Water Security Agency

Municipal Drinking Water Quality Monitoring Guidelines

Edition 5
October 2020

EPB 202

This document replaces the “Municipal Drinking Water Quality Monitoring Guidelines” WQ 148, March 1996 and other previous versions. It is intended for use by individuals concerned with monitoring of drinking water supplies regulated under *The Waterworks and Sewage Works Regulations*

Edition 2: This edition addresses monitoring criteria changes to address data management system issues of significance to the Water Security Agency, to expand the monitoring criteria for bacteriological and turbidity monitoring, to add definitive requirements for pipelines or similar distribution systems, and to clarify the current recommendations for protozoa and chlorinated disinfection by-products.

Edition 3: This edition addresses changes made to section 2.4 - Turbidity Continuous Monitoring.

Edition 4: This edition includes monitoring requirements related to newly introduced standards for parameters found in Table 3 of the Appendix *to The Waterworks and Sewage Works Regulations* as well as other revisions applicable to previously listed parameters as necessary.

Edition 5: October 2020 - Revised sample frequencies for bacteriological, General Chemical, and Health and Toxicity. Added sections for Lead, Copper, and Manganese

The guidelines will be revised and updated as new information warrants change.

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1. Introduction

1.1 Purpose

Drinking water quality monitoring is important to both the consumer and the owner of waterworks systems. Reasons for monitoring drinking water include:

- assessment and assurance of the safety of water for consumptive purposes;
- suitability of the water to meet consumer's aesthetic needs;
- assessment of water treatment needs and information to implement process adjustments;
- assessment of water source protection and/or concerns;
- provision of information for private, commercial, or industrial users; and
- determination of drinking water quality trends and identification of potential concerns.

These guidelines are considered a minimum for monitoring requirements; If special circumstances warrant, the monitoring can be increased or reduced in the waterworks operating permit to address the special needs or parameters not identified in these guidelines. The guidelines outline the requirements for monitoring of water supplied or used for human consumptive use. This guideline may also be employed when determining monitoring requirements for systems supplying water intended or used for hygienic use or for certain pipeline systems as those requirements will vary somewhat and be less comprehensive. Site specific monitoring requirements are specified in the Permit to Operate for each facility.

New raw water sources shall be characterized upon commissioning, ensuring compliance with all parameters listed in Table 3 of *The Waterworks and Sewage Works Regulations.*

1.2 Monitoring Factors

There are several factors that should be considered during the development of a drinking water monitoring schedule. Samples must be collected in an appropriate manner, from an appropriate location and analyzed using an acceptable method to ensure representative results. The main points to consider when developing monitoring guidelines are:

- water supply variations and susceptibility to quality changes (for example, surface water will be subject to seasonal and hydrological changes while groundwater is often less variable on a short-term basis);
- treatment capabilities and performance of the treatment facilities;
- vulnerability of the water supply to potential contamination;
- variations in water quality for some parameters from the time it leaves the water treatment plant/reservoir until the time it reaches the consumers tap;
- the need for and capabilities of conducting on-site measurements;
- past trends in water quality data;
- the laboratory capabilities and cost of monitoring compliance by the owners;
- minimization of effort while providing adequate surveillance;
- size of population (as population increases, users tend to be more diverse, there are more consumers, the systems are more complex, and subject to contamination);
- the availability of water quality data and information on raw water sources should be considered when establishing drinking water monitoring requirements (The Water Security Agency has a good database on a wide range of parameters that are frequently analyzed at designated surface water sites in the province); and
- upstream and downstream sampling on sequential pipelines.

2. Monitoring Guidelines and Rationale

2.1 Bacteriological

Minimum bacteriological monitoring requirements for waterworks relying upon surface and ground water supplies are shown in Table 1.

Table 1: Bacteriological Monitoring Requirements (Total Coliform, *Escherichia coli* & Background Bacteria)

Population	Groundwater Source	Surface Water, Blended or GUDI Source
<100	1 per month	2 per month
101-500	2 per month	1 per week
501-2,000	1 per week	1 per week
2,001-5,000	1 per week	2 per week
5,001-15,000	2 per week	3 per week
15,001-50,000	1 per 8,000 pop. per week (minimum 3 per week)	1 per 4,000 pop. per week (minimum 4 per week)
>50,000	1 per 16,000 pop. per week (minimum 6 per week)	1 per 12,000 pop. per week (minimum 12 per week)

Bacteriological determinations, particularly using total coliform bacteria as an indicator of the potential presence of pathogens, has been a standard monitoring tool for many years. In recent times, monitoring for *Escherichia coli* has replaced monitoring for fecal coliform indicators in treated drinking water supplies and most laboratories now employ methodologies that determine both total coliform and *E. coli* at the same time. Typically, monitoring requirements have been related to the population served by a distribution system. Other factors could include the nature of the supply, its susceptibility to bacteriological contamination, and the historical bacteriological records (submissions and incidence of positive detections).

Bacteriological water quality monitoring is required for systems supplying water for human consumptive use or hygienic use. Sampling locations should be at representative locations in the distribution system. A schedule of multiple locations shall be established to ensure that all zones within a distribution system are routinely monitored.

For those waterworks subject to seasonal population changes the bacteriological monitoring frequency should be adjusted on a seasonal basis in accordance with the frequencies outlined in Table 1.

2.2 Chlorine Residual - On-Site

Free chlorine residual monitoring is required by *The Waterworks and Sewage Works Regulations* for all human consumptive use waterworks chlorinating their drinking water. Unless otherwise required by permit conditions, such as instances where chloramination-based disinfection is employed, the permittee of a waterworks shall maintain the following chlorine residuals:

(a) a free chlorine residual of not less than 0.1 milligrams per litre in the water entering a distribution system; and
(b) a total chlorine residual of not less than 0.5 milligrams per litre or a free chlorine residual of not less than 0.1 milligrams per litre in the water throughout the distribution system.

