



Greater Vancouver Water District

2023 Water Quality Annual Report

Volume 1 of 2

March 2024

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Metro Vancouver acknowledges that the region's residents live, work, and learn on the shared territories of many Indigenous peoples, including 10 local First Nations: ǵíǵǵǵ (Katzie), ǵʷǵ:ńǵǵ (Kwantlen), kʷikʷǵǵǵ (Kwikwetlem), máthxwi (Matsqui), xʷmǵθkʷǵǵǵ (Musqueam), ǵíǵǵt (Qayqayt), se'mya'me (Semiahmoo), Skwxwú7mesh Úxwumixw (Squamish), scǵǵǵǵ mǵsteyǵʷ (Tsawwassen) and sǵilwǵtǵ (Tsleil-Waututh).

Metro Vancouver respects the diverse and distinct histories, languages, and cultures of First Nations, Métis, and Inuit, which collectively enrich our lives and the region.

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Acronyms/Abbreviations

ACU	Apparent Colour Unit
ALARA	As Low As Reasonably Achievable
AO	Aesthetic Objective (characteristics such as taste, colour, appearance, temperature that are not health related)
BTEX	Benzene, Ethylbenzene, Toluene, Xylene
CALA	Canadian Association for Laboratory Accreditation
CO ₂	Carbon Dioxide
CWTP	Coquitlam Water Treatment Plant
DBP	Disinfection By-product
DWMP	<i>Drinking Water Management Plan</i>
DWPR	<i>Drinking Water Protection Regulation</i>
DWTO	<i>Drinking Water Treatment Objectives (Microbiological) for Surface Water Supplies in British Columbia</i>
<i>E. coli</i>	<i>Escherichia coli</i>
GCDWQ	<i>Guidelines for Canadian Drinking Water Quality</i>
GVWD	Greater Vancouver Water District
HPC	Heterotrophic Plate Count
IFE	Individual Filter Effluent
MAC	Maximum Acceptable Concentration
mg/L	Milligram per litre (0.001 g/L)
µg/L	Microgram per litre (0.000001 g/L)
mL	Milliliter
N/A	Not Applicable
NTU	Nephelometric Turbidity Unit
PAH	Polycyclic Aromatic Hydrocarbon
PHAC	Public Health Agency of Canada
PFOA	Perfluorooctanoic Acid
PFOS	Perfluorooctane Sulfonate
pH	Measure of acidity or basicity of water; pH 7 is neutral
SCFP	Seymour Capilano Filtration Plant
THAA	Total Haloacetic Acid
TSI	Trophic State Index
TTHM	Total Trihalomethane
UV ₂₅₄	Ultraviolet Absorbance at 254 nm
VOC	Volatile Organic Compounds
WQMRP	<i>Water Quality Monitoring and Reporting Plan for Metro Vancouver (GVWD) and Local Government Members</i>

Executive Summary

The Greater Vancouver Water District (GVWD) 2023 Water Quality Annual Report is required under the provincial *Drinking Water Protection Regulation* (DWPR), and Metro Vancouver's *Drinking Water Management Plan* (DWMP). The annual report summarizes the analysis of approximately 166,000 tests conducted on samples collected from the GVWD source reservoirs, water treatment plants and transmission system, as well as microbiological water quality of member jurisdictions' systems supplied by the GVWD.

The annual report outlines how Metro Vancouver's water quality monitoring program continues to fulfill its role in confirming that the multiple protection barriers are maintaining high quality drinking water for the region. This includes the continued protection of our water supply areas, effective and efficient water treatment processes, and uninterrupted operation of the water supply system by trained and certified operators.

In 2023, the water quality of the treated drinking water was excellent. All water quality parameters analyzed met or exceeded provincial water quality regulations and the federal *Guidelines for Canadian Drinking Water Quality* (GCDWQ). Results of the analyses of the source water for herbicides, pesticides, volatile organic compounds and radionuclides were all found to be below the recommended limits for these substances as listed in the GCDWQ.

As in past years, heavy rains were the cause of turbidity within the source supply reservoirs. The Capilano source water turbidity peaked in December at 8.4 Nephelometric Turbidity Unit (NTU) following a winter storm. The Seymour source started 2023 with its highest turbidity at 3.7 NTU as a result of heavy rains in December 2022. The Seymour Capilano Filtration Plant (SCFP) effectively removed the excess turbidity. The unfiltered Coquitlam source water was greater than 1.0 NTU for 5 days in 2023, and did not exceed 5.0 NTU throughout the year, complying with *GVWD Permit to Operate*.

The SCFP performance, as measured by the quality of the delivered water, was excellent in 2023. The daily average turbidity of water leaving the Clearwell to enter the GVWD transmission system was an average of 0.29 NTU. Filtration consistently removed iron, colour, and organics from the Capilano and Seymour source waters, and all disinfection requirements were met.

The Coquitlam Water Treatment Plant (CWTP) also delivered excellent water quality, with the ultraviolet treatment and chlorination systems meeting all disinfection requirements. Bacteriological water quality was excellent in the GVWD transmission mains and in-system storage reservoirs. The number of *E. coli* detected in samples from both GVWD and water systems supplied with GVWD water is typically very low. More than 29,400 samples were collected and analyzed for GVWD and GVWD supplied systems in 2023, of which only one sample from a GVWD supplied system was positive for *E. coli*. Three repeat samples for the same location were taken, and no additional *E. coli* were found.

1.0 Source Water Quality

The first barrier to protect the quality of the drinking water supply is the protection of the Water Supply Areas. Source water monitoring provides ongoing confirmation that the barrier is effective, identifies seasonal changes, and provides the monitoring information necessary to adjust the level of water treatment. Regular monitoring of the water sources is a requirement of the *Water Quality Monitoring and Reporting Plan for Metro Vancouver (GVWD) and Local Government Members (WQMRP)*. Refer to Appendix A for details regarding the water sampling frequency.

1.1. Bacteriological Quality of the Source Water

The bacteriological quality of the source water is an important indicator of the degree of any potential contamination, and the treatment required to ensure a safe water supply. *The Drinking Water Treatment Objectives (Microbiological) for Surface Water Supplies in British Columbia* (DWTO) Section 4.3 states “*The number of E. coli in raw water does not exceed 20/100 mL (or if E. coli data are not available less than 100/100 mL of total coliform) in at least 90% of the weekly samples from the previous six months. Treatment target for all water systems is to contain no detectable E. coli or fecal coliform per 100 mL.*”

Table 1 summarizes *E. coli* data for all three GVWD water supply sources. The levels of *E. coli* for all three sources were below the 10% limit in the provincial DWTO.

Table 1: Percent of Samples in Six Continual Months with *E. coli*/100 mL Exceeding 20

	Percent of samples (daily) in a six month period ending on the last day of the month named where <i>E. coli</i> greater than 20/100 mL		
Month	Capilano	Seymour	Coquitlam
Jan	3.3	4.5	1.1
Feb	3.4	4.5	1.1
Mar	3.4	4.5	1.1
Apr	1.1	2.9	0.0
May	0.0	0.0	0.0
Jun	0.0	0.0	0.0
Jul	0.0	0.0	0.0
Aug	0.0	0.0	0.0
Sep	2.7	2.2	0.0
Oct	3.8	3.8	0.5
Nov	3.8	3.8	0.5
Dec	3.8	4.4	0.5

Figure 1 shows the results of the analysis of the source water from 2020 to 2023 at all three intakes compared to the limits for source water bacterial levels in the DWTO. As in previous years, all three sources met the limit of not more than 10% exceeding 20 *E. coli*/100 mL. Also, as is typical, samples collected at the intakes in the Fall and Winter had the highest *E. coli* levels. Typically, *E. coli* can be traced back to high flow levels at the main tributaries of the supply lakes, and a first flush phenomenon after a period of dry weather.

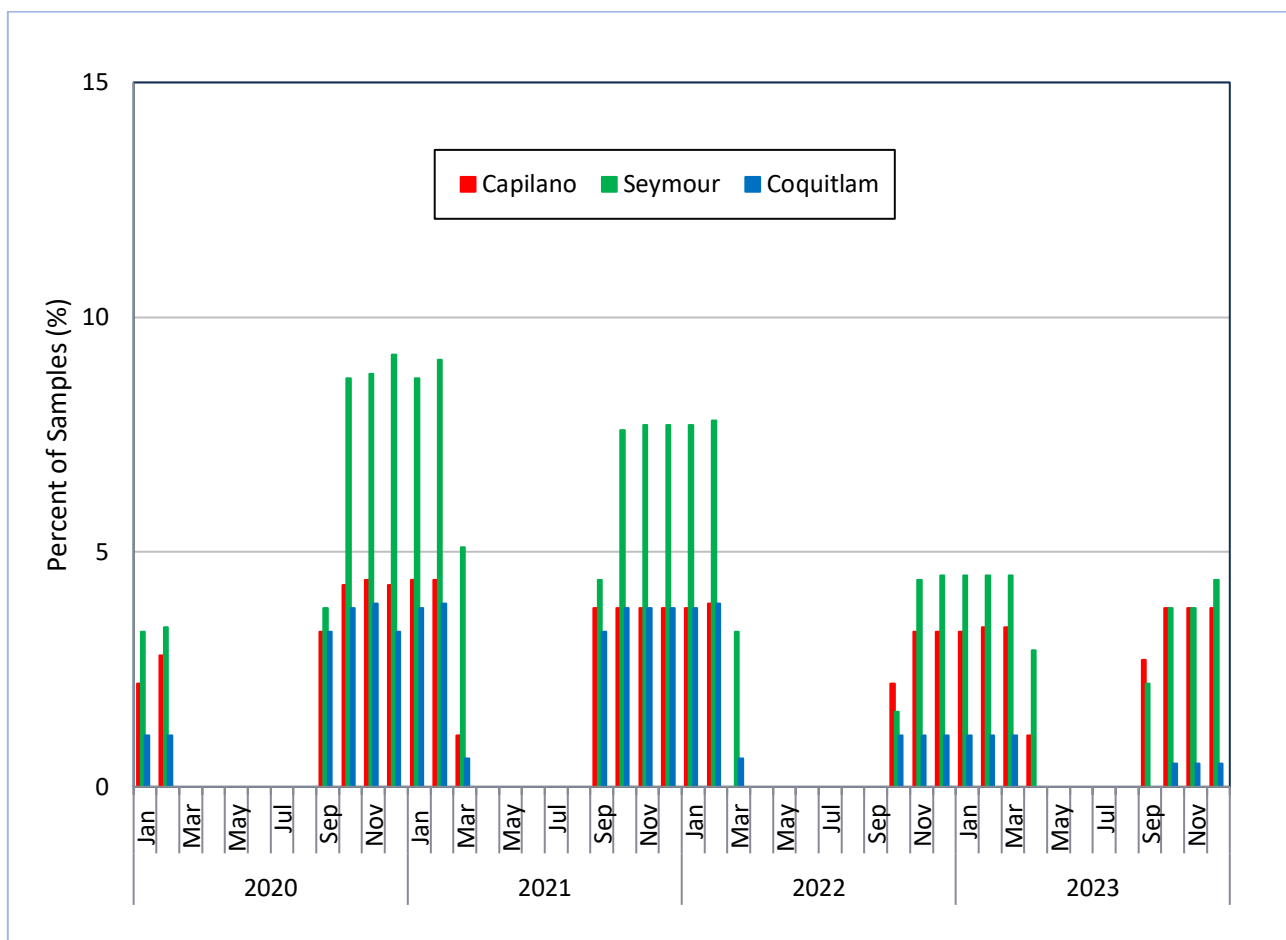


Figure 1: Percent of Samples Exceeding 20 *E. coli*/100 mL at all Three Sources (2020 to 2023)

