATER PARAMETERS

Analysis	Microbiological*	Chemical & Physical	Total Metals	Hydrocarbons	Pesticides
Frequency (per year)	Four times	Two times	One time	One time	One time in summer
Parameter	Giardia Cryptosporidium	Alkalinity, total Turbidity Bicarbonate, Carbonate & Hydroxide Calcium Chloride Conductivity Hardness, total TOC Ammonia Fluoride Magnesium Nitrate Nitrite pH Potassium Sodium Sulphate Total Dissolved Solids (TDS)	Aluminum Antimony Arsenic Barium Beryllium Boron Cadmium Chromium Cobalt Copper Iron Lead Manganese Mercury Molybdenum Nickel Selenium Silver Strontium Thallium Uranium Zinc	Benzene Ethylbenzene Xylenes, total	1,4-dioxane 2,4-D Atrazine + metabolites Bromoxynil Carbaryl Chlorpyrifos Diazinon Dicamba Dimethoate Diquat Diuron Glyphosate Malathion MCPA Metolachlor Metribuzin Microcystin, total NTA Paraquat Phorate Picloram Simazine Trifluralin

**A micro waterworks system using a surface water source that has all the required treatment equipment installed as per section 3.2.1, is exempted from microbiological testing as that treatment will exceed the required log reduction for Giardia, Cryptosporidium, and viruses.*
Due to the variability of water quality in GWUDI water sources, micro waterworks systems using GWUDI must conduct microbiological testing as part of the baseline testing prior to the selection and installation of treatment equipment.

A baseline testing program must include:

- sampling from each raw water source, prior to any treatment (with at least 2 months between collection of samples) for a minimum one (1) year period;
- appropriate timing of sample collection to capture various seasonal conditions and worse case scenarios (heavy rain or snow melt conditions, high flow conditions, spring freshet, low flow conditions, fall high organics); and
- monitoring for the duration of the expected or typical season for seasonal operations.

The risk of contamination of infective *Giardia* and *Cryptosporidium* are dependent on the watershed conditions upstream of the intake or recharge of an aquifer [1]. To evaluate the risk, additional raw water sampling may be required at the Director's discretion following review of sampling result. In addition, the Director may require the use of risk assessment tools such as a sanitary survey to determine if higher log-reduction requirements for *Giardia* and *Cryptosporidium* are necessary [2]. Details of the *Cryptosporidium* and *Giardia* assessment can be found in the Health Canada's Guideline technical document – *Enteric Protozoa: Giardia and Cryptosporidium*, specifically sections 7.1 and 7.2 [3].

At the discretion of the Director, existing micro waterworks systems may be able to use their existing raw water quality baseline testing if it includes all the information required in Table 1.

3.1.2 Confirmatory Testing

The owner and operator of a micro waterworks system must conduct confirmatory testing of raw water at a minimum once every five years, in accordance with Table 1, to compare against raw water baseline testing results and confirm the source water quality has not changed.

If there is a suspected change in the source water, additional raw water testing should be done.

3.2 TREATMENT PROCESS REQUIREMENTS

3.2.1 General

The treatment processes for a micro waterworks system should be sized to ensure the production of adequately disinfected water which meets the water demand.

For all micro waterworks systems, the following pre-engineered, certified treatment components must be installed, at a minimum:

- For surface water as the source:
  - pre-filtration (as determined by filtration equipment manufacturers' specifications),
  - membrane filtration with absolute 1 micron filtration or smaller,
  - UV disinfection, and
  - disinfection with free chlorine
- For GWUDI as the source:
  - pre-filtration (as determined by filtration equipment manufacturers' specifications),
  - filtration with absolute 1 micron filtration or smaller, unless granted a filtration exemption,
  - UV disinfection, and
  - disinfection with free chlorine
- For non-GWUDI groundwater with a chemical MAC exceedance as the source:
  - pre-filtration (as determined by filtration equipment manufacturers' specifications),
  - filtration specific for the parameter(s) identified as exceeding a chemical MAC, and
  - disinfection with free chlorine

For additional details regarding the requirements for the pre-engineered, certified treatment components, the owner and operator of a micro waterworks systems should refer to Sections 3.2.2 – 3.2.3. Where the components of the treatment system are part of a pre-configured package (that complies with Section 2.2.10.17 of the National Plumbing Code of Canada), they may be installed by the owner's representative (such as a plumber).

Micro waterworks systems may encounter situations such as:

- the source water characterization or confirmatory testing indicates additional treatment beyond the minimum listed above is required; or
- after installation, the system has repeated treatment failures that require ongoing operational support.