Surveillance of treated water chlorine residuals is necessary for all waterworks to properly regulate the chlorination process, regardless of population size. Both free and total chlorine residual monitoring is necessary to get a complete picture. Chorine residual monitoring is required for systems supplying water for human consumptive use and those hygienic use systems where disinfection is performed in accordance with permit requirements. Chlorine residual monitoring must be completed on-site.

The minimum basic monitoring is:

- for free chlorine residual, once per day from treated water entering the distribution system; and
- for free and total chlorine residuals, at the same frequency and locations used for bacteriological sampling

Waterworks serving more than 5,000 consumers should consider employing continuous chlorine residual monitoring at the water treatment plant. Integrating continuous chlorine residual monitoring with an alarm or audible notification system is also recommended. Where surface or blended source waterworks are subject to seasonal, storm induced, or other variability in source water quality, increased chlorine residual monitoring at the water treatment plant is encouraged and may be required in the waterworks operating permit.

Where chloramination is employed, monitoring for total chlorine residual is to be employed for water entering the distribution system and at the same time and frequency as bacteriological water quality sample(s) collection from the distribution system, as a minimum.

Additional free chlorine, free ammonia and monochloramine monitoring may be required to determine process performance, in accordance with permit conditions.

2.3 Odour, Taste and Temperature

Odour and taste problems tend to be consumer- and site-specific; monitoring is continually carried out by consumers. Incidents of problematic taste and odour should be promptly investigated to determine possible causes. Routine monitoring is not proposed.

Temperature should be periodically monitored at the water treatment plant to gauge treatment efficiency (disinfection and oxidation). For aesthetic considerations, the community may also wish to take temperature measurement in the distribution system. Temperature measurement is site-specific and routine monitoring is not required.

2.4 Turbidity

The minimum routine monitoring is targeted to water leaving each filter and each train (for membrane filtration) for surface water, blended, or GUDI treatment plants, and treated water entering the distribution system for groundwater treatment plants. Distribution sampling, for aesthetic objective purposes, is recommended for operational information and management. Turbidity measurements are required for all waterworks that provide water for human consumptive use, in accordance with Table 2. Routine turbidity measurements are not required by hygienic systems, although it is recommended.

Table 2: On-Site Turbidity Monitoring Requirements (Minimum)

Population	Groundwater Source	Surface Water, Blended or GUDI Source
<100	1 per day	1 per day (Continuous for membranes) 1 per week on the raw water supply.
101-500	1 per day	1 per day (Continuous for membranes) 1 per week on the raw water supply.
501-2,000	1 per day	2 per day (minimum of 6 hours apart) (Continuous for membranes) 1 per week on the raw water supply.
2,001-5,000	2 per day (minimum of 6 hours apart)	Continuous 1 per week on the raw water supply.
5,001-15,000	Continuous	Continuous 1 per week on the raw water supply.
15,001-50,000	Continuous	Continuous 1 per day on the raw water supply.
>50,000	Continuous	Continuous 1 per day on the raw water supply.

Turbidity is an important water quality parameter, especially for surface water containing organic particulates, because it affects bacteriological quality and treatment performance. Depending upon the composition of the turbidity, interference with chlorination can range from negligible to severe.

Turbidity measurement is a valuable process control tool for surface water treatment. Suitable and easily operated turbidimeters are available for use in water treatment plants. In larger facilities, continuous reading units are becoming common. Frequent monitoring of turbidity, particularly for waterworks obtaining raw water from surface, blended, or GUDI sources will aid in tracking and maintaining treatment process optimization and ultimately, the safety of the water supply. Where surface, blended, or GUDI sources serving less than 2000 consumers are subject to seasonal, storm induced or other variability in source water quality, increased turbidity monitoring up to a frequency of four times per day is encouraged and may be required if specified in the waterworks operating permit. For those waterworks subject to seasonal population changes the turbidity monitoring frequency should be adjusted on a seasonal basis in accordance with the frequencies outlined in Table 2.

Turbidity monitoring of treated surface, blended, or GUDI source water from membrane treatment systems should be continuous in nature. Regulatory requirements are that 99 per cent of discrete samples or continuous measurements each month meet the turbidity requirement.

Criteria for Turbidity Continuous Monitoring

Continuous monitoring for turbidity should include, as a minimum:

- polling of turbidity monitors on each filter on a basis of at least once every five minutes. The five-minute polling should be an average of a set of data taken at smaller intervals (i.e.: every 5, 10, or 30 seconds, for example);
- reporting of information returned from polling monitors on each filter, including maximum, minimum, and mean values, at least once every 15 minutes. The 15-minute polling statistics can be the maximum, minimum, and mean values from the five-minute averages; and,
- report any polling result that exceeds the applicable absolute maximum value (i.e.: 1.0 NTU for surface water - chemically assisted filtration; 0.1 NTU surface water - membrane filtration; 3.0 NTU - slow sand or diatomaceous earth filtration; Groundwater - see permit value).

Turbidity monitoring in the distribution system can also help the understanding of system conditions and will become increasingly important as drinking water standards for manganese are introduced in the future. Continuous turbidity monitoring at the point where water enters the distribution system may be advisable for a larger community (City or > 5,000 population served) and/or where a larger centre is served by a treated water pipeline. Such monitoring may be of value in ensuring safe drinking water, especially where the source of treated water is remote to the community and aid in distinguishing the source of any changes in treated water turbidity. Significant accumulations of manganese can often occur in water pipelines and drinking water distribution systems, especially in situations where cast iron or ductile iron water mains are employed. In these instances, along with direct monitoring of manganese, operators may be better able to understand the source of manganese in their distribution systems.