1.2. Source Water Monitoring for *Giardia* and *Cryptosporidium*

Unfiltered surface water supplies have the potential of containing the protozoan pathogens *Giardia* and *Cryptosporidium*. Outbreaks of *Giardiasis* occurred in a number of locations in BC and Washington State in the late 1980s, and Metro Vancouver has been monitoring source water for *Giardia* since 1987. Since 1992, Metro Vancouver has participated in a program with the Environmental Microbiology Laboratory of the BC Centre of Disease Control Public Health Laboratory to gather more information about the number and nature of cysts found in the GVWD water supplies. The program has involved collecting samples from the Capilano, Seymour and Coquitlam sources upstream of disinfection.

Complete results of the 2023 testing program are contained in the “Metro Vancouver Detection of Waterborne *Cryptosporidium* and *Giardia* Annual Report January - December, 2023”, prepared by the Environmental Microbiology Laboratory of the BC Centre for Disease Control Public Health Laboratory, attached as Appendix D.

Six of twelve (50%) samples collected at Capilano, one of the twelve (8%) at Seymour, and one of twelve (8%) at Coquitlam were positive for *Giardia* in 2023. Table 2 summarizes *Giardia* data for the past ten years (Seymour sample collection began in 2022).

Table 2: Percent of Source Water Samples Positive for *Giardia*

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Capilano	18	18	50	58	33	33	33	25	17	50
Seymour									0	8
Coquitlam	8	0	17	67	8	25	25	25	8	8

Zero of twelve (0%) samples collected at Capilano, one of twelve (8%) at Seymour, and zero of twelve at Coquitlam were positive for *Cryptosporidium* in 2023. Table 3 summarizes *Cryptosporidium* data for the past 10 years (Seymour sample collection began in 2022).

Table 3: Percent of Source Water Samples Positive for *Cryptosporidium*

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Capilano	9	9	25	17	8	0	0	0	0	0
Seymour									0	8
Coquitlam	0	0	0	0	0	0	0	0	0	0

Year to year fluctuations are demonstrated for *Giardia* and *Cryptosporidium*, and there has typically been considerable variation in the results.

At the SCFP, monitoring for *Giardia* and *Cryptosporidium* has focused on the recycled water returning to the head of the plant, and this monitoring has confirmed that the procedures in place effectively control the levels of *Giardia* and *Cryptosporidium* in the recycled wash water from the filters. Zero of twelve (0%) samples collected were positive for *Giardia*, and zero of twelve (0%) were positive for *Cryptosporidium* in 2023. Table 4 shows the percentage of samples positive for *Giardia* and *Cryptosporidium* for the past 10 years.

Table 4: Percent of Recycled Water Samples Positive for *Giardia* and *Cryptosporidium*

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
<i>Giardia</i>	0	8	17	8	0	0	0	0	0	0
<i>Cryptosporidium</i>	0	0	0	0	0	0	0	0	0	0

1.3. Turbidity

As shown in Figure 2, GVWD water sources have been susceptible to turbidity events due to high runoff from storms, which can cause slides and stream scouring in the Water Supply Areas, or from re-suspension of sediment from the edges of the lakes during periods of low water levels. The DWTO allows a utility to be exempt from filtration if a minimum of two disinfectants providing 4-log reduction of viruses and 3-log reduction of *Cryptosporidium* and *Giardia* are used; the number of *E. coli* in raw water does not exceed 20/100 mL in at least 90% of the weekly samples from the previous six months; average daily turbidity level before disinfection is around 1 NTU, but does not exceed 5 NTU for more than two days in a 12-month period; and a watershed control program is maintained. Historically, the turbidity levels on both the Capilano and Seymour sources would not meet these criteria, and filtration was implemented for both supplies.

Section 4.4 of the DWTO (Version 1.2, November 2012) contains the following provision for filtration exemption:

“For nonfiltered surface water to be acceptable as a drinking water source supply, average daily turbidity levels should be established through sampling at equal intervals (at least every four hours) immediately

before the disinfectant is applied. Turbidity levels of around 1.0 NTU but not exceeding 5.0 NTU for more than two days in a 12-month period should be demonstrated in the absence of filtration. In addition, source water turbidity also should not show evidence of harbouring microbiological contaminants in excess of the exemption criteria.”

Capilano and Seymour water is filtered, therefore the above source water criteria does not apply to the delivered water from these sources. Coquitlam, which is unfiltered, was in service for all of 2023 in accordance with the DWTO.

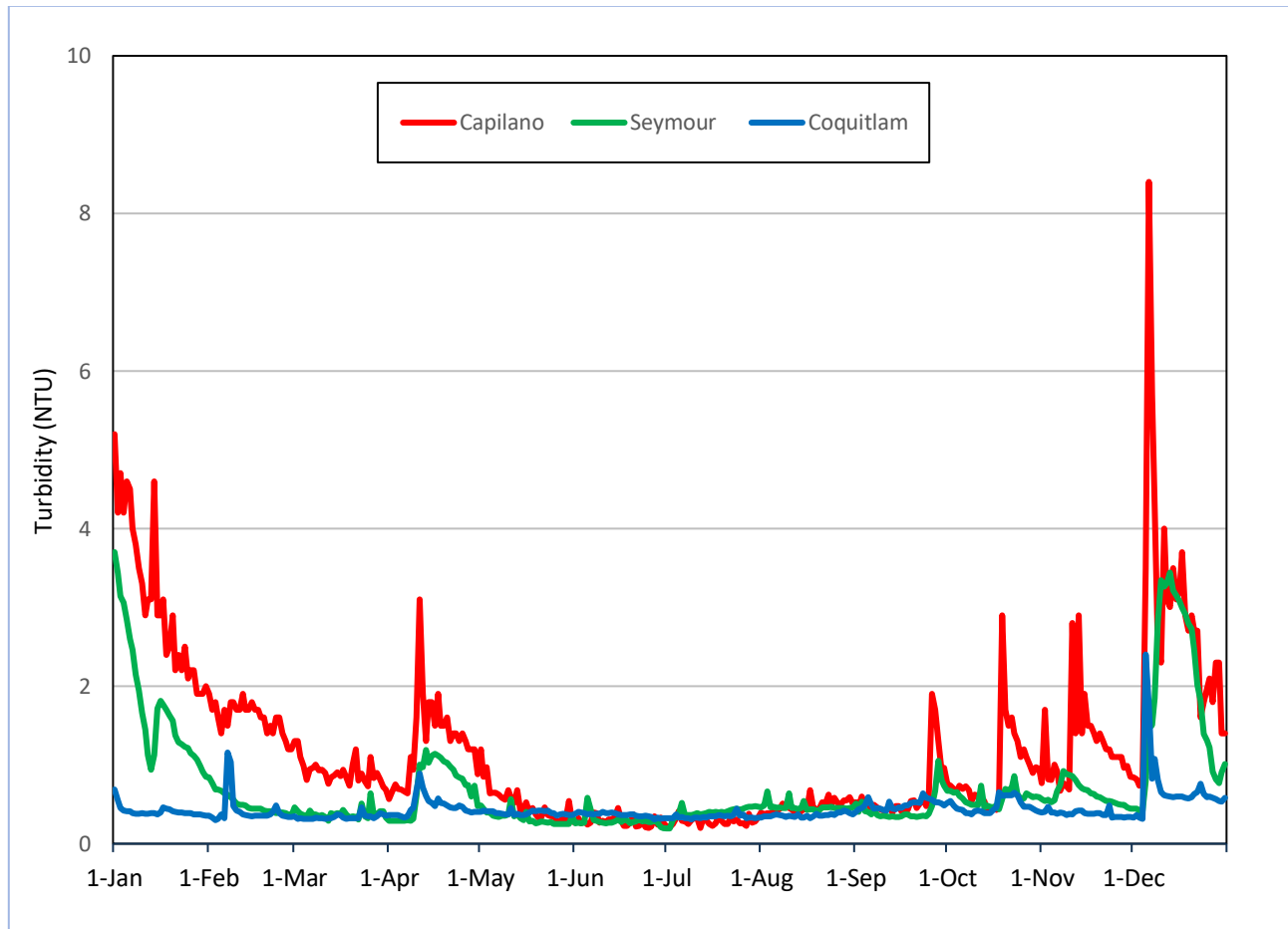


Figure 2: Average Daily Turbidity of Source Water (From In-line Readings)

1.4. Chemistry

1.4.1. Chemical and Physical Analysis of the Source Water

The chemical and physical characteristics of the GVWD source water are summarized in Appendix B of this report; detailed analytical results are provided in Volume 2. The results from the chemical and physical analyses of the source water in 2023 were similar to those for previous years. The analysis was carried out by accredited laboratories using methods based on the current version of *Standard Methods for the Examination of Water and Wastewater*.

