Nova Scotia Treatment Standards for

Municipal Drinking Water Systems

NOVA SCOTIA

Version Control

This document replaces:

Document Title	Date
Nova Scotia Treatment Standards for Municipal Drinking Water Systems	Mar. 2012
Guidelines for the Determination of Natural Filtration Log Removal Credit for Giardia	Jan. 2006
Treatment Standard for Municipal Groundwater Source Water Facilities	May 2003
Protocol for Determining Groundwater Under the Direct Influence of Surface Water	Dec. 2002
Treatment Standard for Municipal Surface Source Water Treatment Facilities	Dec. 2002

Approved by: Lora MacEachern, Deputy Minister

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PART I
Context and General Requirements

1 Purpose and Application of this Document

1.1 Purpose

The purpose of this document is to set out the minimum requirements an Approval Holder of a Municipal Public Drinking Water Supply in Nova Scotia must meet to achieve compliance with the health-based treatment goals for enteric viruses and protozoa in accordance with Health Canada's Guidelines for Canadian Drinking Water Quality, as amended from time to time.

Adhering to these requirements will assist in the production of clean, safe drinking water for public health protection while minimizing potential adverse environment effects.

1.2 Application

The requirements outlined in this document (the standards) apply to Municipal Public Drinking Water Supplies in Nova Scotia, as defined in the *Water and Wastewater Facilities and Public Drinking Water Supplies Regulations*, that use any of the source water types outlined below or purchase water for distribution only.

Applicable source water types

- Surface water
  - Where "surface water" means water that is found in lakes, rivers, streams, ponds, surface water impoundments, and other natural watercourses.
- Groundwater under the direct influence of surface water (GUDI)
  - Where "groundwater under the direct influence of surface water" (GUDI) means "any water beneath the surface of the ground with:
    a. significant occurrence of insects or other macro-organisms, algae, organic debris, or large-diameter pathogens such as *Giardia* and *Cryptosporidium*; or

b. significant and relatively rapid shifts in water characteristics such as turbidity, temperature, conductivity, or pH that closely correlate to climatological or surface water conditions" (U.S. EPA, 1991).

- Groundwater not under the direct influence of surface water (non-GUDI)
  - Where "non-GUDI" means a well that has been classified as not under the direct influence of surface water based on the *Protocol for Determining Groundwater Under the Direct Influence of Surface Water* (Appendix A) and has been accepted as such in writing by a Department of Environment and Climate Change (the Department) Regional Hydrogeologist.

Water purchased for distribution

Municipal Public Drinking Water Supplies that purchase treated water for distribution only must obtain the water from another Municipal Public Drinking Water Supply that complies with these standards.

2 Treatment Components and Document Structure

Nova Scotia's approach to drinking water treatment is based on the universally accepted multiple-barrier approach to drinking water management. This document is organized by components of the multi-barrier approach, with each part outlining the minimum requirements an Approval Holder must meet related to that component, as follows:

- Source Water Protection (Part II)
- Adequate Treatment and Operation (Part III)
- Distribution System Integrity (Part IV)
- Management of Waste Streams (Part V)
- Operations, Monitoring, Reporting and Management (Part VI)

3 Compliance

3.1 Newly Constructed Municipal Public Drinking Water Supplies

a. An Approval Holder of a Municipal Public Drinking Water Supply that begins operation after these standards come into effect (June 15th, 2022) must, upon commissioning, meet these standards as well as the requirements outlined in the *Atlantic Canada Water Supply Guidelines (Atlantic Canada Guidelines*), as amended from time to time.

b. The Approval Holder shall meet the minimum treatment requirements and adhere to the process of assigning log removal and inactivation credits for enteric protozoa and viruses as outlined in Appendix C based on source water type.

c. Groundwater wells must comply with the *Protocol for Determining Groundwater Under the Direct Influence of Surface Water* outlined in Appendix A and the bacterial monitoring and treatment requirements outlined in Part III, Section 3 while undergoing the GUDI process.

d. Subject to Part V Section 2.1, for an Approval Holder of a new Municipal Public Drinking Water Supply proposing to discharge filter backwash to a freshwater watercourse, the Department may consider site-specific effluent limits based upon a one year receiving water study.

3.2 Requirements by Source Water Type

The Department's requirements are based on the potential pathogens of concern in the source water used by a Municipal Public Drinking Water Supply and whether the Approval Holder treats water or purchases water from another Municipal Public Drinking Water Supply. Table 1 outlines the sections of this document Approval Holders' must comply with based on their source water type and the potential pathogens of concern.

Where multiple raw water sources are combined and treated in the same Municipal Public Drinking Water Supply, the minimum treatment requirements shall be based on the highest risk source water as outlined in Appendix C.

Table 1: Applicable Requirements by Source Water Type

Requirements that must be Complied with Based on the Municipal Public Drinking Water Supply Source water	**Surface Water**	**Non-GUDI and GUDI** (Assigned a Department-accepted Natural Filtration Log credit)	**GUDI** (Not Assigned a Department-accepted Natural Filtration Log Credit)	**Distribution only**
Part I Context and General Requirements				
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Section 6 – Back-up Water Systems (For Systems that have a Back-up Water Supply)	x	x	x	
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Requirements that must be Complied with Based on the Municipal Public Drinking Water Supply Source water	**Surface Water**	**Non-GUDI and GUDI** (Assigned a Department-accepted Natural Filtration Log credit)	**GUDI** (Not Assigned a Department-accepted Natural Filtration Log Credit)	**Distribution only**
Part III Treatment and Operational Requirements				
Section 1 – Treatment and Operational Requirements (Surface water and GUDI Sources not Assigned a Department-accepted Natural Filtration Log Credit)	x		x	
Section 2 – Treatment and Operational requirements (Non-GUDI and GUDI Sources Assigned a Department-accepted Natural Filtration Log Credit)		x		
Section 3 – Bacterial Monitoring and Treatment Requirements in Groundwater Systems Undergoing GUDI Evaluation		x	x	
Section 4 – Bypassing Treatment	x	x	x	x

Requirements that must be Complied with Based on the Municipal Public Drinking Water Supply Source water	**Surface Water**	**Non-GUDI and GUDI** (Assigned a Department-accepted Natural Filtration Log credit)	**GUDI** (Not Assigned a Department-accepted Natural Filtration Log Credit)	**Distribution only**
Part IV Requirements for Distribution Systems				
Section 1 – Secondary Disinfection	x	x	x	x
Section 2 – Distribution System Turbidity	x	x	x	x
Section 3 – Cross-Connection Control	x	x	x	x
Section 4 – Corrosion Control, Lead and Copper Management	x	x	x	x

Requirements that must be Complied with Based on the Municipal Public Drinking Water Supply Source water	**Surface Water**	**Non-GUDI and GUDI** (Assigned a Department-accepted Natural Filtration Log credit)	**GUDI** (Not Assigned a Department-accepted Natural Filtration Log Credit)	**Distribution only**
Part V Management of Waste Streams				
Section 1 – Waste Residuals Management (Applies only to Facilities that Generate Waste Residuals)	x	x	x	
Section 2.1 – Filter Backwash Discharge to Freshwater Aquatic Environments (Applies only to Facilities that Direct Filter Backwash to Freshwater)	x	x	x	
Section 2.2 – Filter Backwash Discharge to Non-Aquatic Environments (Applies only to Facilities that Direct Filter Backwash to Non-aquatic Environments)	x	x	x	

Requirements that must be Complied with Based on the Municipal Public Drinking Water Supply Source water	**Surface Water**	**Non-GUDI and GUDI** (Assigned a Department-accepted Natural Filtration Log credit)	**GUDI** (Not Assigned a Department-accepted Natural Filtration Log Credit)	**Distribution only**
Part VI Operations, Monitoring, Reporting, and Management				
Section 1 – Operations	x	x	x	x
Section 2 – Annual Monitoring Program	x	x	x	x
Section 3 – Reporting and Record Keeping	x	x	x	x
Section 4 – Management of Operations	x	x	x	x

4 System Assessment Reports and Corrective Action Plans

4.1 Purpose

The purpose of a **System Assessment Report** is to verify that the Approval Holder of the Municipal Public Drinking Water Supply meets current standards, including the minimum requirements set out by this document.

System Assessment Reports support the Approval Holder and the Department to:

- Evaluate the capability of the system to consistently and reliably deliver an adequate quantity of safe drinking water;
- Verify compliance with regulatory requirements, as amended from time to time; and
- Consider options and costs to address deficiencies.

The purpose of a **Corrective Action Plan** is to outline the implementation schedule that an Approval Holder must follow to address all deficiencies identified by the System Assessment Report.

It is the Approval Holder's responsibility to ensure that funding is in place to complete the System Assessment Report process and implement any required corrective action.

4.2 Contents

The Approval Holder must complete a System Assessment Report in accordance with the *Terms of Reference for System Assessment Reports for Municipal Drinking Water Systems*, as amended from time to time, published by the Department. The submitted System Assessment Report must be acceptable to the Department and must include the following components:

- A characterization of the source water;
- An evaluation of any changes that could affect the GUDI status;
- An evaluation of treatment processes, facilities, and equipment;
- An evaluation of the distribution system;
- An evaluation of waste streams; and
- A review of operations, maintenance, monitoring and management of the Municipal Public Drinking Water Supply

The Corrective Action Plan must be acceptable to the Department.,

4.3 Reporting Timelines

A Municipal Public Drinking Water Supply shall be assessed at least every ten years, or sooner, if required, as outlined below.

Timelines for existing Municipal Public Drinking Water Supplies:

System Assessment Reports: An Approval Holder with an existing Approval to Operate at the time these standards come into effect (June 15th, 2022) must submit a System Assessment Report on or before April 1st, 2023, and thereafter must submit a Report on or before April 1st of every subsequent ten-year period (e.g., April 1st, 2033; April 1st, 2043; etc.) for as long as the Municipal Public Drinking Water Supply is in operation. The Approval Holder must submit three copies of the completed System Assessment Report to the local Department office.

Corrective Action Plans: An Approval Holder with an existing Approval to Operate at the time these standards come into effect (June 15th, 2022) must submit a Corrective Action Plan to the local Department office on or before October 1st of the same year the System Assessment Report was due to address deficiencies identified by the System Assessment Report.

Timelines for Holders of Approvals issued after June 15th, 2022:

System Assessment Reports: An Approval Holder with an approval issued after June 15th, 2022, will receive a site-specific deadline from the Department by which they must submit their System Assessment Report. It is required that all newly constructed Municipal Public Drinking Water Supplies meet the standards outlined in this document. After the initial assessment, future System Assessment Reports shall be submitted on or before April 1st, 2033, and every ten years thereafter.

Corrective Action Plans: An Approval Holder with an Approval to Operate issued after June 15th, 2022, must submit a Corrective Action Plan to the Department within six months of the submission of the System Assessment Report. After the initial Corrective Action Plan is received, future Corrective Action Plans shall be submitted on or before October 1st, 2033, and every ten years thereafter.

5 Requirements Related to the Protocol for Determining Groundwater Under the Direct Influence of Surface Water (GUDI Protocol)

The GUDI Protocol (Appendix A) provides a process for determining whether a water well is classified as “groundwater under the direct influence of surface water” (GUDI) and, if so, its specific GUDI risk classification. This classification determines the applicable treatment and monitoring requirements.

a. An Approval Holder that relies on groundwater must ensure that all wells in the Municipal Public Drinking Water Supply have been classified in accordance with *The Protocol for Determining Groundwater Under the Direct Influence of Surface Water (*GUDI Protocol) (Appendix A), as amended from time to time.

b. A well assigned a GUDI classification under the previous *Nova Scotia Municipal Drinking Water Treatment Standards*, dated March 2012, does not need to be re-assessed and the existing Department-accepted classification remains valid unless evidence provided in the System Assessment Report, or other information, indicates a need for reclassification based on Appendix A section A.3.6.

c. The Approval Holder is responsible for completing the GUDI Protocol as outlined in Appendix A and submitting the resulting GUDI classification to the Department for review and acceptance.

d. GUDI classifications must be made by a Qualified Hydrogeologist registered to practice in Nova Scotia by the Association of Professional Geoscientists of Nova Scotia (Geoscientists Nova Scotia) or the Association of Professional Engineers of Nova Scotia (Engineers Nova Scotia). The classifying Qualified Hydrogeologist is considered the person responsible for all aspects of the GUDI Protocol assessment and this includes a duty to ensure the proper collection, integrity and use of data in accordance with the GUDI Protocol.

e. The completion of the GUDI Protocol and the classification of wells must be acceptable to a Department Regional Hydrogeologist.

6 Backup Water Systems

6.1 Notification

a. Prior to the use of a backup water system, the Approval Holder must immediately notify the Department, provide rationale for the use of the backup water system and identify the anticipated period of time that the backup system will be in service.

6.2 Boil Water Advisories

a. For backup systems that do not meet the requirements set out in this document, the Approval Holder must immediately initiate a boil water advisory as stated in the *Guidelines for Monitoring Public Drinking Water Supplies – Part I,* as amended from time to time, prior to the use of the backup system. The Approval Holder shall maintain the boil advisory until otherwise advised by the Department.

b. For backup systems that meet the standards set out in this document, the Approval Holder may continue to operate without the issuance of a boil water advisory until the main system is put back into service or as otherwise directed by the Department.

PART II
Source Water Protection Requirements

The Municipal Public Drinking Water Supply Approval Holder is responsible for taking reasonable steps to protect the source from contamination.

1 Development of a Source Water Protection Plan

a. The Approval Holder must develop a source water protection plan (SWPP) in accordance with the following five guidance documents, as amended from time to time, published by the Department.
    - Step 1 - Form a Source Water Protection Advisory Committee
    - Step 2 - Delineation of a Source Water Protection Area Boundary
    - Step 3 - Identify Potential Contaminants and Assess Risk
    - Step 4 - Develop a Source Water Protection Management Plan
    - Step *5* - Develop a Monitoring Program to Evaluate the Effectiveness of a Source Water Protection Plan
b. The Approval Holder shall complete the risk identification process in accordance with the following criteria, dependent on the system source water type:
    - Surface water: within the natural watershed boundary;
    - GUDI sources: within the natural watershed boundary and the 25-year time-of-travel; or
    - Non-GUDI sources: within the 25-year time-of-travel.

2 Submission and Review

a. The Approval Holder shall submit a SWPP, including an implementation schedule, to the Department for review. The SWPP and schedule must be deemed acceptable by the Department.

b. The Approval Holder shall review the SWPP and implementation plan annually. The Approval Holder shall summarize the results of the annual review, using the checklist published by the Department, in the Municipal Public Drinking Water Supply annual report due annually on or before April 1st.

c. The Approval Holder shall modify the SWPP, including updating the plan, if directed to do so by the Department.

PART III
Requirements for Adequate Treatment and Operation

For newly constructed Municipal Public Drinking Water Supplies (including all constructed wells) or those undergoing process modification, the Approval Holder shall adhere to the minimum treatment requirements and process for assigning pathogen log reduction credits outlined in Appendices C and D to meet the minimum health-based treatment goals for enteric viruses and protozoa.

1 Treatment and Operational Requirements for Surface Water and GUDI Sources Not Assigned a Department-Accepted Natural Filtration Log Credit[1]

1.1 General Requirements

a. Using both the engineered filtration and disinfection processes, the Municipal Public Drinking Water Supply must meet the following treatment efficiencies:
    i. Treatment shall ensure 3-log reduction of *Giardia* and *Cryptosporidium*; and
    ii. Treatment shall ensure 4-log reduction of viruses.
b. Primary disinfection though the use of chlorine, UV, and/or Department-accepted alternate disinfectant such as chlorine dioxide or ozone shall achieve a minimum of 0.5-log inactivation for *Giardia* when used in conjunction with filtration. The disinfection log inactivation shall be based on CT/IT values calculated as described in Appendix C.
c. The Approval Holder shall adhere to the requirements outlined in Table 2 based on the type of primary disinfectant used.

[1] High-risk GUDI sources are not eligible to receive a Department accepted natural filtration log credit.

Table 2: Operational Requirements Based on Type of Primary Disinfectant

Primary Disinfectant	Requirements
Free chlorine **Note:** Chloramines are not acceptable for use as a primary disinfectant.	a. The Approval Holder shall meet the required CT value, at a minimum, as outlined in Appendices C and D. b. In the event the minimum required CT is not achieved, contingencies shall be in place to prevent the distribution of inadequately disinfected water. c. The Approval Holder shall contact the Department to determine if site-specific requirements may apply.
Ultraviolet (UV) Light	The Approval Holder shall meet the following requirements: a. UV systems must provide a minimum dosage of 40 mJ/cm^2 at all points within the reactor at all times when water is passing through the unit, unless an alternate dose has been accepted by the Department. b. UV intensity and flow through the reactors shall be monitored a minimum of once every five minutes to ensure UV dose is greater than or equal to 40 mJ/cm^2, or alternate Department accepted dose. c. UV transmittance shall be calculated at a minimum of daily. d. Contingencies shall be in place to prevent the distribution of water if the UV dose drops below 40 mJ/cm^2, or alternate Department accepted dose, including during lamp warm-up time. Water flow shall be stopped, directed to waste, or another method of disinfection shall be used. e. In the event of UV bulb breakage during operation, contingencies shall be in place to prevent the distribution of inadequately disinfected water. f. The UV disinfection unit shall be equipped with UV sensors reading calibrated UV intensity. The UV sensors shall be calibrated on a monthly basis. Off-line reference sensors used for calibration shall be of equal quality to the on-line sensors and shall be calibrated annually. g. The Approval Holder shall record the results of the calibration as part of their QA/QC program and provide the results to the Department immediately upon request. h. The UV system shall be equipped with an alarm notification and shutdown procedures in the event of: – High temperature in the reactor, lamp, ballast or transformer; – High flow rate that causes dose to fall below design specifications; – Low UV dose; – Low UV intensity; – UV has shutdown; or – Any other emergency situation. i. The UV transmittance analyzer shall be calibrated weekly. j. UV lamp operation shall be monitored in a manner that ensures bulb replacement can be accomplished prior to the maximum

Primary Disinfectant	Requirements
	lamp life expectancy. k. The Approval Holder shall receive written verification from an independent third party that the manufacturer's system will continually meet the 40 mJ/cm^2 requirement, or alternate Department-accepted dose, and provide this information to the Department immediately upon request. l. The Approval Holder shall contact the Department to determine - if specific requirements may apply.
Chlorine dioxide	a. The Approval Holder shall meet the required CT value, at a minimum, as outlined in Appendices C and D. b. In the event the minimum CT is not achieved, contingencies shall be in place to prevent the distribution of inadequately disinfected water. c. The feed dose shall not exceed a maximum of 1.2 mg/L. d. The Approval Holder shall contact the Department to determine if site-specific requirements may apply.
Ozone	a. The Approval Holder shall meet the required CT value at a minimum as outlined in Appendices C and D. b. In the event the minimum CT is not achieved, contingencies shall be in place to prevent the distribution of inadequately disinfected water. c. The Approval Holder shall contact the Department to determine if site-specific requirements may apply.

1.2 Primary Disinfection

1.2.1 Disinfection Units

a. The Municipal Public Drinking Water Supply shall have a minimum of two primary disinfection units to ensure that inadequately disinfected water is not distributed.

b. Each disinfection unit shall be capable of meeting the maximum day demand flow.

c. Where more than two disinfection units are provided, the maximum day demand flow shall be met when the largest unit is out of service.

1.2.2 Monitoring

a. Continuous on-line monitoring of the primary disinfection process is required at each Municipal Public Drinking Water Supply.

b. Measurements must be taken and recorded at a minimum of once every five minutes to ensure that inadequately disinfected water does not enter the distribution system.

c. Water systems shall be equipped with alarm capabilities to notify operations staff if the disinfection process fails to operate properly to prevent inadequately disinfected water from being distributed. Contingencies shall be in place to prevent the distribution of inadequately disinfected water.

1.2.3 Standard Operating Procedures (SOPs)

a. SOPs for the disinfection process shall be developed, implemented, and communicated to all operations staff and documented in the operations manual required by these standards.

b. The procedures and a log indicating the date and method of communication to staff shall be made available to the Department immediately upon request.

c. SOPs shall indicate the design ranges for achieving CT (e.g., for free chlorine disinfection - minimum temperature and chlorine residual; maximum flow and pH) and/or IT (e.g., minimum UV intensity, minimum UV transmittance, and maximum water flow).

d. When operational conditions are outside the design ranges for achieving CT/IT, the Approval Holder shall notify the Department as soon as the Approval Holder becomes aware, investigate the cause, and take necessary corrective action. CT/IT shall be calculated during every such event.

1.3 Turbidity and Filtration Requirements

a. Continuous or grab sample monitoring for turbidity is required at least once a day for the raw water prior to pre-treatment.

b. Filters:

    i. A minimum of two filters or membrane units (redundancy) are required.

    ii. Where two filters or membrane units are provided, each shall be capable of supplying maximum daily demands with the largest filter or membrane out of service.

    iii. Where more than two filters or membrane units are provided, the maximum day demand shall be met with the largest filter or membrane out of service.

c. Based on the type of filtration technology, the Approval Holder shall adhere to the requirements outlined in Table 3.

d. Continuous or grab sample monitoring of the filter-to-waste product is required. Unless otherwise specified in the Approval to Operate, sampling and testing shall be completed prior to returning the filter to operation.

e. The filtration process shall be operated in such a manner as to remove an individual filter or membrane unit from service if the turbidity exceeds the values specified in Table 3.

f. Filtration processes for pathogen reduction are required to be continuously monitored, with turbidity measurements collected and recorded at a minimum frequency of once every five minutes.

g. Filtration processes shall have a shut off feature and alarm when turbidity criteria are not achieved.

h. The Approval Holder shall notify the Department as soon as they become aware of turbidity values that do not meet the requirements of Table 3.

i. SOPs for the filtration process shall be developed, implemented, and communicated to all operations staff and documented in the operations manual required herein. The procedures and log of communication shall be made available to the Department immediately upon request.

Table 3: Filtration Requirements for Surface Water and GUDI Sources Not Assigned a Department-accepted Natural Filtration Log Credit

Treatment Technology	Individual Filter Turbidity Limits (unless stated otherwise) and Operational Requirements
Conventional filtration[1] - includeschemical mixing, coagulation, flocculation, clarification and rapid gravity filtration	a. Shall be less than or equal to 0.2 NTU in at least 95% of the measurements made or at least 95% of the time each calendar month. b. Shall not exceed 1.0 NTU at any time. c. Filter-to-waste[2] filters shall be capable of directing filtered water to waste or recycle immediately following a backwash for a period of time until the filtrate turbidity value is below 0.2 NTU. d. For direct filtration systems that use free chlorine alone as their primary disinfectant, to achieve log reduction requirements for *Cryptosporidium*, the turbidity shall be less than or equal to 0.15 NTU in at least 95% of the measurements made or at least 95% of the time each calendar month.
Direct filtration[1] - includes chemical mixing, coagulation, flocculation, and rapid gravity filtration	
Slow sand filtration	a. Shall be less than or equal to 1.0 NTU in at least 95% of the measurements made or at least 95% of the time each calendar month. b. Shall not exceed 3.0 NTU at any time. c. Filter-to-waste[2] shall be provided to ensure filtered water, immediately after filter cleaning, is directed to a waste or recycle stream.
Diatomaceous earth filtration	a. Shall be less than or equal to 1.0 NTU in at least 95% of the measurements made or at least 95% of the time each calendar month. b. Shall not exceed 3.0 NTU at any time. c. Filter-to-waste[2] shall be provided to ensure filtered water, immediately after filter backwashing, is directed to a waste or recycle stream.

Treatment Technology	Individual Filter Turbidity Limits (unless stated otherwise) and Operational Requirements
Micro-filtration and Ultra-filtration	a. Shall be less than or equal to 0.1 NTU in at least 99% of the measurements made or at least 99% of the time each calendar month. b. If turbidity exceeds 0.1 NTU for more than 15 minutes, direct integrity testing shall be immediately conducted on the membrane treatment unit. c. Shall not exceed 0.3 NTU at any time. d. Filter-to-waste[2] shall be provided for operational flexibility. e. The membrane system used for pathogen reduction shall have continuous indirect integrity testing. f. Continuous indirect integrity testing shall be conducted at a minimum frequency of once every 5 minutes. Indirect integrity testing shall follow that outlined in the EPA *Membrane Filtration Guidance Manual*, as amended from time to time. g. The actual removal efficiency of a membrane shall be verified by third party challenge testing. Acceptable challenge testing shall follow that provided in the EPA *Membrane Filtration Guidance Manual*, as amended from time to time. h. Direct integrity testing shall be able to verify a log removal value equal to or greater than the removal credit awarded to the membrane filtration process. i. Direct integrity testing shall be conducted on each membrane filtration unit at least once per day and as soon as the Approval Holder becomes aware when the turbidity exceeds 0.1 NTU for more than 15 minutes.

Treatment Technology	Individual Filter Turbidity Limits (unless stated otherwise) and Operational Requirements
Reverse osmosis and Nano-filtration	a. Shall be less than or equal to 0.1 NTU in at least 99% of the measurements made or at least 99% of the time each calendar month. b. Shall not exceed 0.3 NTU at any time. c. Filter-to-waste[2] shall be provided for operational flexibility. d. To receive pathogen log reduction credits, direct integrity testing shall be available to verify removal efficiency. If the membrane process is assigned pathogen log reduction credits by the Department, the Approval Holder shall adhere to the following additional requirements: i. The membrane system used for pathogen reduction shall have continuous indirect integrity testing. ii. Continuous indirect integrity testing shall be conducted at a minimum frequency of once every 5 minutes. Indirect integrity testing shall follow that outlined in the EPA *Membrane Filtration Guidance Manual*, as amended from time to time. e. The actual removal efficiency of a membrane shall be verified by third party challenge testing. Acceptable challenge testing shall follow that provided in the EPA *Membrane Filtration Guidance Manual*, as amended from time to time. f. Direct integrity testing shall be able to verify a log removal value equal to or greater than the removal credit awarded to the membrane filtration process. g. Direct integrity testing shall be conducted on each membrane filtration unit at least once per day and as soon as the Approval Holder becomes aware when the turbidity exceeds 0.1 NTU for more than 15 minutes.

Treatment Technology	Individual Filter Turbidity Limits (unless stated otherwise) and Operational Requirements
Cartridge filtration (1 micron absolute pore size)	a. For systems serving less than 500 persons, differential pressure across the filter medium is measured and recorded a minimum of once daily and does not exceed the manufacturer's requirements. b. For systems serving more than 500 persons, differential pressure across the filter medium is continuously measured and recorded at a minimum frequency of one measurement every five minutes and does not exceed the manufacturer's requirements. c. Shall be less than or equal to 0.3 NTU in at least 95% of the measurements made or at least 95% of the time each calendar month. d. Shall not exceed 1.0 NTU at any time e. The cartridge filtration process is tested and confirmed by an independent testing agency for at least 3 log removal of *Cryptosporidium* oocysts or surrogate particles. Challenge testing shall demonstrate at least 3 log removal of *Cryptosporidium* oocysts and *Giardia* cysts.

1 Municipal Public Drinking Water Supplies with conventional or direct filtration that achieve 0.15 NTU 95% of the time each calendar month in combined or individual filter effluent are eligible to receive additional log removal credits for protozoa to meet minimum treatment requirements as follows: combined 0.5-log; individual 1.0-log.

2 Alternatives that demonstrate an equivalent benefit to filter-to-waste may be considered by the Department on a case-by-case basis for existing Municipal Public Drinking Water Supplies. All new facilities shall include a filter-to-waste provision.

2 Treatment and Operational Requirements for Non-GUDI and GUDI Sources Assigned a Department-Accepted Natural Filtration Log Credit(s)

As the operational requirements are similar for both non-GUDI and GUDI sources assigned a Department-accepted natural filtration log credit, the Approval Holder shall adhere to the requirements outlined in this section. Where there are differences in requirements for non-GUDI and GUDI sources assigned a Department-accepted natural filtration log credit, the differences are specified.

The Approval Holder of a Municipal Public Drinking Water Supply using a GUDI source of supply may apply to the Department for a natural filtration log credits(s) as outlined in Appendix B.

2.1 General Requirements

2.1.1 Non-GUDI

Treatment shall be sufficient to ensure 4 log reduction of viruses for each well or, if water from individual wells is combined, for the combined flow.

2.1.2 Low-Risk and Medium-Risk GUDI

a. Using both the natural filtration and disinfection processes, the Approval Holder shall meet the following treatment efficiencies:
    i. Treatment shall be sufficient to ensure 3-log reduction of *Giardia* and *Cryptosporidium*; and
    ii. Treatment shall be sufficient to ensure 4-log reduction of viruses.
b. **For Low-Risk GUDI:** Upon acceptance by a Department Regional Hydrogeologist, verified natural filtration allows a 3-log reduction credit to be assigned for Giardia and Cryptosporidium treatment.
c. **For Medium-Risk GUDI:** Upon acceptance by a Department Regional Hydrogeologist, verified natural filtration allows a 1-log reduction credit to be assigned for Giardia and Cryptosporidium treatment.

2.2 Primary Disinfection Requirements

The Approval Holder shall adhere to the requirements outlined in Table 2 based on the type of primary disinfectant used.