2.5 Ammonia and Dissolved Organic Carbon

Many raw water sources have exhibited the presence of either naturally occurring ammonia (particularly in groundwater sources) or dissolved organic carbon or in some cases both. While it has not been considered necessary to establish health-based guideline's for either of these parameters, they can have a potential impact on water quality through affecting the disinfection process or the formation of disinfection by-products. The need for monitoring of these parameters will be determined on a site-specific basis. Routine monitoring is not required.

2.6 Colour

Colour is primarily of aesthetic concern. However, since it is sometimes organic in nature, it can be associated with other water quality concerns, such as trihalomethane formation. Groundwater generally contains little colour. Surface water is more susceptible due to vegetation decay cycles and runoff influences. Although colour testing would normally be done on-site, routine monitoring is not required.

2.7 pH

The importance of pH in distributed water is normally related to the corrosion or scale-forming properties of water and to the efficiency of chlorine disinfection. Raw water pH can impact coagulation performance. Water treatment processes, such as lime soda softening and high-dosage alum coagulation, can alter the pH. Surface water can vary seasonally and even daily, especially if there are high densities of algae. Groundwater usually has a stable pH.

Unless pH has an impact on or is altered by treatment processes in use, such as certain membrane filtration systems, it is not an important control measurement. Meters and less accurate colour comparators are available for on-site pH measurements.

2.8 Sulphide (as H_2S)

Sulphide can be present in raw surface water due to bacterial decomposition processes, under anaerobic conditions. In groundwater, sulphide can be generated biologically or may originate from a gaseous environment in the aquifer. Sulphide may also be produced in household hot-water heaters. In addition to its distinctive odour, sulphide gas can be corrosive and hazardous in confined spaces.

Any measurement of sulphide as hydrogen sulphide gas dissolved in water should be done on-site. The need for such analyses will be determined on a site-specific basis. Routine monitoring is not required.

2.9 General Chemical (Major Ions)

The composition and concentration of the specific chemicals covered by the General Chemical panel identify the water's chemical composition. This will vary among source water. A groundwater supply generally will have less variability than a surface water supply, which tends to vary at least on a seasonal basis. In general, samples should be collected from treated water entering the distribution system as outlined in Table 3.

Table 3: General Chemical Monitoring Guidelines

Population	Groundwater Source	Surface Water, Blended or GUDI Source
<100	1 per 2 years	1 per 2 years
101-500	1 per 2 years	1 per 2 years
501- 5000	1 per 2 years	1 per year
5001-100000	1 per 6 months	1 per 3 months
>100000	1 per 6 months	1 per 3 months
General Chemicals are classified as the following parameters: Alkalinity (as $CaCO_3$), Bicarbonate, Calcium, Carbonate, Chloride, Conductivity, Fluoride (for non-fluoridating communities), Hardness (as $CaCO_3$), Magnesium, Potassium, Nitrate, Sodium, Sulphate and Total Dissolved Solids.		

2.10 Health and Toxicity

Samples for the Health and Toxicity panel should be collected from treated water entering the distribution system.

In much of Saskatchewan's groundwater, concentrations of iron and/or manganese frequently exceed the *Guidelines for Canadian Drinking Water Quality* and removal processes are routinely employed. Regular on-site iron and manganese measurements are important for process control in facilities intending to remove these constituents.

The Health and Toxicity panel also includes aluminum, antimony, arsenic, barium, boron, cadmium, chromium, lead, selenium, silver, and uranium.

Monitoring guidelines for health and toxicity parameters are outlined in Table 4 and are to be collected from the water treatment plant reservoir before entry to the distribution system.

Table 4: Health and Toxicity Monitoring Guidelines

Population	Groundwater Source	Surface Water, Blended or GUDI Source
<100	1 per 2 years	1 per 2 years
101-500	1 per 2 years	1 per 2 years
501-5000	1 per 2 years	1 per year
5001-25000	1 per 6 months	1 per 3 months
>25000	1 per 6 months	1 per 3 months
Health and Toxicity are classified as the following parameters: Aluminum, Antimony, Arsenic, Barium, Boron, Cadmium, Chromium, Copper, Iron, Lead, Manganese, Selenium, Silver, Uranium and Zinc.		

2.11 Cyanide

Monitoring requirements for cyanide are shown in Table 5. Cyanide can exist in many forms. The free cyanide is a concern with respect to human toxicity. Cyanide concentrations in groundwater and surface water are typically very low. Significant cyanide concentrations are most often a result of a site-specific pollutant source.

Table 5: Cyanide Monitoring Guidelines

Population	Groundwater Source	Surface Water, Blended of GUDI Source
<5000	Nil	Nil
5001-25000	Annually	Annually
>25000	1 per 6 months	1 per 6 months

2.12 Mercury

Mercury enters water supplies naturally and via man-made sources. Mercury concentrations in groundwater and surface water tend to be very low. Adherence of mercury onto sediments typically results in higher concentrations in bottom sediments. Monitoring guidelines are shown in Table 6.

Table 6: Mercury Monitoring Guidelines

Population	Groundwater Source	Surface Water, Blended or GUDI Source
<5000	Nil	Nil
5001-25000	Annually	Annually
>25000	1 per 6 months	1 per 6 months

2.13 Fluoride

Fluoride is often added to drinking water for the prevention of dental decay. Excessive fluoride concentrations may cause mottling (brown spots) on teeth. Split samples should be periodically obtained to compare off-site and on-site measurements. Off-site fluoride monitoring guidelines are shown in Table 7.