In these situations, the owner and operator of a micro waterworks systems may wish to consult with the department and local equipment suppliers on potential options. Where more complex treatment processes are needed, the proposed treatment design may require authentication by a qualified Professional Engineer licensed by the APEGA. In these cases, the waterworks system will no longer be considered a micro waterworks.

All substances, materials, or compounds (e.g., pipes, coatings, filter media, solders, valves, gaskets, lubricants, resins, process equipment, etc.) that may come in contact with water being treated in a micro waterworks system or with water that has been treated must follow the requirements as specified in section 1.7.2.1 of the Municipal Standards, unless otherwise specified in this Micro Standards.

3.2.2 Filtration

3.2.2.1 General

If filtration is needed to meet the water treatment performance targets listed in Table 2 for cysts, oocysts, and virus levels, the owner and operator of a micro waterworks system must install a filtration unit(s) that:

- achieve a minimum of 1-µm absolute removal criteria to ensure the effective removal of cysts and oocysts (*Giardia* and *Cryptosporidium*); and
- is either a cartridge, ceramic, or membranes filter.

Regardless of the type of filtration unit(s) installed, the filtration unit(s) must be certified:

- under NSF 53 with labelling stating “cyst reduction” (based on a 99.95% challenge test with live *Cryptosporidium* or 3 micro diameter latex microbeads);
- under NSF 419;
- as a 1-µm absolute filter based on ASTM and manufacture specifications; or
- by an alternative third party authorized by the Director, that ensures the technology achieves equivalent filtration.

Manufacturers may recommend pre-filtration (roughing filters) be installed upstream of the 1-µm absolute barrier to reduce the loading on the more expensive 1-µm absolute filter.

3.2.2.2 Filtration Exemption for Micro Waterworks Utilizing a GWUDI Source Water

Where a groundwater source is determined to be GWUDI and where the source water quality conditions are suitable to avoid filtration as determined by the Director, inactivation of *Giardia*, *Cryptosporidium* and viruses may be achieved by disinfection only.

Where the Director determines that source water quality conditions are suitable to avoid filtration, inactivation of *Giardia*, *Cryptosporidium* and viruses may then be achieved by disinfection only, if the performance targets of Table 2 can still be met.

If there is a change in the source water in the future, the filtration exemption may no longer apply.

When a micro waterworks system has been granted a filtration exemption, the focus shifts from reliance on turbidity measurements to UV dosage. The UVT and UV dosage meter within the UV unit will automatically shut-down the treatment process when the unit begins to operate outside of the manufacturer’s specifications (e.g., when turbidity gets too high).

3.2.2.3 MAC Exceedances in Source Water

Filtration units for metals and other chemicals must, at a minimum:

- be certified under NSF 53 with contaminant-reduction claims for the specific parameters of concern; or
- have filter media that has NSF 61 certification.

Any auxiliary treatment units for reduction or removal of the parameters listed in Table 4 must carry NSF certification for the parameter being controlled. Otherwise, the auxiliary treatment units must be designed and signed off by a professional engineer.

Alternately, it may be appropriate to blend source waters to achieve compliance for a specific drinking water parameter. The analysis for blending should include:

- an analysis of the water quality from the sources under consideration, including any seasonal water quality changes that could affect the blending strategy;
- a description of the blending strategy, including calculations of flow and finished water quality, monitoring, controls, and alarm or shutdown conditions; and
- a preliminary schematic that shows piping, control valves, monitoring points, and other important features.

3.2.3 Disinfection

3.2.3.1 General

All micro waterworks systems must provide disinfection to:

- inactivate the pathogens not removed by filtration, and achieve the level of cysts/oocysts reduction listed in Table 2;
- inactivate viruses and achieve the level of virus reduction listed in Table 2; and
- maintain chlorine residual in the piping network or water distribution system as specified in Table 4.

3.2.3.2 Ultraviolet (UV) Light

When UV inactivation is used to meet Water Treatment Performance Limits listed in Table 2, the UV units must, at a minimum, meet NSF 55A requirements.

A solenoid valve or automatic shut-off must be installed to prevent the flow of water into the clearwell when the UV unit experiences an upset condition or power failure.

A minimum UV dose of 40 mJ/cm^2 is insufficient to inactivate adenovirus [4]. Installation of UV equipment must meet disinfection performance requirements based on additive log-reduction chlorine contact time credits, including free chlorine primary disinfection.

