

Nova Scotia Treatment Standards for **Municipal Drinking Water Systems**

Appendix A

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

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

APPENDIX A Protocol for Determining Groundwater Under the Direct Influence of Surface Water (GUDI Protocol)	1
A1 Introduction	3
A1.1 Nova Scotia GUDI.....	4
A1.2 General Requirements.....	6
A2 GUDI Assessment Process.....	7
A2.1 Step 1 – Screening Evaluation.....	7
A2.1.1 Sensitive Settings.....	7
A2.1.2 Proximity to Surface Water.....	7
A2.1.3 Well Construction.....	8
A2.1.4 Water Quality.....	8
A2.1.5 Step 1 Results.....	8
A2.2 Step 2 – Hydrogeological Investigation	10
A2.2.1 Well and Aquifer Conditions	10
A2.2.2 Surface Water Monitoring.....	11
A2.2.3 Groundwater Quality Monitoring	12
A2.2.4 Groundwater Hydraulic Conditions.....	13
A2.2.5 Step 2 Results.....	14
A2.3 Step 3 – Microscopic Particulate Analysis (MPA)	14
A3 GUDI Classification.....	16
A3.1 Non-GUDI	16
A3.2 GUDI - Low Risk.....	16
A3.3 GUDI - Medium Risk.....	16
A3.4 GUDI – High Risk.....	16
A3.5 GUDI - Corrections and Uncertainties.....	17
A3.6 GUDI – Reclassification Process	17
Reclassification of Wells	17
A4 GUDI Assessment and Determination Report	19
A5 Submission Form for GUDI Determinations	20
A6 References.....	27

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.