Table 7: Off-Site Fluoride Monitoring Guidelines

Population	Groundwater Source	Surface Water, Blended or GUDI Source
<500	1 per month	1 per month
501-5000	1 per week	1 per week
5001-100000	1 per week	1 per week
>100000	1 per week	1 per week
Note: For waterworks not fluoridating refer to the monitoring under General Chemical section. This monitoring schedule is for waterworks adding fluoride to drinking water or where fluoride levels consistently exceed the maximum acceptable concentration		

On-site testing at the water treatment plant for all waterworks artificially adding fluoride is required daily regardless of population size.

2.14 Trihalomethanes (THM), Haloacetic Acids (HAA) and Other Chlorinated Disinfection By-Products

Trihalomethanes are generated during the water treatment process as a by-product of free chlorine reactions. The term THMs refers to the total concentration of chloroform, bromodichloromethane, dibromochloromethane and bromoform compounds. Significant levels of THMs may occur when the raw water is obtained from a surface water supply. However, there may be specific situations where groundwater may be of a quality to produce THMs. Samples should be collected from representative locations in the distribution system in accordance with Table 8. To calculate a THM value, the winter, spring, summer and fall readings will be averaged to calculate an annual average value. THM values illustrate seasonal variability, therefore, it is necessary to sample on a seasonal basis.

In addition to THMs, other substances such as Haloacetic Acids (HAA) are created in minute concentrations during chlorine-based disinfection processes. Some of the more prevalent HAAs created during disinfection processes include monochloroacetic acid, dichloroacetic acid, trichloroacetic acid, monobromoacetic acid and dibromoacetic acid. The term HAA_5 refers to the total concentration of these five compounds.

Waterworks are to monitor THM and HAA concentrations in accordance with Table 8 at the most relevant location where anticipated peak concentrations can be anticipated in the distribution system. In the case of THM monitoring peak concentrations can typically be found at the most distant ends of the distribution system and/or in locations where water stagnates within the mains due to low flow. Monitoring locations for HAA's is to be performed at the same location year-round as the Maximum Acceptable Concentration (MAC) is based on a locational running average. For systems serving more than 2000 people, initial monitoring to determine just where peak concentrations in the distribution system is occurring is recommended, since in larger systems peak concentrations of HAA's often occurs at a midpoint within the distribution system. Periodic monitoring for THM and HAA at the treatment plant/reservoir may also prove valuable in assessing the effectiveness of treatment changes intended to reduce the concentration of disinfection by-products or following significant changes in disinfectants employed or contact time; however, these samples should not be used for determining compliance.

For systems testing multiple sites within the distribution system, the annual average value from each site will be determined. Compliance with the regulations will require that each test site be compliant.

Drinking water systems utilizing Surface Water, Blended, GUDI and Susceptible Groundwater Sources may qualify for reduced THM and HAA sampling. Specifically, if these drinking water systems have taken quarterly samples for at least eight consecutive quarters, they may cease to sample for eight consecutive calendar quarters provided:

1. No test result in the previous eight consecutive calendar quarters indicated that the concentration of THMs were greater than 0.08 mg/l nor HAAs were greater than 0.050 mg/L.
2. The drinking water system's raw water supply has not changed,

3. No alterations have been made to the drinking water system, and
4. The Water Security Agency has not provided written direction to sample each calendar quarter.

After eight consecutive calendar quarters with no sampling, the drinking water system must resume sampling and testing for THMs and HAAs for four consecutive calendar quarters. At this point, provided the criteria listed above continue to be met, the system may continue to rotate between four consecutive calendar quarters of testing and eight consecutive calendar quarters with no testing.

Table 8: Trihalomethane and Haloacetic Acid Monitoring Guidelines

Population	Groundwater Source THMs ONLY	Surface Water, Blended, GUDI and Susceptible Groundwater Sources THMs and HAAs
<500	1 sample for THM in January for 1 year.	1 sample every 3 months during spring, summer, fall and winter
501-5000	1 sample in each of January and July for 1 year.	1 sample every 3 months during spring, summer, fall and winter
5001-100000	1 sample every 3 months during spring, summer, fall and winter for 1 year Then 1 sample every 3 months during spring, summer, fall and winter every 5th year.	2 samples every 3 months during spring, summer, fall and winter
>100000	1 sample every 3 months during spring, summer, fall and winter for 2 consecutive years. Then 1 sample every 3 months during spring, summer, fall and winter every 5th year.	4 samples every 3 months during spring, summer, fall and winter

2.15 Synthetic Organic Chemicals

It is expected that the detection of the many synthetic organic chemicals in Saskatchewan's groundwater and surface water would be very rare. Detection of any of these chemicals would most likely be associated with a site-specific pollution event, hence the monitoring frequencies, outlined in Table 9, are low.

Table 9: Monitoring Guidelines for Synthetic Organic Chemicals

Population	Groundwater Source	Surface Water, Blended or GUDI Source
<5000	Nil	Nil
5001-100000	1 every 3 years	1 every 2 years
>100000	Annually	Annually
Synthetic organic chemicals are classified as the following parameters: Carbon Tetrachloride; 1,2 Dichlorobenzene; 1,4 Dichlorobenzene; 1,2 Dichloroethane; 1,1 Dichloroethylene; Dichloromethane; 2,4 Dichlorophenol; Monochlorobenzene; Tetrachloroethylene; 2,3,4,6 Tetrachlorophenol; Trichloroethylene; 2,4,6, Trichlorophenol; and Vinyl Chloride.		