2.2.1 Disinfection:

a. **For non-GUDI and low-risk GUDI assigned a Department-accepted natural filtration log credit,** primary disinfection through the use of chlorine, UV, and/or a Department-accepted alternate disinfection method shall contribute a minimum of 4-log inactivation for viruses for each well or, if water from individual wells is combined, for the combined flow.

b. **For medium-risk-GUDI assigned a Department-accepted natural filtration log credit,** primary disinfection through the use of chlorine, UV, and/or a Department-accepted alternate disinfection method shall contribute a minimum of 2-log inactivation for *Giardia* and *Cryptosporidium* and 4-log reduction viruses for each well or, if water from individual wells is combined, for the combined flow.

c. The disinfection log inactivation shall be based on CT/IT values calculated as described in Appendix C.

2.2.2 Disinfection Units:

a. Flow from each well or the combined flow, if water from individual wells is combined, shall have a minimum of two primary disinfection units configured to apply disinfection treatment at all times to ensure that inadequately disinfected water does not enter the water distribution system, unless the Approval Holder makes an application for system-wide redundancy and the application is accepted by the Department.

    i. Each disinfection unit shall be capable of meeting the maximum day demand flow.

b. Where more than two disinfection units are provided, the maximum day demand flow shall be met when the largest unit is out of service.

2.2.3 Monitoring:

a. Continuous on-line monitoring of the primary disinfection process is required at each Municipal Public Drinking Water Supply with measurements taken at a minimum of once every five minutes to ensure that inadequately disinfected water does not enter the distribution system.

b. Water systems shall be equipped with alarm capabilities to notify operations staff if the disinfection process fails to operate properly to prevent inadequately disinfected water from being distributed.

2.2.4 Standard Operating Procedures (SOPs):

a. SOPs for the disinfection process shall be developed, implemented and communicated to all operations staff and documented in the operations manual required by these standards.

b. The procedures and a log indicating the date and method of communication to staff shall be made available to the Department immediately upon request.

c. SOPs shall indicate the design ranges for achieving CT (e.g., for free chlorine disinfection - minimum temperature and chlorine residual; maximum flow and pH) and/or IT (e.g., minimum UV intensity, minimum UV transmittance, and maximum water flow).

d. When operational conditions are outside the design ranges for achieving CT/IT, the Approval Holder shall notify the Department as soon as they become aware, investigate the cause, and take necessary corrective action. CT/IT shall be calculated during every such event.

2.3 Turbidity Requirements

2.3.1 Non-GUDI

a. The turbidity levels entering the water distribution system from each well or combination of wells shall not exceed 1.0 NTU in:

   i. at least 95% of the measurements taken by grab sample for each calendar month; or
   ii. at least 95% of the time each calendar month if continuous monitoring is the method of turbidity measurement.

b. A daily grab sample, collected once per day, or continuous monitoring, with measurements taken at no more than five-minute intervals, is required at each wellhead or combined flow.

c. If the Municipal Public Drinking Water Supply cannot meet the 1.0 NTU turbidity requirements described in these standards, the Approval Holder may request to the Department that a less stringent value apply provided the Approval Holder can demonstrate to the Department that the turbidity is not health-related and that the disinfection process is not compromised by the use of a less stringent value.

2.3.2 Low-Risk and Medium-Risk GUDI

a. The turbidity value at each wellhead shall be equal to or less than 1.0 NTU in:

   i. at least 95% of the measurements; or

   ii. at least 95% of the time based on each calendar month.

b. Continuous turbidity monitoring and recording is required for each GUDI well, with measurements taken at no more than five-minute intervals.

c. If the Municipal Public Drinking Water Supply cannot meet the 1.0 NTU turbidity requirements described in these standards, the Approval Holder may request to the Department that a less stringent value apply provided the Approval Holder can demonstrate to the Department that the turbidity is not health-related and that the disinfection process is not compromised by the use of a less stringent value.

3 Bacterial Monitoring and Treatment Requirements in Groundwater Systems during the GUDI Evaluation

a. For groundwater wells, a minimum of two raw water bacteria (total coliform and *E. coli*) samples shall be collected to assess the water quality screening criteria in Step 1 of the GUDI Protocol (Appendix A), as amended from time to time. These samples must be collected at the middle and end of the 72-hour pumping test, as suggested in the Department's *Guide to Groundwater Withdrawal Approvals*, as amended from time to time.

b. If a well being assessed under the GUDI protocol has bacteria detected in either of the two raw water samples, the Approval Holder must carry out additional sampling to confirm whether bacteria continue to be present.

    i. The Approval Holder must collect a minimum of two additional samples, separated by a minimum of 24 hours, as outlined in Section A.2.1 of Appendix A.

    ii. If any of the additional samples contain bacteria, the well shall fail Step 1, unless additional corrective action is undertaken, and further additional sampling demonstrates the well does not contain bacteria in the latest two consecutive samples.

    iii. The iterative process of corrective action to a well followed by additional sampling may only be carried out twice before Step 1 results must be determined.

c. For groundwater wells that fail Step 1 of the GUDI Protocol (Appendix A), as amended from time to time, for reasons other than water quality, the following shall apply:

    i. The well may be connected to the distribution system to allow the completion of Steps 2 and 3 of the Protocol, in which case, the following shall apply:

        – The well shall be equipped with a disinfection system capable of achieving 4-log reduction for viruses;

        – A minimum of 0.4 mg/L free chlorine residual shall be maintained at the end of the distribution system; and

        – Twice weekly sampling and analysis for total coliform and *E.coli* bacteria of water in the distribution system shall be conducted.

d. If the well failed Step 1 due to total coliform or *E. coli* bacteria presence, or if any subsequent samples are confirmed for bacteria, and the well is connected to the distribution system for the completion of the GUDI Protocol, the following shall apply:
    i. The well shall be equipped with a disinfection system capable of achieving 3-log reduction for protozoa;
    ii. The well shall be equipped with a disinfection system capable of achieving 4-log reduction for viruses;
    iii. A 0.4 mg/L free chlorine residual shall be maintained at the furthest point in the distribution system; and
    iv. Twice weekly sampling and analysis for total coliform and *E. coli* bacteria of water in the distribution system shall be conducted.
e. Step 2 of the GUDI Protocol shall be completed under proposed "normal operating conditions" (e.g., proposed flow rate, well on/off cycling, etc.) for 52 weeks of operation in accordance with the GUDI Protocol (Appendix A), as amended from time to time..
f. Step 3 shall be completed in accordance with the GUDI Protocol (Appendix A), as amended from time to time.

4 Bypassing Treatment

4.1 Notification

When it is necessary to use a by-pass to divert water around one or more treatment processes required to achieve log reduction requirements for enteric viruses and protozoa, the Approval Holder shall immediately notify the Department, provide rationale for the need to bypass treatment and identify the anticipated period of time that the by-pass will be necessary.

4.2 Boil Water Advisory

When it is necessary to use a by-pass to divert water around one or more treatment processes, the Approval Holder shall immediately initiate a boil water advisory as outlined in *the Guidelines for Monitoring Public Drinking Water Supplies – Part I*, as amended from time to time. The Approval Holder shall maintain the boil advisory until otherwise advised by the Department.

PART IV
Requirements for Distribution Systems

All Approval Holders must comply with the requirements outlined in this section.

Distribution system integrity: The Department recommends Approval Holders have active programs in place to deal with threats to distribution system integrity, including ageing infrastructure, leaks, pressure transients, storage tanks, and pumping stations.

1 Secondary Disinfection

1.1 Free Chlorine

For Approval Holders using free chlorine as their secondary disinfectant, the following requirements must be met:

a. The disinfection process shall be operated in such a manner so as to ensure that a minimum free chlorine residual of 0.2 mg/L is achieved throughout the water distribution system at all times, except for systems using groundwater sources undergoing a GUDI assessment where the water is distributed for human consumption. In this case a minimum free chlorine residual of 0.4 mg/L shall be achieved throughout the water distribution system at all times.

b. The maximum free chlorine residual shall not exceed 4 mg/L.

1.2 Chloramines

For Approval Holders using chloramines (combined chlorine) as their secondary disinfectant, the following requirements must be met:

a. The disinfection process shall be operated in such a manner as to ensure that a minimum combined chlorine residual of 1 mg/L is achieved throughout the water distribution system at all times.

b. The maximum combined chlorine residual shall not exceed 3 mg/L.

1.3 Monitoring

a. Continuous monitoring and recording of the free or combined chlorine residual is required for finished water leaving the Municipal Public Drinking Water Supply and entering the water distribution system with measurements taken at no more than five-minute intervals.

b. Continuous monitoring and recording of the free or combined chlorine residual is required for the water leaving any water storage structure within the water distribution system, with measurements taken at no more than five-minute intervals.

c. Monitoring of the water distribution system for free or combined chlorine residual is required. Unless specified otherwise in the Approval to Operate, sampling frequency is the same as for bacteriological sampling requirements as stated in the *"Guidelines for Monitoring Public Drinking Water Supplies– Part I"*, as amended from time to time.

1.4 Notification

a. The Approval Holder shall immediately notify the Department and undertake corrective action if the minimum free or combined chlorine residual drops below the minimum required concentration..

1.5 Standard Operation Procedures (SOPs)

a. SOPs for the secondary disinfection process shall be developed, implemented, and communicated to all operations staff and documented in the operations manual required by these standards. The procedures and the log of communication shall be made available immediately upon request by the Department.

2 Distribution System Turbidity

a. A turbidity value of 5.0 NTU or less shall be achieved in the water distribution system.

b. Unless specified otherwise in the Approval to Operate, sampling and testing frequency is the same as for bacteriological sampling requirements as stated in the *Guidelines for Monitoring Public Drinking Water Supplies – Part I*, as amended from time to time.

c. Where turbidity values of greater than 5.0 NTU are observed in the water distribution system, the Approval Holder shall investigate the cause, notify the Department immediately, and take corrective action as necessary.

3 Cross-Connection Control

a. The Approval Holder shall develop and implement a Department-accepted Cross-Connection Control Program to protect the Municipal Public Drinking Water Supply from contamination due to cross-connections from commercial, institutional, industrial, multi-unit residential, and agricultural facilities, at a minimum, and avoid any cross-connections within the Municipal Public Drinking Water Supply.

    i. For guidance on how to develop a Cross-Connection Control Program, see *A Guide to Assist Nova Scotia Municipal Waterworks Develop A Cross Connection Control Program*, as amended from time to time.

b. The Cross-Connection Control Program shall be submitted to the Department for review. Upon review, the Department may require changes to the program.

c. Once accepted by the Department, the Approval Holder shall implement their accepted Cross-Connection Control Program. Documentation of the implementation of the program shall be made available to the Department immediately upon request.

d. The Approval Holder shall provide an update on the status of the Cross Connection Control Program in the annual report due on or before April 1st of each year, including any modifications to the plan or implementation schedule, and a summary of the activities taken to achieve the goals and objectives of the program.

4 Corrosion Control, Lead and Copper Sampling

a. The treated water shall minimize corrosion of the water distribution and/or plumbing systems.

b. The Approval Holder shall adhere to the minimum corrosion monitoring program requirements included in Appendix H of this document.

c. The Approval Holder shall adhere to the minimum sampling, notification, corrective action, and reporting requirements for lead and copper outlined in *Requirements for Lead and Copper Management –Municipal Public Drinking Water Supplies*, as amended from time to time.

    i. If the Approval Holder receives a laboratory analysis result for lead or copper above the maximum acceptable concentration as specified in the most recent version of Health Canada's *Guidelines for Canadian Drinking Water Quality*, as amended from time to time, the Approval Holder shall immediately notify the Department, notify the residence owner within 14 days of receiving the results from the lab and prepare a corrective action plan to address the exceedance as outlined in the *Requirements for Lead and Copper Management – Municipal Public Drinking Water Supplies*, as amended from time to time.

    ii. The Approval Holder shall submit the corrective action plan to the Department on or before October 31st of the same year the lead or copper exceedance occurred.

    iii. The corrective action plan shall be acceptable to the Department.

PART V
Management of Waste Streams

Waste streams from all Municipal Public Drinking Water Supplies must be properly managed. Drinking water treatment waste streams may include, but are not limited to, filter backwash water, filter backwash solids, clarified solids, and spent media. Membrane filtration technology produces other waste streams that must be properly managed in accordance with Appendix G.

1 Waste Residuals Management

a. All residual solid waste generated by the Municipal Public Drinking Water Supply shall be managed in accordance with a Residuals Management Plan accepted by the Department. Written authorization is required from the Department to modify the residuals management plan.

b. The Residuals Management Plan shall contain, at a minimum, the following information for each waste stream:

    - Type of residual;
    - Processing method; and
    - Expected annual volume of residuals to be generated by the activity.

c. The Approval Holder shall record the following information each time residuals are removed from the facility and make the records available to the Department immediately upon request:

    - The type of residual;
    - The volume of each residual transported, expressed as cubic metres or kilograms;
    - The name of the hauler, if applicable;
    - Date of transport; and
    - Final destination of residuals.

2 Filter Backwash Water

a. Filter backwash water shall be discharged to a location accepted by the Department.

b. If water from the filter backwash treatment system is discharged to the raw water reservoir/intake, it shall be at a location which is downstream of the raw water intake.

c. When an existing Municipal Public Drinking Water Supply already has a discharge upstream, the Approval Holder shall demonstrate no impact on raw water quality. Otherwise, the Approval Holder shall develop a corrective action plan to remediate the situation. The corrective action plan shall be acceptable to the Department.

d. Recycling of filter backwash water is permitted to the head of the treatment process provided it is acceptable to the Department. The Approval Holder shall contact the Department for site-specific requirements.

2.1 Discharges into a Freshwater Watercourse

2.1.1 Effluent Discharge Criteria

Where filter backwash water discharges to a freshwater watercourse, the following shall apply:

a. Discharge shall be non-acutely lethal with acute toxicity determined using a Daphnia (D magna) single concentration 48-hour test or another method accepted by the Department.

b. Maximum concentration of total suspended solids shall not exceed 25 mg/L unless otherwise specified in the operating approval.

c. Chlorine residual shall not exceed 0.02 mg/L.

d. pH shall be in the range of 6.5 to 9.0. If it is not possible to achieve this pH range, the Approval Holder shall complete a study to determine background values and recommend “end of pipe” discharge criteria for pH. The study shall be acceptable to the Department.

e. Total aluminum:

- ≤ 0.005 mg/L where the receiving water pH is < 6.5
- ≤ 0.1 mg/L where the receiving water pH is > 6.5

f. Sampling frequency shall meet the minimum requirements as outlined in Table 4 – Minimum Effluent Monitoring Requirements.

g. The Department may establish discharge criteria for other parameters of concern.

2.1.2 Site-specific Discharge Criteria Study

If a Municipal Public Drinking Water Supply cannot achieve effluent criteria for total aluminum, the Approval Holder may complete a study to propose site-specific aluminum discharge limits.

a. The study shall meet the minimum criteria outlined in *A Guide to Assist Nova Scotia Municipal Water Works Develop Site Specific Aluminum Effluent Discharge Criteria for Filter Backwash Discharges Into a Freshwater Watercourse*, as amended from time to time.

b. The study shall be acceptable to the Department.

c. Discharge criteria limits shall be specified by the Department once the study has been reviewed and accepted.

d. Consultation may be required with the Department, Environment and Climate Change Canada, and Fisheries and Oceans Canada.

2.1.3 Compliance

Once discharge criteria limits have been set, the Approval Holder shall comply with the following:

a. Discharge criteria limits shall be met before discharging into the watercourse (i.e., end of pipe limits) with the exception of aluminum discharge limits, which may be met at the edge of a mixing zone as accepted by the Department.

b. Discharge criteria shall be met in 95% of samples.

c. Sampling frequency shall meet the minimum requirements as outlined in Table 4 – Minimum Effluent Monitoring Requirements except where the Approval Holder is utilizing the assimilative capacity of the receiving water to meet effluent discharge criteria. In such circumstances, additional sampling is required as outlined in *A Guide to Assist Nova Scotia Municipal Water Works Develop Site Specific Aluminum Effluent Discharge Criteria for Filter Backwash Discharges Into a Freshwater Watercourse*, as amended from time to time.

It should be noted that membrane processes may concentrate naturally occurring compounds such as metals, solids and radionuclides in the waste streams. It is important that Approval Holders with membrane filtration technology establish discharge criteria, particularly where aluminum is naturally occurring in the source water.

2.1.4 Minimum Monitoring Requirements:

Table 4: Minimum Effluent Monitoring Requirements

Parameter	Analysis	Sampling Method	Frequency	Location(s)
Total Aluminum	Lab	Grab	**Continuous discharges**: monthly **Intermittent discharges:** at each discharge event or monthly for facilities with multiple discharge events each month.	End-of-pipe discharge
Chlorine Residual	Lab or Field	Grab		
Total Suspended Solids	Lab	Grab		
pH	Field	In Situ		
Acute toxicity test: 48h *Daphnia magna* single concentration	Lab	**Continuous discharges:** 24-hour composite flow proportional or equal time/equal volume. **Intermittent discharges:** 2 grab samples, one at the start of discharge and one near the end.	Upon request from Department	End-of- pipe discharge

2.2 Filter Backwash Discharges to Land or Soil

A Discharge Management Plan shall be developed by the Approval Holder using the guidance document entitled *A Guide to Assist Nova Scotia Municipal Water Works Develop a Discharge Management Plan for Filter Backwash Discharges to Land* published by the Department, as amended from time to time.

a. The Approval Holder shall submit the Discharge Management Plan to the Department for review and acceptance. Upon review, the Department may require modifications to the Discharge Management Plan.

b. The Discharge Management plan is subject to acceptance of the plan by the Department and the Approval Holder shall not discharge filter backwash water to a non-aquatic environment prior to the acceptance of the Discharge Management Plan by the Department.

c. The Approval Holder shall not conduct any discharge to a non-aquatic environment unless it is done in accordance with the accepted Discharge Management Plan.

d. The Approval Holder shall modify and update the Discharge Management Plan, if directed by the Department.

2.3 Filter Backwash Discharges to a Marine or Brackish Environment

Where filter backwash water discharges to a marine or brackish environment, the Approval Holder shall contact the Department to determine what requirements shall apply. The Approval Holder shall comply with these requirements.

PART VI
Requirements Related to Operations, Monitoring, Reporting and Management

1 Operations

1.1 Operations Manual and General Requirements

a. The Approval Holder shall prepare an Operations Manual in accordance with *A Guide to Assist Nova Scotia Municipal Water Works Develop a Comprehensive Operations Manual*, as amended from time to time and keep it up-to-date.

b. A copy of the Operations Manual is to be kept on-site, or a Department-accepted alternate location, at all times, and is to be made available for review immediately upon request by the Department.

c. The Approval Holder shall ensure that all employees are trained in accordance with the Operations Manual and shall keep a record of training at the Municipal Public Drinking Water Supply for a minimum period of five (5) years.

d. A set of drawings of the Municipal Public Drinking Water Supply, incorporating any amendments made from time to time, shall be retained on-site or a Department accepted alternate location for as long as the Municipal Public Drinking Water Supply is in operation and are to be made available for inspection or review by Department staff immediately upon request.

e. The Approval Holder shall establish procedures for receiving and responding to complaints including a reporting system that records and documents what steps were taken to determine the cause of complaint and the corrective measures taken to alleviate the cause and prevent its recurrence.

f. The Approval Holder shall establish security measures to assure the safety of the Municipal Public Drinking Water Supply system.

1.2 Emergency Notification Procedures

a. The Approval Holder shall establish and submit, to the Department, Emergency Notification Procedures to be used to contact the Department and other relevant authorities in the case of an emergency situation.

b. The Approval Holder shall ensure that the Emergency Notification Procedures are reviewed and updated on a yearly basis. The Approval Holder shall document in the annual report what modifications were made to the Emergency Notification Procedures and how the procedures were communicated to their staff.

c. A copy of the Emergency Notification Procedures is to be maintained on-site, at the Municipal Public Drinking Water Supply or a Department-accepted alternate location, at all times, and are to be made available for review immediately upon request by the Department.

d. The Approval Holder shall ensure that all employees are trained in accordance with the Emergency Notification Procedures and shall keep a record of training at the facility for a minimum period of five (5) years.

1.3 Contingency Plan

a. The Approval Holder shall ensure the development and implementation of a Contingency Plan for the Municipal Public Drinking Water Supply system.

b. The Contingency Plan is to meet the minimum requirements of the Department's *A Guide to Assist Nova Scotia Municipal Water Works Develop a Comprehensive Operations Manual* and *Contingency Planning Guidelines* as amended from time to time.

c. The Approval Holder shall ensure that the Contingency Plan is reviewed and updated on a yearly basis. The Approval Holder shall document in the annual report what modifications were made to the plan and how the plan was communicated to their staff.

d. The Approval Holder shall ensure that all employees are trained in accordance with the Contingency Plan and shall keep a record of training at the facility or Department accepted alternat location for a minimum period of five (5) years

2 Annual Monitoring Program

a. The Approval Holder is responsible for implementing, on an annual basis, a monitoring program and subsequent revisions as deemed acceptable by the Department.

b. Samples shall be collected from the Municipal Public Drinking Water Supply in accordance with a monitoring program that meets the minimum requirements outlined in the *Guidelines for Monitoring Public Drinking Water Supplies – Part I*, Appendix H of these standards, and *A Guide to Assist Nova Scotia Municipal Water Works Prepare Annual Sampling Plans*, as amended from time to time.

   - **Note:** The Approval Holder shall comply with the sampling requirements outlined in their accepted annual sampling plan. Sampling requirements are found in Appendix H of this document, based on source water type. Fillable word documents based on source water type are also available on the Department's website to assist the Approval Holder to prepare their annual sampling plan.

   i. All monitoring data required to be reported to the Department must include the units of measurement.

   ii. Sampling shall be representative of the water distribution system.

c. The Approval Holder shall not move, relocate or otherwise alter the location of the sampling locations indicated in the accepted monitoring program without written permission from the Department.

d. Following a review of the analytical results, the Department may alter the frequencies, location, and parameters for analyses or require other remedial action.

e. On or before October 1st of each year, the Approval Holder shall recommend to the Department the monitoring program for the Municipal Public Drinking Water Supply for the following calendar year, highlighting any proposed changes and the reason for the changes. Any existing monitoring program shall remain in place until the recommended monitoring program is accepted by the Department.

f. Any flow measuring devices and continuous water quality analyzers and indicators with alarm systems shall be installed, maintained and calibrated as specified by the instrument manufacturer's instructions. Calibration logs for each instrument shall be maintained at the site and be available for inspection immediately upon request by the Department.

g. The Approval Holder shall establish a QA/QC program to validate the measurements obtained from continuous monitoring equipment and for all analysis conducted at the Municipal Public Drinking Water Supply or a non-certified laboratory.

3 Reporting and Record-Keeping

3.1 Immediate Reporting

The Approval Holder shall immediately notify the Department, by telephone, when any of the following occurs:

a. Whenever the presence of total coliforms or *E. coli* bacteria is detected in the treated water;

b. Upon receipt of results that indicate a maximum acceptable concentration has been exceeded in the treated water;

c. There is a lack of disinfection or failure of the filtration process (where present) that prevents the Approval Holder from achieving the minimum treatment requirements for 3-log reduction for protozoa (surface water and GUDI sources) and 4-log reduction for viruses (all systems);

d. There is a failure of a treatment process necessary to reduce the concentration of a parameter below the MAC specified in the most recent edition of Health Canada's *Guidelines for Canadian Drinking Water Quality*, as amended from time to time;

e. Exceedance of turbidity values as specified in:

    i. Table 3 based on the type of filtration technology for surface water supplies and GUDI sources where a Department-accepted natural filtration log credit was not awarded,

    ii. Section Part III Section 2.3 for non-GUDI and GUDI sources where a Department-accepted natural filtration log credit was awarded;

f. Use of emergency water supply from an untreated or inadequately treated source;

g. A serious incident of raw water contamination including, but not limited to, an incident of surface water flooding of the well head area;

h. When it is necessary to use a by-pass;

i. When it is necessary to use a back-up water supply;

j. Any incidents of non-compliance with these standards and the Approval to Operate;

k. Any other incident that may adversely affect the quality of water within the system (including line breakage, cross connection, negative pressure, etc. that may result in contamination of potable water);

l. If the chlorine residual in the water distribution system is less than that stipulated in Part IV of these standards;

m. If the GUDI status of a well changes based on the results of MPA testing; or

n. If the Municipal Public Drinking Water Supply does not have an Operator in Direct Responsible Charge (ODRC) of the treatment and/or distribution system.

3.2 Annual Reporting

3.2.1 Annual Report Timeline

The Approval Holder shall submit an annual report to the Department on or before April 1st following the completion of the calendar year being reported upon.

3.2.2 Annual Report Content

The annual report shall contain, but not necessarily be limited to, the following information:

a. A summary and discussion of the quantity of water supplied during the reporting period on a per-month basis showing design values, maximum daily flow and average daily flow for each month and any other parameters or conditions specified in the Water Withdrawal Approval.

b. A summary and interpretation of analytical results obtained in accordance with the monitoring and record keeping requirements of these standards and the Approval to Operate, including an explanation for any exceedance of the maximum acceptable concentration of health-related parameters listed in the *"Guidelines for Canadian Drinking Water Quality"*, latest edition and the actions taken to address the exceedance(s).

c. Minimum annual reporting requirements as outlined in the *Requirements for Lead and Copper Management – Municipal Public Drinking Water Supplies*, as amended from time to time.

d. A summary and interpretation of the analytical results obtained from the treatment process backwash monitoring program including but not limited to explanation for any exceedance of the effluent limits specified in these standards or the operating approval.

e. Annual trend graphs for parameters that are continuously monitored.

f. The date and description of any emergency or upset conditions which occurred during the period being reported upon and action taken to correct them.

g. Any modifications to the contingency plan or emergency notification procedures including a description of how the information was communicated to staff.

h. A list of the names of each laboratory used by the Approval Holder and the parameters analyzed by each laboratory.

i. An update on the status of the Source Water Protection Plan, including any modifications to the plan or implementation schedule, and a summary of activities taken to achieve the goals and objectives of the plan.

j. An update on the status of the Cross Connection Control Program, including any modifications to the plan or implementation schedule, and a summary of the activities taken to achieve the goals and objectives of the program.

k. **If using free chlorine as a secondary disinfectant**, all incidents of free chlorine residual below 0.20 mg/L in the water distribution system, or below 0.4 mg/L in the case of Municipal Public Drinking Water Supplies undergoing a GUDI assessment where water is distributed for human consumption shall be detailed with a description of any actions taken.

l. **If using combined chlorine as a secondary disinfectant**, all incidents of total chlorine residual below 1.0 mg/L in the water distribution system shall be detailed with a description of any actions taken.

m. Verification that the operational conditions remained within the design range for achieving required CT/IT; if operational conditions went outside the design ranges, CT/IT calculations and a summary of corrective actions taken must be provided.

n. For Municipal Public Drinking Water Supplies that generate waste from the treatment process, a summary of residual waste removed from the system, including type, volume (m^3 or kg), hauler and date of transport, if applicable, and final destination.

o. Incidents of non-compliance with these standards or the Approval to Operate, the date it was reported to the Department, and corrective actions taken by the Approval Holder.

p. Any complaints received and the steps taken to determine the cause of the complaint and the corrective measures taken to alleviate the cause and prevent its recurrence.

q. A review of the QA/QC program to validate the measurements obtained from continuous monitoring equipment and for all analysis conducted at the Municipal Public Drinking Water Supply or a non-certified laboratory. The review shall highlight any results where there is greater than 5% variation in the samples along with any actions taken to correct this.

r. A list of each certified operator and their level of certification.

s. For Municipal Public Drinking Water Supplies that use surface water and GUDI sources with no Department-accepted natural filtration log credit awarded, mathematical verification that the turbidity of the water leaving the individual filters does not exceed the turbidity limits specified in Table 3 based on the type of filtration technology.

t. For Municipal Public Drinking Water Supplies using non-GUDI sources, mathematical verification that the turbidity of the water leaving the individual well(s) or combined flow does not exceed the turbidity limits specified in Part III section 2.3 requirement a.

u. For Municipal Public Drinking Water Supplies using low-risk and/or medium-risk GUDI sources with a Department-accepted natural filtration log credit awarded, mathematical verification that the turbidity of the water leaving the individual well(s) does not exceed the turbidity limit specified in Part III section 2.3 requirement b.

3.3 Information Available for Review upon Request

a. The Approval Holder shall provide information to the Department upon request, including but not limited to, the following:

    i. The name of each laboratory used, and the parameters analysed by that laboratory;

    ii. Verification that the UV system (if applicable) is capable of continually meeting the dosage requirement of 40 mJ/cm^2 or the dosage requirement otherwise accepted by the Department;

    iii. Any monitoring results or reports required;

    iv. Verification that chemicals used in the treatment process and all materials contacting the water meet ANSI standard NSF/60 (for chemical additives) or NSF/61 (for materials);

    v. Standard Operating Procedures for the filtration and disinfection processes; and

    vi. Laboratory certificates of analysis.

b. The Approval Holder shall keep records continually updated in such a way, that weekly and/or monthly reporting of monitoring and sampling results can be immediately sent to the Department upon request.

c. The Approval Holder shall ensure information is available for inspection or review upon request by Department, including but not limited to the following:

    i. The operations manual including the emergency notification and contingency planning documents;

    ii. Municipal Public Drinking Water Supply drawings, incorporating any amendments made from time to time; and

    iii. Calibration logs for instrumentation, such as flow measuring devices and continuous water quality analysers and indicators.