1.4.2. Analysis of Water for Organic Components and Radionuclides

Analyses of the source water for a variety of organic and other compounds, including all of the compounds with a specified Maximum Acceptable Concentration (MAC) in the GCDWQ, is carried out on an annual basis in accordance with the WQMRP. The results are contained in Appendix C of this report and in Volume 2. No parameters were detected above the applicable GCDWQ health based limits.

1.4.3. PFOS and PFOA

Perfluorooctane Sulfonate (PFOS) and Perfluorooctanoic Acid (PFOA) testing is conducted on source waters and the results are detailed in Table 5. Common sources of these synthetic chemicals are from consumer products and fire-fighting foam, used for their water and oil repellant properties. Neither parameter was detected above the applicable health based limits in 2023.

Table 5: Monitoring of Source Waters for PFOS and PFOA

Parameter	Capilano (ng/L)			Seymour (ng/L)			Coquitlam (ng/L)			MAC (ng/L)
	11-Apr	28-Jun	5-Dec	11-Apr	28-Jun	7-Dec	11-Apr	28-Jun	5-Dec	
PFOS	<0.20	<0.80 ¹	<0.20	<0.20	<0.80 ¹	<0.20	<0.20	<0.80 ¹	<0.20	600
PFOA	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	200

¹The reporting limit was 0.80 ng/L for these testing events.

1.4.4. Limnology

The annual reservoir limnology monitoring, started in 2014, collects limnology data (physical, chemical and biological parameters) for the Capilano, Seymour and Coquitlam supply reservoirs. Reservoir monitoring information is important in proactively managing the supply reservoirs as water quality could be impacted by environmental variability and climate change. This program assists in ensuring that variation and trends in reservoir quality are scientifically tracked over time.

Water sampling of the source reservoirs and inflow streams and tributaries is conducted between April and November. Biological productivity that can influence water quality is highest during this time of year, making it an important time for taking samples and measurements. Monthly sampling of the source water is conducted and sample analysis undertaken by accredited labs. More frequent water quality data is measured by arrays of scientific instruments in each reservoir.

Metro Vancouver analysis of 2023 data resulted, as in previous years, in confirmation that the three reservoirs are ultra-oligotrophic as shown on Table 6, which means they have low nutrient levels, low levels of biological production, and are considered to be very high quality source waters.

Table 6: Comparison of Water Quality in GVWD Water Supply Sources to Standard Water Quality Classifications

Parameter	Average Value			
	Max value to obtain Ultra-oligotrophic status ¹	Capilano Reservoir 2014-2023 (2023 only)	Seymour Reservoir 2014-2023 (2023 only)	Coquitlam Reservoir 2014-2023 (2023 only)
Total Phosphorus (µg/L)	5.0	3.1 (3.2)	3.1 (2.6)	3.1 (2.4)
Total Nitrogen (µg/L)	250	121 (110)	120 (115)	127 (114)
Phytoplankton Biomass (µg/L of chlorophyll-a)	0.5	0.48 (0.91)	0.55 (0.57)	0.59 (0.63)
Status of Reservoirs		Ultra-oligotrophic	Ultra-oligotrophic	Ultra-oligotrophic

¹Wetzel, R.G. 2001 Lake and River Ecosystems. 3rd edition. Academic Press. New York.

The Trophic State Index (TSI) is used to infer change over time in water quality based on the amount of algal biomass in the water column of each source reservoir. Figure 3 shows TSI values over the last 10 years for each of the three primary reservoirs, which will continue to be tracked and referenced to assist in monitoring changing weather, climate and nutrient conditions.

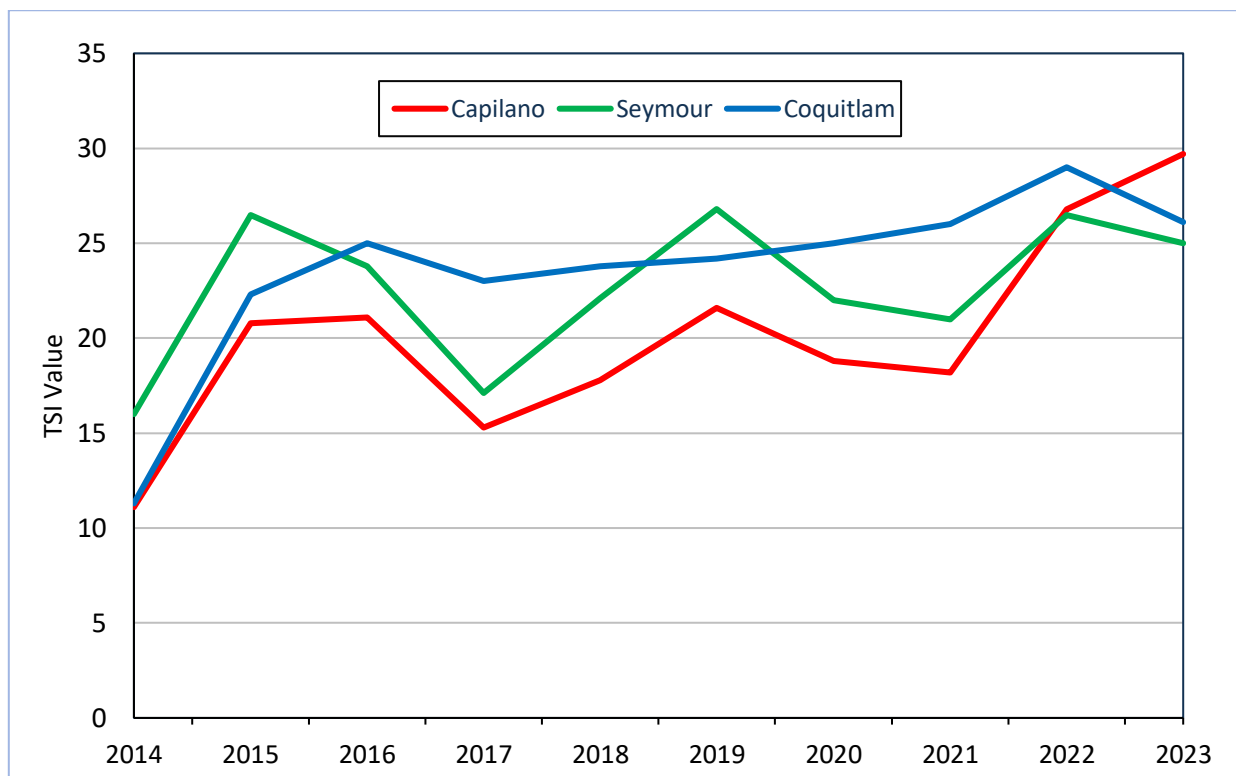


Figure 3: Trophic State Index of Source Waters

The ultra-oligotrophic classification and low TSI values are highly desirable for source drinking water supply and shows that the GVWD Water Supply Areas continue to supply high quality source water.

There is worldwide interest in blue-green algae (also known as cyanobacteria) in drinking water reservoirs. These algae can produce toxins that are collectively known as microcystins. A common cyanobacterium in

GVWD reservoirs is called *Merismopedia* spp., which is thought to produce these microcystins. Despite the presence of cyanobacteria, the concentration of microcystins in GVWD reservoirs remains below the level of 1.5 µg/L stipulated in the GCDWQ. This desirable condition is due to the ultra-oligotrophic status of the supply reservoirs. Metro Vancouver continues to monitor cyanobacteria, including *Merismopedia* spp., as well as processes in the source reservoirs that control the growth of cyanobacteria and other algae. These data are routinely used to help predict changes to water quality over time related to climatic and environmental change, and aid in making proactive decisions about ongoing source reservoir management strategies.

2.0 Quality Control Assessment of Water Treatment

Primary treatment of the source water is the second barrier, following source water protection, used to assure the quality of the water supply.

Metro Vancouver filters water from the Capilano and Seymour source reservoirs at the SCFP, which is located in GVWD's Lower Seymour Conservation Reserve. Twin tunnels connect the two supply sources. The untreated Capilano source water is pumped through the Raw Water Tunnel and is blended with the Seymour source water (under regular operations) at the inlet to the SCFP. Both treated sources enter the Clearwell at the SCFP for further treatment before the blended water is transmitted to the region, supplying about two thirds of the region's drinking water. Blended treated water returns to the Capilano service area through the Treated Water Tunnel, providing high quality drinking water to the Capilano area, while the remainder is transmitted through the Seymour system. This system typically supplies about two thirds of the region's drinking water.

The CWTP is located north of the City of Coquitlam, and typically supplies about one third of the region's drinking water. Due to the historically low turbidity levels, the Coquitlam source water is not filtered.

Metro Vancouver operates the water supply system under the *GVWD Permit to Operate* issued jointly by Vancouver Coastal Health and Fraser Health. The permit stipulates that Metro Vancouver must meet the requirements to achieve at least a 4-log (99.99%) reduction and/or inactivation of Viruses, and at least a 3-log (99.9%) reduction and/or inactivation of *Giardia* cysts and *Cryptosporidium* oocysts. Operationally, Metro Vancouver meets the permit requirements, managing the microbial risks using a combination of direct filtration, ultraviolet (UV) light and chlorine at the SCFP, and ozone, UV light and chlorine at the CWTP.

2.1. Seymour Capilano Filtration Plant

The SCFP is a chemically assisted direct filtration plant, which uses polyaluminum chloride as a coagulant with polymers to improve particle removal. These substances help aggregate particles to form visible floc. The flocculated particles are removed by passing this water through a filter medium of anthracite and sand. The result is the production of filtered water, which is then exposed to UV light as the water exits each filter. The final processes are the addition of sodium hypochlorite (chlorine) and calcium hydroxide (hydrated lime) before the water enters the Clearwell. The Clearwell, divided into the West and East Cells, is a large water storage reservoir that stores and allows controlled passage and mixing of water with the injected chlorine and hydrated lime. The Clearwell provides sufficient retention (or contact time) with chlorine to provide any further disinfection required after filtration and UV light treatment.

As part of corrosion control, Carbon dioxide (CO₂) in solution is added to trim pH once the desired alkalinity is reached using hydrated lime. After the Clearwell, the finished water enters the transmission system at the Seymour Treated Water Valve Chamber. The quality of the water produced has been excellent leaving the SCFP.