2.16 Benzene, Toluene, Ethylbenzene and Xylenes (BTEX)

Due to the volatile nature of these chemicals, concentrations in surface water are generally very low. Detectable values in groundwater are normally associated with site-specific pollution sources particularly the petroleum industry. BTEX monitoring frequencies are outlined in Table 10.

Table 10: Benzene, Toluene, Ethylbenzene and Xylene Monitoring Guidelines

Population	Groundwater Source	Surface Water, Blended or GUDI Source
<5000	Nil	Nil
5001-100000	1 every 3 years	1 every 2 years
>100000	Annually	Annually
BTEX involves the parameters: Benzene, Toluene, Ethylbenzene, and Xylenes that are all volatile.		

2.17 Benzo (a) Pyrene (BaP), Perfluorooctane Sulfonate (PFOS) and Perfluorooctanoic Acid (PFOA)

BaP is generated by the incomplete combustion of organic material and is generally associated with industrial atmospheric discharges and automobile exhaust. It may also be found in source waters that receive treated wastewater effluents. Surface water near industrialized areas is more susceptible to BaP contamination. PFOS and PFOA are found in similar locations but are also found in locations affected by land spreading of septic tank waste as well as land or water affected by Aqueous Film-Forming Foam (AFFF). New raw water sources should be characterized upon commissioning of use and existing groundwater supplies should be characterized where susceptible to contamination as noted above. The monitoring frequencies for BaP, PFOS and PFOA are outlined in Table 11.

Table 11: Benzo (a) Pyrene, Perfluorooctane Sulfonate (PFOS) and Perfluorooctanoic Acid (PFOA) Monitoring Guidelines

Population	Groundwater Source	Surface Water, Blended or GUDI Source
<5000	Nil	Nil
5001-100000	1 every 3 years	1 every 2 years*
>100000	Annually	Annually*

*Quarterly monitoring may be necessitated when BaP, PFOS or PFOA has been detected in previous samples and in water sources susceptible to contamination.

2.18 Pesticides

Since the potential for pesticide detection may vary seasonally because local use also varies, and since there have been very few problems in Saskatchewan, pesticide monitoring is minimal. New raw water sources should be characterized upon commissioning of use. The monitoring guidelines for pesticides are shown in Table 12. The guideline for Pentachlorophenol has been withdrawn from the national drinking water quality guidelines but remains in Saskatchewan's listing of parameters as of January 2016.

Table 12: Pesticide Monitoring Guidelines

Population	Groundwater Source	Surface Water, Blended or GUDI Source
<5000	Nil	Nil
5001-100000	1 every 3 years	1 every 2 years
>100000	Annually	Annually
Pesticides to be analyzed for in Saskatchewan are: Atrazine, Bromoxynil (Buctril), Carbofuran, Chloropyrifos, Dicamba (Banvel), 2,4 Dichlorophenoxyacetic acid (2,4-D), Diclofop-Methyl (Hoe Grass), Dimethoate, Malathion, 2-Methyl-4-Chlorophenoxyacetic Acid (MCPA), Pentachlorophenol (PCP), Picloram and Trifluralin (Treflan).		

2.19 Chlorate and Chlorite

Chlorate and chlorite are compounds that may be found in drinking water when chlorine dioxide is used as a disinfection process. Chlorate can also be found in trace levels in hypochlorite solutions or when these solutions are not stored and/or used appropriately. Chlorine dioxide for primary disinfection should not exceed a maximum feed rate of 1.2 mg/L, an operational measure that will help ensure that chlorate and chlorite drinking water quality standards will be met. Optimization of on-site chlorine dioxide generation processes is also important to ensure that chlorine dioxide will not be overly contaminated with chlorite. The use of only NSF/ANSI 60 certified disinfectants will minimize exposure to consumers via drinking water due to trace chlorate residuals found in hypochlorite disinfectants.

Monitoring requirements for chlorate and chlorite are essential for waterworks that employ chlorine dioxide primary disinfection as component of their drinking water treatment processes. In medium and larger waterworks, chlorite concentrations tend to occur mid-way within the distribution systems whereas maximum chlorate concentrations tend to occur at distal ends of the distribution system or where water stagnates within water mains. Monitoring of smaller systems service less than 1,000 people should be performed in distant ends of the distribution system. Sampling for these parameters should be undertaken on a frequency in accordance with Table 13 at the locations noted above. In all cases where there are significant adjustments in chlorine dioxide primary disinfectant levels, further treated water monitoring should be undertaken to determine the effect of such changes on chlorate and chlorite formation in the treated water supply.

Table 13: Chlorate and Chlorite Monitoring Guidelines for Waterworks Employing Chlorine Dioxide Primary Disinfection

Population	Groundwater	Surface Water, Blended or GUDI Source
<5000	Annually	Semi-annually, summer and winter
5001-100000	Semi-annually, summer and winter	1 sample every 3 months during spring, summer, fall and winter
>100000	Semi-annually, summer and winter	2 samples every 3 months during spring, summer, fall and winter

2.20 Bromate

Bromate compounds may be found in drinking water because of water treatment processes and the use of disinfectants rather than as a natural contaminant of raw water supplies. Given the sedimentary nature of Saskatchewan soils, bromide exists in our raw water supplies. Bromate compounds may be formed when ozonation processes are used to treat drinking water. Bromate also exists in trace levels in hypochlorite disinfectant solutions as a remnant of the disinfectant manufacturing processes. The use of only NSF/ANSI 60 certified disinfectants will minimize consumer exposure, via drinking water, due to trace bromate residuals found in hypochlorite disinfectants. Waterworks employing breakpoint chlorination shall be required to monitor bromate concentrations on a site-specific basis if maximum disinfectant use levels are being exceeded. Bromate concentrations in treated water supplies reliant on surface water sources may vary seasonally.