3.4 Record Keeping

The Approval Holder must retain the following records for the prescribed time periods, as a minimum:

a. Bacteriological, chlorine residual, turbidity analyses, and differential pressure measurements (for cartridge filters assigned log reduction credits for protozoa) shall be kept for two years;

b. Calibration, maintenance records and continuous monitoring data shall be retained for a period of five years;

c. All incidents of suspected and/or confirmed disease outbreaks attributed to the Municipal Public Drinking Water Supply shall be documented and kept for a minimum of ten years;

d. Chemical analysis shall be kept for ten years;

e. Annual water withdrawal records shall be kept for ten years; and

f. A copy of project reports, construction documents and treatment/distribution system drawings and inspection reports shall be kept for the life of the Municipal Public Drinking Water Supply.

4 Management of Operations

Classified water treatment and water distributions facilities shall be operated by certified operators in accordance with the *Water and Wastewater Facilities and Public Drinking Water Supplies Regulations,* made pursuant to the *Environment Act*.

PART VII
GLOSSARY AND REFERENCES

Glossary

Average day demand means the average amount of water necessary in a 24-hour timeframe to meet all needs of all customers. It is determined by dividing annual usage by the total number of days in the year.

Contact time denoted as T_{10} is an effective contact time for disinfection in minutes and represents the time when 10 percent of the water passes the contact unit; thatis 90 percent of the water remains in the unit and will be exposed to longer disinfection within the unit. T_{10} can be established by tracer studies or calculatedusing theoretical hydraulic detention times multiplied by an appropriate baffling factor.

Conventional filtration means a treatment process that includes chemical mixing, coagulation, flocculation, clarification (sedimentation or dissolved air flotation) and rapid gravity filtration. All filters should be designed so that the filtered water immediately after filter backwashing is directed into a waste stream ("filter-to-waste" provision).

Cryptosporidium means a widespread intestinal coccidian protozoan parasite about 3.5 micrometres in diameter, causing diarrhea and capable of infecting humans, birds, fish and snakes. It is responsible for waterborne disease outbreaks.

Department means the Nova Scotia Department of Environment and Climate Change.

Diatomaceous earth means the microscopic remains of the discarded outer surfaceof diatoms.

Diatomaceous earth filtration means a filtration method on which diatomaceous earth is used as the filtering medium.

Direct filtration means a treatment process that includes chemical mixing, coagulation, flocculation and rapid gravity filtration (e.g., no clarification process). All filters should be designed so that the filtered water immediately after filter backwashing is directed into a waste stream ('filter-to-waste" provision).

Disinfectant means an agent that destroys or inactivates harmful microorganisms.

Disinfection means the process of destroying or inactivating pathogenic organisms by either chemical or physical means.

Disinfection by-products means the chemical by-products that are formed when a disinfectant reacts with organic matter in the water.

Filtrate means the liquid that has passed through a filter.

Filtration means the removal of suspended materials in a fluid stream by passage of the fluid through a filter medium.

Filter-to-waste means a practice of discharging filtered water directly to disposal immediately following backwashing until the filtered water is of acceptable quality.

Giardia means the genus name for a group of single-celled, flagellated, pathogenic protozoans found in a variety of vertebrates, including mammals, birds and reptiles. These organisms exist either as trophozoites or as cysts, depending on the stage of the life cycle.

Log reduction means a negative of the base 10 logarithm of the fraction of pathogens remaining after the treatment process.

Maximum day demand means the highest daily use rate during the year.

Membrane filtration means a filtration process that uses pressure-driven semi-permeable membranes to reject particles and produce a filtrate. The most appropriate type of membrane depends on a number of factors including targeted material to be removed, source water quality characteristics, treated water quality requirements, membrane pore size, molecular weight cut-off, membrane materialand system configuration. A "filter-to-waste" feature should be provided for initial start-up and commissioning of the membrane system and for emergency diversions in the event of a membrane integrity breach.

Municipal Public Drinking Water *Supply* means a public drinking water supply that holds a municipal water works approval issued under the *Activities Designation Regulations,* made pursuant *to the Environment Act,* for the collection, production, treatment, storage, supply, or distribution of potable piped water to the public.

Municipal water utility means a utility owned, operated or managed by a municipality, village or service commission either directly or through a board or commission, for the purpose of producing, transmitting, delivering or furnishing water directly or indirectly to or for the public.

Natural attenuation means the attenuation of particles through in-situ soil, filtration or adsorption prior to a location from which the water is withdrawn (e.g., well).

Natural watershed boundary means the area drained by or contributing to a stream,lake or other body of water. It is the area that topographically appears to contribute all the water that passes through a given cross-section of a stream. Topography is the change in height of land relative to sea level.

Peak hourly demand means the highest hourly use rate during the year; it is typically two to four times the average day flow and is generally supplied from storage tanks.

Redundancy means a minimum of two process units shall be provided (e.g., two filters, two primary disinfection units, two pumps, etc.). Where only two process units are provided, each shall be capable of meeting the maximum day demand at the unit's rated capacity. Where more than two process units are provided, the process shall be capable of meeting maximum day demand with the largest unit out of service.

Slow sand filtration means filtration that depends on the formation of schmutzdecke, which is a layer of bacteria, algae and other microorganisms on a biopopulation within the sand bed. Raw water passes through the sand bed where physical, chemical and biological mechanisms remove contaminants. The most important removal mechanism has been attributed to the biological process. No chemicals are added nor is there a need to backwash. The filter is cleaned by scrapping off the clogged sand and eventually replacing the sand. A filter-to-waste feature should be provided so that the filtered waste immediately after filter cleaning is directed into a waste stream.

Time-of-travel means the determination of the time in days/years for groundwater recharge to travel from a certain field point to the wellhead. In the Nova Scotia GUDI Protocol (Appendix A) time-of-travel (TOT) is evaluated by measuring chemical and physical site data. Such data is used to evaluate the hydraulic connection through the aquifer and evaluating whether this could allow rapid recharge of the well by water directly influenced by surface water. Appendix A outlines the use of groundwater and surface water chemical and physical data for evaluation. Based on guidance regarding protozoa viability (Appendix A reference AWWA 1996), a TOT of less than 90 days is considered indicative of “rapid recharge”.

For Source Water Protection Planning (SWPP) required for municipal well sources in Nova Scotia (see Part II), time-of-travel is often determined by modelling and has an additional context of longer-term protection and land-use planning zones. The 25-year zone is the largest zone. This zone is used to protect against chemical contaminants such as chlorinated solvents, nitrates and road salt. The 25-year zone sets the outer boundary for the source water protection planning process.

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APPENDIX A

Protocol for Determining Groundwater Under the Direct Influence of Surface Water (GUDI Protocol)

Appendix to the Nova Scotia Treatment Standards for Municipal Drinking Water Systems published by the Department of Environment and Climate Change

Updated May 2022

Table of Contents

A1 Introduction

The purpose of this document is to provide a process for determining whether a water well is classified as either groundwater under the direct influence of surface water (GUDI) or as non-GUDI. This classification is used for determining water supply treatment requirements. The GUDI assessment process described in this document is based on guidance provided by U.S.EPA (1991), AWWA (1996), AWWA (2001) and the Ontario MOE (2001). Treatment requirements and the general requirements related to the use of this Protocol are provided in the main body and additional appendices of the *Nova Scotia Treatment Standards for Municipal Drinking Water Systems*, as amended from time to time.

All municipal water well sources in Nova Scotia must be initially assessed for their GUDI classification. GUDI is an acronym for "groundwater under the direct influence of surface water. It refers to situations where microbial pathogens can travel from surface water through an aquifer to a water well. GUDI is defined as (U.S.EPA, 1991): "*any water beneath the surface of the ground with:*

i. *significant occurrence of insects or other macro-organisms, algae, organic debris, or large-diameter pathogens such as Giardia lamblia or Cryptosporidium; or*

ii. *significant and relatively rapid shifts in water characteristics such as turbidity, temperature, conductivity, or pH which closely correlate to climatological or surface water conditions."*

Part (ii) of the definition is typically assessed first and involves determining whether there is a significant hydraulic connection between the groundwater source (that supplies the water well) and surface water. A significant hydraulic connection implies that groundwater rapidly recharged by surface water could allow microbial pathogens to enter the groundwater source. Part (i) of the definition relates to whether there are particulates present in the well water that are indicative of surface water. This is determined using Microscopic Particulate Analysis (MPA) which analyzes for significant numbers of macro-organisms, pathogens, algae, and other surrogate indicators of surface water.

A1.1 Nova Scotia GUDI

The Nova Scotia GUDI assessment process consists of three steps. The steps are shown on the flow chart in Figure A.1 and an explanation of each step is provided in Section A2 of this appendix. The process can take up to two years to complete due to the monitoring requirements under Steps 2 and 3.

Step 1 is a screening step used to rapidly identify obvious non-GUDI water wells based on available information.

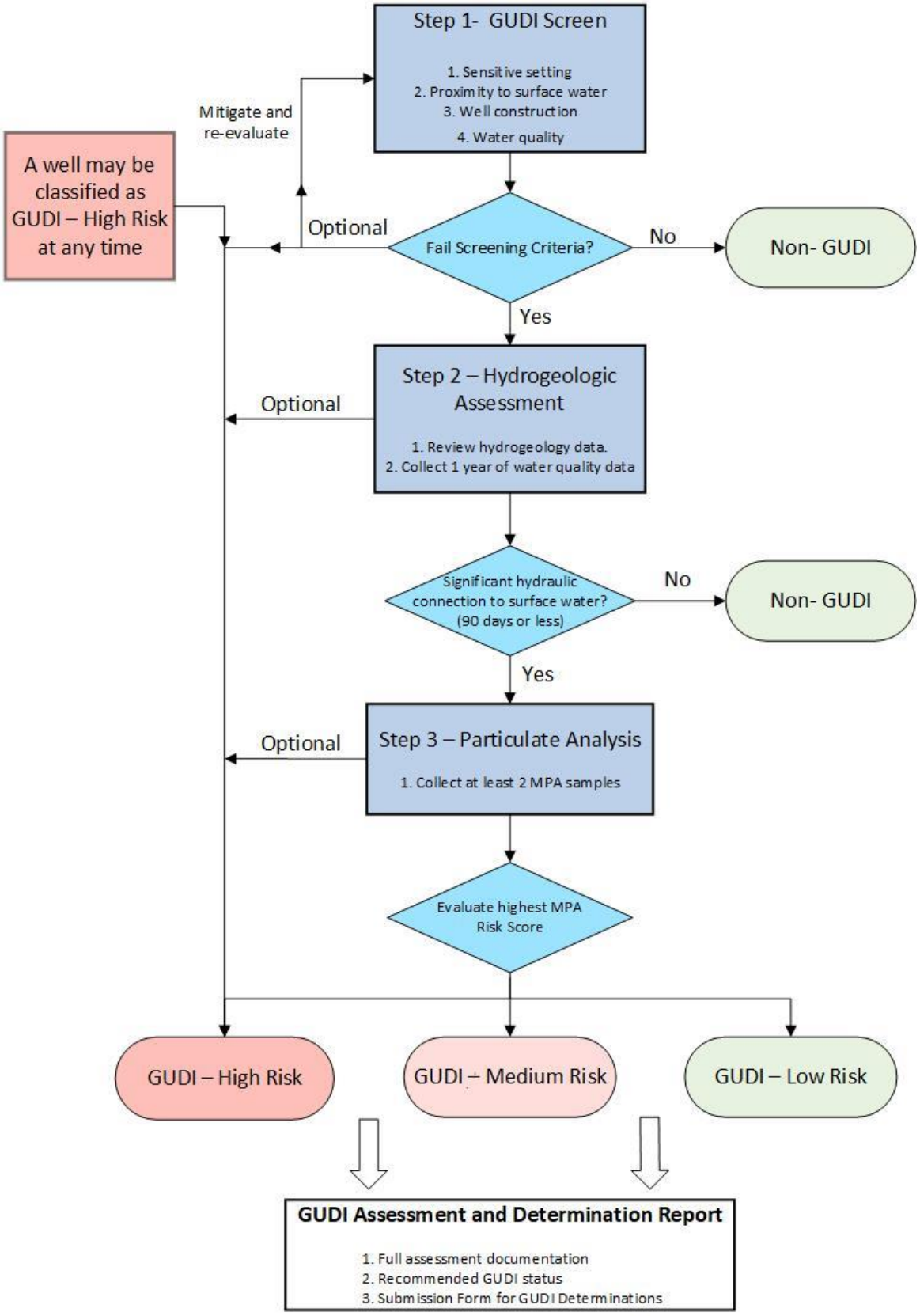
Step 2 is used to determine if there is a hydraulic connection through the aquifer that could allow rapid recharge of the well by water directly influenced by surface water (including infiltrating precipitation). Rapid recharge means recharge that occurs between the well and surface water with a travel time of 90 days or less.

In addition, Step 2 includes a review of available hydrogeologic information and one year of water quality monitoring at the wellhead and a nearby surface water body.

Step 3 is used to determine if there are surface water particulates (e.g., insects, organic debris, etc.) or pathogens present in the well that indicate it has been influenced by surface water. This is done using the Microscopic Particulate Analysis (MPA), which evaluates the presence and significance of indicators in sample results. The travel time results from Step 2 are needed to determine when the MPA samples are to be collected.

The completion of the process results in a GUDI classification of low, medium or high risk. The risk classification determines the required treatment for the source, as provided in the *Nova Scotia Treatment Standards for Municipal Drinking Water Systems (Part III - Requirements for Adequate Treatment and Operation)*, as amended from time to time.

Figure A.1: GUDI Assessment Flow Chart



A1.2 General Requirements

The following general requirements must be met during the GUDI assessment process:

a. GUDI assessments shall be carried out by, or under the supervision of, a Qualified Hydrogeologist which is defined here as a person with hydrogeology training and experience, registered to practice in Nova Scotia by the Association of Professional Geoscientists of Nova Scotia (Geoscientists Nova Scotia) or the Association of Professional Engineers of Nova Scotia (Engineers Nova Scotia). The classifying Qualified Hydrogeologist is considered the person responsible for all aspects of the GUDI Protocol assessment including a duty to ensure the proper collection, integrity and use of data in accordance with the GUDI Protocol.

b. A GUDI assessment shall be completed for each individual well in a wellfield. Following a complete GUDI assessment, each individual well shall be classified as either GUDI (Low, Medium or High Risk) or non-GUDI.

c. For water wells undergoing Step 2 and Step 3 of the GUDI assessment, raw water samples shall be collected from each individual well and not from a point in the distribution system where water has already been mixed with water from other sources.

d. MPA samples represent a “snapshot in time” and they are not the only piece of evidence to be considered when determining the GUDI classification of a water supply. The Qualified Hydrogeologist making the assessment must consider all available information when making a GUDI determination.

e. A well may be determined to be GUDI at any point in the process of evaluation without completing all three steps of the full assessment. In this case, the final classification must be GUDI High Risk, to ensure adequate treatment for protection of public health.

f. If there is significant uncertainty following the GUDI assessment, it is appropriate to err on the side of public health and safety and consider the well to be GUDI High Risk. If a water well is declared GUDI – High Risk at any point in the process, additional investigation steps are not required.

g. A GUDI Assessment and Determination Report and the Submission Form shall be completed for all water wells undergoing a GUDI assessment and provided to the Department of Environment and Climate Change (Department). These must be acceptable to the Department Regional Hydrogeologist.

A2 GUDI Assessment Process

A2.1 Step 1 – Screening Evaluation

The objective of this step is to identify obvious non-GUDI water wells that do not need further investigation. The screening step will normally include a review of relevant water supply information, well construction details and a site visit. If the well passes Step 1 it can be classified as non-GUDI. If the well fails Step 1 it shall proceed to Step 2, or be declared GUDI – High Risk.

For a water well to be considered non-GUDI it must satisfy all of the four screening criteria listed below (A2.1.1–A2.1.4). If it does not meet all four criteria, it fails Step 1 and proceeds to Step 2.

A2.1.1 Sensitive Settings

Sensitive settings are locations where wells have a greater probability of being contaminated by surface water. The water well location and the source of groundwater shall not fall into any of the following sensitive setting categories:

a. Spring;

b. Infiltration gallery;

c. Horizontal collection well;

d. Karst aquifer;

e. Unconfined or surficial aquifer;

f. Fractured bedrock with surface outcropping within 60 m; or

g. Enhanced recharge infiltration systems.

A2.1.2 Proximity to Surface Water

The well must be farther than 60 metres from the location of the nearest surface water body, which includes water bodies with intermittent or permanent water conditions. A surface water body is defined as water open to the atmosphere and subject to surface runoff, such as ponds, lakes, wetlands, lagoons, reservoirs, estuaries, rivers, streams, brooks and ditches.

A2.1.3 Well Construction

The well shall:

a. Have a well casing that extends at least 12 metres below ground surface;

b. Have a fully grouted well casing annular seal that will prevent surface water or shallow infiltration groundwater from migrating within the annular space and entering the well. In line with ACWWA (2022), "Grout should extend from the bottom of the casing to a point immediately below the pitless adapter connection.";

c. Meet the requirements outlined in the current version of the Nova Scotia *Well Construction Regulations*; and

d. Comply with the ACWWA (2022, or most recent update) *Atlantic Canada Water Supply Guidelines*.

If there is a discrepancy between well construction requirements in the *Nova Scotia Treatment Standards for Municipal Drinking Water Systems, the Nova Scotia Well Construction Regulations or the Atlantic Canada Water Supply Guidelines*, as amended from time to time, the more stringent requirements shall apply.

A2.1.4 Water Quality

a. Water quality is to be assessed from raw, untreated well water samples for each individual well where GUDI status is being determined.

b. For all water wells, a minimum of two (2) raw water samples shall initially be collected to assess bacteria (total coliform and *E. coli*). To pass Step 1, both samples must meet the criteria of 0 MPN/100 ml, or "absent" for both total coliform and *E. coli*.

A2.1.5 Step 1 Results

a. A well that passes Step 1 may be classified as a non-GUDI well.

b. If a well initially appears likely to fail any criteria in Step 1 due to well construction issues, modifications can be made to the well prior to completing Step 1 to attempt to meet the screening criteria. If any well construction improvements are planned, they must be completed prior to proceeding to Step 2 because changes to the well may affect the results of Step 2 and Step 3. In such cases, refer to Section A3.5 *GUDI – Corrections and Uncertainties*.

c. If the well fails Step 1 because bacteria (total coliform and *E. coli*) were detected and confirmed, corrective actions can be made that may include additional well disinfection.

d. Following any modifications, or corrective action during Step 1 additional sampling shall then be carried out to determine whether bacteria continue to be present.
    - The Approval Holder must collect a minimum of two additional bacteria samples, separated by a minimum of 24 hours, as outlined in Section A2.1.4.
    - If any of the additional samples contain bacteria, the well shall fail Step 1, unless additional corrective action is undertaken, and further additional sampling demonstrates the well does not contain bacteria in the latest two consecutive samples.
    - The iterative process of corrective action to a well, followed by additional sampling, may only be carried out twice before Step 1 results must be determined.

e. Wells that do not complete or may otherwise fail Step 1 also have the option to directly be determined as GUDI – High Risk and treat accordingly.

f. Refer to the *Nova Scotia Treatment Standards for Municipal Drinking Water Systems – Part III, Section 3, Bacterial Monitoring and Treatment Requirements in Groundwater Systems* During the GUDI Evaluation for treatment and monitoring requirements for wells that are connected to a distribution system, prior to the completion of the GUDI Protocol.

A2.2 Step 2 – Hydrogeological Investigation

The objective of Step 2 is to evaluate site hydrogeological conditions and determine if there is a hydraulic connection that could allow rapid recharge of the well by surface water or precipitation. Step 2 includes the collection of one year of groundwater levels and water quality data (turbidity, temperature, pH, and electrical conductivity) and a review of available hydrogeologic information. Additional hydrogeologic data may also be collected if the review of available data indicates there is insufficient information to determine if a hydraulic connection is present.

The well(s) being assessed during Step 2 will typically be in probationary production and must be pumped at the anticipated withdrawal rates. The pumping rates in place during the Step 2 assessment must be documented in the GUDI Assessment and Determination Report. Any future desired increases to well withdrawal rates may necessitate re-evaluation of Step 2.

The hydrogeologic information review shall be used to assess whether there is potential for a hydraulic connection and to estimate the time-of-travel (TOT) between the well and surface water (including rain or snow melt water). The review shall include, but not necessarily be limited to, an evaluation of the information outlined below in subsections A2.2.1-A2.2.4.

A2.2.1 Well and Aquifer Conditions

The review must include a description of well and aquifer conditions including:

a. Well characteristics (well depth, casing depth, annular seal, etc.);

b. Local geology and stratigraphy; and

c. Aquifer characteristics (e.g. aquifer type, properties of confining or unconfined layers, unsaturated zone thickness, hydraulic conductivity, effective porosity, type of aquifer porosity – primary (pore space) or secondary (fracture), depth to water bearing zones, and the physical degree of connection between the surface water and aquifer – does the surface water body penetrate the aquifer?).

A2.2.2 Surface Water Monitoring

a. Raw water quality data shall be collected at the well and any nearby surface water body (within 150 metres, or a larger distance as determined by a Qualified Hydrogeologist's assessment) for a period of one year to determine if there is a close relationship between changes in the surface water quality and the well water quality. Patterns are best recognized from one-year hydrographs; however, a shorter evaluation time may be sufficient if a hydraulic connection is recognized early in the monitoring program.

b. Precipitation data (including snow melt data if applicable) shall be used for comparison to the groundwater temperature, pH and electrical conductivity data. A standard rainfall gauge shall be used at the well site to measure precipitation. The precipitation records from an Environment and Climate Change Canada station, or another recognized and documented climate station, can be used in lieu of an on-site standard rainfall gauge, if the climate station is located within 10 km of the wellhead.

c. Physical characteristics of the surface water body (e.g. type, width and length, surface area, depth, seasonal flow rates and substrate conditions) shall be collected and documented.

A2.2.3 Groundwater Quality Monitoring

a. Water quality parameters shall be collected for a period of one year and shall include, but not necessarily be limited to turbidity, temperature, pH, and electrical conductivity. These parameters shall be measured on a weekly basis at a minimum, however hourly or daily measurements collected with a datalogger are recommended. Additional water quality parameter measurements such as water chemistry (e.g., metals and/or general ionic parameters) may be helpful for providing additional data during the evaluation.

b. Microbiological testing shall include total coliform and *E. coli* bacteria collected on at least a monthly basis, or more frequently if a well is providing water supply, while undergoing GUDI Step 1, 2 or 3. Additional microbiological testing such as for enterococci or heterotrophic plate counts (HPC) may be helpful in providing additional data during the evaluation.

c. The water quality data shall be plotted and the graphs reviewed for significant and rapid shifts in water characteristics and obvious similarities between the surface water and groundwater data. The time lag, or amplitude shift, between peaks or inflection points of the surface water and groundwater turbidity, temperature, pH and electrical conductivity graphs shall be used to estimate the time of travel (TOT).

d. In cases where there is no surface water body within 150 m of the wellhead to be monitored, it is acceptable to evaluate only the effects of rainfall (precipitation) infiltration effects on the well. For this, the use of a standard rainfall gauge for monitoring quantity is acceptable. This methodology requires measurement of the daily quantity of rainfall. The water quality characteristics of rainfall are not required as monitoring parameters, however, concurrent ambient air, or ground surface temperature monitoring with rainfall measurement is recommended.

e. To assess potential groundwater connection to surface infiltration from rain, measured groundwater parameters such as turbidity, temperature, pH, and electrical conductivity are used as indicators by evaluating any time lag, or amplitude shift, between peaks or inflection points of the groundwater graphs that could be related to time plots of rainfall quantity. The assumption being made is that rainfall infiltration is of different physical and chemical quality and may influence groundwater quality parameters shifts. An estimate of TOT can then be made.

A2.2.4 Groundwater Hydraulic Conditions

a. Hydraulic conditions shall be assessed based on data from a well pumping test (normally required under the *Activity Designation Regulations* for water withdrawal approval) and may also include other data. This assessment shall include evaluation of:
    - Hydraulic gradients (including vertical and horizontal flow gradients) between the well and the surface water body or any observation wells;
    - Variation of surface water levels with time;
    - Variations in observation well/aquifer static water levels;
    - Groundwater drawdown levels over time; and
    - Calculated groundwater flow velocities during pumping (where data is available).

b. Water level data shall be collected in each pumping well. Minimum daily measurements are required and hourly data collected by automatic data loggers is recommended.

c. The water level data shall be plotted on groundwater hydrographs to visualize periods of high and low groundwater levels as potential responses correlated with surface water factors including precipitation events, snow melt events, pumping well drawdown and surface water recharge.

d. Finally, where equivalent porous media conditions are assumed applicable to the water supply aquifer, an additional estimate of TOT using the groundwater flow seepage velocity equation (v=ki/n) may be used to provide a comparative theoretical estimate. For this, input data from pumping tests (where available) will provide the best results.

A2.2.5 Step 2 Results

a. Groundwater TOT between the well and surface water source(s), including infiltrating precipitation, shall be determined based on all the data collected from meeting the requirements outlined in A2.2.1 through to A2.2.4. All results and the methods used to determine TOT shall be summarized, compared and presented in the GUDI assessment documentation submitted to the Department.

b. Correlations of one-year groundwater and surface water chemical and physical water quality hydrograph data (including water quality, groundwater levels and precipitation monitoring) shall be included in the documentation as well as the groundwater TOT between surface water and the water supply well.

c. The well is considered rapidly recharged if the TOT is less than 90 days.

d. Based on the results of data collected during Step 2, the Qualified Hydrogeologist shall determine if there is a hydraulic connection that could allow rapid recharge of the well by surface water, rain or snow melt water within 90 days. If there is no such hydraulic connection, the well passes Step 2 and can be classified as non-GUDI. If there is a hydraulic connection that could allow recharge within 90 days, or if no conclusions can be reached in Step 2, then the well fails Step 2, is considered to be GUDI and shall proceed to Step 3 to determine risk level, i.e., low, medium, or high.

A2.3 Step 3 – Microscopic Particulate Analysis (MPA)

Wells that fail Step 2 have demonstrated a potentially significant and relatively rapid (within 90 days) hydraulic connection between groundwater and surface water. The objective of Step 3 is to determine the degree to which natural filtration provides removal of pathogens potentially present in surface waters, during recharge to wells. MPA testing evaluates the significance and occurrence of large diameter pathogenic organisms themselves (i.e. *Giardia lamblia* and *Cryptosporidium*) as well as macro-organisms, algae, etc., that are indicators for the potential transport of surface water pathogens.

Step 3 is determined using Microscopic Particulate Analysis (MPA) in accordance with the method described in U.S. EPA, 1992, or an alternative method approved in writing by a Department Regional Hydrogeologist. In addition to the U.S. EPA 1992 method, the Department recommends the MPA modifications outlined in the following document: *Approved Modifications to the MPA Consensus Method for use in Nova Scotia* (NSE July 2013).

a. A minimum of two MPA samples shall be collected and analyzed following the recommended laboratory procedures for each well being evaluated. In addition, if an intermittent or permanent surface water body is present within 150 m of the well, or within a larger distance as determined to be of concern for the situation by a Qualified Hydrogeologist, the surface water body also shall have concurrent MPA samples collected.

b. Samples are to be collected during periods when there is the greatest probability that surface water is impacting groundwater as described below. The results from Step 2 shall be used to help select the most appropriate MPA sampling times (e.g., if there is a 15 day TOT, then the well shall be sampled 15 days after a heavy rainfall).

c. One sample shall be collected in the late spring (May or June) and one sample is to be collected in the late fall (October, November or December). Samples shall be collected following the TOT estimated from Step 2 after a heavy rainfall (25 mm within 48 hrs) or equivalent snow melt.

d. Any proposed modifications to sample collection based on sample timing, rainfall volumes or, rain/snow melt combinations outside of those described above must be submitted to the Department Regional Hydrogeologist for approval, prior to implementation. It is important to note that, while very important, optimal timing of MPA sampling is difficult to verify, and that MPA results are only part of the information to be used in the overall GUDI treatment determination.

e. The MPA scores shall be evaluated based on the risk factors specified by the U.S. EPA (1992) as follows:

    - Low risk = MPA score < 10
    - Medium risk = MPA score 10 to 19
    - High risk = MPA score >20

f. MPA results shall be submitted to the Department in the Qualified Hydrogeologist's GUDI Assessment and Determination Report, including documentation of the timing of the MPA sample collection relative to weather events and confirming that the timing corresponds to a period in which there is the greatest probability that surface water is impacting groundwater in the sampled well, as described above.

Although Step 3 is designed to sample for MPA at the times of greatest risk to a water supply there is no assurance that low MPA results at any one time indicates complete absence of pathogens or related indicators in a water supply. The occurrence of pathogenic organisms in surface water is unpredictable and may occur at any time. For this reason, there is a requirement for regular monitoring for pathogens in wells that have demonstrated any level of GUDI conditions.

A3 GUDI Classification

The final determination of whether a well is GUDI (Low, Medium or High Risk) or non-GUDI shall be based on the evidence collected during Steps 1, 2, and 3 and is subject to review and acceptance by a Department Regional Hydrogeologist. If accepted, the GUDI classification shall be used in the determination of treatment and follow-up monitoring requirements, following the provisions of the main body of this document, the *Nova Scotia Treatment Standards for Municipal Drinking Water Systems*, as amended from time to time.

A3.1 Non-GUDI

Wells that pass the Step 1 Screening Evaluation, or that have no evidence of existing or potential significant hydraulic connection with surface water (i.e., Step 2 is passed) shall be classified as non-GUDI. These are considered secure groundwater sources.