2.1.1. Filtration

Filtration of the Capilano and Seymour water sources improves the characteristics of the delivered water. One improvement is the removal of the brown hue that is characteristic of Capilano and Seymour source waters. This is achieved with the removal of naturally occurring compounds, resulting in a visible decrease in colour and increase in clarity. In addition, suspended particles in water that cause light to scatter (turbidity) are also removed. The end product is water that is very clear, and may have a slight bluish tinge.

Figure 4 compares the apparent colour of SCFP filtered water with Capilano and Seymour source waters for 2023. During a winter rainfall event, the apparent colour of the Seymour and Capilano source waters feeding the SCFP each had a reading of 34 Apparent Colour Unit (ACU). After the removal of the organic material through filtration, the colour was 2 ACU. Throughout 2023, the colour of the filtered water delivered to the public was never greater than 3 ACU.

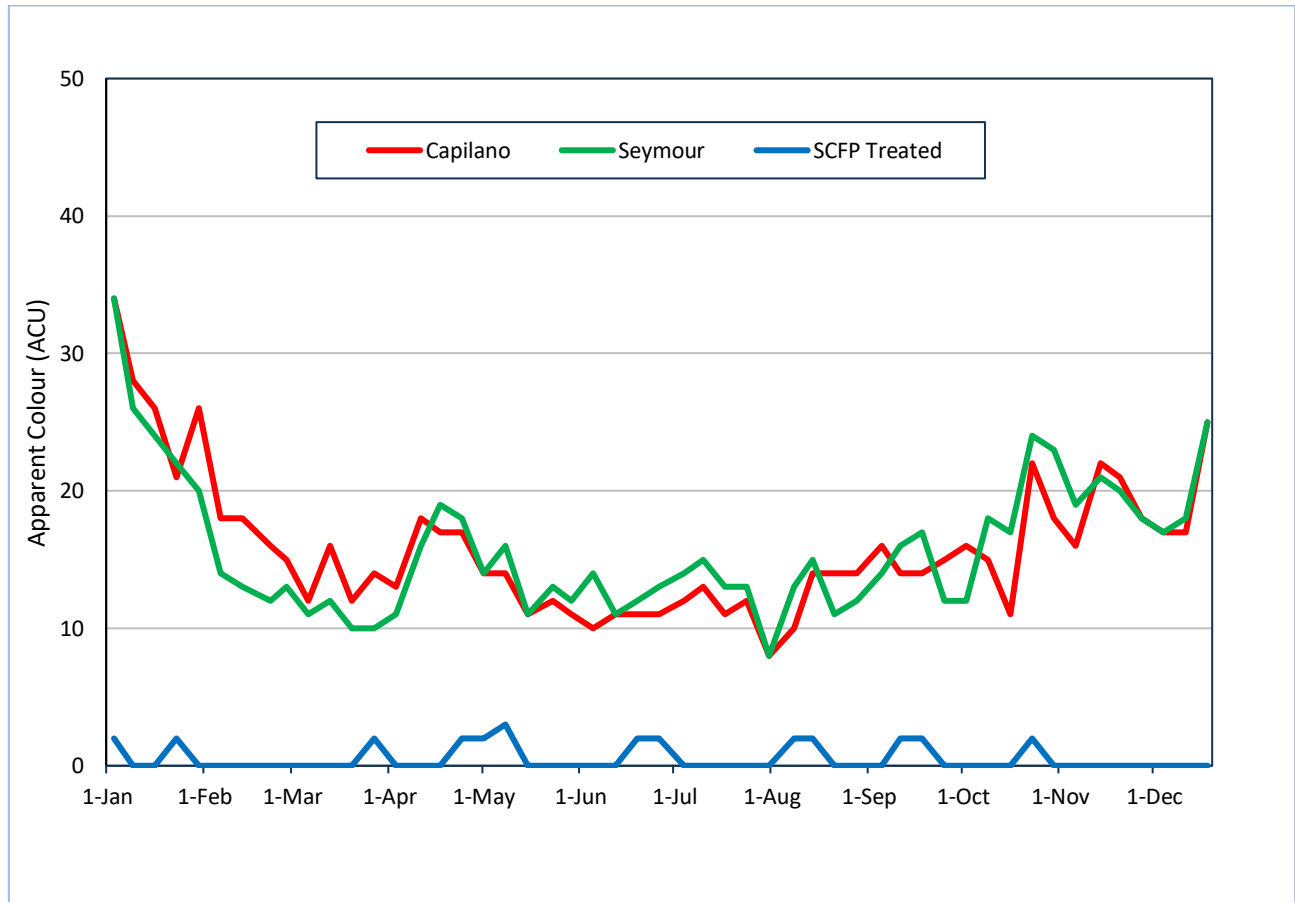


Figure 4: Apparent Colour Levels Before and After Filtration

Figure 5 compares turbidity of the two source waters that feed the SCFP to the turbidity level of the finished water. The Seymour source experienced an average daily turbidity greater than 1.0 NTU during 61 days. The Capilano source exceeded 1.0 NTU during 146 days. Since both sources are filtered at the SCFP, the maximum turbidity of the treated water was 1.10 NTU, measured on January 12, and the annual average was 0.22 NTU.

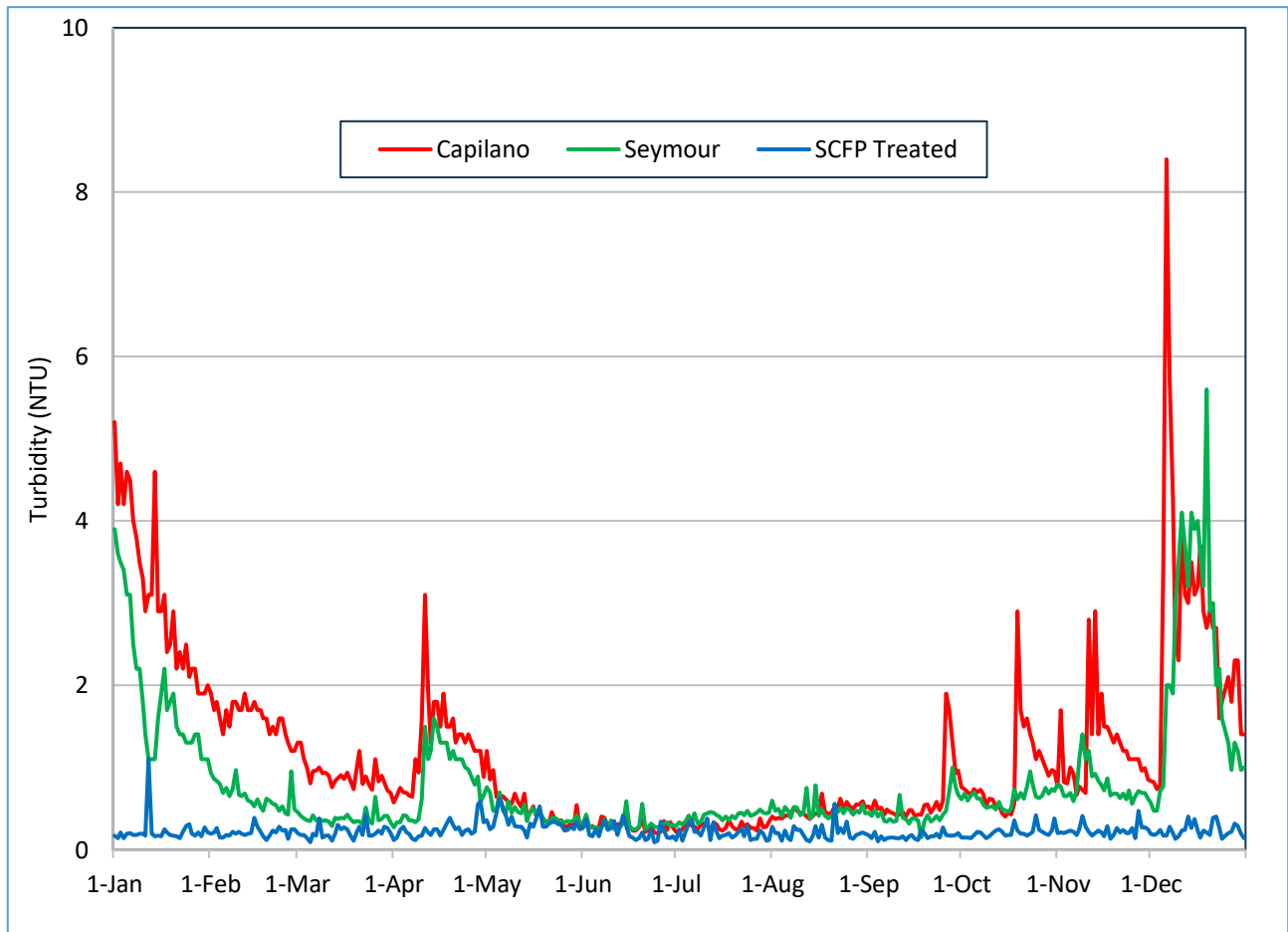


Figure 5: Daily Turbidity Levels Before and After Filtration

Removal of turbidity in the source water improves the aesthetic qualities of the water, but it also has the benefit of removing certain types of pathogenic microorganisms that may be present. At a minimum, properly run direct filtration plants such as the SFCP will remove up to 2.5 log (two log is a 99% reduction) of *Giardia* and *Cryptosporidium*, plus 1 log of viruses. To ensure this removal, it is critical that the performance of each filter determined by the turbidity of its effluent is monitored on a continuous basis.

The GCDWQ states: *“For conventional and direct filtration, less than or equal to 0.3 nephelometric turbidity units (NTU) in at least 95% of measurements either per filter cycle or per month and never to exceed 1.0 NTU.”*

According to the GCDWQ, ideally, the turbidity from each filter would never exceed 0.1 NTU; however, there are rare occurrences of turbidity readings that exceed this ideal level. The turbidity performance of all 24 filters is measured by examining the percent of time that the turbidity of each Individual Filter Effluent (IFE) met the turbidity guidelines of not greater than 1.0 NTU, and at least 95% of the time less than 0.3 NTU. This is summarized in Table 7. In 2023, there were no incidents where the IFE was greater than 1.0 NTU, and the few incidences of filter turbidity readings that were greater than 0.3 NTU were well within the 95% limit.