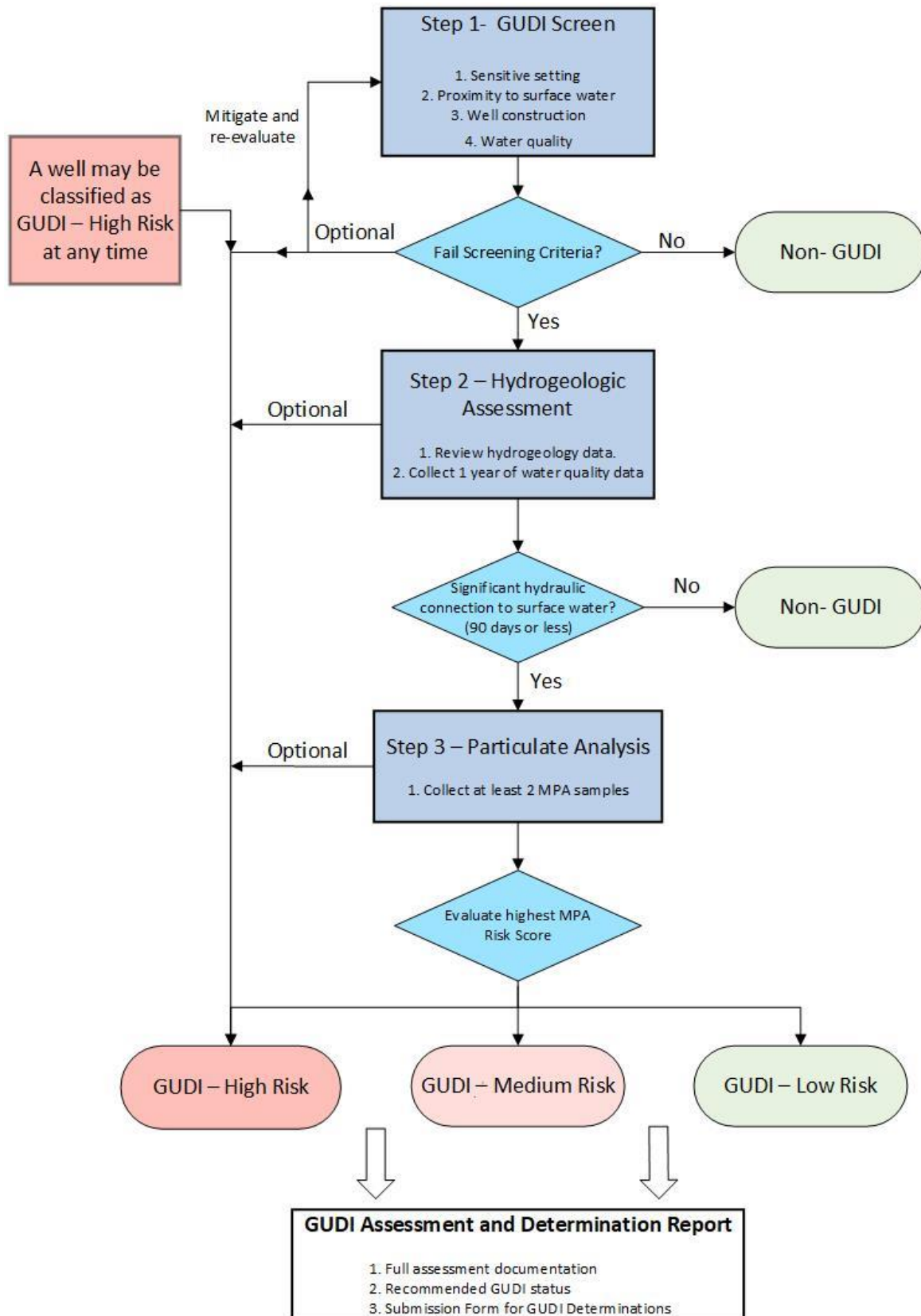
Step 2 is used to determine if there is a hydraulic connection through the aquifer that could allow rapid recharge of the well by water directly influenced by surface water (including infiltrating precipitation). Rapid recharge means recharge that occurs between the well and surface water with a travel 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:		
	<ul style="list-style-type: none"> • Spring 		
	<ul style="list-style-type: none"> • Infiltration gallery 		
	<ul style="list-style-type: none"> • Horizontal collection well 		
	<ul style="list-style-type: none"> • Well in karst aquifer 		
	<ul style="list-style-type: none"> • Unconfined or surficial aquifer 		
	<ul style="list-style-type: none"> • Fractured bedrock aquifer with surface outcropping within 60 m • Enhanced recharge/infiltration systems 		
Proximity to Surface Water	Well is <u>greater than</u> 60 metres from an intermittent or permanent surface water body or drainage ditch (as defined in Section)		
Well Construction	Well <u>meets</u> all current Well Construction Regulations <u>and includes</u> the following additional protections: <ul style="list-style-type: none"> – 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 <i>E. coli</i> bacteria confirming: 0 MPN/100 ml or "Absent"		
Step 1 Results	<ol style="list-style-type: none"> 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 	<input type="checkbox"/> Pass Step 1	<input type="checkbox"/> 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	<ul style="list-style-type: none"> • Well characteristics • Local geology and stratigraphy • Aquifer characteristics 		
Surface Water Monitoring	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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) <ul style="list-style-type: none"> • Data shall be plotted, compared and evaluated to surface water indicators • Determine time lag, or amplitude shift for indicators • Groundwater microbiology – total coliform, <i>E. coli</i> (plus other indicators) 		
Groundwater Hydraulic Conditions	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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
	<ul style="list-style-type: none"> - 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 		
	<ul style="list-style-type: none"> • Groundwater time-of travel (TOT) to well is more than 90 days 	<input type="checkbox"/> Pass Step 2 = non-GUDI	
	<ul style="list-style-type: none"> • 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 		<input type="checkbox"/> Fail Step 2 = GUDI

Section	Summary Condition	Indicate Findings	
STEP 3	<p>Microscopic Particulate Analysis (MPA) Summary (see APPENDIX A - Protocol for Determining Groundwater Under the Direct Influence of Surface Water (GUDI Protocol) for full description)</p>	Investigation Completed (Yes/No)	MPA Lab Findings (EPA Risk Category = Low, Medium or High)
	<ul style="list-style-type: none"> • Follow the USEPA 1992 Consensus Method; may include the Department of Environment and Climate Change's Approved Modifications (NSE July 2013) • For each: <ol style="list-style-type: none"> 1. Water supply well; and 2. Surface water body within 150 m (if present) <ul style="list-style-type: none"> – 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)
	<p>The GUDI Classification must be one of the following types (a classification is not in effect until accepted in writing by the Department):</p> <ul style="list-style-type: none"> • Non-GUDI • GUDI Low Risk • GUDI Medium Risk • GUDI High Risk 		
A4 Report	GUDI Assessment And Determination Report	Completed	
		Yes	No
	<ul style="list-style-type: none"> • 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 Water* 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 Direct Influence 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.