A3.2 GUDI - Low Risk

A well that fails Step 2 and for which all the MPA scores during Step 3 are low risk, shall be considered GUDI - Low Risk.

A3.3 GUDI - Medium Risk

A well that fails Step 2 and has any medium risk MPA scores (but no high risk scores) during Step 3 shall be classified as GUDI – Medium Risk.

A3.4 GUDI – High Risk

A well that fails Step 2 and has any high risk MPA scores during Step 3, or for which the option to classify as GUDI – High Risk has been made at any time during either Step 1 or Step 2, shall be classified as GUDI – High Risk.

A3.5 GUDI - Corrections and Uncertainties

If corrective action(s) are completed to correct deficiencies following Step 1, Step 2 or Step 3 (such as well construction or water quality), the well may potentially be reclassified. However, to do so all relevant parts of both Step 2 and Step 3 may need to be repeated (if already conducted) and the results re-assessed, as they may be impacted by the corrective action(s).

Prior to proceeding with corrective action(s), the proposed approach must be accepted in writing by a Department Regional Hydrogeologist. If the well is reclassified, ongoing monitoring requirements may be required, as per the guidance on the modification of sources in US EPA (1991).

The process for potential reclassification of wells is provided below.

A3.6 GUDI – Reclassification Process

Reclassification of Wells

Reclassification of a previously classified well may be required, or requested, if there are changes to the well construction, or well setting, that could cause significant changes to the groundwater and surface water interaction and affect water quality. This includes changes to both a lower classification (e.g. low risk GUDI), or to a higher risk classification (e.g. high risk GUDI). The conditions for reclassification must be documented by the Approval Holder in its System Assessment Report. The process for determining whether reclassification is required is as follows:

a. Changes to the GUDI classification of a well to a lower category may be considered following the collection of at least five years of MPA sample results demonstrating favourable MPA scores (i.e. sample results should consistently be lower than the previously established MPA risk levels).

b. If the operational monitoring MPA risk scores of any low-risk GUDI well increases to medium- or high-risk, or if the MPA risk scores of any medium-risk GUDI increases to high-risk, the Approval Holder must immediately notify the Department and take any necessary corrective action. Corrective actions could include such things as modifying the well construction, providing additional filtration treatment for protozoa based on the new GUDI classification, etc.

c. The System Assessment Report must evaluate changes to conditions relevant to GUDI, including observed changes to detailed information from Section A.2.1 and Section A.2.2, and determine if there is a need to re-assess the classification at that time. At any time, relevant other information indicating potential increased risk conditions must also be evaluated by the Approval Holder for the effects on classification.

d. All requests for reclassification must be submitted to a Department Regional Hydrogeologist for acceptance and shall include all relevant MPA scores and an evaluation of all GUDI assessment work completed to-date. The evaluation shall be completed by a Qualified Hydrogeologist.

e. Changes from GUDI to non-GUDI status will not be considered unless the change is validated by a new, complete GUDI assessment incorporating all steps of the GUDI Protocol.

f. Reclassification may be required at any time, at the discretion of the Department.

A4 GUDI Assessment and Determination Report

The GUDI Assessment and Determination Report must be prepared and signed by a Qualified Hydrogeologist.

Detailed documentation of all steps, data, interpretation, and findings used for recommending the GUDI determination shall be documented in a GUDI Assessment and Determination Report that is to be submitted to a Department Regional Hydrogeologist for review and acceptance. Reports ending with Step 1 or Step 2 are to include all information up to and including the completion of the final step taken in their process.

In addition, the A.5 Submission Form for GUDI Determinations is to be completed and submitted as part of the completed Report for all determinations.

Clear recommendations for the GUDI Determination shall be made as well as recommended follow-up actions such as additional work or enhanced monitoring that may be relevant, or required, following the *Nova Scotia Treatment Standards for Municipal Drinking Water Systems*, as amended from time to time.

A5 Submission Form for GUDI Determinations

Section	Summary Condition	Indicate Findings	
Step 1	**Screening Criteria** (see APPENDIX A - Protocol for Determining Groundwater Under the Direct Influence of Surface Water (GUDI Protocol) for complete description of requirements)	**Meets Summary Condition**	
		Yes	**No**
Sensitive Settings	Shall include none of the following settings:		
	• Spring		
	• Infiltration gallery		
	• Horizontal collection well		
	• Well in karst aquifer		
	• Unconfined or surficial aquifer		
	• Fractured bedrock aquifer with surface outcropping within 60 m		
	• Enhanced recharge/infiltration systems		
Proximity to Surface Water	Well is greater than 60 metres from an intermittent or permanent surface water body or drainage ditch (as defined in Section)		
Well Construction	Well meets all current Well Construction Regulations and includes the following additional protections: – 12 m of steel casing – Fully grouted well casing annular seal (from bottom of casing to pitless adapter)		

Section	Summary Condition	Indicate Findings	
Step 1	**Screening Criteria** (see APPENDIX A - Protocol for Determining Groundwater Under the Direct Influence of Surface Water (GUDI Protocol) for complete description of requirements)	**Meets Summary Condition**	
		Yes	**No**
Water Quality	Well has at least 2 (initial) current or 2 (additional investigation), consecutive raw (untreated) groundwater samples with results for total coliform and *E. coli* bacteria confirming: 0 MPN/100 ml or "Absent"		
Step 1 Results	1. Finding that shows <u>all</u> "Yes" = Pass and is considered "non-GUDI" and a secure Groundwater source 2. <u>Any</u> finding of "No" = Fail and, unless first corrected, must continue with Step 2 Hydrogeological Investigation	☐ **Pass Step 1**	☐ **Fail Step 1**

Section	Summary Condition	Indicate Findings	
Step 2	**Hydrogeological Investigation** Summary (see APPENDIX A - Protocol for Determining Groundwater Under the Direct Influence of Surface Water (GUDI Protocol) for complete description)	**Investigation Complete**	
		Yes	**No**
Well and Aquifer Conditions	• Well characteristics • Local geology and stratigraphy • Aquifer characteristics		
Surface Water Monitoring	• Raw water quality data collected at the well • Water quality data from nearby (<150 m) surface water body if available • Monitoring period of at least one year • Precipitation data collected onsite or from an ECCC weather station within 10 km • Description of surface water body within 150 m		
Groundwater Quality	• Groundwater physical/chemical quality parameters - turbidity,		

Section	Summary Condition	Indicate Findings	
Step 2	**Hydrogeological Investigation** Summary (see APPENDIX A - Protocol for Determining Groundwater Under the Direct Influence of Surface Water (GUDI Protocol) for complete description)	**Investigation Complete**	
		Yes	**No**
Monitoring	temperature, pH and electrical conductivity (plus other indicators) • Data shall be plotted, compared and evaluated to surface water indicators • Determine time lag, or amplitude shift for indicators • Groundwater microbiology – total coliform, *E. coli* (plus other indicators)		
Groundwater Hydraulic Conditions	• Vertical and horizontal hydraulic gradients • Variation of surface water levels with time • Groundwater levels over time • Data shall be plotted, compared and evaluated to surface water indicators • Determine time lag, or amplitude shift for indicators • Groundwater flow velocities calculated during pumping test • Plot groundwater hydrographs to visualize variations over time • Correlate with surface water factors including precipitation events, snow melt events, pumping well drawdown and surface water recharge • Estimate of time-of-travel (TOT) based on groundwater hydraulic observations • Additional optional theoretical estimate of TOT using the groundwater flow seepage velocity equation (v=ki/n) (for comparison only)		
Step 2 Results	• Summarize all the data collected in Step 2 and provide a determination for groundwater time-of-travel (TOT) between supply intake and surface water source(s). Includes:		

Section	Summary Condition	Indicate Findings	
Step 2	**Hydrogeological Investigation** Summary (see APPENDIX A - Protocol for Determining Groundwater Under the Direct Influence of Surface Water (GUDI Protocol) for complete description)	**Investigation Complete**	
		Yes	**No**
	– Evaluation of TOT based on time lag/amplitude shifts in water quality data hydrographs – Evaluation of TOT based on time lag/amplitude shifts water level hydrographs and surface water data – For comparison only – provide optional theoretical groundwater velocity TOT		
	• Groundwater time-of travel (TOT) to well is more than 90 days	☐ **Pass Step 2 = non-GUDI**	
	• The well is considered rapidly recharged if the groundwater TOT is less than 90 days; or • If no conclusions can be reached in Step 2, then the well fails Step 2 and shall proceed to Step 3		☐ **Fail Step 2 = GUDI**

Section	Summary Condition	Indicate Findings	
STEP 3	**Microscopic Particulate Analysis (MPA)** Summary (see APPENDIX A - Protocol for Determining Groundwater Under the Direct Influence of Surface Water (GUDI Protocol) for full description)	**Investigation Completed (Yes/No)**	**MPA Lab Findings (EPA Risk Category = Low, Medium or High)**
	• Follow the USEPA 1992 Consensus Method; may include the Department of Environment and Climate Change's Approved Modifications (NSE July 2013) • For each: 1. Water supply well; and 2. Surface water body within 150 m (if present) – Collect a minimum of two MPA samples – Sample during both the Spring and Fall periods following Step 2 requirements – Following local rainfall of >25 mm in 48 hrs or equivalent snow melt – Sampling time following rain/snow melt event based on Step 2 TOT		
Step 3 Results	Classification as reported by accredited laboratory for Low, Medium or High Risk based on EPA methodology		

GUDI Classification	GUDI Classification	Recommendation Category	
		Non-GUDI	GUDI (type)
	The GUDI Classification must be one of the following types (a classification is not in effect until accepted in writing by the Department): • Non-GUDI • GUDI Low Risk • GUDI Medium Risk • GUDI High Risk		

A4 Report	GUDI Assessment And Determination Report	Completed	
		Yes	No
	• Report and form completed and submitted • Includes description of any follow up work or enhanced monitoring recommended • Signed below by a Qualified Hydrogeologist registered to practice in Nova Scotia by the Association of Professional Geoscientists of Nova Scotia (Geoscientists Nova Scotia) or the Association of Professional Engineers of Nova Scotia (Engineers Nova Scotia). • Final recommended GUDI classification of each well is clearly specified in the report		

Qualified Hydrogeologist Declaration

I acknowledge it is an offence under Section 158 of the Environment Act to provide false or misleading information and confirm to the best of my knowledge and belief the information provided in this form and supporting documentation is true and accurate and complies with the relevant provisions of the *Environment Act* and the *Nova Scotia Treatment Standards for Municipal Drinking Water Systems*.

By signing below, I confirm my qualifications as prescribed within the standards. In addition, I confirm I have followed and ensured that all aspects of the *Protocol for Determining Groundwater Under the Direct Influence of Surface Wate*r have been met in the GUDI assessment and reporting.

Signature: _____ Date: _____

Name (Print): _____

Professional Association: _____

Registration Number:_____

A6 References

American Water Works Association (AWWA). 1996. Determining Groundwater Under the Direct Influence of Surface Water.

American Water Works Association (AWWA). 2001. Investigation of Criteria for GWUDI Determination.

Atlantic Canada Water and Wastewater Association (ACWWA). 2022. Atlantic Canada Water Supply Guidelines.

Nova Scotia Environment (NSE). July 2013. Approved Modifications to the MPA Consensus Method for use in Nova Scotia.

Ontario Ministry of the Environment (MOE). 2001. Terms of Reference, Hydrogeological Study to Examine Groundwater Sources Potentially Under DirectInfluence of Surface Water. October 2001.

U.S. Environmental Protection Agency (U.S.EPA). 1991. Guidance Manual for Compliance with the Filtration and Disinfection Requirements for Public Water Systems Using Surface Waters. U.S. Environmental Protection Agency, Office of Drinking Water. March 1991.

U.S. Environmental Protection Agency (U.S.EPA). 1992. Consensus Method for Determining Groundwater Under the Direct Influence of Surface Water Using Microscopic Particulate Analysis (MPA). U.S. Environmental Protection Agency. EPA 910/9-92-029. October 1992.

APPENDIX B

Guidelines for the Determination of Natural Filtration Log Removal Credits for Protozoa

B1 Introduction

Natural filtration refers to the ability of an aquifer to remove microscopic particulates,such as *Giardia and Cryptosporidium*, as groundwater migrates through the aquifer towards a water well. Natural filtration is most appropriately applied as one component of a treatment process and is best suited to systems with minimal influence of surface water.

The purpose of this appendix is to outline the criteria for determining which Municipal Public Drinking Water Supply systems in Nova Scotia that use groundwater as a source are eligible for a natural filtration log removal credit for protozoa and describe how these Municipal Public Drinking Water Supplies can apply for this credit.

B2 Eligible Systems

A Municipal Public Drinking Water Supply system is eligible for a natural filtration log removal credit if it meets the following conditions:

a. All three steps of the *Protocol for Determining Groundwater Under the Direct Influence of Surface Water* (GUDI Protocol - Appendix A), as amended from time to time, have been completed;

b. The supply has been determined to be GUDI;

c. The supply has been determined to be medium or low risk based on the Microscopic Particulate Analysis (MPA) results from Step 3 of the GUDI Protocol; and

d. An additional MPA test, taken after the Step 3 GUDI Protocol MPA samples, confirms the well is medium or low risk.

B3 How to Apply for a Natural Filtration Credit

To be awarded a natural filtration credit, eligible Approval Holders shall apply in writing to the Department district office where the water system is located.

The written application shall include the following information for each well:

a. Water supply name;

b. Well name and map showing well location;

c. Confirmation that the well has completed the GUDI Protocol and it has been classified as a GUDI - Medium Risk or GUDI - Low Risk; and

d. Confirmation that, based on geological maps, well log information, and water supply information, the well is not located in one of the following settings:

   – Spring;

   – Infiltration gallery;

   – Horizontal collection well;

   – Karst aquifers; or

   – Enhanced recharge infiltration systems.

e. Results from an additional MPA test, taken after the Step 3 GUDI Protocol MPA samples, to confirm the well is medium or low risk.

f. Groundwater quality data from Step 2, in particular raw water turbidity data and raw water total coliform and *E. coli*.

g. Assessment of wells with respect to their potential location within floodplains. Floodplain location can be assessed using existing information such as flood maps, local topography, geomorphology, municipal documents, local historical knowledge and air photos. If wells are either known to be, or may have high likelihood of being within 1:100 year floodplains it is expected that contingency plans will be developed to mitigate flooding effects on the wells.

h. Confirmation that the well is not located within 60 metres of a surface water body that has the potential for stream channel erosion. Note that the potential for stream channel erosion can be evaluated by examining the history of high-flow and flood events at the site and by reviewing air photographs for evidence of stream channel meander.

The information submitted shall be complete and acceptable to the Department.

The applicant will receive a written response from the Department indicating whether a natural filtration credit will be awarded.

B4 Criteria for Awarding a Natural Filtration Credit

Natural filtration log removal credits will be awarded by the Department to eligible systems on a case-by-case basis.

To be considered for a natural filtration credit, medium or low risk GUDI systems are required to perform at least one additional MPA test, taken after the Step 3 MPA samples, to confirm the original MPA results collected during Step 3 of the GUDI study. The additional MPA test shall be collected when the well is most susceptible to surface water influence as described and determined in Appendix A.

If the additional MPA results indicate that the sample has a high risk score, the system is not eligible for a natural filtration credit.

If the results of the additional MPA testing confirm results of medium or low risk scores, the system is eligible for a natural filtration credit.

- All medium risk GUDI systems will receive a 1.0 log removal credit for protozoa, unless there are site-specific reasons that indicate a natural filtration log removal credit should not be awarded.
- All low risk GUDI systems will receive a 3.0 log removal credit for protozoa, unless there are site-specific reasons that indicate natural filtration log removal credits should not be awarded.

Site-specific issues will also be considered by the Department when awarding a natural filtration credit.

APPENDIX C

Minimum Treatment Requirements and Process for Assigning Pathogen Log Reduction Credits to Filtration and Disinfection Processes

C1 Purpose

The purpose of this appendix is to outline the requirements for the assignment of log reduction credits for the removal or inactivation of pathogenic microorganisms (enteric protozoa, viruses, and bacteria) in Municipal Public Drinking Water Supply systems. This information must be used by the Approval Holder, design engineer, and any other person or persons responsible for the planning and design of new Municipal Public Drinking Water Supply systems in Nova Scotia or when considering modifications to existing systems. Bacterial reduction is typically sufficient if treatment systems are designed to meet enteric protozoa and virus log reduction requirements outlined in this document.

C2 Minimum Treatment Requirements

The Approval Holder shall ensure the level of treatment provided to remove or inactivate pathogenic organisms is commensurate with the source water type, as outlined in Table C1.

Where multiple raw water sources are combined and treated in the same Municipal Public Drinking Water Supply, the minimum log reduction requirements shall be based on the source water with the highest log reduction requirements for enteric protozoa and viruses.

Table C1: Minimum Pathogen Log Reduction and Treatment Requirements

Source Water Type	Minimum Required Pathogen Log Inactivation and Removal			Minimum Treatment
	***Cryptosporidium* oocysts**	***Giardia* cysts**	**Viruses**	
Surface Water and GUDI sources not assigned a Department-accepted natural filtration log credit	3-log	3-log	4-log	**Engineered filtration and disinfection** • Filtration shall be assigned treatment credits as outlined in Table C2. • Disinfection shall provide a minimum 0.5 log inactivation of *Giardia* cysts. • Where UV is used as a primary disinfectant and additional log inactivation is required for enteric viruses, chemical disinfection shall be used to meet the remaining log inactivation criteria for enteric viruses. • Where UV, ozone, or chlorine dioxide is used as a primary disinfectant, free chlorine or chloramines shall be used to provide secondary disinfection of the distribution system.
Medium-risk GUDI sources assigned a Department-accepted natural filtration log credit	3-log	3-log	4-log	**Filtration and disinfection** • Filtration may be via natural in-situ attenuation as outlined in Appendix B • Natural filtration is assigned a 1 log reduction for *Cryptosporidium* oocysts and *Giardia* cysts. • If the natural filtration log credit is awarded, UV disinfection is required to meet the remaining log reduction requirements for *Cryptosporidium* oocysts and *Giardia* cysts. • Chemical disinfection is required to meet remaining log inactivation criteria for viruses and provide secondary disinfection of the distribution system.
Low-risk GUDI sources assigned a Department-accepted natural filtration	3-log	3-log	4-log	**Filtration and disinfection** • Filtration may be via natural in-situ

Source Water Type	Minimum Required Pathogen Log Inactivation and Removal			Minimum Treatment
	***Cryptosporidium* oocysts**	***Giardia* cysts**	**Viruses**	
log credit				attenuation as outlined in Appendix B • Natural filtration is assigned a 3-log reduction for *Cryptosporidium* oocysts and *Giardia* cysts. • Chemical disinfection is required to meet remaining log inactivation criteria for viruses and provide secondary disinfection of the distribution system.
Non-GUDI sources	0-log	0-log	4-log	**Disinfection** • Chemical disinfection is required to meet log inactivation criteria for viruses and provide secondary disinfection of the distribution system.

C3 Determining Log Removal Credits for Filtration and Disinfection Treatment Processes

The following steps shall be taken by the Approval Holder or design engineer to determine the log removal credits for enteric protozoa and viruses assigned to the filtration process, if applicable, and the remaining credits that the disinfection process shall be designed to achieve:

a. Confirm the log reduction requirements for the source water type as outlined in Table C1.

b. Find the filtration log removal credits associated with the type of filtration system(s) employed as outlined in Table C2 and subtract this from the requirements specified in Table C1.

c. Determine if any additional filtration credits are available from enhanced filtration performance (if applicable) and subtract this from the remainder above.

d. The result is the log inactivation portion that shall be met by the disinfection process.

Systems using surface water and GUDI sources not assigned a Department-accepted natural filtration log credit: Engineered filtration is required for surface water and GUDI sources not assigned a Department-accepted natural filtration log credit. Additionally, a minimum of 0.5-log inactivation for *Giardia* must be provided by the disinfection process.

C4 Treatment Credits for Filtration (Log Removal)

Drinking water treatment technologies meeting the turbidity limits and operational requirements outlined in Table C2 will be assigned the corresponding log removal credits for *Cryptosporidium, Giardia* and viruses by the Department.

Municipal Public Drinking Water Supplies with Engineered Filtration: If the Approval Holder or design engineer believes the engineered filtration technology can achieve a higher log removal credit than is identified in Table C2, a higher log removal credit may be granted by the Department based on a demonstration of filter performance. For example, Municipal Public Drinking Water Supply systems with conventional or direct filtration that achieve 0.15 NTU 95% of the time each calendar month in combined filter effluent are eligible to receive an additional 0.5-log removal credit for protozoa. Municipal Public Drinking Water Supply systems with conventional or direct filtration that achieve 0.15 NTU 95% of the time each calendar month in individual filter effluent are eligible to receive an additional 1.0-log removal credit for protozoa.

Table C2- Log Removal Credits Assigned to Treatment Technologies Meeting Prescribed Turbidity Limits and Other Requirements

Treatment Technology	Protozoa Credit		Virus Credit[1]	Individual Filter Turbidity Limits (unless stated otherwise) and Operational Requirements
	Cryptosporidium[1]	*Giardia* [1]		
Conventional filtration[2] – includes chemical mixing, coagulation, flocculation, clarification, and rapid gravity filtration	3.0-log		2.0-log	a. Shall be less than or equal to 0.2 NTU in at least 95% of the measurements made or at least 95% of the time each calendar month. b. Shall not exceed 1.0 NTU at any time. c. Filter-to-waste[3] - filters shall be capable of directing filtered water to waste or recycle immediately following a backwash for a period of time until the filtrate turbidity value is below 0.2 NTU d. For direct filtration systems that use free chlorine alone as their primary disinfectant, to achieve log reduction requirements for *Cryptosporidium*, the turbidity shall be less than or equal to 0.15 NTU in at least 95% of the measurements made or at least 95% of the time each calendar month.
Direct filtration [2] - includes chemical mixing, coagulation,flocculation, and rapid gravityfiltration	2.5-log		1.0-log	
Slow sand filtration	3.0-log		2.0-log	a. Shall be less than or equal to 1.0 NTU in at least 95% of the measurements made or at least 95% of the time each calendar month. b. Shall not exceed 3.0 NTU at any time. c. Filter-to-waste[3] shall be provided to ensure filtered water, immediately after filter cleaning, is directed to a waste or recycle stream.
Diatomaceous earth filtration	3.0-log		1.0-log	a. Shall be less than or equal to 1.0 NTU in at least 95% of the measurements made or at least 95% of the time each calendar month. b. Shall not exceed 3.0 NTU at any time. c. Filter-to-waste[3] shall be provided to ensure filtered water, immediately after filter backwashing, is

Treatment Technology	Protozoa Credit		Virus Credit[1]	Individual Filter Turbidity Limits (unless stated otherwise) and Operational Requirements
	Cryptosporidium[1]	*Giardia* [1]		
				directed to a waste or recycle stream.
Micro-filtration[4,5,6]	Removal efficiency demonstrated through challenge testing and verified by direct integrity testing.		No Credit	a. Shall be less than or equal to 0.1 NTU in at least 99% of the measurements made or at least 99% of the time each calendar month. b. If turbidity exceeds 0.1 NTU for more than 15 minutes, direct integrity testing shall be immediately conducted on the membrane treatment unit. c. Shall not exceed 0.3 NTU at any time. d. Filter-to-waste[3] shall be provided for operational flexibility. e. The membrane system used for pathogen reduction shall have continuous indirect integrity testing. f. Continuous indirect integrity testing shall be conducted at a minimum frequency of once every 5 minutes. Indirect integrity testing shall follow that outlined in the EPA *Membrane Filtration Guidance Manual*, as amended from time to time. g. The actual removal efficiency of a membrane shall be verified by third party challenge testing. Acceptable challenge testing shall follow that provided in the EPA *Membrane Filtration Guidance Manual*, as amended from time to time. h. Direct integrity testing shall be able to verify a log removal value equal to or greater than the removal
Ultra-filtration[4,5,6]	Removal efficiency demonstrated through challenge testing and verified by direct integrity testing.		Removal efficiency demonstrated through challenge testing and verified by direct integrity testing.	

Treatment Technology	Protozoa Credit		Virus Credit[1]	Individual Filter Turbidity Limits (unless stated otherwise) and Operational Requirements
	Cryptosporidium[1]	*Giardia* [1]		
				credit awarded to the membrane filtration process. i. Direct integrity testing shall be conducted on each membrane filtration unit at least once per day and as soon as the Approval Holder becomes aware when the turbidity exceeds 0.1 NTU for more than 15 minutes.
Reverse osmosis and nanofiltration[4,5,6]	Removal efficiency demonstrated through challenge testing and verified by direct integrity testing.		Removal efficiency demonstrated through challenge testing and verified by direct integrity testing.	a. Shall be less than or equal to 0.1 NTU in at least 99% of the measurements made or at least 99% of the time each calendar month. b. Shall not exceed 0.3 NTU at any time. c. Filter-to-waste[3]- a filter-to-waste feature shall be provided foroperational flexibility. d. To assign pathogen log reduction credits for reverse osmosis and nano-filtration units, direct integrity testing shall be available to verify removal efficiency. e. If the membrane process is assigned pathogen log reduction credits by the Department, the Approval Holder shall adhere to the following additional requirements: i. The membrane system used for pathogen reduction shall have continuous indirect integrity testing. ii. Continuous indirect integrity testing shall be conducted at a minimum frequency of once every 5 minutes. Indirect integrity testing shall follow that outlined in the EPA's *Membrane Filtration Guidance Manual*, as amended from time to time. f. The actual removal efficiency of a membrane shall

Treatment Technology	Protozoa Credit		Virus Credit[1]	Individual Filter Turbidity Limits (unless stated otherwise) and Operational Requirements
	Cryptosporidium[1]	*Giardia* [1]		
				be verified by third party challenge testing. Acceptable challenge testing shall follow that provided in the EPA's *Membrane Filtration Guidance Manual*, as amended from time to time. g. Direct integrity testing shall be able to verify a log removal value equal to or greater than the removal credit awarded to the membrane filtration process. h. Direct integrity testing shall be conducted on each membrane filtration unit at least once per day and as soon as the Approval Holder becomes aware when the turbidity exceeds 0.1 NTU for more than 15 minutes.

Treatment Technology	Protozoa Credit		Virus Credit[1]	Individual Filter Turbidity Limits (unless stated otherwise) and Operational Requirements
	Cryptosporidium[1]	*Giardia* [1]		
Cartridge filtration, one unit (1 micron absolute pore size)	2-log		No credit	a. For systems serving less than 500 persons, differential pressure across the filter medium is measured and recorded a minimum of once daily and does not exceed the manufacturer's requirements. b. For systems serving more than 500 persons, differential pressure across the filter medium is continuously measured and recorded at a minimum frequency of one measurement every five minutes and does not exceed the manufacturer's requirements. c. Shall be less than or equal to 0.3 NTU in at least 95% of the measurements made or at least 95% of the time each calendar month. d. Shall not exceed 1.0 NTU at any time. e. The cartridge filtration process is tested and confirmed by an independent testing agency for at least 3 log removal of *Cryptosporidium* oocysts or surrogate particles. Challenge testing shall demonstrate at least 3 log removal of *Cryptosporidium* oocysts and *Giardia* cysts.
Cartridge filtration, two units in series (1 micron absolute pore size)	2.5-log		No credit	
Natural In-situ Attenuation for Medium Risk GUDI Sources[7]	1.0-log [7]		No credit	a. Shall be less than or equal to 1.0 NTU in at least 95% of the measurements made or at least 95% of the time each calendar month at each individual GUDI wellhead. b. Continuous turbidity monitoring - required at each individual GUDI wellhead. c. Microscopic Particulate Analysis[8] - MPA testing is required every two years for each individual GUDI well following a significant rainfall in

Treatment Technology	Protozoa Credit		Virus Credit[1]	Individual Filter Turbidity Limits (unless stated otherwise) and Operational Requirements
	Cryptosporidium[1]	*Giardia* [1]		
				accordance with Step 3 of the GUDI protocol[8].
Natural In-situ Attenuation for Low-Risk GUDI Sources[7]	3.0-log[7]		No credit	a. Shall be less than or equal to 1.0 NTU in at least 95% of the measurements made or at least 95% of the time each calendar month at each individual GUDI wellhead or the combined flow. b. Continuous turbidity monitoring - required at each individual GUDI wellhead. c. Microscopic Particulate Analysis[8] - MPA testing is required every two years for each individual GUDI well following a significant rainfall in accordance with Step 3 of the GUDI protocol[8].

1 Disinfection shall provide a minimum 0.5-log inactivation for *Giardia* unless a higher log inactivation credit is required. Where disinfection is used to address any shortfall in the log reduction requirements for *Cryptosporidium*, an alternate disinfectant such as UV, chlorine dioxide or ozone shall be required.

2 Municipal Public Drinking Water Supplies with conventional or direct filtration that achieve 0.15 NTU 95% of the time each calendar month in combined or individual filter effluent are eligible to receive additional log removal credits for protozoa to meet minimum treatment requirements as follows: combined 0.5-log; individual 1.0-log.

3 Alternatives that demonstrate an equivalent benefit to filter-to-waste may be considered by the Department on a case-by-case basis for existing facilities. All new systems shall include a filter-to-waste provision.

4 If membrane filtration is the sole treatment technology employed, disinfection shall follow the filtration process to meet virus inactivation requirements.