Table 7: Monthly Filter Effluent Turbidity Summary

Month	Occurrence of IFE Turbidity greater than 1.0 NTU (None Allowed)	Percent of Time IFE Turbidity was less than 0.3 NTU (Minimum 95% Required)
January	0	99.999
February	0	100
March	0	100
April	0	100
May	0	100
June	0	100
July	0	100
August	0	100
September	0	100
October	0	100
November	0	100
December	0	99.995

Under normal operating conditions, the average maximum turbidity of the water, post filtration, and before disinfection and corrosion control at SCFP was 0.05 NTU.

All water that flows through the filters immediately passes through the UV units. The intensity of the UV lamps automatically increases when there is an increase in turbidity or colour of the water exiting each filter. After UV treatment, the water is chlorinated as it enters the Clearwell.

2.1.2. Ultraviolet Treatment

The effluent from each filter is treated with UV light as the water exits the filter. UV treatment is effective in altering the DNA structure of *Giardia* and *Cryptosporidium* thus rendering cysts and oocysts, respectively, of these parasites, non-infectious. Other disinfectants, especially chlorine, are ineffective against *Cryptosporidium* oocysts at reasonable dosages. In the unlikely event of a breakthrough of *Cryptosporidium* oocysts, especially at the end of a filter run, UV light is present to render any parasites that may be present as non-infectious. Cysts and oocysts are not able to proliferate inside the intestines of human hosts to cause illness after a sufficient dose of UV light. The target dosage for UV light is to achieve 2-Log (99%) *Giardia* and *Cryptosporidium* inactivation.

Under normal operating conditions, two rows of lamps operating at 75% power provide sufficient UV light to meet the dosage requirement for 2-log reduction of *Giardia* and *Cryptosporidium*.

Table 8 summarizes the performance of the SCFP UV system in 2023.

Table 8: Percent of Volume Meeting Ultraviolet Dosage Requirements at SCFP

Month	Percent of Monthly Volume $\geq$ 2-log of <i>Giardia</i> and <i>Cryptosporidium</i> Inactivation (95 of monthly volume required)
January	99.93
February	99.97
March	99.95
April	99.97
May	99.95
June	99.95
July	99.96
August	99.95
September	99.95
October	99.95
November	99.87
December	99.93

2.1.3. Chlorination

Chlorination is used for disinfection at the SCFP, as well as at downstream secondary disinfection stations, to minimize bacterial regrowth in the GVWD transmission and GVWD supplied distribution systems. Chlorination provides 4-log virus inactivation with liquid sodium hypochlorite. The chlorination system was operational 100% of the time in 2023.

2.2. Coquitlam Water Treatment Plant

The Coquitlam Water Treatment Plant (CWTP) treats the Coquitlam source water using multiple disinfection barriers, specifically, ozone, UV and chlorine, and provides corrosion control. The Coquitlam source water is not filtered. Ozone contact is achieved in a stainless steel contactor pipeline that connects the Ozonation facility with the Corrosion Control and Chlorination facility. The primary function of ozone is to improve the transmissivity of the water (clarity) for subsequent UV light treatment and oxidize organic precursors responsible for the formation of disinfection by-products (DBPs) following chlorination.

Ozone also provides disinfection capacity for *Giardia* and viruses. UV light is the primary process for inactivation of *Giardia* and *Cryptosporidium* and chlorine for viruses. Corrosion control is achieved using sodium carbonate and CO₂; the latter is added to trim the pH once the desired alkalinity is reached. After chlorination, the finished water enters the transmission system. The quality of the water produced has been excellent leaving the CWTP.

2.2.1. Ozonation

Ozone is intended as a pre-treatment, however, also provides backup for inactivation of *Giardia* when the UV treatment system is offline. Ozonation also provides additional virus inactivation to chlorination. The ozonation system was operational for 99.4% of the time in 2023. The ozone outages were due to a combination of planned and unplanned events that included electrical/instrument maintenance, ozone dosing tests, and ozone generator faults, testing or power loss.

2.2.2. Ultraviolet Treatment

UV light treatment provides for primary disinfection, and achieves 3-log inactivation of the chlorine-resistant micro-organisms, *Giardia* and *Cryptosporidium*. The water is directed into 8 UV units. BC *Guidelines for Ultraviolet Disinfection of Drinking Water* requires that the ultraviolet disinfection process results in target *Giardia* and *Cryptosporidium* inactivation in at least 95% of the treated water volume on a monthly basis, which is summarized in Table 9. There was no loss of UV in 2023 and 99.89% of the water volume was treated to the above specifications; the small percentage of water that did not meet the criteria was the result of unexpected issues, as well as planned power outages required to test the emergency back-up power system.

Table 9: Percent of Volume Meeting Ultraviolet Dosage Requirements at CWTP

Month	Percent of Monthly Volume $\geq$ 3-log <i>Giardia</i> and <i>Cryptosporidium</i> Inactivation (Minimum 95% Required)
January	99.86
February	99.87
March	99.87
April	99.90
May	99.90
June	99.86
July	99.93
August	99.93
September	99.94
October	99.92
November	99.80
December	99.91

2.2.3. Chlorination

Chlorination is used for disinfection at the CWTP, as well as at secondary disinfection stations to minimize bacterial regrowth in the GVWD transmission and GVWD supplied distribution systems. Chlorination provides 4-log virus inactivation using a liquid sodium hypochlorite solution. The chlorination system operated 100% of the time in 2023.

2.3. Secondary Disinfection

There are eight secondary disinfection stations operated by Metro Vancouver. The purpose of these stations is to increase the chlorine residual in the GVWD transmission and GVWD supplied distribution systems to meet a target residual based on a number of factors, including source water turbidity, the

amount of bacterial regrowth detected in GVWD supplied distribution system samples, and the chlorine demand in the water. The rate of chlorine decay is lower in the areas receiving filtered water from the SCFP and consequently, lower chlorine dosage levels are required to maintain desired chlorine residual levels. The target chlorine residual leaving the SCFP is 0.8 mg/L. The target chlorine residual leaving the CWTP ranges from 1.20 to 1.50 mg/L. These chlorine residuals leaving the treatment plants have been established to maintain target chlorine residuals throughout the transmission system of 0.5 mg/L or greater. The secondary disinfection facilities receiving SCFP water frequently have an incoming chlorine residual high enough that boosting is not required.

Table 10 summarizes the performance of the secondary disinfection facilities in 2023.

Table 10: Performance of Secondary Disinfection Facilities

Facility	Branch Main	Average Free Chlorine (mg/L)	Range of Free Chlorine (mg/L)	Source Water
Clayton	Whalley/Clayton	1.22	1.01-1.58	Supplied by CWTP water.
	Jericho/Clayton	1.22	1.02-1.62	
Chilco	Capilano No.4 and No.5	0.74	0.60-0.85	Supplied by SCFP water.
Pitt River	Haney Main No.2	1.23	0.96-1.60	Supplied by CWTP water.
	Haney Main No.3	1.23	1.00-1.61	
Newton	Surrey Hickleton Main	1.10	0.56-1.54	Alternately supplied by SCFP and CWTP water. During the low demand season, the re-chlorination station was by-passed as per the request from the City of Surrey for their operations.
Kersland	Capilano No.4 and No.5	0.87	0.72-1.09	Supplied by SCFP water.
Central Park	South Burnaby Main No.1	0.77	0.66-0.95	Primarily supplied by SCFP water. Occasionally supplied by CWTP water, depending on flow demands.
	South Burnaby Main No.2	0.91	0.66-1.22	
Cape Horn	Coquitlam Main No.2	1.23	0.90-1.64	Supplied by CWTP water.
	Coquitlam Main No.3	1.23	1.07-1.60	
Vancouver Heights	Boundary Road Main No.5	0.84	0.75-0.98	Supplied by SCFP water.

2.4. Corrosion Control

Metro Vancouver’s corrosion control program began in the 1990s, and involves several steps to reduce pipe corrosion. As part of the current *Corrosion Control Program: Copper Pipes Protection* initiative, further changes in pH and alkalinity were made in June 2021 to help reduce pipe corrosion through the addition of natural minerals. Corrosion control parameters are continually monitored to assess need for future adjustments.

The untreated water from all three sources had a pH lower than the limit of the GCDWQ of pH 7.0.

In the SCFP process, filtered water is dosed with calcium hydroxide (hydrated lime) to raise its pH and alkalinity before it enters the Clearwell. To achieve the desired alkalinity, the resultant pH is trimmed using CO₂ to bring it down to target levels.

At the Coquitlam source, the commissioning of the CO₂ system at the CWTP began in 2019, and was fully operational in 2021. The CO₂ system, with the addition of sodium carbonate (soda ash), allows the GVWD to meet new target pH and alkalinity values across the entire transmission system. Similar to the SCFP, the CO₂ system is used to trim the resultant pH to desired target levels.

The average pH of the treated water leaving SCFP and CWTP was 8.6 and 8.4, respectively, during 2023.

Performance of the corrosion control facilities is summarized in Table 11.

Table 11: Performance of Corrosion Control Facilities

Facility	Performance	Discussion
SCFP Corrosion Control	pH ranged from 7.9 – 9.3	The annual average pH was 8.6, was continually monitored with online instrumentation, and within the GCDWQ range.
CWTP Corrosion Control	pH ranged from 6.8 – 9.6	The annual average pH was 8.4 and continually monitoring with online instrumentation. The GCDWQ of 7.0-10.5 was not met on June 14 for 1 hour due to an equipment fault, when the pH dropped to 6.8.

3.0 Transmission/Distribution System Water Quality

Schedule A of the BC *Drinking Water Protection Regulation* (DWPR) contains standards for the bacteriological quality of potable water in the province. There are three components of this standard that apply to large utilities such as GVWD and GVWD supplied systems. These are:

Part 1: No sample should be positive for *E. coli*.

Part 2: Not more than 10% of the samples in a 30-day period should be positive for total coliform bacteria when more than one sample is collected.

Part 3: No sample should contain more than 10 total coliform bacteria per 100 mL.