Monitoring requirements for bromate are essential for waterworks that employ ozonation as a component of their drinking water treatment processes. In the case of waterworks reliant on groundwater, monitoring frequency may be reduced if the standard of 0.01 mg/L is achieved and if no significant changes in average concentration is observed after three years of monitoring. In all cases where there are significant adjustments in ozonation treatment levels, further treated water monitoring should be undertaken to determine the effect of such changes on bromate formation in the treated water supply. All samples should be collected from a point before treated water enters the distribution system.

Table 14: Bromate Monitoring Guidelines for Waterworks Employing Ozonation

Population	Groundwater	Surface Water, Blended or GUDI Source
0-100	Semi-annually, summer and winter	Semi-annually, summer and winter
101-500	Semi-annually, summer and winter	1 sample every 3 months during spring, summer, fall and winter
501-5000	1 sample every 3 months during spring, summer, fall and winter	1 sample every 3 months during spring, summer, fall and winter
5001-100000	1 sample every 3 months during spring, summer, fall and winter	1 sample every 3 months during spring, summer, fall and winter
>100000	2 samples every 3 months during spring, summer, fall and winter	2 samples every 3 months during spring, summer, fall and winter

2.21 Manganese

Manganese occurs naturally in the environment and is widely distributed in air, water, and soil. It is not found in the elemental form in the environment but can exist in several oxidation states. Manganese may be present in water in the environment from natural sources (rock and soil weathering) or because of human activities (such as mining, industrial discharges and landfill leaching). It is used in various industries, including in the steel industry, in the manufacture of various products (e.g., fireworks, dry-cell batteries, fertilizers, fungicides and cosmetics and paints). Manganese may also be added to water as an oxidizing agent (permanganate) or as an impurity in coagulants used in the treatment of drinking water.

This maximum acceptable concentration (MAC) assesses all identified health risks associated with manganese in drinking water. It incorporates new studies and approaches and takes into consideration the availability of appropriate treatment technology. Based on reviews, the drinking water guideline for manganese is a MAC of 0.12 mg/L (120 µg/L), based on infants, the most sensitive population. Although the MAC established is based on infants, this value is intended to protect all Canadians.

Concerns regarding the presence of manganese in drinking water are often related to consumer complaints regarding discoloured water. The aesthetic objective (AO) of 0.02 mg/L (20 µg/L) is intended to minimize the occurrence of discoloured water complaints based on the presence of manganese oxides and to improve consumer confidence in drinking water quality.

The MAC applies to water entering and within the distribution system. Therefore, monitoring for manganese should be conducted at the point of entry to the distribution system, as well as throughout the distribution system. Samples should be collected so that an overall assessment of manganese levels in the distribution system can be made, including an estimate of the potential exposure of consumers to manganese at the tap. Some samples should be collected from sites within the distribution system that are near the treatment plant

Table 15: Manganese Testing entering the Distribution System (May be conducted onsite)

Population	Treated water entering the distribution at a water treatment facility where $KMnO_4$ is utilized as a treatment chemical or source water that is known to contain manganese in excess of the MAC (includes surface water treatment facilities).
<500	1 per month
501-5,000	2 per month
>5,000	1 per week

Table 16: Manganese in the Distribution System (Sent to accredited laboratory)

Population	All systems where manganese exceeds a monthly average of 0.05mg/l entering the distribution system
<100	0
101-500	1 sample every 3 months during spring, summer, fall and winter
501-5,000	2 sample every 3 months during spring, summer, fall and winter
5001-100,000	3 samples every 3 months during spring, summer, fall and winter
>100,000	4 samples every 3 months during spring, summer, fall and winter

2.22 Microcystin toxins.

Microcystins are a type of toxin produced by cyanobacteria (blue-green algae). Microcystins are hepatotoxic (toxic to the liver) and are one of several types of toxins that may be produced because of cyanobacterial blooms in surface water sources in Saskatchewan. Microcystin-LR is a secondary metabolite produced by a common cyanobacteria species and has found to be the most frequently occurring and often studied form of cyanobacterial toxin. Some Saskatchewan surface waters tend to be susceptible to algal blooms due to their nutrient rich nature, coupled with warm and sunny summer conditions. Elevated toxin concentrations are most often encountered during the die-off of heavy algal blooms and may be highest in the locale where algal blooms accumulate in downwind areas on shorelines. The major route of human exposure to microcystins is via drinking water.

Although, the MAC is based on the toxicity of microcystin-LR, it is important to measure total microcystins, which include all measurable microcystin variants, not just the microcystin-LR that are both dissolved in the water and bound within the cyanobacterial cells.

Monitoring requirements for Microcystin-LR and/or total microcystins are outlined in Table 17. Generally, waterworks reliant on surface water supplies susceptible to algae blooms should develop an action plan to prepare for monitoring and managing raw and treated water potentially affected by blue-green algae blooms. Often, monitoring of the source water supply where water intakes may receive water affected by a decaying algae bloom is the first step. Screening of raw water samples using enzyme-linked immunosorbent assay (ELISA) test kits is an acceptable first step in determining total microcystin concentrations. Monitoring of raw and treated supplies may be necessary to detect the onset of elevated microcystin concentrations in a source supply and, thereafter, monitoring of treated water quality may become necessary when raw water microcystin-LR levels exceed 0.0015 mg/L. Monitoring of raw and treated water may be required to ensure treated water meets the standards.