5 Membrane removal efficiency shall be demonstrated through challenge testing and verified by direct integrity testing. See Appendix G for additional information on membrane filtration.

6 If the unit passes direct integrity testing, it may continue to be used for water treatment; if not, the unit shall be taken out of service.

7 A natural in-situ attenuation log credit may be assigned if the *Guidelines for the Determination of Natural Filtration Log Removal for Protozoa* are followed (Appendix B) and the Department Regional Hydrogeologist accepts the determination in writing.

8 MPA testing shall be completed in accordance with Step 3 of the Protocol for Determining Groundwater Under the Direct Influence of Surface Water as outlined in Appendix A (e.g. if there is a 15 day time-of-travel, then the well shall be sampled 15 days after a surface water event).

C5 Disinfection Credits (Log Inactivation)

Disinfection is required to inactivate any microbial pathogens that pass through previous treatment processes.

a. Disinfection shall provide any remaining log reduction credits necessary to meet the minimum treatment requirements specified in Table C1.

b. Where disinfection is used to address any shortfall in the log reduction requirements for *Cryptosporidium*, an alternate disinfectant such as UV, chlorine dioxide, or ozone is required.

c. Where UV disinfection is used to inactivate protozoa, chemical disinfection is required to meet remaining log inactivation requirements for viruses.

d. Where UV, chlorine dioxide, or ozone are used as primary disinfectants, free chlorine or chloramines must be used to provide secondary disinfection of the distribution system.

C5.1 CT Concept for Chemical Disinfection

Nova Scotia's treatment standards require application of the CT concept for chemical disinfection. CT is calculated by multiplying the disinfectant concentration (C) by the time that 10 percent of the water is in contact with the disinfectant (T10). T10 is calculated by multiplying the theoretical hydraulic detention time (e.g., tank volume divided by flow rate) by the baffling factor of the contact chamber. T10 may also be established by tracer studies.

The CT equation is as follows:

Formula: CT = Concentration (mg/L) x Time (minutes) x Baffling Factor

C5.1.1 Acceptable Primary Disinfectants

The Approval Holder shall use Department-accepted chemical disinfectants including free chlorine, chlorine dioxide, or ozone. Due to the poor disinfecting capability of chloramines, chloramines are not accepted by the Department as a primary disinfectant.

C5.1.2 Baffling Factors

The baffling factor used in CT calculations shall be acceptable to the Department. Baffling factors are provided in Table C3. Examples of baffling factors to use for sample contact chamber designs are included in Appendix E.

C5.1.3 Clearwell or Storage Tank Volume and Flowrate

For Approval Holders that include the volume of water in the clearwell or on-site storage tank for CT determination, the calculation shall be made based on the minimum operating level in the tank. The highest flow condition shall also be confirmed (inflow or outflow).

Note: Distribution system storage is not eligible for CT credits. The required CT shall be achieved before the municipal public drinking water supply's first customer.

C5.1.4 CT Ratio (CT Achieved/CT Required)

a. The Approval Holder shall compare the calculated CT achieved using the equation above to the CT required. The CT required is found in log inactivation tables for *Cryptosporidium*, *Giardia* and/or viruses first published by the US EPA. CT tables for free chlorine, chlorine dioxide, and ozone are included in Appendix D. The science-based impacts of pH and temperature on the effectiveness of some disinfectants have been taken into account where applicable.

b. The Approval Holder shall ensure the ratio of the calculated value (CT achieved) to the table value (CT required) is equal to or greater than one to receive log inactivation credits for the disinfection process.

c. The Approval Holder shall ensure design ranges for the disinfection process are set for worst case scenarios For free chlorine, worst case design ranges typically include the following:

    - Lowest temperature of the water to be disinfected;
    - Highest pH value of the water to be disinfected with chlorine;
    - Lowest chlorine residual found at the outlet of the designated chlorine contact volume; and
    - Minimum contact time (typically occurs under highest flow conditions).

Sample CT calculations are provided in Appendix F for various sources and treatment technologies.

Where free chlorine is used, it is recommended that the Approval Holder minimizes the formation of disinfection by-products. However, this should be done in consideration of operational requirements (e.g., water quality and quantity, distribution system disinfectant residual, etc.) and without compromising the effectiveness of disinfection.

C5.1.5 Disinfection Byproducts

The Approval Holder shall balance effective disinfection for microbial protection against the creation of disinfection by-products.

The Approval Holder shall make every effort to maintain concentrations of disinfection by-products as low as reasonably achievable without compromising the effectiveness of primary disinfection.

Table C3: Baffling Factors

Baffling Condition	Baffling Factor T10/T0	Baffling Description
Unbaffled (mixed flow)	0.1	• Agitated basin • Very low length-to-width ratio • High inlet and outlet flow velocities • High potential for stagnant zones and short-circuiting
Poor	0.3	• Single or multiple unbaffled inlets and outlets • No intra-basin baffles • Potential for stagnant zones or short-circuiting
Average	0.5	• Baffled inlet or outlet • Some intra-basin baffles
Superior	0.7	• Perforated inlet baffle • Serpentine or perforated intra-basin baffles • Outlet weir or perforated launders • Most of tank volume is utilized
Perfect (plug flow)	1	• Length to width ratio greater than or equal to 10:1 • Perforated inlet, outlet and intra-basin baffles

C5.2 IT Concept for UV Disinfection

These treatment standards require application of the IT concept. IT is calculated by multiplying the UV intensity (I) by the exposure time (T) to demonstrate that required disinfection credits are achieved.

Formula: UV dose = UV intensity (Watts/cm^2) x Time of exposure (seconds)

The amount of UV light delivered to pathogens in a reactor is called "UV dose" and is measured in millijoules per square centimetre (mJ/cm^2). The UV dose depends on:

- UV intensity, or magnitude of UV light, measured by UV intensity sensors in Watts/cm^2 or Watts/m^2;
- UV transmittance (UVT); and
- Water flow rate and hydraulics in the reactor.

Previous treatment standards required a minimum UV dose (IT) of 40 mJ/cm^2 for all Municipal Public Drinking Water Supplies. A UV dose of 40 mJ/cm^2 achieves 0.5-log reduction for viruses based on adenovirus inactivation.

a. Where UV light is used for primary disinfection, chemical disinfection shall be required to meet any remaining log inactivation criteria for viruses.

b. Where UV light is used for primary disinfection a lower UV dose than 40mJ/cm^2 may be acceptable to the Department for enteric protozoa (i.e., *Giardia, Cryptosporidium*) based on required log inactivation credits, UV lamp design and validation, energy conservation goals, etc.

c. For virus inactivation, the target microorganism will remain adenovirus (0.5 log inactivation at 40 mJ/cm^2) for municipal drinking water supplies unless the Approval Holder demonstrates that there is no risk of adenovirus being present. In this case, rotavirus may be considered the target virus. Log inactivation credits will be considered and accepted by the Department on a system-specific basis.

d. Where UV light is used as a primary disinfectant, free chlorine or chloramines shall be required to provide secondary disinfection of the distribution system.

e. To receive inactivation credit, a UV reactor must operate within the validated limits (e.g., intensity is greater than the minimum specified, flow is below the maximum specified, UVT is above the minimum specified).

f. UV systems are required to have a shut off feature and alarm when the equipment malfunctions, loses power or ceases to provide the appropriate level of disinfection.

Additional information is provided in Appendix G.

APPENDIX D

Log Inactivation Information and Tables for Free Chlorine, Chlorine Dioxide, Ozone and Ultraviolet (UV) Light

D1 $CT_{required}$

$CT_{required}$ can be determined by the following methods:

- From CT disinfection tables first published by USEPA; or
- Calculated from equation (for *Giardia* only).

D1.1 Reading $CT_{required}$ from US EPA Disinfection Tables:

CT values can be read from the tables, which follow in the appendix, using the following parameters:

- Required log reduction;
- Minimum temperature of the water;
- Maximum pH of the water; and
- Free chlorine residual concentration before first consumer (when using free chlorine).

Note that tables are specific to target organism (*Giardia*, *Cryptosporidium,* viruses) and type of disinfectant (free chlorine, chlorine dioxide, ozone, UV).

Since water treatment facilities rarely operate at pH, temperature and chlorine concentrations that exactly match the values listed in the CT tables, $CT_{Required}$ must be determined by one of the following methods:

- Linear interpolation method;
- Approximation method.

D1.1.1 Linear Interpolation Method

Linear interpolation method may have to be used several times to find intermediate values for chlorine, temperature and pH (see example 2 in Appendix F).

Because of the complexity of this process, the approximation method is frequently used to find $CT_{required}$.

D1.1.2 The Approximation Method

With the approximation method, conservative values for pH, temperature, and residual disinfectant concentration are used to select a CT value from the table. It is a conservative method that slightly underestimates the actual effectiveness of the disinfection process. However, it requires no mathematical calculations and therefore is simpler and reduces errors.

To find the $CT_{required}$ from the tables using the approximation method:

- Find the CT table for the temperature that is equal or (next) lower to the actual measured water temperature. For example, if the measured water temperature is 7^0C use a table for 5^0C.
- Go to the section of the table for the pH which is equal to or (next) higher than the actual measured pH of the water. For example, if the measured pH is 6.3, use the pH 6.5 section.
- Use the free chlorine concentration that is equal or (next) higher than the actual concentration measured at the plant. For example, if the measured free chlorine concentration is 1.5 mg/L, use the 1.6 mg/L row.

For example, find the $CT_{required}$ for the 0.5 log inactivation credit for *Giardia* and thefollowing water parameters:

- temperature = 7^0C;
- pH =6.7;
- free chlorine = 1.7 mg/L.

Since there is no table for 7^0C, we should select the table with the next lower temperature, which in this case is a table for 5^0C. This table contains pH values 6.5 and pH 7.0. Since our measured value is 6.7, we choose the next higher value, that is pH 7. Finally looking at free chlorine concentration, we see that table contains values for concentrations 1.6 mg/L and 1.8 mg/L. With a measured value of 1.7 mg/L, we use the next higher value, in this case 1.8 mg/L. Using this process, the $CT_{required}$ would be 27.

CT log inactivation tables have been provided in this appendix to facilitate thecalculation of $CT_{required}$ via the linear interpolation or approximation method.

D2 Calculating $CT_{required}$ from Equation (for *Giardia* Only)

The following equation, developed by Martin (1993), is most often used in disinfection calculations for *Giardia*.

$$CTrequired = 0.2828 * pH^{2.69} * Cl^{0.15} * (\log reduction) * 0.933^{temp-5}$$

Where :

CT: Required inactivation number

pH: Measure of the acidity or basicity

Cl: Free chlorine concentration

Log reduction: Required logarithmic reduction in Giardia

Temp: Water temperature

Please note this equation does not apply to *Cryptosporidium* which is not inactivated by chlorine. See the log inactivation tables for alternate disinfectants for *Cryptosporidium* inactivation.

The following table compares $CT_{required}$ as determined by the approximation method and the Martin equation for two scenarios.

Log Reduction Required	Temperature (°C)	pH	Chlorine Residual (mg/L)	Approximation Method[1]	Martin
0.5	0.5	6	0.8	24	23.15
0.5	0.5	7	1.4	37	38.12

Notes:

1. Values taken from the CT tables

CT Log Inactivation Values for *Giardia* using Free Chlorine at 0.5°C

Free Chlorine Concentration mg/L	pH ≤ 6						pH = 6.5						pH = 7.0						pH = 7.5					
	Log Inactivation						Log Inactivation						Log Inactivation						Log Inactivation					
	0.5	1	1.5	2	2.5	3	0.5	1	1.5	2	2.5	3	0.5	1	1.5	2	2.5	3	0.5	1	1.5	2	2.5	3
≤ 0.4	23	46	69	91	114	137	27	54	82	109	136	163	33	65	98	130	163	195	40	79	119	158	198	237
0.6	24	47	71	94	118	141	28	56	84	112	140	168	33	67	100	133	167	200	40	80	120	159	199	239
0.8	24	48	73	97	121	145	29	57	86	115	143	172	34	68	103	137	171	205	41	82	123	164	205	246
1	25	49	74	99	123	148	29	59	88	117	147	176	35	70	105	140	175	210	42	84	127	169	211	253
1.2	25	51	76	101	127	152	30	60	90	120	150	180	36	72	108	143	179	215	43	86	130	173	216	259
1.4	26	52	78	103	129	155	31	61	92	123	153	184	37	74	111	147	184	221	44	89	133	177	222	266
1.6	26	52	79	105	131	157	32	63	95	126	158	189	38	75	113	151	188	226	46	91	137	182	228	273
1.8	27	54	81	108	135	162	32	64	97	129	161	193	39	77	116	154	193	231	47	93	140	186	233	279
2	28	55	83	110	138	165	33	66	99	131	164	197	39	79	118	157	197	236	48	95	143	191	238	286
2.2	28	56	85	113	141	169	34	67	101	134	168	201	40	81	121	161	202	242	50	99	149	198	248	297
2.4	29	57	86	115	143	172	34	68	103	137	171	205	41	82	124	165	206	247	50	99	149	199	248	298
2.6	29	58	88	117	146	175	35	70	105	139	174	209	42	84	126	168	210	252	51	101	152	203	253	304
2.8	30	59	89	119	148	178	36	71	107	142	178	213	43	86	129	171	214	257	52	103	155	207	258	310
3	30	60	91	121	151	181	36	72	109	145	181	217	44	87	131	174	218	261	53	105	158	211	263	316

Free Chlorine Concentration mg/L	pH = 8.0						pH = 8.5						pH ≤9.0					
	Log Inactivation						Log Inactivation						Log Inactivation					
	0.5	1	1.5	2	2.5	3	0.5	1	1.5	2	2.5	3	0.5	1	1.5	2	2.5	3
≤ 0.4	46	92	139	185	231	277	55	110	165	219	274	329	65	130	195	260	325	390
0.6	48	95	143	191	238	286	57	114	171	228	285	342	68	136	204	271	339	407
0.8	49	98	148	197	246	295	59	118	177	236	295	354	70	141	211	281	352	422
1	51	101	152	203	253	304	61	122	183	243	304	365	73	146	219	291	364	437
1.2	52	104	157	209	261	313	63	125	188	251	313	376	75	150	226	301	376	451
1.4	54	107	161	214	268	321	65	129	194	258	323	387	77	155	232	309	387	464
1.6	55	110	165	219	274	329	66	132	199	265	331	397	80	159	239	318	398	477
1.8	56	113	169	225	282	338	68	136	204	271	339	407	82	163	245	326	408	489
2	58	115	173	231	288	346	70	139	209	278	348	417	83	167	250	333	417	500
2.2	59	118	177	235	294	353	71	142	213	284	355	426	85	170	256	341	426	511
2.4	60	120	181	241	301	361	73	145	218	290	363	435	87	174	261	348	435	522
2.6	61	123	184	245	307	368	74	148	222	296	370	444	89	178	267	355	444	533
2.8	63	125	188	250	313	375	75	151	226	301	377	452	91	181	272	362	453	543
3	64	127	191	255	318	382	77	153	230	307	383	460	92	184	276	368	460	552

CT units = min·mg/L

Source: USEPA (1991) Guidance Manual for Compliance with the Filtration and Disinfection Requirements for Public Water Systems Using Surface Water Sources.

CT Log Inactivation Values for *Giardia* using Free Chlorine at 5ºC

Free Chlorine Concentration mg/L	pH ≤ 6						pH = 6.5						pH = 7.0						pH = 7.5					
	Log Inactivation						Log Inactivation						Log Inactivation						Log Inactivation					
	0.5	1	1.5	2	2.5	3	0.5	1	1.5	2	2.5	3	0.5	1	1.5	2	2.5	3	0.5	1	1.5	2	2.5	3
≤ 0.4	16	32	49	65	81	97	20	39	59	78	98	117	23	46	70	93	116	139	28	55	83	111	138	166
0.6	17	33	50	67	83	100	20	40	60	80	100	120	24	48	72	95	119	143	29	57	86	114	143	171
0.8	17	34	52	69	86	103	20	41	61	81	102	122	24	49	73	97	122	146	29	58	88	117	146	175
1	18	35	53	70	88	105	21	42	63	83	104	125	25	50	75	99	124	149	30	60	90	119	149	179
1.2	18	36	54	71	89	107	21	42	64	85	106	127	25	51	76	101	127	152	31	61	92	122	153	183
1.4	18	36	55	73	91	109	22	43	65	87	108	130	26	52	78	103	129	155	31	62	94	125	156	187
1.6	19	37	56	74	93	111	22	44	66	88	110	132	26	53	79	105	132	158	32	64	96	128	160	192
1.8	19	38	57	76	95	114	23	45	68	90	113	135	27	54	81	108	135	162	33	65	98	131	163	196
2	19	39	58	77	97	116	23	46	69	92	115	138	28	55	83	110	138	165	33	67	100	133	167	200
2.2	20	39	59	79	98	118	23	47	70	93	117	140	28	56	85	113	141	169	34	68	102	136	170	204
2.4	20	40	60	80	100	120	24	48	72	95	119	143	29	57	86	115	143	172	35	70	105	139	174	209
2.6	20	41	61	81	102	122	24	49	73	97	122	146	29	58	88	117	146	175	36	71	107	142	178	213
2.8	21	41	62	83	103	124	25	49	74	99	123	148	30	59	89	119	148	178	36	72	109	145	181	217
3	21	42	63	84	105	126	25	50	76	101	126	151	30	61	91	121	152	182	37	74	111	147	184	221

Free Chlorine Concentration mg/L	pH = 8.0						pH = 8.5						pH ≤ 9.0					
	Log Inactivation						Log Inactivation						Log Inactivation					
	0.5	1	1.5	2	2.5	3	0.5	1	1.5	2	2.5	3	0.5	1	1.5	2	2.5	3
≤ 0.4	33	66	99	132	165	198	39	79	118	157	197	236	47	93	140	186	233	279
0.6	34	68	102	136	170	204	41	81	122	163	203	244	49	97	146	194	243	291
0.8	35	70	105	140	175	210	42	84	126	168	210	252	50	100	151	201	251	301
1	36	72	108	144	180	216	43	87	130	173	217	260	52	104	156	208	260	312
1.2	37	74	111	147	184	221	45	89	134	178	223	267	53	107	160	213	267	320
1.4	38	76	114	151	189	227	46	91	137	183	228	274	55	110	165	219	274	329
1.6	39	77	116	155	193	232	47	94	141	187	234	281	56	112	169	225	281	337
1.8	40	79	119	159	198	238	48	96	144	191	239	287	58	115	173	230	288	345
2	41	81	122	162	203	243	49	98	147	196	245	294	59	118	177	235	294	353
2.2	41	83	124	165	207	248	50	100	150	200	250	300	60	120	181	241	301	361
2.4	42	84	127	169	211	253	51	102	153	204	255	306	61	123	184	245	307	368
2.6	43	86	129	172	215	258	52	104	156	208	260	312	63	125	188	250	313	375
2.8	44	88	132	175	219	263	53	106	159	212	265	318	64	127	191	255	318	382
3	45	89	134	179	223	268	54	108	162	216	270	324	65	130	195	259	324	389

CT units = min·mg/L

Source: USEPA (1991) Guidance Manual for Compliance with the Filtration and Disinfection Requirements for Public Water Systems Using Surface Water Sources.

CT Log Inactivation Values for *Giardia* using Free Chlorine at 10°C

Free Chlorine Concentration mg/L	pH ≤ 6						pH = 6.5						pH = 7.0						pH = 7.5					
	Log Inactivation						Log Inactivation						Log Inactivation						Log Inactivation					
	0.5	1	1.5	2	2.5	3	0.5	1	1.5	2	2.5	3	0.5	1	1.5	2	2.5	3	0.5	1	1.5	2	2.5	3
≤ 0.4	12	24	37	49	61	73	15	29	44	59	73	88	17	35	52	69	87	104	21	42	63	83	104	125
0.6	13	25	38	50	63	75	15	30	45	60	75	90	18	36	54	71	89	107	21	43	64	85	107	128
0.8	13	26	39	52	65	78	15	31	46	61	77	92	18	37	55	73	92	110	22	44	66	87	109	131
1	13	26	40	53	66	79	16	31	47	63	78	94	19	37	56	75	93	112	22	45	67	89	112	134
1.2	13	27	40	53	67	80	16	32	48	63	79	95	19	38	57	76	95	114	23	46	69	91	114	137
1.4	14	27	41	55	68	82	16	33	49	65	82	98	19	39	58	77	97	116	23	47	70	93	117	140
1.6	14	28	42	55	69	83	17	33	50	66	83	99	20	40	60	79	99	119	24	48	72	96	120	144
1.8	14	29	43	57	72	86	17	34	51	67	84	101	20	41	61	81	102	122	25	49	74	98	123	147
2	15	29	44	58	73	87	17	35	52	69	87	104	21	41	62	83	103	124	25	50	75	100	125	150
2.2	15	30	45	59	74	89	18	35	53	70	88	105	21	42	64	85	106	127	26	51	77	102	128	153
2.4	15	30	45	60	75	90	18	36	54	71	89	107	22	43	65	86	108	129	26	52	79	105	131	157
2.6	15	31	46	61	77	92	18	37	55	73	92	110	22	44	66	87	109	131	27	53	80	107	133	160
2.8	16	31	47	62	78	93	19	37	56	74	93	111	22	45	67	89	112	134	27	54	82	109	136	163
3	16	32	48	63	79	95	19	38	57	75	94	113	23	46	69	91	114	137	28	55	83	111	138	166

Free Chlorine Concentration mg/L	pH = 8.0						pH = 8.5						pH ≤ 9.0					
	Log Inactivation						Log Inactivation						Log Inactivation					
	0.5	1	1.5	2	2.5	3	0.5	1	1.5	2	2.5	3	0.5	1	1.5	2	2.5	3
≤ 0.4	25	50	75	99	124	149	30	59	89	118	148	177	35	70	105	139	174	209
0.6	26	51	77	102	128	153	31	61	92	122	153	183	36	73	109	145	182	218
0.8	26	53	79	105	132	158	32	63	95	126	158	189	38	75	113	151	188	226
1	27	54	81	108	135	162	33	65	98	130	163	195	39	78	117	156	195	234
1.2	28	55	83	111	138	166	33	67	100	133	167	200	40	80	120	160	200	240
1.4	28	57	85	113	142	170	34	69	103	137	172	206	41	82	124	165	206	247
1.6	29	58	87	116	145	174	35	70	106	141	176	211	42	84	127	169	211	253
1.8	30	60	90	119	149	179	36	72	108	143	179	215	43	86	130	173	216	259
2	30	61	91	121	152	182	37	74	111	147	184	221	44	88	133	177	221	265
2.2	31	62	93	124	155	186	38	75	113	150	188	225	45	90	136	181	226	271
2.4	32	63	95	127	158	190	38	77	115	153	192	230	46	92	138	184	230	276
2.6	32	65	97	129	162	194	39	78	117	156	195	234	47	94	141	187	234	281
2.8	33	66	99	131	164	197	40	80	120	159	199	239	48	96	144	191	239	287
3	34	67	101	134	168	201	41	81	122	162	203	243	49	97	146	195	243	292

CT units = min·mg/L

Source: USEPA (1991) Guidance Manual for Compliance with the Filtration and Disinfection Requirements for Public Water Systems Using Surface Water Sources.

CT Log Inactivation Values for *Giardia* using Free Chlorine at 15°C

Free Chlorine Concentration mg/L	pH ≤ 6						pH = 6.5						pH = 7.0						pH = 7.5					
	Log Inactivation						Log Inactivation						Log Inactivation						Log Inactivation					
	0.5	1	1.5	2	2.5	3	0.5	1	1.5	2	2.5	3	0.5	1	1.5	2	2.5	3	0.5	1	1.5	2	2.5	3
≤ 0.4	8	16	25	33	41	49	10	20	30	39	49	59	12	23	35	47	58	70	14	28	42	55	69	83
0.6	8	17	25	33	42	50	10	20	30	40	50	60	12	24	36	48	60	72	14	29	43	57	72	86
0.8	9	17	26	35	43	52	10	20	31	41	51	61	12	24	37	49	61	73	15	29	44	59	73	88
1	9	18	27	35	44	53	11	21	32	42	53	63	13	25	38	50	63	75	15	30	45	60	75	90
1.2	9	18	27	36	45	54	11	21	32	43	53	64	13	25	38	51	63	76	15	31	46	61	77	92
1.4	9	18	28	37	46	55	11	22	33	43	54	65	13	26	39	52	65	78	16	31	47	63	78	94
1.6	10	19	28	37	47	56	11	22	33	44	55	66	13	26	40	53	66	79	16	32	48	64	80	96
1.8	10	19	29	38	48	57	11	23	34	45	57	68	14	27	41	54	68	81	16	33	49	65	82	98
2	10	19	29	39	48	58	12	23	35	46	58	69	14	28	42	55	69	83	17	33	50	67	83	100
2.2	10	20	30	39	49	59	12	23	35	47	58	70	14	28	43	57	71	85	17	34	51	68	85	102
2.4	10	20	30	40	50	60	12	24	36	48	60	72	14	29	43	57	72	86	18	35	53	70	88	105
2.6	10	20	31	41	51	61	12	24	37	49	61	73	15	29	44	59	73	88	18	36	54	71	89	107
2.8	10	21	31	41	52	62	12	25	37	49	62	74	15	30	45	59	74	89	18	36	55	73	91	109
3	11	21	32	42	53	63	13	25	38	51	63	76	15	30	46	61	76	91	19	37	56	74	93	111

Free Chlorine Concentration mg/L	pH = 8.0						pH = 8.5						pH ≤ 9.0					
	Log Inactivation						Log Inactivation						Log Inactivation					
	0.5	1	1.5	2	2.5	3	0.5	1	1.5	2	2.5	3	0.5	1	1.5	2	2.5	3
≤ 0.4	17	33	50	66	83	99	20	39	59	79	98	118	23	47	70	93	117	140
0.6	17	34	51	68	85	102	20	41	61	81	102	122	24	49	73	97	122	146
0.8	18	35	53	70	88	105	21	42	63	84	105	126	25	50	76	101	126	151
1	18	36	54	72	90	108	22	43	65	87	108	130	26	52	78	104	130	156
1.2	19	37	56	74	93	111	22	45	67	89	112	134	27	53	80	107	133	160
1.4	19	38	57	76	95	114	23	46	69	91	114	137	28	55	83	110	138	165
1.6	19	39	58	77	97	116	24	47	71	94	118	141	28	56	85	113	141	169
1.8	20	40	60	79	99	119	24	48	72	96	120	144	29	58	87	115	144	173
2	20	41	61	81	102	122	25	49	74	98	123	147	30	59	89	118	148	177
2.2	21	41	62	83	103	124	25	50	75	100	125	150	30	60	91	121	151	181
2.4	21	42	64	85	106	127	26	51	77	102	128	153	31	61	92	123	153	184
2.6	22	43	65	86	108	129	26	52	78	104	130	156	31	63	94	125	157	188
2.8	22	44	66	88	110	132	27	53	80	106	133	159	32	64	96	127	159	191
3	22	45	67	89	112	134	27	54	81	108	135	162	33	65	98	130	163	195

CT units = min·mg/L

Source: USEPA (1991) Guidance Manual for Compliance with the Filtration and Disinfection Requirements for Public Water Systems Using Surface Water Sources.

CT Log Inactivation Values for *Giardia* using Free Chlorine at 20°C

Free Chlorine Concentration mg/L	pH ≤ 6						pH = 6.5						pH = 7.0						pH = 7.5					
	Log Inactivation						Log Inactivation						Log Inactivation						Log Inactivation					
	0.5	1	1.5	2	2.5	3	0.5	1	1.5	2	2.5	3	0.5	1	1.5	2	2.5	3	0.5	1	1.5	2	2.5	3
≤ 0.4	6	12	18	24	30	36	7	15	22	29	37	44	9	17	26	35	43	52	10	21	31	41	52	62
0.6	6	13	19	25	32	38	8	15	23	30	38	45	9	18	27	36	45	54	11	21	32	43	53	64
0.8	7	13	20	26	33	39	8	15	23	31	38	46	9	18	28	37	46	55	11	22	33	44	55	66
1	7	13	20	26	33	39	8	16	24	31	39	47	9	19	28	37	47	56	11	22	34	45	56	67
1.2	7	13	20	27	33	40	8	16	24	32	40	48	10	19	29	38	48	57	12	23	35	46	58	69
1.4	7	14	21	27	34	41	8	16	25	33	41	49	10	19	29	39	48	58	12	23	35	47	58	70
1.6	7	14	21	28	35	42	8	17	25	33	42	50	10	20	30	39	49	59	12	24	36	48	60	72
1.8	7	14	22	29	36	43	9	17	26	34	43	51	10	20	31	41	51	61	12	25	37	49	62	74
2	7	15	22	29	37	44	9	17	26	35	43	52	10	21	31	41	52	62	13	25	38	50	63	75
2.2	7	15	22	29	37	44	9	18	27	35	44	53	11	21	32	42	53	63	13	26	39	51	64	77
2.4	8	15	23	30	38	45	9	18	27	36	45	54	11	22	33	43	54	65	13	26	39	52	65	78
2.6	8	15	23	31	38	46	9	18	28	37	46	55	11	22	33	44	55	66	13	27	40	53	67	80
2.8	8	16	24	31	39	47	9	19	28	37	47	56	11	22	34	45	56	67	14	27	41	54	68	81
3	8	16	24	31	39	47	10	19	29	38	48	57	11	23	34	45	57	68	14	28	42	55	69	83

Free Chlorine Concentration mg/L	pH = 8.0						pH = 8.5						pH ≤ 9.0					
	Log Inactivation						Log Inactivation						Log Inactivation					
	0.5	1	1.5	2	2.5	3	0.5	1	1.5	2	2.5	3	0.5	1	1.5	2	2.5	3
≤ 0.4	12	25	37	49	62	74	15	30	45	59	74	89	18	35	53	70	88	105
0.6	13	26	39	51	64	77	15	31	46	61	77	92	18	36	55	73	91	109
0.8	13	26	40	53	66	79	16	32	48	63	79	95	19	38	57	75	94	113
1	14	27	41	54	68	81	16	33	49	65	82	98	20	39	59	78	98	117
1.2	14	28	42	55	69	83	17	33	50	67	83	100	20	40	60	80	100	120
1.4	14	28	43	57	71	85	17	34	52	69	86	103	21	41	62	82	103	123
1.6	15	29	44	58	73	87	18	35	53	70	88	105	21	42	63	84	105	126
1.8	15	30	45	59	74	89	18	36	54	72	90	108	22	43	65	86	108	129
2	15	30	46	61	76	91	18	37	55	73	92	110	22	44	66	88	110	132
2.2	16	31	47	62	78	93	19	38	57	75	94	113	23	45	68	90	113	135
2.4	16	32	48	63	79	95	19	38	58	77	96	115	23	46	69	92	115	138
2.6	16	32	49	65	81	97	20	39	59	78	98	117	24	47	71	94	118	141
2.8	17	33	50	66	83	99	20	40	60	79	99	119	24	48	72	95	119	143
3	17	34	51	67	84	101	20	41	61	81	102	122	24	49	73	97	122	146

CT units = min·mg/L

Source: USEPA (1991) Guidance Manual for Compliance with the Filtration and Disinfection Requirements for Public Water Systems Using Surface Water Sources.