The DWPR does not contain any water standards other than the three limits for *E. coli* and total coliform bacteria. Information on the significance of the detection of these organisms can be found in the GCDWQ – Supporting Documents, specifically:

“E. coli is a member of the total coliform group of bacteria and is the only member that is found exclusively in the faeces of humans and other animals. Its presence in water indicates not only recent faecal contamination of the water but also the possible presence of intestinal disease-causing bacteria, viruses and protozoa.”

“The presence of total coliform bacteria in water in the distribution system (but not in water leaving the treatment plant) indicates that the distribution system may be vulnerable to contamination or may simply be experiencing bacterial regrowth.”

To summarize, the detection of an *E. coli* bacteria in a sample of treated water is an indication of a potentially serious risk. The detection of total coliform bacteria may indicate intrusion into the system, or it may indicate that these bacteria are growing in the system itself (regrowth).

In 2023, 99.8% of the samples tested were negative for coliforms, which is a good indicator of effective water treatment and good transmission and distribution system water quality.

3.1. Microbiological Water Quality in the GVWD System

3.1.1. GVWD Water Mains

Water quality in GVWD water mains is monitored from the point leaving the source and throughout the transmission system. In 2023, there were approximately 4,400 samples collected and tested for the presence of indicator bacteria. The percentage of samples from the GVWD water mains that were positive for total coliform bacteria was very low, and well below the 10% standard. Of the approximately 4,400 samples processed, 14 samples tested positive for total coliforms of which two samples were greater than 10 CFU/100mL. In both instances the residual chlorine values were high and follow up samples did not detect any total coliforms. No samples were positive for *E. coli* bacteria. The compliance of monitoring results from GVWD water mains with BCDWPR criteria is shown in Figure 6.

There were another 434 samples collected from stations where only chlorine residuals are measured. In addition, there are inline stations collecting chlorine data every 10-minutes after chlorination at each source, but these samples are not included in the calculations for compliance monitoring.

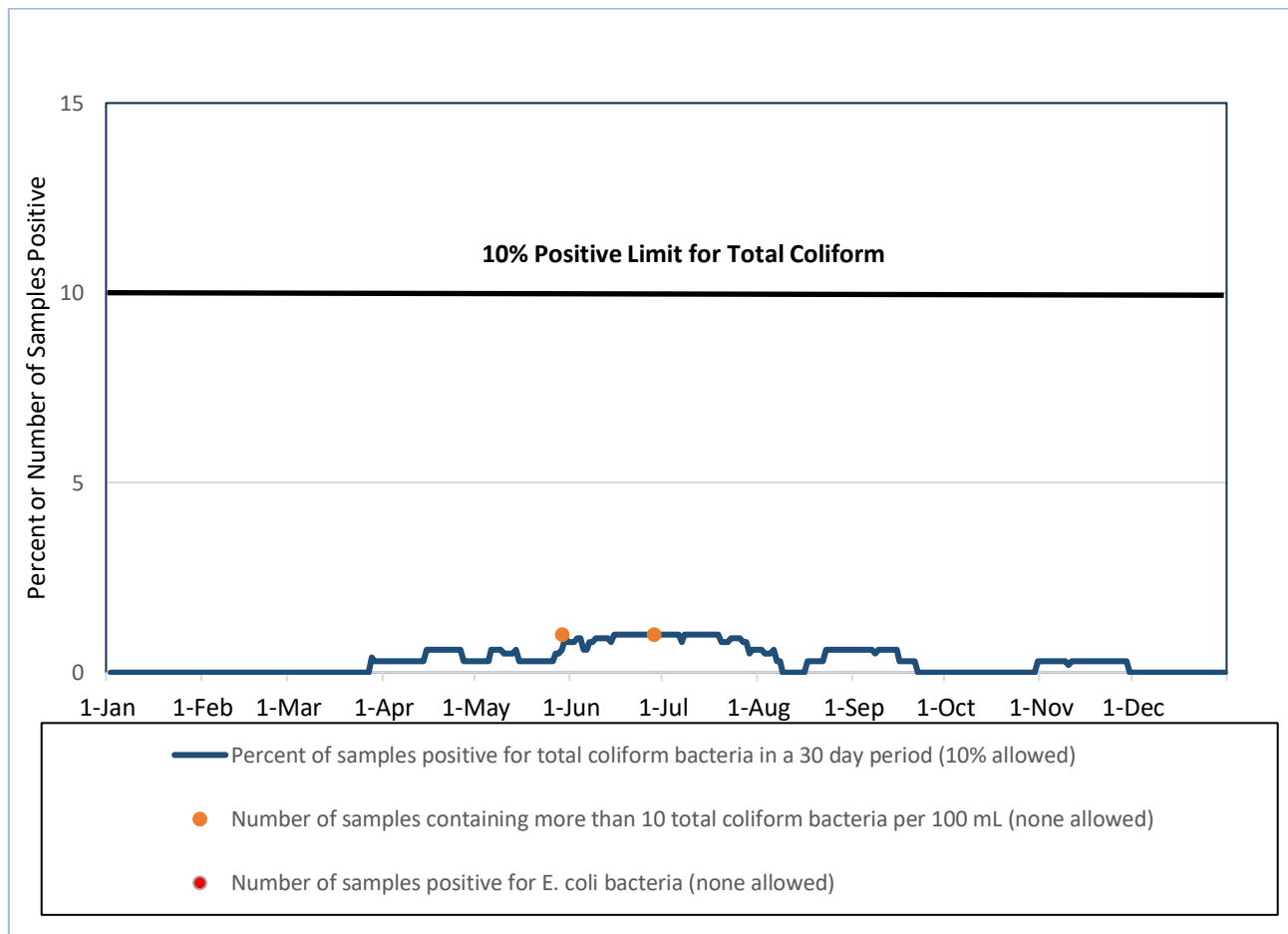


Figure 6: Bacteriological Quality of Water in GVWD Water Mains

3.1.2. GVWD In-System Reservoirs

In 2023, over 1,600 samples were collected from reservoirs that are located throughout the GVWD transmission system. Two samples were positive for total coliforms. No sample from a reservoir was positive for *E. coli*.

The compliance of 2023 monitoring results from GVWD reservoirs with the criteria in the DWPR is shown in Figure 7.

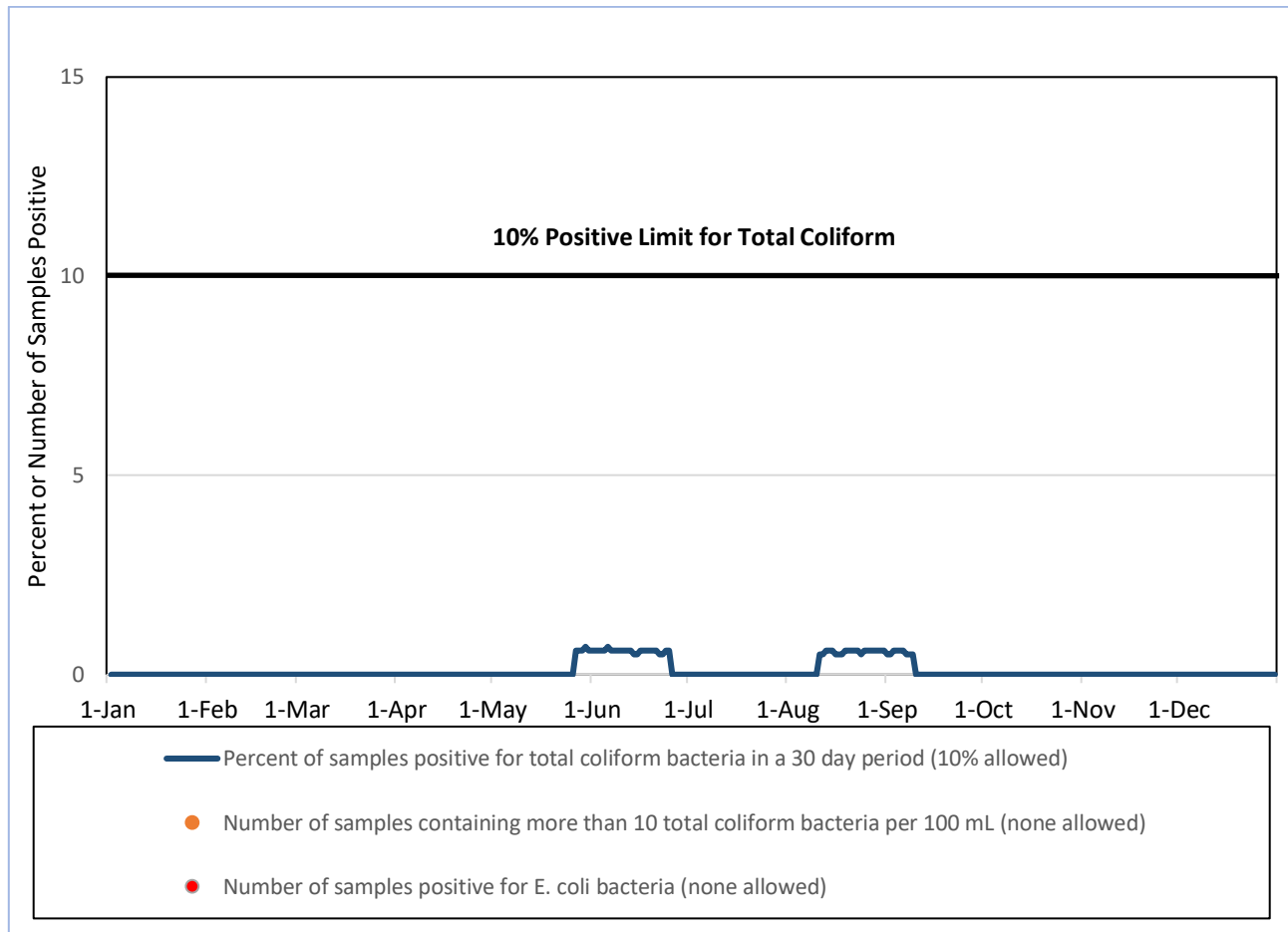


Figure 7: Bacteriological Quality of Water in GVWD In-System Reservoirs

Reservoir water quality is optimized by the use of secondary disinfection coupled with an active reservoir exercising program. As a minimum, weekly monitoring of chlorine residuals and bacteriology results is conducted, which helps inform the need for operational changes to filling cycles.