3.2.3.3 Chlorination

3.2.3.3.1 Chlorine Contact Time (CT) Concept

The micro waterworks system must be installed and operated such that the disinfection using free chlorine achieves a CT performance ratio of > 1.0 for 4.0-log virus inactivation, as per Table 4.

Chlorine contact time is the concentration of chlorine residual multiplied by time. Further information on chlorine contact time calculations can be found in Section 1.3.2.1 of the Municipal Standards.

When naturally occurring ammonia is present, it is difficult to achieve a free chlorine residual. If naturally occurring ammonia is present, the owner and operator of the micro waterworks system may wish to seek additional advice and support.

3.2.3.2.2 Residual

Water entering the piping network or distribution system must contain a chlorine residual of ≥ 0.2 mg/L.

The chlorine residual must be greater than 0.1 mg/L at all points in the piping network or distribution system.

3.2.4 Point of Entry/Point of Use

As an alternative to a centralized water supply system, there are some situations where it may be appropriate to consider POE/POU treatment systems to make the water meet the requirements of Table 2, Table 3, Table 4 and Table 5. POE/POU treatment systems provide a treatment barrier for the water as it enters a building or at the tap where water is consumed.

The responsibility for the continuous operation and maintenance of individual POE/POU treatment systems remains with the owner and operator of the micro waterworks system.

POE/POU units are typically considered in the following situations:

- where only a small quantity of water needs to be treated;
- where there are limited numbers of taps supplying treated water;
- where wastewater disposal is challenging for a centralized treatment process, or
- when there is a chronic chemical contaminant such as fluoride, manganese or arsenic in the source water where POE/POU units may also be used in combination with centralized treatment.

3.3 PERFORMANCE TARGETS

3.3.1 Water Treatment Targets

All micro waterworks systems must meet or exceed the water treatment performance targets listed in Table 2. However, based on the raw water results and risk assessment, the Director may require systems to meet higher *Giardia* and *Cryptosporidium* log-removal performance targets based on the *Giardia* and *Cryptosporidium* assessment found in the Health Canada's Guideline technical document – Enteric Protozoa: *Giardia* and *Cryptosporidium*, specifically sections 7.1 and 7.2 [4].

Treated water in the micro waterworks system must meet the maximum acceptable health-related concentration limits (MACs) for the list of parameters in Table 3, which is a subset of the health-based parameters and limits in the Guidelines for Canadian Drinking Water Quality (GCDWQ), published by Health Canada, as amended.

TABLE 2: MINIMUM WATER TREATMENT PERFORMANCE TARGETS

Parameter	Performance Target	Validation
Log-reduction *Giardia* and *Cryptosporidium*	≥ 3.0	As per NSF validation of equipment modules
Log-reduction viruses	≥ 4.0 (Includes Adenovirus 40 and 41)	As per NSF validation of equipment modules

TABLE 3: TREATED WATER PARAMETERS

Analysis	Microbiological	Chemical & Physical	Total Metals	Hydrocarbons	Pesticides
Parameter	Giardia Cryptosporidium	Alkalinity, total Turbidity Bicarbonate, Carbonate & Hydroxide Calcium Chloride Conductivity Hardness, total TOC Ammonia Fluoride Magnesium Nitrate Nitrite pH Potassium Sodium Sulphate Total Dissolved Solids (TDS) TTHM HAA	Aluminum Antimony Arsenic Barium Beryllium Boron Cadmium Chromium Cobalt Copper Iron Lead Manganese Mercury Molybdenum Nickel Selenium Silver Strontium Thallium Uranium Zinc	Benzene Ethylbenzene Xylenes, total	1,4-dioxane 2,4-D Atrazine + metabolites Bromoxynil Carbaryl Chlorpyrifos Diazinon Dicamba Dimethoate Diquat Diuron Glyphosate Malathion MCPA Metolachlor Metribuzin Microcystin, total NTA Paraquat Phorate Picloram Simazine Trifluralin

3.3.2 Treatment Process Monitoring and Limits

Routine monitoring of microbiological and chemical constituents and performance indicators detects changes in operation, trends in water quality and confirms the efficacy of disinfection processes in treated systems. This information confirms the efficacy of treatment and supports the operator in decision making [5].

Treated water in the micro waterworks system must meet the following limits for all the parameters listed in Table 4.