CT Log Inactivation Values for *Giardia* using Free Chlorine at 25°C

Free Chlorine Concentration mg/L	pH ≤ 6						pH = 6.5						pH = 7.0						pH = 7.5					
	Log Inactivation						Log Inactivation						Log Inactivation						Log Inactivation					
	0.5	1	1.5	2	2.5	3	0.5	1	1.5	2	2.5	3	0.5	1	1.5	2	2.5	3	0.5	1	1.5	2	2.5	3
≤ 0.4	4	8	12	16	20	24	5	10	15	19	24	29	6	12	18	23	29	35	7	14	21	28	35	42
0.6	4	8	13	17	21	25	5	10	15	20	25	30	6	12	18	24	30	36	7	14	22	29	36	43
0.8	4	9	13	17	22	26	5	10	16	21	26	31	6	12	19	25	31	37	7	15	22	29	37	44
1	4	9	13	17	22	26	5	10	16	21	26	31	6	12	19	25	31	37	8	15	23	30	38	45
1.2	5	9	14	18	23	27	5	11	16	21	27	32	6	13	19	25	32	38	8	15	23	31	38	46
1.4	5	9	14	18	23	27	6	11	17	22	28	33	7	13	20	26	33	39	8	16	24	31	39	47
1.6	5	9	14	19	23	28	6	11	17	22	28	33	7	13	20	27	33	40	8	16	24	32	40	48
1.8	5	10	15	19	24	29	6	11	17	23	28	34	7	14	21	27	34	41	8	16	25	33	41	49
2	5	10	15	19	24	29	6	12	18	23	29	35	7	14	21	27	34	41	8	17	25	33	42	50
2.2	5	10	15	20	25	30	6	12	18	23	29	35	7	14	21	28	35	42	9	17	26	34	43	51
2.4	5	10	15	20	25	30	6	12	18	24	30	36	7	14	22	29	36	43	9	17	26	35	43	52
2.6	5	10	16	21	26	31	6	12	19	25	31	37	7	15	22	29	37	44	9	18	27	35	44	53
2.8	5	10	16	21	26	31	6	12	19	25	31	37	8	15	23	30	38	45	9	18	27	36	45	54
3	5	11	16	21	27	32	6	13	19	25	32	38	8	15	23	31	38	46	9	18	28	37	46	55

Free Chlorine Concentration mg/L	pH = 8.0						pH = 8.5						pH ≤ 9.0					
	Log Inactivation						Log Inactivation						Log Inactivation					
	0.5	1	1.5	2	2.5	3	0.5	1	1.5	2	2.5	3	0.5	1	1.5	2	2.5	3
≤ 0.4	8	17	25	33	42	50	10	20	30	39	49	59	12	23	35	47	58	70
0.6	9	17	26	34	43	51	10	20	31	41	51	61	12	24	37	49	61	73
0.8	9	18	27	35	44	53	11	21	32	42	53	63	13	25	38	50	63	75
1	9	18	27	36	45	54	11	22	33	43	54	65	13	26	39	52	65	78
1.2	9	18	28	37	46	55	11	22	34	45	56	67	13	27	40	53	67	80
1.4	10	19	29	38	48	57	12	23	35	46	58	69	14	27	41	55	68	82
1.6	10	19	29	39	48	58	12	23	35	47	58	70	14	28	42	56	70	84
1.8	10	20	30	40	50	60	12	24	36	48	60	72	14	29	43	57	72	86
2	10	20	31	41	51	61	12	25	37	49	62	74	15	29	44	59	73	88
2.2	10	21	31	41	52	62	13	25	38	50	63	75	15	30	45	60	75	90
2.4	11	21	32	42	53	63	13	26	39	51	64	77	15	31	46	61	77	92
2.6	11	22	33	43	54	65	13	26	39	52	65	78	16	31	47	63	78	94
2.8	11	22	33	44	55	66	13	27	40	53	67	80	16	32	48	64	80	96
3	11	22	34	45	56	67	14	27	41	54	68	81	16	32	49	65	81	97

CT units = min·mg/L

Source: USEPA (1991) Guidance Manual for Compliance with the Filtration and Disinfection Requirements for Public Water Systems Using Surface Water Sources.

CT Values for Inactivation of Viruses by Free Chlorine

Temperature (°C)	Log Inactivation					
	2		3		4	
	pH		pH		pH	
	6 to 9	10	6 to 9	10	6 to 9	10
0.5	6	45	9	66	12	90
5	4	30	6	44	8	60
10	3	22	4	33	6	45
15	2	15	3	22	4	30
20	1	11	2	16	3	22
25	1	7	1	11	2	15

CT units = min·mg/L
Source: USEPA (1991) Guidance Manual for Compliance with the Filtration and Disinfection Requirements for Public Water Systems Using Surface Water Sources.

CT Log Inactivation Values for *Cryptosporidium* using Chlorine Dioxide

Log Inactivation	Water Temperature (°C)										
	0.5	1	2	3	5	7	10	15	20	25	30
0.25	159	152	139	128	107	90	69	45	29	19	12
0.50	318	304	279	256	215	180	139	90	58	37	24
1.00	636	609	558	511	429	361	278	179	116	75	48
1.50	954	913	837	767	644	541	416	269	174	112	73
2.00	1271	1217	1115	1022	859	721	555	359	232	150	97
2.50	1589	1521	1394	1278	1073	901	694	449	290	187	121
3.00	1907	1826	1673	1533	1288	1082	833	538	348	225	145

CT units = min·mg/L
Source: (2006) Code of Federal Regulations, 40 CFR 141.720.

CT Log Inactivation Values for *Giardia* using Chlorine Dioxide

Log Inactivation	Water Temperature (°C)					
	<1	5	10	15	20	25
0.50	10	4	4	3	3	2
1.00	21	9	8	6	5	4
1.50	32	13	12	10	8	6
2.00	42	17	15	13	10	7
2.50	52	22	19	16	13	9
3.00	63	26	23	19	15	11

CT Log Inactivation Values of Viruses using Chlorine Dioxide, pH 6-9

Log Inactivation	Temperature (°C)					
	≤1	5	10	15	20	25
2	8.4	5.6	4.2	2.8	2.1	1.4
3	25.6	17.1	12.8	8.6	6.4	4.3
4	50.1	33.4	25.1	16.7	12.5	8.4

CT units = min·mg/L
Source: USEPA (1991) Guidance Manual for Compliance with the Filtration and Disinfection Requirements for Public Water Systems Using Surface Water Sources.

CT Log Inactivation Values for *Cryptosporidium* using Ozone

Log Inactivation	Temperature (°C)									
	≤0.5	1	2	3	5	7	10	15	20	25
0.5	12	12	10	9.5	7.9	6.5	4.9	3.1	2.0	1.2
1.0	24	23	21	19	16	13	9.9	6.2	3.9	2.5
1.5	36	35	31	29	24	20	15	9.3	5.9	3.7
2.0	48	46	42	38	32	26	20	12	7.8	4.9
2.5	60	58	52	48	40	33	25	16	9.8	6.2
3.0	72	69	63	57	47	39	30	19	12	7.4

CT units = min·mg/L
Source: (2006) Code of Federal Regulations, 40 CFR 141.720.

CT Log Inactivation Values for *Giardia* using Ozone

Log Inactivation	Temperature (°C)					
	≤1	5	10	15	20	25
0.5	0.48	0.32	0.23	0.16	0.12	0.08
1.0	0.97	0.63	0.48	0.32	0.24	0.16
1.5	1.5	0.95	0.72	0.48	0.36	0.24
2.0	1.9	1.3	0.95	0.63	0.48	0.32
2.5	2.4	1.6	1.2	0.79	0.6	0.4
3.0	2.9	1.9	1.43	0.95	0.72	0.48

CT units = min·mg/L
Source: USEPA (1991) Guidance Manual for Compliance with the Filtration and Disinfection Requirements for Public Water Systems Using Surface Water Sources.

CT Inactivation Values for Viruses using Ozone

Log Inactivation	Temperature (°C)					
	≤1	5	10	15	20	25
2	0.9	0.6	0.5	0.3	0.25	0.15
3	1.4	0.9	0.8	0.5	0.4	0.25
4	1.8	1.2	1	0.6	0.5	0.3

CT units = min·mg/L
Source: USEPA (1991) Guidance Manual for Compliance with the Filtration and Disinfection Requirements for Public Water Systems Using Surface Water Sources.

UV Dose Log Inactivation Values for *Cryptosporidium*, *Giardia*, and Viruses

Log Inactivation	*Cryptosporidium*	*Giardia*	Viruses*
0.5	1.6	1.5	39
1.0	2.5	2.1	58
1.5	3.9	3.0	79
2.0	5.8	5.2	100
2.5	8.5	7.7	121
3.0	12	11	143
3.5	15	15	163
4.0	22	22	186

* Based on adenovirus inactivation.

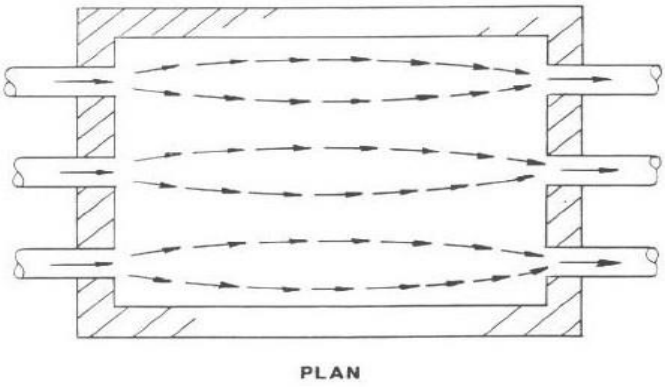
Source (2006) Code of Federal Regulations, 40 CFR 141.720

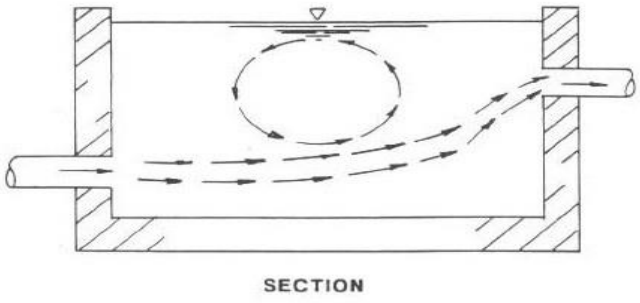
APPENDIX E

Baffling Factors for Sample Contact Chamber Designs

E1 Poor Baffling

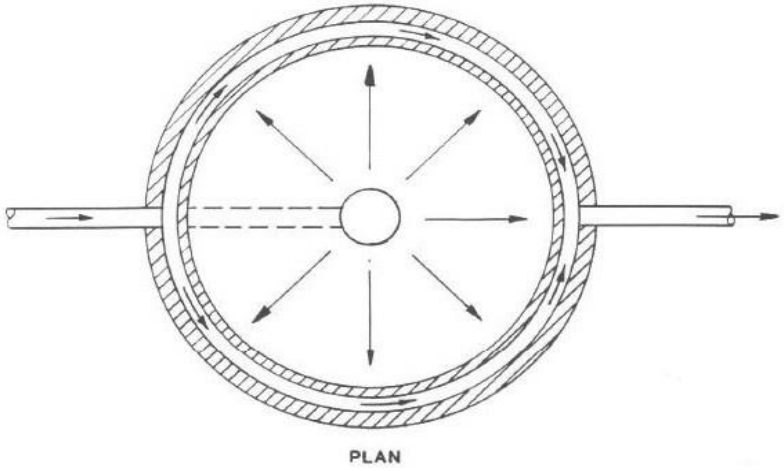
- T_{10}/T_0 = 0.3
- single or multiple unbaffled inlets and outlets
- no intra-basin baffles
- potential for stagnant zones and short-circuiting





E2 Average Baffling

- T_{10}/T_0 = 0.5
- baffled inlet or outlet
- some intra-basin baffles



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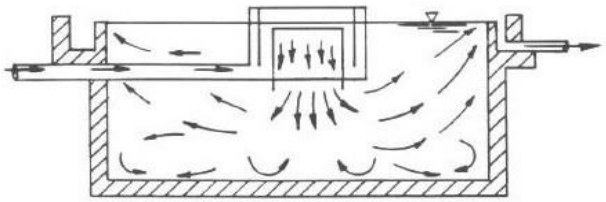
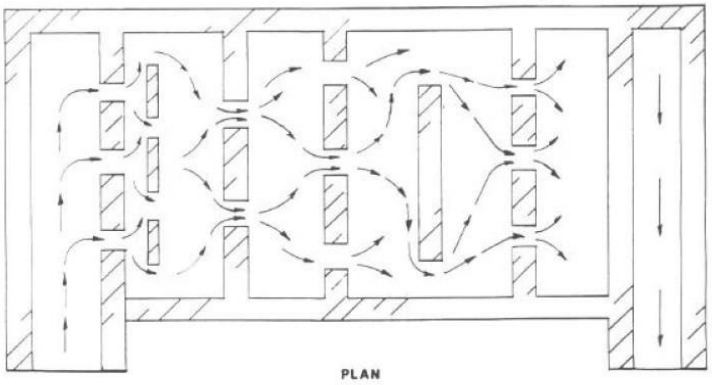
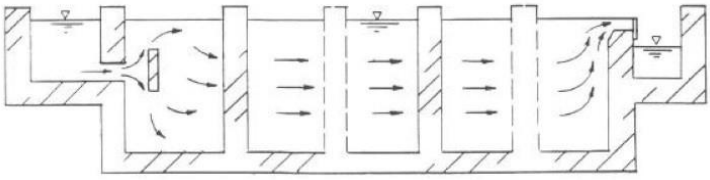


SECTION

E3 Superior Baffling

- T_{10}/T_0 = 0.7
- perforated inlet baffle
- serpentine or perforated intra-basin baffles
- outlet weir or perforated launders
- most of tank volume utilized





APPENDIX F

Sample CT Calculations

EXAMPLE 1

Source Water - Surface Water

The source water is surface water from a river.

Treatment Requirements

Based on source water conditions, the treatment requirements are set at:

3.0-log reduction for *Cryptosporidium* and *Giardia*;

4.0-log reduction for viruses.

Filtration Credits (Log Removal)

The treatment facility is a direct filtration plant. Individual filter effluent turbidity was reviewed and meets the limits of 0.2 NTU 95% of the time. Therefore, this facility receives the following filtration credits towards meeting the treatment requirements:

2.5-log reduction for *Cryptosporidium*;

2.5-log reduction for *Giardia*;

1.0-log reduction for viruses.

Based on the above, log inactivation (disinfection) must provide the following log reduction:

Cryptosporidium		3.0-log reduction required
	Subtract	2.5-log filtration credit
	Equals	**0.5-log** inactivation credit needed
Giardia		3.0-log reduction required
	Subtract	2.5-log filtration credit
	Equals	**0.5-log** inactivation credit needed
Viruses		4.0-log reduction required
	Subtract	1.0-log filtration credit
	Equals	**3.0-log** inactivation credit needed

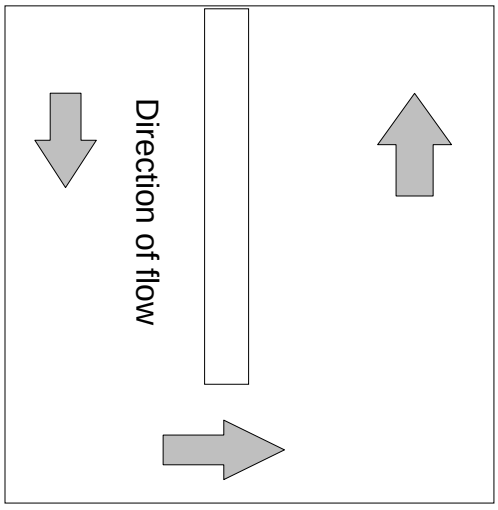
Treatment Deficiency #1

Because this facility has a shortfall in log removal credits for *Cryptosporidium*, an alternate disinfectant such as UV, chlorine dioxide or ozone will be required to meet treatment requirements.

In this example, UV is selected. The UV unit has a minimum dose of 40 mJ/cm^2. This is sufficient to receive a 4-log inactivation credit for *Cryptosporidium* and *Giardia* (see IT tables in Appendix D) which meets the above shortfalls. UV is only assigned a 0.5-log inactivation credit for viruses based on adenovirus. As such, 2.5-log inactivation is required by chlorine.

Disinfection Credits (Log Inactivation)

The contact chamber has the following configuration:



Contact Chamber Specifications:

Volume:	270 cubic metres
Max. Flow:	4.1 MLD
Dimensions:	9.1 m x 10 m x 3 m
Baffling:	Single Baffle
Min. Temperature:	5^{o}C
Highest pH:	7.6

This facility uses free chlorine for primary disinfection. In the winter, the facility has a minimum of 1.0 mg/L free chlorine residual leaving the contact chamber.

Based on the configuration of the contact chamber the length to width ratio is 2:1, which is poor. A baffling factor of 0.3 can be used.

Tank low level occurs when the tank is 70% full.

CT Calculation

Volume of chamber: 270 cubic metres = 270 000 L = 0.27 ML x 0.7 (low level) = 0.189ML

Contact time$_{actual}$: Volume ÷ Max. Flow = 0.189 ML ÷ 4.1 MLD = 0.0461 days x 24hours per day x 60 minutes per hour = 66.4 minutes

CT_{actual}: Concentration of disinfectant x contact time x baffling factor = 1.0 mg/L x 66.4 minutes x 0.3 = 19.9 mg.min/L

$CT_{required}$ (*Giardia*): UV disinfection is providing 4.0-log inactivation for *Cryptosporidium* and *Giardia*.

Adequate for 0.5-log *Giardia*? Yes

$CT_{required}$ (Viruses): Referring to the CT tables in Appendix D, 8 mg.min/L provides 4-log inactivation of viruses at 5°C, pH 6-9

Adequate for viruses? $CT_{actual} \div CT_{required} = 19.9 \div 8 = 2.49$ (greater than 1)
Therefore adequate

Conclusion

This facility will require the installation of an alternate disinfectant, in this example UV, to provide sufficient disinfection for Cryptosporidium and Giardia inactivation. Chemical disinfection will also be required to provide adequate disinfection for virus inactivation based on adenovirus.

EXAMPLE 2

Source Water - Surface Water

The source water is surface water from a lake.

Treatment Requirements

Based on source water conditions, the treatment requirements are set at:

- 3.0-log reduction for *Cryptosporidium* and *Giardia*;
- 4.0-log reduction for viruses.

Filtration Credits (Log Removal)

The treatment facility is a conventional filtration plant. Individual filter effluent turbidity was reviewed and meets the limits of 0.2 NTU 95% of the time. Therefore, this facility receives the following filtration credits towards meeting the treatment requirements:

- 3.0-log reduction for *Cryptosporidium*;
- 3.0-log reduction for *Giardia*;
- 2.0-log reduction for viruses.

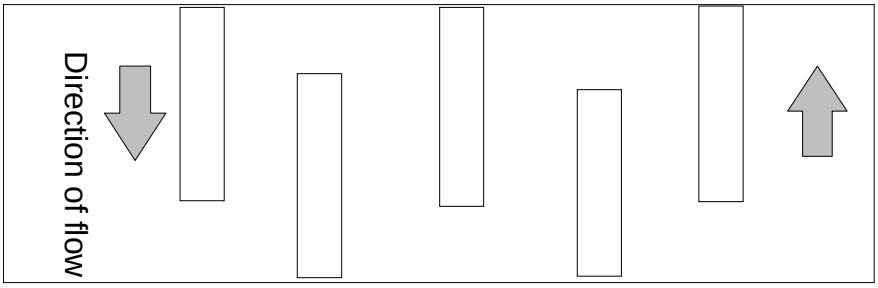
Based on the above, log inactivation (disinfection) must provide the following log reduction:

Cryptosporidium		3.0-log reduction required
	Subtract	3.0-log filtration credit
	Equals	**0.0-log** inactivation credit needed
Giardia		3.0-log reduction required
	Subtract	3.0-log filtration credit
	Equals	**0.0-log** inactivation credit needed
Viruses		4.0-log reduction required
	Subtract	2.0-log filtration credit
	Equals	**2.0-log** inactivation credit needed

There is no shortfall in log removal credits for *Cryptosporidium* in this example.

Disinfection Credits (Log Inactivation)

The contact chamber has the following configuration:



Contact Chamber Specifications:	
Volume:	303 cubic metres
Max. Flow:	3.1 MLD
Dimensions:	5.1 m x 20 m x 3 m
Baffling:	Five Baffles
Min. Temperature:	7°CHighest pH:7.3

This facility uses free chlorine for primary disinfection. In the winter, the facility has a minimum of 0.4 mg/L free chlorine residual leaving the contact chamber.

Based on the configuration of the contact chamber the length to width ratio is 4:1, and multiple baffles, which is good. A baffling factor of 0.7 can be used.

Tank low level occurs when the tank is 85% full.

CT Calculation

Volume of chamber: 303 cubic metres = 303 000 L = 0.303 ML x 0.85 (low level) = 0.258 ML

Contact time$_{actual}$: Volume ÷ Max. Flow = 0.258 ML ÷ 3.1 MLD = 0.0832 days x 24 hours per day x 60 minutes per hour = 119.8 minutes

CT_{actual}: Concentration of disinfectant x contact time x baffling factor =0.4 mg/L x 119.8 minutes x 0.7 = 33.5

Adequate for 0.5-log *Giardia*? Referring to CT Tables in Appendix D:

CT at 5°C and pH 7.0 = 23

CT at 5°C and pH 7.5 = 28

CT at 10°C and pH 7.0 = 18

CT at 10° and pH 7.5 = 21

Therefore:

CT at 7°C and pH 7.3 = 21.6 mg.min/L

$CT_{actual} \div CT_{required}$ = 33.5 ÷ 21.6 = 1.55 (greater than 1)

Therefore adequate

$CT_{required}$ (Viruses): Referring to CT tables in Appendix D,

8.0 mg.min/L provides 4.0-log inactivation of viruses

Adequate for viruses? $CT_{actual} \div CT_{required}$ = 33.5 ÷ 8.0 = 4.19 (greater than 1)

Therefore adequate

Conclusion

This facility adequately removes and inactivates *Cryptosporidium*, *Giardia* and *viruses* and meets Nova Scotia's Drinking Water Treatment Standards.

EXAMPLE 3

Source Water - High Risk GUDI Source

This example demonstrates the requirements for groundwater under the direct influence of surface water. The results from the GUDI protocol indicate that the drilled wells serving the facility have been classified as GUDI – High Risk. This classification has been accepted in writing by a Department Regional Hydrogeologist.

Treatment Requirements

Since the facility has been classified as GUDI – High Risk, the facility requires engineered filtration for pathogen reduction. The treatment requirements for this facility are:

- 3 - Log reduction for *Cryptosporidium* and *Giardia*;
- 4 - Log reduction for viruses.

Filtration Credits (Log Removal)

The facility has a micro-filtration (MF) membrane system with pre-coagulation. Individual filter effluent turbidity was reviewed and meets the limits of 0.1 NTU 99% of the time. Direct integrity testing indicates that the membrane provides 3.14-log removal for protozoa (e.g. *Cryptosporidium* oocysts and *Giardia* cysts). The system receives no credits for the removal for viruses. Therefore, this facility receives the following filtration credits towards meeting the treatment requirements:

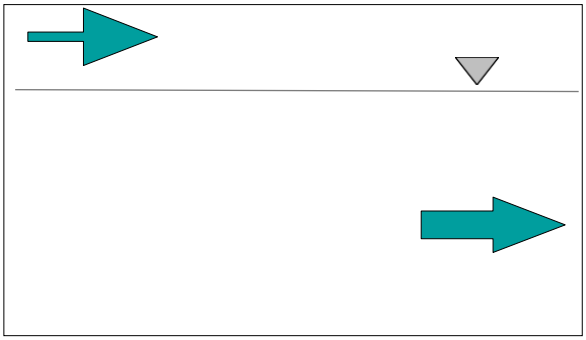
- 3.14-log reduction for *Cryptosporidium*;
- 3.14-log reduction for *Giardia*;
- 0.0-log reduction for viruses.

Based on the above, log inactivation must provide the following log reduction:

Cryptosporidium		3.00-log reduction required
	Subtract	3.14-log filtration credit
	Equals	**0.0-log** inactivation credit needed
Giardia		3.00-log reduction required
	Subtract	3.14-log filtration credit
	Equals	**0.0-log** inactivation credit needed
Viruses		4.0-log reduction required
	Subtract	0.0-log filtration credit
	Equals	**4.0-log** inactivation credit needed

There is no shortfall in log removal credits for *Cryptosporidium* in this example.

The contact chamber has the following configuration:



Contact Chamber Specifications:

Volume:	750 cubic metres
Max. Flow:	12.5 MLD
Dimensions:	5.1 m x 20 m x 3 mBaffling:no baffles, inlet at top of basin, outletat bottom of basin
Min. Temperature:	5°CHighest pH:7.5

The facility uses free chlorine. In the winter, the facility has a minimum of 1.2 mg/ L free chlorine leaving the contact chamber.

Based on the configuration of the contact chamber, there is no baffling with poor mixing. A baffling factor of 0.1 can be used.

Tank low level occurs when the tank is 85% full.

CT Calculation

Volume of chamber: 750 cubic metres = 750 000 L = 0.750 ML x 0.85 (low level) = 0.6375 ML

Contact time$_{actual}$: Volume ÷ Max. Flow = 0.6375 ML ÷ 12.5 MLD = 0.051 days x 24 hours per day x 60 minutes per hour = 73.4 minutes

CT$_{actual}$: Concentration of disinfectant x contact time x baffling factor = 1.2 mg/L x 73.4 minutes x 0.1 = 8.81 mg.min/L

CT$_{required}$ (*Giardia*): Referring to the CT tables in Appendix D, for 0.5-log inactivation of *Giardia* at 5°C and pH 7.5,

CT = 28 mg.min/L

Adequate for 0.5-log *Giardia*?

$CT_{actual} \div CT_{required} = 8.81 \div 28 = 0.31$ (less than 1)

Therefore <u>not</u> adequate

CT$_{required}$ (Viruses): Referring to the CT tables in Appendix D, 8 mg.min/L provides 4.0-log inactivation of viruses at 5°C, pH 6-9

Adequate for viruses? $CT_{actual} \div CT_{required} = 8.81 \div 8 = 1.1$ (greater than 1)
Therefore adequate

Conclusion

The current configuration of the contact chamber is <u>not</u> sufficient to provide 0.5-log inactivation for *Giardia*.The contact chamber can be increased in size, the baffling improved, the chlorine residual increased or UV disinfection can be added.

EXAMPLE 4

Source Water - Medium Risk GUDI Source

This example demonstrates the requirements for groundwater under the direct influence of surface water. The results from the GUDI protocol indicate that the drilled wells serving the facility have been classified as GUDI – Medium Risk. This classification has been accepted in writing by a Department Regional Hydrogeologist.

Treatment Requirements

Since the facility has been classified as a GUDI – Medium Risk, the treatment requirements for this facility are:

- 3 - Log reduction for *Cryptosporidium* and *Giardia*;
- 4 - Log reduction for viruses.

Filtration Credits (Log Removal)

A medium risk GUDI facility is eligible for a 1.0-log natural filtration credit for protozoa if the *Guidelines for the Determination of Natural Filtration Log Removal for Protozoa* are followed (see Appendix B) and a Department Regional Hydrogeologist accepts the determination in writing. This process has been completed and accepted by the Department.

Therefore, this facility receives the following filtration credits towards meeting the treatment requirements:

- 1.0-log reduction for *Cryptosporidium*;
- 1.0-log reduction for *Giardia*;
- 0.0-log reduction for viruses.