Table 17: Microcystin Toxin Monitoring Guidelines (Treated water)

Population	Groundwater or GUDI Source	Surface Water or Blended Source
<100	Nil	Following detection of significant algal blooms affecting a water intake Sample Source water at the point it enters the WTP. If concentration is greater than 0.0015 mg/l sample treated water at WTP
101-5000	Nil	Following detection of significant algal blooms affecting a water intake Sample Source water at the point it enters the WTP. If concentration is greater than 0.0015 mg/l sample treated water at WTP and once in August of each year
5001-100000	Nil	Monthly during algal bloom period
>100000	Nil	Monthly during algal bloom period

2.23 Radiological

Radionuclides are derived from natural sources such as weathering of rocks that contain radioactive substances and by man-made sources, such as nuclear weapons testing, nuclear power generation, and uranium mining or milling operations. Most radionuclides readily adhere to sediments and do not occur in significant amounts in the water column. Groundwater tends to be more susceptible to radionuclide contamination.

In Saskatchewan, radionuclide contamination of water supplies is uncommon and tends to be very site-specific. As a result, radionuclide monitoring will be considered on a case-by-case basis, depending on the vulnerability of the water supply. Waterworks serving populations greater than 100,000 people are to perform annual monitoring for gross alpha, gross beta, lead-210, radium-226, tritium, strontium-90, iodine-131, cesium-137 and potassium-40. For all waterworks other than those with waterworks serving more than 100,000 people, compliance with the *Guidelines for Canadian Drinking Water Quality* may be inferred if the measurements for gross alpha and gross beta activity are less than 0.5 Bq/L and 1 Bq/L, respectively, as these are lower than the strictest Maximum Acceptable Concentrations given the likely proportions of common alpha and beta emitters. If either the gross alpha or gross beta activity levels are exceeded upon initial screening, the treated water supply should be monitored for the suite of radiological isotopes noted above.

2.24 Protozoa: Giardia and Cryptosporidium

Giardia and *Cryptosporidium* are very small protozoans that, when ingested, can cause severe gastrointestinal illness as well as long-lasting or more serious health effects. The establishment of Maximum Acceptable Concentrations for these protozoa in drinking water is not presently possible for several reasons, primarily because the routine analytical methods available for cyst and oocyte detection suffer from low recovery rates. Rather, a health-based 3-log reduction in and/or inactivation of cysts and oocysts treatment goal has been employed to manage potential protozoan contamination of drinking water supplies. Measures such as source water vulnerability assessments, sanitary surveys, waterworks treatment optimization and/or wellhead protection should be implemented to reduce the risk of waterborne disease outbreaks due to the entry and passage or these organisms through the water treatment process.

Giardia and cryptosporidium raw water monitoring requirements, for water entering a water treatment plant, are outlined in Table 16. Additional monitoring of raw and/or treated water quality may be required for systems reliant on surface water as well as those relying on blended or GUDI sources in the event of an operational upset affecting treated water or in the event of a significant environmental event that may affect raw water quality. More in-depth characterization of raw water sources can clarify when monitoring should be performed and when the greatest potential for increases in protozoan contaminant concentrations may occur.

Table 18: Giardia and Cryptosporidium Monitoring Guidelines

Population	Surface Water, Blended or GUDI Source
5000	Nil
5001-100000	Semi-annually and following upsets or significant events that may affect raw water quality
>100000	Quarterly and following upsets or significant events that may affect raw water quality

2.25 Lead & Copper

Lead is usually found in drinking water because of leaching from distribution and plumbing system components. Historically, lead has been used extensively in-service lines, solders, and fittings, making its presence in drinking water more likely in older homes and neighborhoods.

Inorganic lead compounds have been classified as probably carcinogenic to humans, based on findings in experimental animals. However, the cancer effects are not the main health effects of concern in humans.

The toxicity of lead has been extensively documented in humans, based on blood lead levels (BLLs). Effects that have been studied include reduced cognition, increased blood pressure and renal dysfunction in adults, as well as adverse neurodevelopmental and behavioral effects in children. The strongest association observed to date is between increased BLLs in children and reductions in intelligence quotient (IQ) scores. The threshold below which lead is no longer associated with adverse neurodevelopmental effects cannot be identified.

Copper and zinc generally occur below the *Guidelines for Canadian Drinking Water Quality in Saskatchewan* raw water supplies. These constituents can increase in distribution systems due to corrosion of zinc-bearing materials including copper piping and fittings.

Sampling protocols will differ, depending on the desired objective (i.e., identifying sources of lead, controlling corrosion, assessing compliance, estimating exposure to lead). As monitoring of lead at the tap can be done using different sampling protocols, it is important that the selected protocol be appropriate to meet the desired objective.

The objective of sampling protocols in this document is to monitor for typical community exposure to total lead to determine whether there are concerns related to effects on human health. Compliance monitoring should be conducted at the consumer's tap, with priority given to identifying homes with lead service lines, as these are likely to have the highest lead concentrations.

If the objective is to characterize whether distributed water is corrosive to the materials found in the distribution system and household plumbing, the Guidance on Controlling Corrosion in Drinking Water Distribution Systems should be used. Schools and daycare facilities should also be prioritized for monitoring to ensure that the most sensitive population (i.e., young children) is captured. However, a different sampling protocol may need to be considered for schools, daycare facilities and larger buildings or dwellings. It is difficult to assess exposure in these buildings because of their unique and complex plumbing configurations and the large number of pipes and plumbing components. Sampling should be conducted at least once per year, with the number of sites to be monitored determined based on the size of the drinking water system and the type of building, as discussed below.