TABLE 4: WATER TREATMENT PERFORMANCE MONITORING AND LIMITS

Parameter	Performance Limits	Monitoring Location
Turbidity (Filter - Cartridge/Ceramic)	< 0.3 NTU	Post filtration
Turbidity (Filter - Membrane)	< 0.1 NTU	Post filtration
Ultraviolet (UV) Dosage	> 40 mJ/cm^2	Inside UV reactor
% UV Transmittance (% UVT)	>80 % UVT (or as per manufacturers specification for NSF 55A)	Entering UV reactor
Turbidity (Distribution)	≤ 0.5 NTU	Entering distribution system
Free Chlorine (Cl2)	≥ 0.2 mg/L	Entering distribution system
CT performance ratio	>1.0 for 4.0-log virus inactivation	Entering distribution system

3.4 PIPING NETWORK/WATER DISTRIBUTION SYSTEM

The piping network or water distribution system for a micro waterworks system should be sized to ensure the water demand is met.

Piping network or water distribution system piping material and construction practices must, at a minimum, meet the following:

- all of the requirements outlined in Section 1.9 of the Municipal Standards;
- NSF/ANSI 61;
- the Alberta Plumbing Code; or
- International Residential Code.

4. Operator Certification

AEP classifies all waterworks facilities and operator requirements based on AEP's *Water and Wastewater Operators' Certification Guidelines*, as amended or replaced from time to time.

For water treatment, there is currently no certification category consisting of process unit specific training courses particular to micro waterworks systems that is endorsed, approved, and tracked by the AEP Operator Certification Program. Until this certification category is created, no treatment certification is required. However, micro waterworks system owners can benefit from hiring operators with at least a small systems certification under the AEP Operator Certification program, to oversee the day-to-day operations of their waterworks systems.

For micro waterworks systems with a water distribution system, the water distribution classification is based upon the population served by that facility. The level of operator certification required will be the same as the classification of the facility.

The following publicly available resources may be of benefit for operators looking for additional information:

- B.C. Small Water System Help Centre
  - On-line technical resources and self-help tools developed for small water systems in British Columbia.[6]

- B.C. Small Water System Guidebook
  - Guidebook intended to be the first step in helping owners and operators find solutions to the challenges of operating small water systems.[7]
- Guidance on Providing Safe Drinking Water in Areas of Federal Jurisdiction. Version 2
  - Considerations for design, operation and maintenance of very small and micro waterworks systems, developed by Health Canada and the Interdepartmental Working Group on Drinking Water.[8]
- http://www.waterqualitytraining.ca
  - Water quality training materials for micro waterworks systems, developed by the Interdepartmental Water Quality Training Board and made publicly available through the Walkerton Clean Water Centre.[9]

5. Drinking Water Safety Plan

All micro waterworks systems must have a Drinking Water Safety Plan (DWSP) in place, within one (1) year of receiving either:

- written notice from AEP that they are to be regulated under the Micro Standards (for existing micro waterworks); or
- an EPEA registration (for new micro waterworks).

Following completion of a DWSP, micro waterworks system owners and operators must take steps to reduce any high risks that are identified.

Owners and operators must use the template and guidance documents developed by AEP to assist in the ongoing work of risk assessment. The Drinking Water Safety Plans (DWSP) template can be found at: www.environment.alberta.ca/apps/regulateddwq/dwsp.aspx. While the DWSP was originally designed for small to medium sized municipal systems, this template still provides a broad overview of risks typically found in micro waterworks systems.

Consultants can be used as advisors or facilitators, but the owners and operators should be fully engaged in developing the DWSP and are ultimately responsible for implementing effective risk management actions.

6. Operational Considerations

6.1 OPERATIONS PROGRAM

All owners and operators of micro waterworks systems must have an Operations Program in place, to be completed within:

- one (1) year of receipt of written notice from AEP that they are to be regulated under the Micro Standards (for existing micro waterworks); or
- three (3) months prior to supplying water (for new systems).

The Operations Program must contain:

- an Operations Plan; and
- a Maintenance Calendar.

Process control programs support preventive measures by detailing the specific operational factors that will ensure all processes and activities are carried out effectively and efficiently. To assure safe drinking water, an operations program should encompass total system management from source water to consumer.

7. Incident Management

7.1 ALTERNATE ON-DEMAND DRINKING WATER SUPPLY

Plans must be in place to provide an alternate supply of drinking water if treatment difficulties result in insufficient volumes of treated water being available to meet water demand.

These plans could include water supplied via trucked treated water, interconnections with neighboring water utilities, bottled water supplied locally or regionally, and locally produced water. Locally produced water can be obtained by packaging pre-treated water, by using mobile treatment units to inject water into the existing piping network or water distribution system, or by using mobile treatment in conjunction with water packaging or water tap distribution [10].

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