Based on the above, log inactivation must provide the following log reduction:

Cryptosporidium		3.0-log reduction required
	Subtract	1.0-log filtration credit
	Equals	**2.0-log** inactivation credit needed
Giardia		3.00-log reduction required
	Subtract	1.0-log filtration credit
	Equals	**2.0-log** inactivation credit needed
Viruses		4.0-log reduction required
	Subtract	0.0-log filtration credit
	Equals	**4.0-log** inactivation credit needed

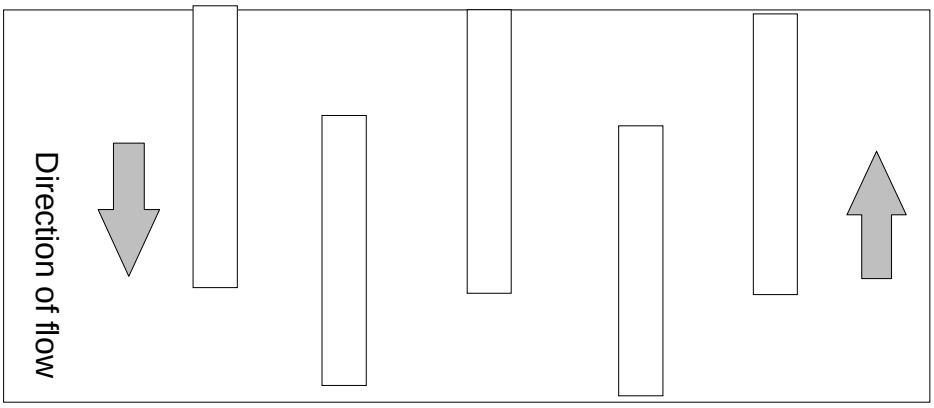
Treatment Deficiency #1

Because this facility has a shortfall in log removal credits for *Cryptosporidium*, an alternate disinfectant such as UV, chlorine dioxide or ozone will be required to meet treatment requirements.

In this example, UV is selected. The UV provides a minimum dose of40 mJ/cm^2. This is sufficient to receive a 4-log inactivation credit for *Cryptosporidium* and *Giardia* (see IT tables in Appendix D) which meets the above shortfalls. UV is only assigned a 0.5-log inactivation credit for viruses based on adenovirus. As such, 3.5-log inactivation for viruses must be addressed. In this example, chlorine is selected to inactivate viruses.

Disinfection Credits (Log Inactivation)

The contact chamber has the following configuration:



Contact Chamber Specifications:

Volume:	450 cubic metres
Max. Flow:	4.5 MLD
Dimensions:	5 m x 30 m x 3 m
Baffling:	Five BafflesMin. Temperature: 10^{o}C Highest pH:7.5

The facility uses free chlorine for virus disinfection. The facility has a minimum of 0.5 mg/L free chlorine residual leaving the contact chamber.

Based on the configuration of the contact chamber the length to width ratio is 4:1, and has multiple baffles, which is good. A baffling factor of 0.7 can be used.

The tank is configured such that it is always full (e.g. outlet weir controls water level).

CT Calculation

Volume of chamber: 450 cubic metres = 450 000 L = 0.450 ML x 1 (low level) = 0.450 ML

Contact time$_{actual}$: Volume ÷ Max. Flow = 0.450 ML ÷ 4.5 MLD = 0.1 days x 24 hours per day x 60 minutes per hour = 144 minutes

CT_{actual}: Concentration of disinfectant x contact time x baffling factor = 0.5 mg/L x 144 minutes x 0.7 = 50.4

$CT_{required}$ (*Giardia*): UV disinfection is providing 4.0-log inactivation for *Cryptosporidium* and *Giardia*.

Adequate for 0.5-log *Giardia*? Yes

$CT_{required}$ (Viruses): Referring to the CT tables in Appendix D, 6 mg·min/L provides 4.0-log inactivation of viruses at 10°C, pH 6-9

Adequate for viruses?

$CT_{actual} \div CT_{required} = 50.4 \div 6 = 8.4$ (greater than 1)
Therefore adequate

Conclusion

This facility will require the installation of an alternate disinfectant, in this example UV, to provide sufficient disinfection for *Cryptosporidium* and *Giardia* inactivation. Chemical disinfection will also be required to provide adequate disinfection for virus inactivation.

EXAMPLE 5

Source Water - Non-GUDI

This example demonstrates the requirements for a non-GUDI source. The results from the GUDI protocol indicate that the drilled wells serving the facility have been classified as non-GUDI. This classification has been accepted in writing by a Department Regional Hydrogeologist.

Treatment Requirements

Since the facility has been classified as non-GUDI, the treatment requirements for this facility are:

- 4 - Log reduction for viruses.

Treatment Adequacy

A non-GUDI facility does not require engineered filtration for pathogen reduction. Therefore, only disinfection is required for the 4-log inactivation of viruses. The Approval Holder has two choices for primary disinfection: chemical disinfection only or UV and chemical disinfection.

The facility well field is located 2.1 km from the first customer with a 12 " ductile iron watermain, which provides plug flow. The baffling factor for the water main is 1. The maximum flow in the system is 4.5 MLD.

The minimum water temperature is 5^0 C.

With chemical disinfection only the utility ensures that the minimum free chlorine concentration at the first customer is 0.4 mg/L.

This facility is considering UV as an added barrier for disinfection, but wanted to compare the two choices before making the final selection.

Option 1: Chemical disinfection only

Volume of the chamber

= Length of water main x cross-sectional area

= 2100 m x 0.073 sq. m = 153 cu. m = 0.153 ML

Contact time$_{actual}$

= Volume/Max. Flow = 0.153 ML /4.5 MLD = 0.034 days x 24 hours per day x 60 minutes per hour = 49.0 min.

CT_{actual} = Concentration of disinfectant x contact time x baffling factor

CT_{actual} = 0.4 mg/L x 49.0 min x 1.0

CT_{actual} = 19.6 mg min/L

$CT_{required}$ (viruses):

Referring to CT Tables in Appendix D, 8 mg·min/L provides 4.0-log inactivation at 5^0 C, pH 6-9

Adequate for viruses?

CT= CT_{actual} ÷ $CT_{required}$ = 19.6 ÷ 8 = 2.45 (greater than 1)

Therefore adequate

Option 2: UV with chemical disinfection

UV will only provide 0.5-log inactivation for viruses based on adenovirus so chemical disinfection will be required for 3.5-log inactivation of viruses. Given that the chemical disinfection would provide most of the inactivation the Approval Holder reduced the free chlorine concentration to 0.3 mg /L as a cost saving measure.

CT_{actual} = Concentration of disinfectant x contact time x baffling factor

CT_{actual} = 0.3 mg/L x 49.0 min x 1.0

CT_{actual} = 14.7 mg-min/L

CT = CT_{actual} ÷ $CT_{required}$ = 14.7 ÷ 8 = 1.84 (greater than 1)

Adequate for viruses? The CT is greater than one, therefore, it is adequate.

Conclusion

Both options are sufficient for disinfection. Since the facility only obtains a 0.5-log reduction credit for viruses for the UV unit based on adenovirus, the Approval Holder must evaluate the additional capital and operating costs of the UV unit, reduced cost of chlorine addition and risk benefit.

EXAMPLE 6

Source Water - Low Risk GUDI Source

This example demonstrates the requirements for groundwater under the direct influence of surface water. The results from the GUDI protocol indicate that the drilled wells serving the facility have been classified as GUDI – Low Risk. This classification has been accepted in writing by the Department Regional Hydrogeologist.

Treatment Requirements

Since the facility has been classified as a GUDI – Low Risk, the treatment requirements for this facility are:

- 3 - Log reduction for *Cryptosporidium* and *Giardia*;
- 4 - Log reduction for viruses.

Filtration Credits (Log Removal)

A low risk GUDI facility is eligible for a 3.0-log natural filtration credit for protozoa if the *Guidelines for the Determination of Natural Filtration Log Removal for Protozoa* are followed (see Appendix B) and the Department's Regional Hydrogeologist accepts the determinationin writing. This process has been completed and accepted by the Department.

Therefore, this facility receives the following filtration credits towards meeting the treatmentrequirements:

- 3.0-log reduction for *Cryptosporidium*;
- 3.0-log reduction for *Giardia*;
- 0.0-log reduction for viruses.

Based on the above, log inactivation must provide the following log reduction:

Cryptosporidium		3.0-log reduction required
	Subtract	3.0-log filtration credit
	Equals	**0.0-log** inactivation credit needed
Giardia		3.0-log reduction required
	Subtract	3.0-log filtration credit
	Equals	**0.0-log** inactivation credit needed
Viruses		4.0-log reduction required
	Subtract	0.0-log filtration credit
	Equals	**4.0-log** inactivation credit needed

Treatment Adequacy

A low-risk GUDI source does not require engineered filtration for pathogen reduction. Therefore, only disinfection is required for the 4-log inactivation of viruses. The facility has two choices for primary disinfection: chemical disinfection only or UV and chemical disinfection. The facility chooses chemical disinfection only through the use of free chlorine.

The facility well field is located 2.1 km from the first customer with a 12" ductile iron water main, which provides plug flow. The baffling factor for the water main is 1. The maximum flow in the system is 4.5 MLD.

The minimum water temperature is 5^0 C.

With chemical disinfection only the utility ensures that the minimum free chlorine concentration at the first customer is 0.4 mg/L.

Volume of the chamber

= Length of water main x cross-sectional area
= 2100 m x 0.073 sq. m = 153 cu. m = 0.153 ML

Contact time$_{actual}$

= Volume/Max. Flow = 0.153 ML /4.5 MLD = 0.034 days x 24 hours per day x 60 minutes per hour = 49.0 min

CT Calculation

CT_{actual} = Concentration of disinfectant x contact time x baffling factor

CT_{actual} = 0.4 mg / L x 49.0 min x 1.0

CT_{actual} = 19.6 mg min/L

$CT_{required}$ (viruses):

Referring to CT Tables in Appendix D, 8 mg·min/L provides 4.0-log inactivation at 5^0 C, pH 6-9

Adequate for viruses?

CT= $CT_{actual} \div CT_{required}$ = 19.6 ÷ 8 = 2.45 (greater than 1)
Therefore adequate

Conclusion

With the Department accepted natural filtration log credit and chemical disinfection this facility adequately removes and inactivates *Cryptosporidium*, *Giardia* and viruses and meets Nova Scotia's Drinking Water Treatment Standards.

Appendix G

Technical Considerations for Filtration and Disinfection Processes

G.1 Ultraviolet (UV) Light Disinfection

The use of UV disinfection systems for water treatment is becoming more common in Nova Scotia. UV dose delivery depends on a number of factors including reactor design (hydrodynamics), flow rate, UV transmittance of water, UV intensity, lamp output, lamp placement, aging, fouling and microbe inactivation kinetics. A safety factor is added to establish a design dose and is established through UV validation.

UV validation testing is usually conducted by the UV manufacturer or a third party to pre-validate their reactors to determine the operating conditions under which a UV reactor would deliver the validated dose. The validation testing is conducted for the full-scale testing of the reactor that will actually be used in field and inactivation of a test micro-organism with dose-response characteristics quantified through bioassay tests. The operating conditions include flow rate, UV intensity, UV lampstatus, an account for UV absorbance of the water, lamp fouling, aging inlet and outlet piping configuration of the UV reactor and measurement of uncertainty of on-line sensors, etc.

The purpose of this appendix is to specify minimum requirements when UV is used for primary disinfection. UV systems should be designed taking into account:

- Redundancy and reliability;
- Minimum dose and performance requirements;
- UV transmittance (UVT); and
- Scaling and fouling.

G.1.1 Redundancy and Reliability

a. A minimum of two UV treatment units are required in parallel to provide redundancy regardless of the design of the system.

b. Where two units are provided, each unit shall be capable of meeting the maximum day demand flow. Where more than two units are provided, the maximum day demand flow shall be met with the largest unit out of service.

c. The UV dose must be equal to or greater than 40 mJ/cm^2, or Department accepted alternate dose.

d. UV intensity and flow through the reactors, shall be monitored a minimum of once every five minutes to ensure the UV dose is greater than or equal to 40 mJ/cm^2 or Department accepted alternate dose.

e. Provisions shall be in place to prevent the distribution of water if UV dosedrops below 40 mJ/cm^2, or Department accepted alternate dose.

f. Each UV unit shall be equipped with an alarm notification and shutdown in the event of:

- High temperature in the reactor, lamp, ballast or transformer;
- High flow rates that causes the dose to fall below design specifications;
- Low UV dose;
- Low UV intensity;
- Low UVT that causes dose to fall below design specifications;
- UV has shutdown; or
- Any other emergency situation.

Note: NSF 55, Class A units are acceptable for small systems with flow less than 25 lgpm (30 USgpm).

g. In the case of a power outage or power quality problems, which cause one or more of the UV units to become inoperable, contingencies shall be in place that prevent inadequately disinfected water from being distributed, including during the lamp warm-up time.

h. The UV disinfection unit shall be equipped with UV sensors reading calibrated UV intensity. The UV sensors shall be calibrated on a monthly basis. Off-line reference sensors used for calibration shall be of equal quality to the on-line sensors and shall be calibrated annually.

i. UVT analyzers shall be calibrated weekly.

j. UV equipment replacement components shall be equal to or better than components used during validation.

k. The UV lamp shall be monitored in a manner that ensures bulb replacement is accomplished prior to the maximum lamp life expectancy.

l. In the case of UV bulb breakage during operation, provisions shall be in place to contain the broken lamp, and contingencies shall be in place that prevent inadequately disinfected water from being distributed.

G.1.2 Minimum Dose and Performance Requirements

a. UV systems shall be certified to provide a minimum dose of 40 mJ/cm^2 or a Department-accepted alternate dose at all points within the reactor at all times when water is passing through the treatment process. Acceptable certification includes:
    - US EPA UVDGM;
    - German guideline DVGW W294;
    - Austrian standard ONORM M 5873; and
    - NSF Standard 55 Class A (for small systems with flow less than 25 Igpm (30 USgpm))

b. The Approval Holder shall provide to the Department an independent third-party validation that demonstrates the manufacturer's system will meet the 40 mJ/cm^2 or Department accepted alternate dose. The UV dose shall be sufficient to ensure log inactivation requirements.

c. If the UV dose is inadequate to achieve the required virus reduction, UV shall be followed by another disinfectant such as chlorine with the appropriate CT to achieve log inactivation requirements for viruses.

d. UV shall always be followed by a secondary disinfectant such as chlorine to maintain a residual in the water distribution system.

e. The quality of the raw water entering the UV system shall meet the manufacturer's requirements or pre-treatment shall be installed to ensure the quality of the raw water entering the UV system meets the manufacturer's requirements.

f. If the UV manufacturer has not specified water quality requirements, the following are recommended:
    - Turbidity: <1.0 NTU;
    - Hardness: <120 mg/L;
    - Iron: <0.3 mg/L;
    - Manganese: <0.05 mg/L;
    - Hydrogen sulfide: not detectable;
    - Total suspended solids: <10 mg/L;
    - pH: 6.5-9.5;
    - Total coliforms: <1000/100mL; and
    - UVT: >75%

G.1.3 UV Transmittance (UVT)

a. UVT is an important water quality parameter for determining the efficacy of the UV unit. UVT is a measure of the UV light at 254 nm that transmits through the water column in the UV chamber. UVT is described by the following equation.

$$UVT = 100 \times 10^{-A254}$$

b. Knowledge of the UV254 absorbance/transmittance of the water to be treated is critical when designing for good performance of UV systems.

c. Design of UV systems should ideally be based on the worst-case water transmittance of at least 12 months of UVT data for each facility (e.g. using the 5th percentile of monthly, bimonthly or weekly samples) (Bolton and Cotton, 2008).

d. UV units should be installed with UV sensors so that %UVT is calculated at a minimum daily. Alarms should be installed and configured in such a manner that alarms sound when UVT is below the manufacturer's specifications.

G.1.4 Scaling and Fouling

a. Scaling and fouling of the quartz sleeve can have a significant influence on disinfection efficacy. Over time, water quality parameters can form or deposit on the sleeve and interfere with the UV light penetrating the water column. Scaling and fouling results from the presence of metals, hardness, alkalinity, and particulate suspended in the water column.

b. Scaling and fouling can be controlled if proper maintenance of the UV unit has been performed. Frequency of cleaning will vary depending on the water quality characteristics. Maintenance of the quartz sleeve shall be performed based on the manufacturer's recommendations.

c. UV units shall have on-line mechanical sleeve cleaning devices or provision for physical-chemical cleaning.

G.2 On-site Generation of Sodium Hypochlorite

G.2.1 Salt Quality

The salt supplied shall be tested and certified as meeting the specifications of NSF 60. The salt shall contain no organic binders, flow control agents or resin cleaning material.

G.2.2 Equipment Quality

The electrolyzer and generator shall be certified as meeting the specifications of NSF 61 for use in drinking water systems.

G.2.3 Redundancy

A minimum of two electrolyzers are required to provide redundancy. Where two units are provided, each shall be capable of meeting the maximum day demand flow. Where more than two disinfection units are provided, the maximum day flow shall be met with the largest unit out of service.

G.2.4 Other Requirements

Appropriate precautions shall be in place to handle hydrogen gas.

G.3 Membrane Treatment Technology Requirements

The use of membranes for water treatment is becoming more common, especially in Nova Scotia. The purpose of this appendix is to state the requirements that membrane water treatment plants shall be required to meet in Nova Scotia with regard to:

- The number of membrane treatment units (e.g., trains, skids, racks, stages, etc.)
- Challenge Testing
- Direct Integrity Testing
- Continuous Indirect Integrity Testing
- Turbidity
- Filter-to-waste

G.3.1 Number of Membrane Treatment Units

Case studies of existing membrane plants have shown that having additional capacity has been extremely beneficial to deal with unexpected fouling rates and the corresponding decrease in flux to compensate for the higher fouling rates (AWWARF, 2004). The EPA *Membrane Filtration Guidance Manual*, as amended from time to time states that standard operational unit processes such as backwashing, chemical cleaning, and integrity testing may be problematic if it becomes necessary to conduct these processes more frequently than was planned. The effect can be more pronounced for smaller systems with fewer membrane treatment units. As well, filter redundancy is an industry-wide practice that helps ensure that a safe and a consistent quality and quantity of water is provided.

G.3.2 Membrane Treatment Units Used for Pathogen Reduction Credits

a. A minimum of two membrane treatment units are required in parallel to provide redundancy regardless of the design capacity of the system.

b. Where only two units are provided, each shall be capable of meeting the maximum daily design flow at the approved flux rate.

c. Where more than two membrane treatment units are provided, the maximum daily design flow shall be met with the largest unit out of service at the approved flux rate.

d. Design parameters established by manufacturer shall not be exceeded.

G.3.3 Integrated Membrane Systems

An integrated membrane system is one that incorporates microfiltration/ ultrafiltration (MF/UF) for pathogen reduction credits followed by nanofiltration/reverse osmosis (NF/RO) for the reduction of organics to reduce the formation of disinfection by-products.

Membrane treatment units used for pathogen reduction credits shall meet the requirements outlined G.3.2. In addition, the Approval Holder shall provide documentation that there will be no operational scenarios where the NF/RO system for organics reduction will be operated without pre-treatment by the MF/UF system for pathogen reduction unless stipulated in the Approval to Operate.

Membrane treatment units used for the reduction of organics shall meet the following requirements:

a. 0 to 1,000 m^3/d - one or two membrane treatment units may be provided.

   Where only one membrane treatment unit is provided, the following requirements shall apply:

   - a shelf spare shall be provided for the following equipment: pressure pump, pressure meter, transducer, pressure switches, conductivity meter, fuses and any other unique electrical device.
   - the unit shall be sized to meet 100% of the maximum daily design flow at the approved flux rate.

   Where two membrane treatment units are provided:

   - each unit may be sized to meet a minimum of 50% of the maximum daily design flow at the approved flux rate.

b. 1,001 to 2,000 m^3/d - a minimum of two membrane treatment units shall be provided. Each unit may be sized to meet a minimum of 50% of the maximum daily design flow at the approved flux rate.

c. Greater than 2,000 m^3/d - a minimum of two membrane treatment units shall be provided. Where only two units are provided, each shall be capable of meeting the maximum daily design flow at the approved flux rate. Where more than two membrane treatment units are provided, the maximum daily design flow shall be met with the largest unit out of service at the approved flux rate.

Regardless of the capacity of the membrane units, the design parameters set by the manufacturer shall not be exceeded.

G.3.4 Challenge Testing

The objective of challenge testing is to demonstrate pathogen removal efficiency. It is intended to be a one-time, product-specific test to establish the maximum log reduction credit that the product is eligible to receive. Challenge testing involves seeding the feed water with an acceptable challenge particulate and measuring the log reduction in the concentration of the challenge particulate between the feed and filtrate. Testing shall be conducted on a full-scale membrane module or small-scale module that is identical in material and similar in construction as that used at the treatment facility.

The actual removal efficiency of a membrane shall be verified by third party challenge testing. This is a one-time product specific test and is not site-specific. Acceptable challenge testing shall follow that provided in the EPA *Membrane Filtration Guidance Manual*, as amended from time to time, or an acceptable equivalent. This documentation shall be provided to the Department upon request.

G.3.5 Direct Integrity Testing

The purpose of direct integrity testing is to verify the removal efficiency of a membrane filtration system on an ongoing basis during operation. This will verify that the membrane has no integrity breaches of a magnitude that would compromise the ability of the membrane to achieve the pathogen reduction required. Direct integrity testing is a physical test applied directly to the pathogen barrier associated with a membrane treatment unit (e.g. an individual train, skid, rack, stage, etc.) in order to identify and isolate integrity breaches.

Direct integrity testing is commonly accomplished using pressure-based tests or marker-based tests. As new types of direct integrity tests are developed in the future, they may be used provided the basic requirements for test resolution, sensitivity, and frequency can be satisfied.

G.3.6 Membrane Treatment Units Used for Pathogen Reduction Credits

The integrity of the membrane system and the actual removal efficiency of the membrane shall be demonstrated by direct integrity testing of the membrane under normal operating conditions. Direct integrity testing shall follow that outlined in the EPA *Membrane Filtration Guidance Manual*, as amended from time to time, or an acceptable equivalent.

Direct integrity testing shall be responsive to an integrity breach in the order of three micrometres or less.

Direct integrity testing shall be conducted on each membrane treatment unit at a frequency of no less than once each day that the unit is in operation. Less frequent testing may be approved if supported by demonstrated process reliability, the use of multiple barriers effective for cysts (*Giardia*), oocysts (*Cryptosporidium*) or viruses or reliable process safeguards.

G.3.7 Continuous Indirect Integrity Testing

The objective of continuous indirect integrity monitoring is to monitor a membrane filtrate system for significant integrity problems between direct integrity test applications. Indirect methods do not assess the integrity of the membrane barrier directly, but instead utilize water quality parameters as a surrogate to infer information about membrane integrity based on the levels of the monitored parameters relative to the known baseline in a fully integral system. Although indirect integrity monitoring is generally not as sensitive for detecting integrity breaches as the various direct methods, the indirect methods do have the advantage of being able to be applied to continuously monitor membrane filtrate quality during production, thus providing some means of assessing integrity between direct integrity test applications.

In addition to continuous turbidity monitoring, other methods of indirect testing include particle counting, particle monitoring, conductivity monitoring (for NF/RO systems), or others as deemed acceptable by the Department.

G.3.8 Membrane Treatment Units Used for Pathogen Reduction Credits

All membranes shall have continuous indirect integrity testing. Indirect integrity testing shall follow that outlined in the EPA *Membrane Filtration Guidance Manual*, as amended from time to time, or an acceptable equivalent.

Continuous indirect integrity testing shall be conducted at a minimum frequency of once every 5 minutes.

G.3.9 Integrated Membrane Systems

Membrane treatment units used for pathogen reduction credits - shall meet the requirements outlined in G.3.2 above.

Membrane treatment units used for the reduction of organics – the Approval Holder shall have a means of verifying the rejection rate and rectifying any performance issues.

G.3.10 Turbidity

The treated water turbidity levels from individual membrane units shall be based on continuous measurements of turbidity, using an on-line turbidimeter, with results recorded at a minimum frequency of once every five minutes.

If turbidity exceeds 0.1 NTU for more than 15 minutes, direct integrity testing shall be immediately conducted on the membrane treatment unit. If the unit passes direct integrity testing, it may continue to be used for water treatment; if not, the unit shall be taken out of service.

G.3.11 Filter-to-waste

A “filter-to-waste” feature shall be provided for:

- Initial start-up and commissioning of the membrane system;
- Those systems that have to be tested on-line during production in the event of a membrane integrity breach; and
- Emergency diversion of water.

The filter-to-waste feature for membranes is to provide operational flexibility and therefore shall not have any filter ripening conditions associated with it in an Approval to Operate.

G.4 Management of Waste Streams

Waste streams that are generated from backwash and cleaning cycles shall be managed properly. The use of membrane technology produces the following waste streams:

- Filter backwash wastewater;
- Filter backwash solids;
- Clean-in-place chemical waste;
- Chemically enhanced backwash (CEB) wastewater and solids.

The Approval Holder should provide an estimate of the waste stream composition and concentrations. It should be noted that membrane treatment processes may concentrate naturally-occurring compounds such as metals, solids and radionuclides in the waste streams.

G.4.1 Filter Backwash Water

The Approval Holder shall manage filter backwash water in accordance with Part V, Section 2.

G.4.2 Filter Backwash Solids

The Approval Holder shall manage filter backwash solids in accordance with Part V, Section 1.

G.4.3 Clean-in-place (CIP) Chemical Waste

Membranes require periodic chemical cleaning, which involves re-circulating cleaning chemicals and scouring the membrane surface, to reduce fouling. CIP chemical wastes shall be disposed in a manner that is acceptable to the Department. Neutralization of

cleaning solutions shall be provided including dechlorination such that the chlorine residual concentration shall not exceed 0.02 mg/l and adjustment of pH such that the pH is within a range of 6.5 to 9.0 (unless background values are outside this range in which case pH shall be within 0.2 of background). The CIP chemical waste stream may be neutralized in the process tank where CIP has taken place or transferred to a holding tank until neutralization has occurred.

G.4.4 Chemically Enhanced Backwash (CEB) Wastewater and Solids

Membranes may require periodic enhanced backwash, which involves injecting chlorine, caustic, or acid during a filter backwash cycle to improve, and lengthen cycles before CIP is required. CEB wastewater shall meet the requirements outlined in G.4.1 and G.4.3. CEB solids shall meet the requirements outlined in G.4.2.

APPENDIX H

Minimum Sampling Requirements based on Source Water Type

Table of Contents

H1 Sampling Requirements for Municipal Public Drinking Water Supplies using Surface Water

Water Quality Parameters	Sample Location	Minimum Sampling Frequency
Turbidity		
Turbidity	Raw water	Continuous at no more than 5 minute intervals or daily grab
	Individual filter effluent	Continuous at no more than 5 minute intervals
	Filtered water directed to waste	Continuous at no more than 5 minute intervals or grab sample during filter-to-waste
	Distribution system sample points	Weekly grab sample
Primary Disinfection (Note: Parameters to be monitored depend on the disinfection method used)		
Free Chlorine		
Free Chlorine Residual	CT control point (water entering distribution system)	Continuous at no more than 5 minute intervals – must meet CT design criteria
Temperature	CT control point	Continuous at no more than 5 minute intervals or daily grab – must meet CT design criteria
pH	CT control point	Continuous at no more than 5 minute intervals - must meet CT design criteria
UV		
UV (IT)	UV chamber	Continuous at no more than 5 minute intervals – minimum UV dose of 40 mJ/cm^2 unless an alternate dose accepted by the Department.

Water Quality Parameters	Sample Location	Minimum Sampling Frequency
Chlorine Dioxide		
Chlorine Dioxide	CT control point	Continuous at no more than 5 minute intervals – must meet CT design criteria
Temperature	CT control point	Continuous at no more than 5 minute intervals or daily grab – must meet CT design criteria
pH	CT control point	Continuous at no more than 5 minute intervals – must meet CT design criteria
Ozone		
Ozone	CT control point	Continuous at no more than 5 minute intervals – must meet CT design criteria
	Air Quality (off-gas destruct unit)	Continuous at no more than 5 minute intervals* *Should be interlocked with the ozone generator controls to shut down system if excess ozone is detected
Temperature	CT control point	Continuous at no more than 5 minute intervals or daily grab – must meet CT design criteria
pH	CT control point	Continuous at no more than 5 minute intervals – must meet CT design criteria

Water Quality Parameters	Sample Location	Minimum Sampling Frequency
Secondary Disinfection (Note: Parameters to be monitored depend on the disinfection method used)		
Free Chlorine		
Free Chlorine Residual	Storage structure outlet	Continuous at no more than 5 minute intervals
	Distribution system sample points	Weekly grab sample
Chloramines		
Combined Chlorine Residual	Storage structure outlet	Continuous at no more than 5 minute intervals
	Distribution system sample points	Weekly grab sample
Microbial Quality		
Total Coliforms and *E. coli* (present/absent)	Water entering the distribution system	Weekly grab sample
	Distribution system sample points	Weekly grab sample
Viruses	Raw water	As requested by the Department
	Water distribution system	As requested by the Department
Giardia and Cryptosporidium	Raw water	As requested by the Department
	Water distribution system	As requested by the Department
Cyanobacteria	Raw water	Visual monitoring at least weekly for evidence of bloom formation from May to October.