Table 12 provides an overview of the status of the GVWD reservoirs from 2020 to 2023. During certain times of the year, it is not possible to cycle reservoirs as often as desired due to operational constraints. Despite this constraint, only two samples out of more than 1,600 samples taken from in-system reservoirs contained total coliforms. The water quality as determined by coliform bacteria was excellent in all reservoirs.

Table 12: Status of GVWD Reservoirs (2020-2023)

Reservoir (Capacity in Million Litres)	Average free chlorine residual (mg/L)				Discussion
	2020	2021	2022	2023	
Burnaby Mountain Reservoir (13.2)	0.57	0.53	0.49	0.43	No operational issues.
Burnaby Tank (2.3)	0.60	0.57	0.56	0.52	No operational issues.
Cape Horn Reservoir (40.0)	0.78	0.71	0.78	0.82	No operational issues.
Central Park Reservoir (35.0)	0.66	0.54	0.56	0.43	Cleaned February 27 – April 3, 2023.
Clayton Reservoir (21.6)	1.08	1.1	1.05	1.09	Cell 1 was out of service for low demand season, winter 2022-2023. Cleaned April 11-April 16. Returned to service April 16 for high demand season. Cell 2 isolated November 3 for low demand season, will return to service in Spring 2024.
Glenmore Tanks (1.0)	0.77	0.73	0.67	0.68	No operational issues
Grandview Reservoir (13.5)	0.80	0.85	0.84	0.71	Out of service and Cleaned November 22-December 15.
Greenwood Reservoir (8.8)	0.75	0.70	0.68	0.70	No operational issues.
Hellings Tank (4.3)	0.54	0.56	0.52	0.44	Cell 1 was out of service and cleaned March 27-April 7. Returned to service April 7.
Jericho Reservoir (20.0)	N/A	1.10	0.92	0.87	Cell 1 was isolated November 14 for low demand season. Will return to service in Spring 2024. Cell 2 was commissioned on June 21.
Kennedy Reservoir (16.3)	0.58	0.65	0.60	0.57	No operational issues.
Kersland Reservoir (73.7)	0.66	0.65	0.61	0.53	No operational issues.
Little Mountain Reservoir (171.0)	0.72	0.69	0.66	0.65	No operational issues.
Maple Ridge Reservoir (20.0)	0.44	0.46	0.43	0.52	Reservoir was cleaned by divers in December.
Newton Reservoir (32.0)	0.55	0.44	0.64	0.45	Cell 1 isolated October 16 for the low demand season. Cell 2 cleaned April 17-April 25, returned to service April 28.
Pebble Hill Reservoir (42.2)	0.66	0.54	0.61	0.49	Cell 1 cleaned April 24-May 4. Cell 2 cleaned May 1-10. Cell 3 isolated November 1 for low demand season.
Prospect Reservoir (4.4)	0.76	0.73	0.69	0.70	No operational issues.
Sasamat Reservoir (26.0)	0.65	0.62	0.61	0.50	No operational issues.
Sunnyside Reservoir (22.7)	0.73	0.85	0.78	0.68	No operational issues.
Vancouver Heights Reservoir (43.0)	0.82	0.78	0.71	0.75	No operational issues.
Westburnco Reservoir (73.0)	0.64	0.60	0.65	0.55	No operational issues.
Whalley Reservoir (33.4)	0.73	0.71	0.65	0.72	No operational issues.

3.2. Microbiological Water Quality in GVWD Supplied Systems

For samples collected from GVWD supplied systems, the percent positive per month for total coliform bacteria from 2020-2023 is shown in Figure 8.

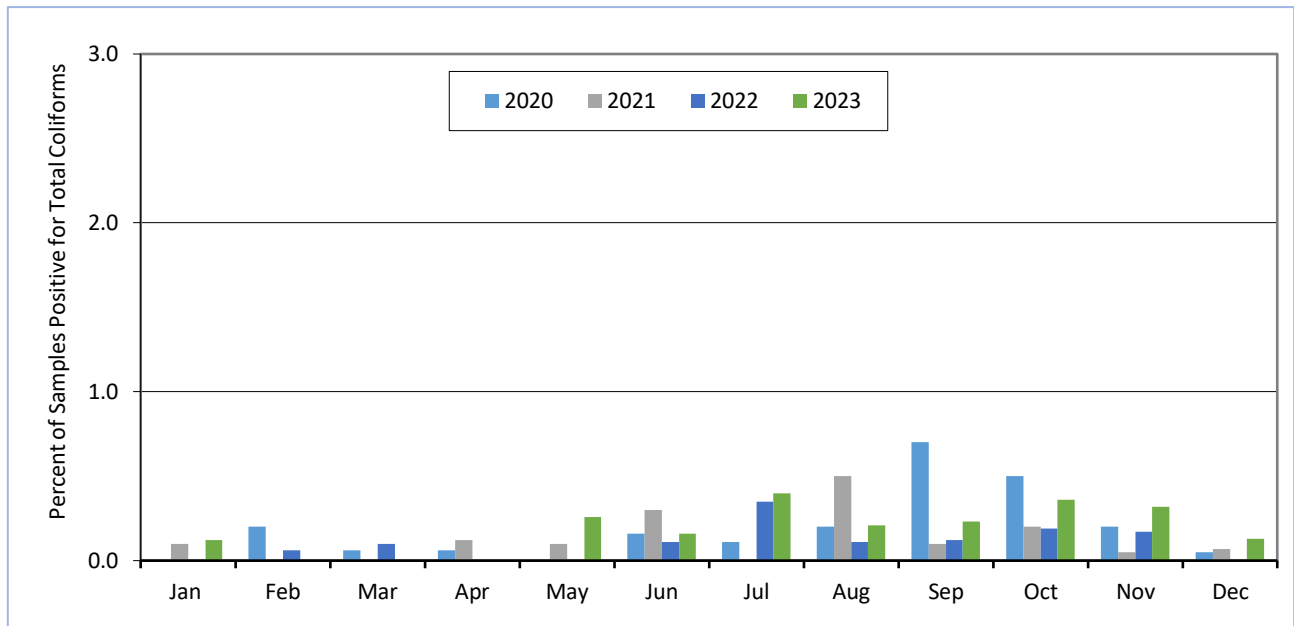


Figure 8: Bacteriological Quality of Water in GVWD Supplied Systems

The percentage of samples positive for total coliform bacteria continues to be low; the annual average in 2023 was 0.18%.

For Part 1 of the DWPR, no sample should be positive for *E. coli*. A single sample in October from a GVWD supplied system was positive for *E. coli*. All subsequent samples taken over the following three days were negative.

For Part 2, not more than 10% of the samples in a 30-day period should be positive for total coliform bacteria when more than one sample is collected. While there were 40 samples with total coliforms detected out of over 21,200, none of the GVWD supplied systems had more than 10% of samples positive for total coliforms.

For Part 3, no sample should contain more than 10 total coliform bacteria per 100 mL; for samples from GVWD supplied systems, this requirement was met in 2023 with the following six exceptions: one in June, two in July, one in August and two in November. Follow up samples did not detect any total coliforms.

Table 13 shows the compliance with the bacteriological standards (3 parts) in the DWPR for samples taken within the distribution systems of the 21 water systems that are supplied with GVWD water.

Table 13: GVWD Connected Water Systems Water Quality Compared to the Provincial Bacteriological Standards

Month	Number of water systems that met Part 1 No sample should be positive for <i>E.coli</i>	Number of water systems that met Part 2 Not more than 10% of the samples in a 30-day period should be positive for total coliform bacteria	Number of water systems that met Part 3 No sample should contain more than 10 total coliform bacteria per 100 mL	Number of water systems that met all requirements
January	21	21	21	21
February	21	21	21	21
March	21	21	21	21
April	21	21	21	21
May	21	21	21	21
June	21	21	20	20
July	21	21	19	19
August	21	21	20	20
September	21	21	21	21
October	20	21	21	20
November	21	21	19	19
December	21	21	21	21

3.3. Disinfection By-Products in the Transmission/Distribution Systems

As the treated water moves through the GVWD transmission system and into the infrastructure of distribution systems connected to the GVWD, changes in water quality occur. This is mainly due to the reaction between the chlorine in the water (added during primary and secondary disinfection) with naturally occurring organic matter in the water.

One of the most significant changes is the production of chlorinated Disinfection By-Products (DBPs). DBPs is a term used to describe a group of organic and inorganic compounds formed during water disinfection.

Reactions between dissolved natural organic matter and chlorine can lead to the formation of a variety of halogenated DBPs. There are two major groups of chlorinated DBPs: Trihalomethanes and Haloacetic Acids. Total Trihalomethanes (TTHMs) represents the four compounds: chloroform, bromodichloromethane, dibromochloromethane, and bromoform. Total Haloacetic Acids (THAAs) represents five of the compounds: dibromoacetic acid, dichloroacetic acid, monobromoacetic acid, monochloroacetic acid and trichloroacetic acid. Factors that affect DBP formation, include: amount of chlorine added to water, reaction time, concentration and characteristics of dissolved organic materials (precursors), water temperature, and water pH. In general, DBPs continue to form as long as chlorine and reactive DBP precursors are present in the water.

The MAC in the GCDWQ for TTHMs is a locational yearly running average of 100 µg/L (0.1 mg/L) based on quarterly samples. A comparison of TTHM levels in the GVWD and GVWD supplied systems in 2023 is shown in Figure 9. All TTHM results from GVWD water mains and GVWD supplied systems were below the MAC of 100 µg/L.



2023 Average GVWD System TTHM = 26 ppb
 2023 Average GVWD Supplied Systems TTHM = 34 ppb

TTHM Levels for GVWD System Sites		TTHM Levels at GVWD Supplied Systems Sites	
	≥ 0 and < 20		≥ 0 and < 20
	≥ 20 and < 40		≥ 20 and < 40
	≥ 40 and < 60		≥ 40 and < 60
	≥ 60 and < 80		≥ 60 and < 80
	≥ 80 and < 100		≥ 80 and < 100
	≥ 100		≥ 100

MAC for TTHM is 100 µg/L (or ppb)

Figure 9: Average Total Trihalomethane Levels

The other group of DBPs of interest is the THAA group. Comparison of THAA in the GVWD and GVWD supplied systems in 2023 is shown in Figure 10. In 2023, all THAA results from GVWD water mains and GVWD supplied systems were below the MAC of 80 µg/L.