Initial characterization:

Systems serving more than 50,000 people are required to conduct two rounds of initial lead tap monitoring at the standard number of sites.

Systems serving 50,000 or fewer people are required to conduct a minimum of one round of initial monitoring at the standard number of sites. If samples collected during the initial round, from systems serving 50,000 or fewer people, exceed the MAC of 5 µg/l of lead in more than 10 per cent of the samples, then they must conduct a second round of lead sampling at the standard number of sites.

Sample locations should focus on areas which are known to contain lead services or older buildings which may contain lead service lines. However, a few samples should be randomly taken from all areas of the distribution system.

Sampling will include samples from within private residences and commercial business, along with points from the distribution system not influenced by service lines or internal plumbing fixtures. These samples from “points in the distribution system” can be taken from hydrants or flush out points.

Either random daytime (RDT) or 30-minute stagnation (30MS) sampling protocols can be used for single- or multi-family (fewer than eight units) residential sites. These protocols capture typical exposures and are considered appropriate for identifying priority areas for actions to reduce lead concentrations. For large residential buildings such as apartment buildings or seniors’ residences, an RDT sampling protocol is recommended for these sites to capture typical exposures.

RDT sampling: A 1-liter sample should be collected randomly during the day from a drinking water tap in each of the residences. Samples should be collected without prior flushing; no stagnation period is prescribed, to better reflect consumer use.

30MS sampling: The tap should be flushed for five minutes, allowed to stand for a thirty-minute stagnation period, during which time no water should be drawn from any outlet within the residence (including flushing of toilets). Two 1 L samples should then be collected at a medium to high flow rate (greater than five L/minute). The lead concentration is determined by averaging the results from the two samples.

Standard Sampling - Number of Sample Locations			
Population Served by Drinking Water System	**Number of Sampling Points in Plumbing that Serves Private Residences**	**Number of Sampling Points in Plumbing that Does Not Serve Private Residences**	**Number of Sampling Points in Distribution System**
1 – 99	5	1	1
100 – 499	10	1	2
500 - 3,299	20	2	4
3,300 - 9,999	40	4	8
10,000 - 49,999	60	6	12
50,000 - 99,999	80	8	16
100,000 or more	100	10	20

Ongoing Reduced Sampling:

Systems that have completed their initial sampling can be reduced to 1-, 3- or 9- year sampling based on their results in the initial characterization.

Systems serving a population under 10,000 with < 10 per cent of samples exceeding the MAC of 5 µg/l can conduct reduced sampling on a 9-year frequency.

Systems serving a population between 10,000 and 100,000 with < 10 per cent of samples exceeding the AC of 5 µg/l can conduct reduced sampling on a 3-year frequency.

Systems serving a population over 100,000 with < 10 per cent of samples exceeding the MAC of 5 µg/l can conduct reduced sampling on a 1-year frequency.

Reduced Sampling – Number of Sample Locations			
Population Served by Drinking Water System	**Number of Sampling Points in Plumbing that Serves Private Residences**	**Number of Sampling Points in Plumbing that Does Not Serve Private Residences**	**Number of Sampling Points in Distribution System**
1 - 99	3	0	1
100 - 499	5	1	1
500 - 3,299	10	1	2
3,300 - 9,999	20	2	3
10,000 - 49,999	30	3	4
50,000 - 99,999	40	4	8
100,000 or more	50	5	10

When would reduced sampling no longer apply?

The system must revert to standard sampling if more than 10 per cent of all the plumbing samples taken during any one period of testing exceeded the MAC.

3.0 Pipeline and Similar Distribution Systems

This section is intended to clarify monitoring requirements for pipelines and independently owned distribution systems that provide water from a separately owned and approved municipal source or other separately owned and approved source. Pipeline systems that treat and distribute their own source of water are classified as waterworks and are subject to the same water source type and population-based monitoring requirements identified in sections 2.1 to 2.23 inclusive.

Pipeline systems or independently owned distribution systems, where captured by Section 17 of *The Waterworks and Sewage Works Regulations*, receiving water from a separately owned and approved treatment facility and/or treated water pipeline, are subject to water source type and population based monitoring as identified in sections 2.1 Bacteriological, 2.2 Chlorine Residual – On-Site and 2.14 Trihalomethanes, Haloacetic Acids and Other Chlorinated Disinfection By-Products.

A water pipeline may monitor for free and total chlorine residual entering the pipeline system or for free and total chlorine residual at a representative location within the pipeline's distribution system. The monitoring sites chosen may depend on the presence of any re-chlorination equipment along the pipeline; however, compliance with minimum disinfectant residual requirements must be informed by the monitoring locations selected.

For pipelines serving fewer than 15 service connections, an exemption from the monitoring requirements of Section 2.14 may be considered. More than one monitoring schedule may be required for a pipeline system based on the location, complexity, and number of branch pipelines.

It may not be necessary to monitor all sequentially connected pipeline systems for Trihalomethanes and/or Haloacetic Acids if the occurrence of these substances in the system is understood and levels of contaminants can be reasonably established providing they do not utilize re-chlorination equipment.

Guidance on monitoring of Limited Scope Pipelines is governed under "WSA 504 – Limited Scope Water Pipeline Protocol." Under that protocol limited scope pipelines are to perform bacteriological water quality monitoring on a minimum of a monthly basis. Where chlorine residual levels in pipelines supplying potable water to a limited scope pipeline has not otherwise been confirmed, and where system specific configuration allows the collection of representative samples, site specific permit-based monitoring requirements for determination of chlorine residual may be considered to further assure safe water.