<table>
<tr><th>Water Quality Parameters</th><th>Sample Location</th><th>Minimum Sampling Frequency</th></tr>
<tr><td rowspan="2">Cyanobacterial toxins - Total Microcystins</td><td>Raw water</td><td>During a bloom

Minimum of every 5 years as part of full health-related parameter suite (during warmest month)</td></tr>
<tr><td>Treated water</td><td>During a bloom

Minimum of every 5 years as part of full health-related parameter suite (during warmest month)</td></tr>
<tr><td colspan="3">Corrosion Monitoring Program</td></tr>
<tr><td>pH
Alkalinity
Conductivity
Temperature
Chlorine or chloramine residual
Corrosion inhibitor residual (if used)</td><td>Point of entry and representative locations within the distribution system based on population served:

<table><tr><td>Population Served</td><td># of distribution samples</td></tr><tr><td><100</td><td>1</td></tr><tr><td>101-500</td><td>2</td></tr><tr><td>501-3,300</td><td>3</td></tr><tr><td>3,301-10,000</td><td>4</td></tr><tr><td>10,001-100,000</td><td>6</td></tr><tr><td>>100, 000</td><td>10</td></tr></table></td><td>Quarterly grab sample</td></tr>
<tr><td>Lead and Copper</td><td colspan="2">As per the “Requirements for Lead and Copper Management Municipal Public Drinking Water Supplies”</td></tr>
</table>

Water Quality Parameters	Sample Location	Minimum Sampling Frequency
Process Control		
Water Volume	Raw water entering facility	Continuous at no more than 5 minute intervals -must meet CT/IT design criteria
Free ammonia (as N) – for facilities using chloramination	Select distribution system sample point(s)* *Sampling points should include distribution system storage and dead ends	Weekly
Nitrate/nitrite (as N) – for facilities using chloramination	Select distribution system sample point(s)* *Sampling points should include distribution system storage and dead ends	Weekly
Fluoride – for facilities that add fluoride	Water entering the distribution system	Daily
Disinfection By-products		
Total Trihalomethanes (THMs)	Select distribution system sample point(s) – representative of highest level. Areas in the distribution system with the longest disinfectant retention time.	Quarterly - locational running annual average (lraa) based on a minimum of 4 quarterly samples.
Haloacetic Acids (HAAs)	Select distribution system sample point(s) – where historical data show the highest concentration. Where historical data is not available concentrations shall be monitored in the middle and extremities of the distribution system.	Quarterly - locational running annual average (lraa) based on a minimum of 4 quarterly samples.
Chlorate and chlorite – if using chlorine dioxide	Select distribution system sample point(s) – mid-system and end locations	Quarterly
Chlorate – if storing sodium hypochlorite more than 3 months	Water entering distribution system	Quarterly

Water Quality Parameters	Sample Location	Minimum Sampling Frequency
Bromate – if using ozone	Select distribution system sample point(s) – water entering distribution system	Monthly
Bromate – if storing sodium hypochlorite more than 3 months	Water entering distribution system	Quarterly
N-Nitrosodimethylamine (NDMA) – if using chloramines for secondary disinfection	Water entering distribution system and far-point in distribution system	Quarterly
N-Nitrosodimethylamine (NDMA) – chlorinated systems	Water entering distribution system.	Quarterly * *After four quarterly samples collected over a year period the Approval Holder may request a reduction to annual sampling if NDMA is not detected in the treated water.

Water Quality Parameters	Sample Location	Minimum Sampling Frequency
Treatment Process - Backwash Wastewater Parameters, locations and frequencies in accordance with this standard, the operating approval and the accepted annual monitoring program.		
General Chemical and Physical Quality		
General chemical and physical parameters listed in the Guidelines for Monitoring Public Drinking Water Supplies Part I	Raw and treated water	Minimum annually
Manganese	Raw water (prior to treatment) Entering the distribution system Distribution system	Quarterly * The Approval Holder may request a reduction in sample frequency if it is determined that manganese is not a parameter of concern for the water supply.
Guidelines for Canadian Drinking Water Quality		
All health-related parameters in the Guidelines for Canadian Drinking Water Quality	Raw and treated water	Every 5 years unless system assessment report or source water protection plan requires more frequent monitoring.
Source Water Protection		
Parameters as per the source water protection monitoring program	Locations and frequencies in accordance with the source water protection monitoring program.	

H2 Sampling Requirements for Municipal Public Drinking Water Supplies using GUDI Sources not Assigned a Department-Accepted Natural Filtration Log Credit

Water Quality Parameters	Sample Location	Minimum Sampling Frequency
Turbidity		
Turbidity	Raw water	Continuous at no more than 5 minute intervals or daily grab
	Individual filter effluent	Continuous at no more than 5 minute intervals
	Filtered water directed to waste	Continuous at no more than 5 minute intervals or grab sample during filter-to-waste
	Distribution system sample points	Weekly grab sample
Primary Disinfection (Note: Parameters to be monitored depend on the disinfection method used)		
Free Chlorine		
Free Chlorine Residual	CT control point (water entering the distribution system)	Continuous at no more than 5 minute intervals – must meet CT design criteria
Temperature	CT control point	Continuous at no more than 5 minute intervals or daily grab – must meet CT design criteria
pH	CT control point	Continuous at no more than 5 minute intervals – must meet CT design criteria
UV		
UV (IT)	UV chamber	Continuous at no more than 5 minute intervals – minimum UV dose of 40mJ/cm^2 unless alternate dose has been accepted by the Department
Chlorine Dioxide		
Chlorine Dioxide	CT control point	Continuous at no more than

Water Quality Parameters	Sample Location	Minimum Sampling Frequency
		5 minute intervals – must meet CT design criteria
Temperature	CT control point	Continuous at no more than 5 minute intervals or daily grab- must meet CT design criteria
pH	CT control point	Continuous at no more than 5 minute intervals – must meet cT design criteria
Ozone		
Ozone	CT control point	Continuous at no more than 5 minute intervals – must meet CT design criteria
	Air Quality (off-gas destruct unit)	Continuous at no more than 5 minute intervals* *Should be interlocked with the ozone generator controls to shut down system if excess ozone is detected
Temperature	CT control point	Continuous at no more than 5 minute intervals or daily grab – must meet CT design criteria
pH	CT control point	Continuous at no more than 5 minute intervals – must meet CT design criteria

Water Quality Parameters	Sample Location	Minimum Sampling Frequency
Secondary Disinfection (Note: Parameters to be monitored depend on the disinfection method used)		
Free Chlorine		
Free Chlorine Residual	Storage structure outlet	Continuous at no more than 5 minute intervals
	Distribution system sample points	Weekly grab sample
Chloramines		
Combined Chlorine Residual	Storage structure outlet	Continuous at no more than 5 minute intervals
	Distribution system sample points	Weekly grab sample
Microbial Quality		
Total Coliforms and *E. coli* (present/absent) * During the GUDI assessment if water is distributed for consumption twice weekly sampling is required for water entering the distribution system and distribution system sample points.	Water entering the distribution system	Weekly grab sample
	Distribution system sample points	Weekly grab sample
	Raw water from individual well(s)	As requested by the Department
Viruses	Raw water	As requested by the Department
	Water distribution system	As requested by the Department
Giardia and Cryptosporidium	Raw water	As requested by the Department
	Water distribution system	As requested by the Department

<table>
<tr><th>Water Quality Parameters</th><th>Sample Location</th><th>Minimum Sampling Frequency</th></tr>
<tr><td colspan="3">Corrosion Monitoring Program</td></tr>
<tr><td>pH
Alkalinity
Conductivity
Temperature
Chlorine or chloramine residual
Corrosion inhibitor residual (if used)</td><td>Point of entry and representative locations within the distribution system based on population served:
<table><tr><th>Population Served</th><th># of distribution samples</th></tr><tr><td><100</td><td>1</td></tr><tr><td>101-500</td><td>2</td></tr><tr><td>501-3,300</td><td>3</td></tr><tr><td>3,301-10,000</td><td>4</td></tr><tr><td>10,001-100,000</td><td>6</td></tr><tr><td>>100, 000</td><td>10</td></tr></table></td><td>Quarterly grab sample</td></tr>
<tr><td>Lead and Copper</td><td colspan="2">As per the “Requirements for Lead and Copper Management Municipal Public Drinking Water Supplies”</td></tr>
<tr><td colspan="3">Process Control</td></tr>
<tr><td>Water Volume</td><td>Raw water entering facility</td><td>Continuous at no more than 5 minute intervals- must meet CT/IT design criteria.</td></tr>
<tr><td>Free ammonia (as N) – for facilities using chloramination</td><td>Select distribution system sample point(s)*

*Sampling points should include distribution system storage and dead ends</td><td>Weekly</td></tr>
<tr><td>Nitrate/nitrite (as N) – for facilities using chloramination</td><td>Select distribution system sample point(s)*

* Sampling points should include distribution system storage and dead ends</td><td>Weekly</td></tr>
<tr><td>Fluoride – for facilities that add fluoride</td><td>Water entering the distribution system</td><td>Daily</td></tr>
</table>

Water Quality Parameters	Sample Location	Minimum Sampling Frequency
Disinfection By-products		
Total Trihalomethanes (THMs)	Select distribution system sample point(s) – representative of highest level. Areas in the distribution system with the longest disinfectant retention time.	Quarterly - locational running annual average (lraa) based on a minimum of 4 quarterly samples.
Haloacetic Acids (HAAs)	Select distribution system sample point(s) – where historical data show the highest concentration. Where historical data is not available concentrations shall be monitored in the middle and extremities of the distribution system.	Quarterly - locational running annual average (lraa) based on a minimum of 4 quarterly samples.
Chlorate and chlorite – if using chlorine dioxide	Select distribution system sample point(s) – mid-system and end locations	Quarterly
Chlorate – if storing sodium hypochlorite more than 3 months	Water entering distribution system	Quarterly
Bromate – if using ozone	Select distribution system sample point(s) – water entering distribution system	Monthly
Bromate – if storing sodium hypochlorite more than 3 months	Water entering distribution system	Quarterly
N-Nitrosodimethylamine (NDMA) – if using chloramines for secondary disinfection	Water entering distribution system and far-point in distribution system	Quarterly

Water Quality Parameters	Sample Location	Minimum Sampling Frequency
N-Nitrosodimethylamine (NDMA) – chlorinated systems	Water entering distribution system.	Quarterly * * After four quarterly samples collected over a year period the Approval Holder may request a reduction to annual sampling if NDMA is not detected in the treated water.
Treatment Process Backwash Water Parameters, locations and frequencies in accordance with this standard, the operating approval and the accepted annual monitoring program.		
General Chemical and Physical Quality		
General chemical and physical parameters listed in the Guidelines for Monitoring Public Drinking Water Supplies Part I	Raw and treated water	Minimum annually
Manganese	Raw water (prior to treatment) Entering the distribution system Distribution system	Twice per year (spring and fall) Quarterly Quarterly * The Approval Holder may request a reduction in sample frequency, if it is determined that manganese is not a parameter of concern for the water supply.

Water Quality Parameters	Sample Location	Minimum Sampling Frequency
Guidelines for Canadian Drinking Water Quality		
All health-related parameters in the Guidelines for Canadian Drinking Water Quality	Raw and treated water	Every 5 years unless system assessment report or source water protection plan requires more frequent monitoring
Source Water Protection		
Parameters as per the source water protection monitoring program	Locations and frequencies in accordance with the source water protection monitoring program.	

H3 Sampling Requirements for Municipal Public Drinking Water Supplies using Medium Risk and Low Risk GUDI Sources with a Department-Accepted Natural Filtration Log Credit

Water Quality Parameters	Sample Location	Minimum Sampling Frequency
Turbidity		
Turbidity	Individual GUDI well (at wellhead)	Continuous at no more than 5 minute intervals
	Distribution system sample points	Weekly grab sample
Primary Disinfection (Note: Parameters to be monitored depend on the disinfection method used)		
Free Chlorine		
Free Chlorine Residual	CT control point (water entering the distribution system)	Continuous at no more than 5 minute intervals – must meet CT design criteria
Temperature	CT control point	Continuous at no more than 5 minute intervals or daily grab – must meet CT design criteria
pH	CT control point	Continuous at no more than 5 minute intervals or daily grab– must meet CT design criteria
UV		
UV (IT)	UV chamber	Continuous at no more than 5 minute intervals. Minimum UV dose of 40mJ/cm^2 is required unless alternate dose has been accepted by the Department

Water Quality Parameters	Sample Location	Minimum Sampling Frequency
Chlorine Dioxide		
Chlorine Dioxide	CT control point	Continuous at no more than 5 minute intervals – must meet CT design criteria
Temperature	CT control point	Continuous at no more than 5 minute intervals or daily grab – must meet CT design criteria
pH	CT control point	Continuous at no more than 5 minute intervals or daily grab – must meet CT design criteria
Ozone		
Ozone	CT control point	Continuous at no more than 5 minute intervals – must meet CT design criteria
	Air Quality (off-gas destruct unit)	Continuous at no more than 5 minute intervals* *Should be interlocked with the ozone generator controls to shut down system if excess ozone is detected
Temperature	CT control point	Continuous at no more than 5 minute intervals or daily grab – must meet CT design criteria
pH	CT control point	Continuous at no more than 5 minute intervals or daily grab – must meet CT design criteria

Water Quality Parameters	Sample Location	Minimum Sampling Frequency
Secondary Disinfection (Note: Parameters to be monitored depend on disinfection method used)		
Free Chlorine		
Free Chlorine Residual	Storage structure outlet	Continuous at no more than 5 minute intervals
	Distribution system sample points	Weekly grab sample
Chloramines		
Combined Chlorine Residual	Storage structure outlet	Continuous at no more than 5 minute intervals
	Distribution system sample points	Weekly grab sample
Microbial Quality		
Total Coliforms and *E. coli* (present/absent) * During the GUDI assessment if water is distributed for consumption twice weekly sampling is required for water entering the distribution system and distribution system sample points.	Water entering the distribution system	Weekly grab sample
	Distribution system sample points	Weekly grab sample
	Raw water from individual well(s)	As requested by the Department
Microscopic Particulate Analysis (MPA)	Raw water from each individual GUDI well	Every two years as per GUDI Protocol (Appendix A)
Viruses	Raw water	As requested by the Department
	Water distribution system	As requested by the Department
Giardia and Cryptosporidium	Raw water	As requested by the Department
	Water distribution system	As requested by the Department

<table>
<tr><th>Water Quality Parameters</th><th>Sample Location</th><th>Minimum Sampling Frequency</th></tr>
<tr><td colspan="3">Corrosion Monitoring Program</td></tr>
<tr><td>pH
Alkalinity
Temperature
Conductivity
Chlorine or chloramine residual
Corrosion inhibitor residual (if used)</td><td>Point of entry and representative locations within the distribution system based on population served:
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<tr><td>Lead and Copper</td><td colspan="2">As per the “Requirements for Lead and Copper Management Municipal Public Drinking Water Supplies”</td></tr>
</table>

Water Quality Parameters	Sample Location	Minimum Sampling Frequency
Process Control		
Water Volume	Each individual well	Continuous at no more than five minute intervals - must meet CT/IT design criteria.
Free ammonia (as N) – for facilities using chloramination	Select distribution system sample point(s)* *Sampling points should include distribution system storage and dead ends	Weekly
Nitrate/nitrite (as N) – for facilities using chloramination	Select distribution system sample point(s)* *Sampling points should include distribution system storage and dead ends	Weekly
Fluoride – for facilities that add fluoride	Water entering the distribution system	Daily
Disinfection By-products		
Total Trihalomethanes (THMs)	Select distribution system sample point(s) – representative of highest level. Areas in the distribution system with the longest disinfectant retention time.	Quarterly - locational running annual average (lraa) based on a minimum of 4 quarterly samples.
Haloacetic Acids (HAAs)	Select distribution system sample point(s) – where historical data show the highest concentration. Where historical data is not available concentrations shall be monitored in the middle and extremities of the distribution system.	Quarterly - locational running annual average (lraa) based on a minimum of 4 quarterly samples.
Chlorate and chlorite – if using chlorine dioxide	Select distribution system sample point(s) – mid-system and end locations	Quarterly
Chlorate – if storing sodium hypochlorite more than 3 months	Water entering distribution system	Quarterly

Water Quality Parameters	Sample Location	Minimum Sampling Frequency
Bromate – if using ozone	Select distribution system sample point(s) – water entering distribution system	Monthly
Bromate – if storing sodium hypochlorite more than 3 months	Water entering distribution system	Quarterly
N-Nitrosodimethylamine (NDMA) – if using chloramines for secondary disinfection	Water entering distribution system and far-point in distribution system	Quarterly

Water Quality Parameters	Sample Location	Minimum Sampling Frequency
Treatment Process Backwash Wastewater Parameters, locations, and frequencies in accordance with this standard, the operating approval and the accepted annual monitoring program.		
General Chemical and Physical Quality		
General chemical and physical parameters listed in the Guidelines for Monitoring Public Drinking Water Supplies Part I	Raw and treated water	Minimum annually
Manganese	Raw water (prior to treatment) Entering the distribution system Distribution system	• Twice per year (spring and fall) • Quarterly • Quarterly * The Approval Holder may request a reduction in sample frequency, if it is determined that manganese is not a parameter of concern for the water supply.
Guidelines for Canadian Drinking Water Quality		
All health-related parameters in the Guidelines for Canadian Drinking Water Quality	Raw and treated water	Every 5 years unless system assessment report or source water protection plan requires more frequent monitoring.
Source Water Protection		
Parameters as per the source water protection monitoring program	Locations and frequencies in accordance with the source water protection monitoring program.	

H4 Sampling Requirements for Municipal Public Drinking Water Supplies using Non-GUDI Sources

Water Quality Parameters	Sample Location	Minimum Sampling Frequency
Turbidity		
Turbidity	At individual wellheads or the combined flow	Continuous at no more than 5 minute intervals or daily grab sample.
	Distribution system sample points	Weekly grab sample
Primary Disinfection (Note: Parameters to be monitored depend on the disinfection method used)		
Free Chlorine		
Free Chlorine Residual	CT control point (water entering the distribution system)	Continuous at no more than 5 minute intervals – must meet CT design criteria
Temperature	CT control point	Continuous at no more than 5 minute intervals or daily grab – must meet CT design criteria
pH	CT control point	Continuous at no more than 5 minute intervals or daily grab– must meet CT design criteria
UV		
UV (IT)	UV chamber	Continuous at no more than 5 minute intervals. Minimum UV dose of 40mJ/cm^2 is required unless an alternate dose has been accepted by the Department

Water Quality Parameters	Sample Location	Minimum Sampling Frequency
Chlorine Dioxide		
Chlorine Dioxide	CT control point	Continuous at no more than 5 minute intervals – must meet CT design criteria
Temperature	CT control point	Continuous at no more than 5 minute intervals or daily grab – must meet CT design criteria
pH	CT control point	Continuous at no more than 5 minute intervals or daily grab– must meet CT design criteria
Ozone		
Ozone	CT control point	Continuous at no more than 5 minute intervals – must meet CT design criteria
	Air Quality (off-gas destruct unit)	Continuous at no more than 5 minute intervals* *Should be interlocked with the ozone generator controls to shut down system if excess ozone is detected
Temperature	CT control point	Continuous at no more than 5 minute intervals or daily grab – must meet CT design criteria
pH	CT control point	Continuous at no more than 5 minute intervals or daily grab– must meet CT design criteria

Water Quality Parameters	Sample Location	Minimum Sampling Frequency
Secondary Disinfection (Note: Parameters to be monitored depend on the disinfection method used)		
Free Chlorine		
Free Chlorine Residual	Storage structure outlet	Continuous at no more than 5 minute intervals
	Distribution system sample points	Weekly grab sample
Chloramines		
Combined Chlorine Residual	Storage structure outlet	Continuous at no more than 5 minute intervals
	Distribution system sample points	Weekly grab sample
Microbial Quality		
Total coliforms and *E. coli* (present/absent) * During the GUDI assessment if water is distributed for consumption twice weekly sampling is required for water entering the distribution system and distribution system sample points.	Distribution system sample points	Weekly grab sample
	Raw water from individual well(s)	As requested by the Department
Viruses	Raw water	As requested by the Department
	Water distribution system	As requested by the Department

<table>
<tr><th>Water Quality Parameters</th><th>Sample Location</th><th>Minimum Sampling Frequency</th></tr>
<tr><td colspan="3">Corrosion Monitoring Program</td></tr>
<tr><td>pH
Alkalinity
Conductivity
Temperature
Chlorine or chloramine residual
Corrosion inhibitor residual (if used)</td><td>Point of entry and representative locations within the distribution system based on population served:
<table><tr><th>Population Served</th><th># of distribution samples</th></tr><tr><td><100</td><td>1</td></tr><tr><td>101-500</td><td>2</td></tr><tr><td>501-3,300</td><td>3</td></tr><tr><td>3,301-10,000</td><td>4</td></tr><tr><td>10,001-100,000</td><td>6</td></tr><tr><td>>100, 000</td><td>10</td></tr></table></td><td>Quarterly grab sample</td></tr>
<tr><td>Lead and Copper</td><td colspan="2">As per the “Requirements for Lead and Copper Management Municipal Public Drinking Water Supplies”</td></tr>
</table>

Water Quality Parameters	Sample Location	Minimum Sampling Frequency
Process Control		
Water Volume	Each individual well	Continuous at no more than 5 minute intervals. Must meet CT/IT design criteria.
Free ammonia (as N) – for facilities using chloramination	Select distribution system sample point(s)* *Sampling points should include distribution system storage and dead ends	Weekly
Nitrate/nitrite (as N) – for facilities using chloramination	Select distribution system sample point(s)* *Sampling points should include distribution system storage and dead ends	Weekly
Fluoride – for facilities that add fluoride	Water entering the distribution system	Daily
Disinfection By-products		
Total Trihalomethanes (THMs)	Select distribution system sample point(s) – representative of highest level. Areas in the distribution system with the longest disinfectant retention time.	Quarterly*- locational running annual average (lraa) based on a minimum of 4 quarterly samples. * The Approval Holder may request a reduction in sample frequency to annual, if the lraa based on a minimum of four quarterly samples collected from each location is < 0.010mg/L.

Water Quality Parameters	Sample Location	Minimum Sampling Frequency
Haloacetic Acids (HAAs)	Select distribution system sample point(s) – where historical data show the highest concentration. Where historical data is not available concentrations shall be monitored in the middle and extremities of the distribution system.	Quarterly* - locational running annual average (lraa) based on a minimum of 4 quarterly samples. * The Approval Holder may request a reduction in sample frequency to annual, if the lraa based on a minimum of four quarterly samples collected from each location is < 0.010mg/L
Chlorate and chlorite – if using chlorine dioxide	Select distribution system sample point(s) – mid-system and end locations	Quarterly
Chlorate – if storing sodium hypochlorite more than 3 months	Water entering distribution system	Quarterly
Bromate – if using ozone	Select distribution system sample point(s) – water entering distribution system	Monthly
Bromate – if storing sodium hypochlorite more than 3 months	Water entering distribution system	Quarterly
N-Nitrosodimethylamine (NDMA) – if using chloramines for secondary disinfection	Water entering distribution system and far-point in distribution system	Quarterly

Water Quality Parameters	Sample Location	Minimum Sampling Frequency
Treatment Process Backwash Wastewater If required, parameters, locations and frequencies in accordance with this standard, the operating approval and the accepted annual monitoring program.		
General Chemical and Physical Quality		
General chemical and physical parameters listed in the Guidelines for Monitoring Public Drinking Water Supplies Part I	Raw and treated water	Minimum every two-years
Manganese	Raw water (prior to treatment) Entering the distribution system Distribution system	Twice per year (spring and fall) Quarterly Quarterly * The Approval Holder may request a reduction in sample frequency, if it is determined that manganese is not a parameter of concern for the water supply.
Guidelines for Canadian Drinking Water Quality		
All health-related parameters in the Guidelines for Canadian Drinking Water Quality	Raw and treated water	Every 5 years unless system assessment report or source water protection plan requires more frequent monitoring.
Source Water Protection		
Parameters as per the source water protection monitoring program	Locations and frequencies in accordance with the source water protection monitoring program.	

H5 Sampling Requirements for Municipal Public Drinking Water Supplies that Distribute Water Only

Water Quality Parameters	Sample Location	Minimum Sampling Frequency
Turbidity		
Turbidity	Distribution system sample points	Weekly grab sample
Secondary Disinfection (Note: Parameters to be monitored depend on disinfection method used)		
Free Chlorine		
Free Chlorine Residual	Water Entering Distribution System	Continuous at no more than 5 minute intervals
	Storage structure outlet	Continuous at no more than 5 minute intervals
	Distribution system sample points	Weekly grab sample
Chloramines		
Combined Chlorine Residual	Water Entering Distribution System	Continuous at no more than 5 minute intervals
	Storage structure outlet	Continuous at no more than 5 minute intervals
	Distribution system sample points	Weekly grab sample
Microbial Quality		
Total coliforms and *E. coli* (present/absent)	Distribution system sample points	Weekly grab sample
Viruses	Raw water	As requested by the Department
	Water distribution system	As requested by the Department

<table>
<tr><th>Water Quality Parameters</th><th>Sample Location</th><th>Minimum Sampling Frequency</th></tr>
<tr><td>Giardia and Cryptosporidium</td><td>Raw water</td><td>As requested by the Department</td></tr>
<tr><td></td><td>Water distribution system</td><td>As requested by the Department</td></tr>
<tr><td colspan="3">Corrosion Monitoring Program</td></tr>
<tr><td>pH
Alkalinity
Conductivity
Temperature
Chlorine or chloramine residual
Corrosion inhibitor residual (if used)</td><td>Entering distribution system and representative locations within the distribution system based on population served:

<table><tr><th>Population Served</th><th># of distribution samples</th></tr><tr><td><100</td><td>1</td></tr><tr><td>101-500</td><td>2</td></tr><tr><td>501-3,300</td><td>3</td></tr><tr><td>3,301-10,000</td><td>4</td></tr><tr><td>10,001-100,000</td><td>6</td></tr><tr><td>>100, 000</td><td>10</td></tr></table></td><td>Quarterly grab sample</td></tr>
<tr><td>Lead and Copper</td><td colspan="2">As per the “Requirements for Lead and Copper Management Municipal Public Drinking Water Supplies”</td></tr>
<tr><td colspan="3">Process Control</td></tr>
<tr><td>Water Volume</td><td>Entering distribution system</td><td>Continuous at no more than 5 minute intervals</td></tr>
<tr><td>pH</td><td>Entering distribution system</td><td>Continuous at no more than 5 minute intervals or daily grab</td></tr>
<tr><td>Free ammonia (as N) – for facilities using chloramination</td><td>Select distribution system sample point(s)*

*Sampling points should include distribution system storage and dead ends</td><td>Weekly</td></tr>
<tr><td>Nitrate/nitrite (as N) – for facilities using chloramination</td><td>Select distribution system sample point(s)*

*Sampling points should include distribution system</td><td>Weekly</td></tr>
</table>

Water Quality Parameters	Sample Location	Minimum Sampling Frequency
	storage and dead ends	
Disinfection By-products		
Total Trihalomethanes (THMs)	Select distribution system sample point(s) – representative of highest level. Areas in the distribution system with the longest disinfectant retention time.	Quarterly - locational running annual average (lraa) based on a minimum of 4 quarterly samples. * If the Approval Holder of the supply where treated water is purchased received a reduction in sampling frequency to annual from the Department, the Approval Holder of the stand-alone distribution system may request a reduction in sample frequency to annual.
Haloacetic Acids (HAAs)	Select distribution system sample point(s) – where historical data show the highest concentration. Where historical data is not available concentrations shall be monitored in the middle and extremities of the distribution system.	Quarterly - locational running annual average (lraa) based on a minimum of 4 quarterly samples. * If the Approval Holder of the supply where treated water is purchased received a reduction in sample frequency from the Department to annual, the Approval Holder of the stand-alone distribution system may request a reduction in sample frequency to annual.
Chlorate and chlorite – if purchasing water from a treatment facility using chlorine dioxide	Mid-system and end locations of the distribution systems	Quarterly
Chlorate – if storing sodium hypochlorite more than 3 months	Water entering distribution system	Quarterly
Bromate – if purchasing water from a treatment facility using ozone	Water entering distribution system	Monthly
Bromate – if storing sodium hypochlorite more than 3 months	Water entering distribution system	Quarterly
N-Nitrosodimethylamine (NDMA) – if using chloramines for secondary	Water entering distribution system and far-point in distribution system	Quarterly

Water Quality Parameters	Sample Location	Minimum Sampling Frequency
disinfection		

General Chemical and Physical Quality		
General chemical and physical parameters listed in the Guidelines for Monitoring Public Drinking Water Supplies Part I	Select distribution system sample point(s)* *Sample location(s) shall be selected that are representative of the water distribution system.	Annual – for distribution systems served by surface water or GUDI sources. Every two years – for distribution systems served by non-GUDI groundwater sources.
Manganese	Select distribution system sample locations	Quarterly * The Approval Holder may request a reduction in sample frequency, if it is determined that manganese is not a parameter of concern in the treated water purchased for distribution.
Guidelines for Canadian Drinking Water Quality		
All health-related parameters in the Guidelines for Canadian Drinking Water Quality	As requested by the Department	As requested by the Department * The Approval Holder shall request a copy of the laboratory results from the treatment facility the water is obtained from and retain the results for a period of ten years.