2023 Average GVWD System THAA = 20 ppb

2023 Average GVWD Supplied Systems THAA = 20 ppb

THAA Levels for GVWD System Sites		THAA Levels at GVWD Supplied Systems Sites	
	≥ 0 and < 20		≥ 0 and < 20
	≥ 20 and < 40		≥ 20 and < 40
	≥ 40 and < 60		≥ 40 and < 60
	≥ 60 and < 80		≥ 60 and < 80
	≥ 80 and < 100		≥ 80 and < 100
	≥ 100		≥ 100

MAC for THAA is 80 µg/L (or ppb)

Figure 10: Average Total Haloacetic Acid Levels

4.0 Quality Assurance/Quality Control

Since 1994, the Metro Vancouver Microbiology Laboratory has participated in the BC Centre for Disease Control Public Health Laboratory Enhanced Water Quality Assurance Program, and has been approved by the Provincial Medical Health Officer to perform microbiological analysis of drinking water as required in the DWPR. An ongoing requirement of this approval is successful participation in the provincial *Clinical Microbiology Proficiency Testing Program*, or its equivalent. Representatives of the Approval Committee for Bacteriology Laboratories inspect the Metro Vancouver Microbiology Laboratory at the Lake City Operations Centre on a routine basis as part of the on-going approval process by the Provincial Health Officer. The next inspection is planned for 2025.

In addition to the approval process discussed above, the Metro Vancouver Laboratories are accredited by the Canadian Association for Laboratory Accreditation (CALA) for the analysis of specific parameters to the ISO/IEC 17025 *General requirements for the competence of testing and calibrations laboratories* international standard.

Representatives from CALA have assessed the Metro Vancouver Laboratories bi-annually since 1995. The most recent on-site audit took place in September 2023, and the Metro Vancouver Laboratories have been granted accreditation until 2026. The next CALA assessment will take place in the fall of 2025. The Scope of Accreditation is available on the CALA website – www.cala.ca.

The *Canadian Biosafety Standard* is the national standard for facilities where human and terrestrial animal pathogens are handled and regulated by the Public Health Agency of Canada (PHAC) under the *Human Pathogens and Toxins Act* and the *Human Pathogens and Toxins Regulations*. PHAC oversees the biosafety and biosecurity operations of the Metro Vancouver microbiology laboratory and periodically carries out facility inspections. Such an inspection was performed in February 2023 with no major deficiencies observed, and any minor observations have been corrected.

5.0 Results Summary

Source Water Quality

- Turbidity levels of the delivered water met the requirements of the GCDWQ.
- The Capilano supply was in service for the entire year. Heavy rainfall events in early December resulted in the Capilano source water turbidity peaking just over 8.4 NTU.
- The Seymour supply was in service for the entire year. Heavy rainfall events in late 2022 resulted in the Seymour source starting 2023 with its highest turbidity reading of 3.7 NTU.
- The Coquitlam supply was in service for the entire year. The unfiltered Coquitlam source water was greater than 1.0 NTU for 5 days, but did not exceed 5.0 NTU anytime in the year. The system supplied drinking water in compliance with *GVWD Permit to Operate*.
- The microbiological quality of the three source waters was excellent. The levels of bacteria and protozoa detected were low, and indicative of high quality source water.
- Coquitlam source water quality met the bacteriological requirements for an unfiltered source supply as specified in the GCDWQ.
- Results of the source water analyses for herbicides, pesticides, volatile organic compounds and radionuclides were all found to be below the recommended limits as listed in the GCDWQ.

Water Treatment

- The Seymour Capilano Filtration Plant (SCFP) performance, as measured by the quality of the delivered water, was excellent. The daily average turbidity of water leaving the Clearwell to enter the GVWD transmission system was an average of 0.29 NTU.
- Turbidity levels for Individual Filter Effluent met the turbidity requirements of the GCDWQ.
- Filtration consistently removed iron, colour and naturally occurring organics from the Capilano and Seymour source water.
- There were no outages of disinfection treatment at the SCFP, or the Coquitlam Water Treatment Plant (CWTP).
- In June, there was a one-hour outage of corrosion control at CWTP, resulting in a temporary low pH of 6.8 leaving the plant.
- The secondary disinfection stations increased the residual chlorine when required.

Transmission/Distribution System Water Quality

- Bacteriological water quality was excellent in the GVWD transmission water mains and in-system storage reservoirs. The number of *E. coli* detected in samples from both GVWD and water systems supplied with GVWD water is typically very low. More than 29,400 samples were collected and analyzed for GVWD and GVWD supplied systems, of which one member jurisdiction sample was positive for *E. coli*. Three repeat samples were taken, and no additional *E. coli* were found.
- The average levels of the Total Trihalomethane chlorine disinfection by-products measured in the delivered water in the GVWD and member jurisdiction systems were 26 µg/L (0.026 mg/L) and 34 µg/L (0.034 mg/L), respectively. The average level for the Total Haloacetic Acid chlorine disinfection by-products measured in the delivered water in both the GVWD and member jurisdiction systems was 20 µg/L (0.020 mg/L). All DBP levels were below limits established in the GCDWQ.

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Appendix A — Water Sampling Frequency

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Water Type	Parameter	Minimum Frequency
Untreated, Source Water	Total coliform and <i>E. coli</i>	Daily
	HPC	Daily
	pH	Daily
	Turbidity	Daily
	<i>Giardia</i> and <i>Cryptosporidium</i>	Monthly
	Alkalinity, Ammonia, colour, iron, organic carbon	Weekly
	Calcium, chloride, fluoride, hardness, magnesium, manganese, nitrate, nitrite, phosphorus, sulphate	Monthly
	Aluminum, residue, silica, sodium	Bi-monthly
	TTHMs, THAAs	Quarterly
	Antimony, arsenic, barium, boron, cadmium, chromium, copper, cyanide, lead, mercury, nickel, phenols, potassium, selenium, silver, uranium, zinc	Semi-annually
	Pesticides and herbicides	Annually
	PAHs, BTEX	Annually
	PFOS, PFOA	Annually
	VOCs	Annually
	Radionuclides	Annually
Treated Water before Transmission	Total coliform and <i>E. coli</i>	Daily
	Free chlorine, pH, temperature	Daily
	Turbidity	Daily
	Alkalinity, Ammonia, colour, conductivity, iron, organic carbon, aluminum at SCFP only	Weekly
	Aluminum, sodium, total and suspended solids (residue)	Bi-Monthly
	TTHMs, THAAs	Quarterly at selected sites
	Antimony, arsenic, barium, boron, cadmium, chromium, copper, cyanide, lead, mercury, nickel, phenols, selenium, silver, zinc	Semi-annually
GVWD Water Mains	Total coliform and <i>E. coli</i> , HPC	Weekly
	Free chlorine, pH, temperature	Weekly
	TTHMs, THAAs	Quarterly at selected sites
	PAHs, BTEX, vinyl chloride	Semi-annually at selected sites
GVWD Reservoirs	Total coliform and <i>E. coli</i> , HPC	Weekly
	Turbidity	Weekly
GVWD Supplied Distribution Systems	Total coliform and <i>E. coli</i> , HPC	Weekly
	Free chlorine, temperature	Weekly
	Turbidity	Weekly
	TTHMs, THAAs, pH	Quarterly at selected sites
	Aluminum, antimony, arsenic, barium, boron, cadmium, calcium, chromium, copper, iron, lead, magnesium, manganese, mercury, selenium, silver, sodium, zinc, vinyl chloride	Semi-annually at selected sites

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Appendix B — Chemical and Physical Analysis Summaries

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Physical and Chemical Analysis of Water Supply

2023 – Capilano Water System

Parameter	Untreated ¹	Treated ²		Canadian Guideline		
	Average	Average	Range	Days Exceeded	Limit ³	Reason Established
Alkalinity as CaCO ₃ (mg/L)	2.9	21	17-26	N/A	None	N/A
Aluminum Dissolved (µg/L)	66	33	19-69	N/A	None	N/A
Aluminum Total (µg/L)	130	34	17-76	0	2,900	Health
Antimony Total (µg/L)	<0.5	<0.5	<0.5	0	6	Health
Arsenic Total (µg/L)	<0.5	<0.5	<0.5	0	10 (ALARA)	Health
Barium Total (µg/L)	2.8	2.8	2.3-3.2	0	2,000	Health
Boron Total (µg/L)	<10	<10	<10	0	5,000	Health
Bromate (µg/L)	<10	<10	<10	0	10	Health
Bromide (µg/L)	<10	<10	<10	N/A	None	N/A
Cadmium Total (µg/L)	<0.2	<0.2	<0.2	0	7	Health
Calcium Total (µg/L)	1,190	8,290	6,900-9,540	N/A	None	N/A
Carbon Organic - Dissolved (mg/L)	1.6	0.7	0.5-1.0	N/A	None	N/A
Carbon Organic - Total (mg/L)	1.6	0.7	0.5-0.9	N/A	None	N/A
Chlorate (µg/L)	<10	30	16-68	0	1,000	Health
Chloride (mg/L)	<0.6	2.6	2.3-3.2	0	≤ 250	Aesthetic
Chromium Total (µg/L)	<0.08	<0.06	<0.05-0.09	0	50	Health
Cobalt Total (µg/L)	<0.5	<0.5	<0.5	N/A	None	N/A
Colour - Apparent (ACU)	16	<2	<2-3	N/A	None	N/A
Colour - True (TCU)	10	<1	<1-2	0	≤ 15	Aesthetic
Conductivity (µmhos/cm)	11	51	42-60	N/A	None	N/A
Copper Total (µg/L)	3.2	<0.5	<0.5	0	2,000/1,000	Health/Aesthetic
Cyanide Total (mg/L)	<0.02	<0.02	<0.02	0	0.2	Health
Cyanobacterial Toxins – Microcystin – LR (µg/L)	<0.20	N/A	N/A	0	1.5	Health
Fluoride (mg/L)	<0.05	<0.05	<0.05	0	1.5	Health
Haloacetic Acids Total (µg/L)	<1	12	10-14	0	80 (ALARA)	Health
Hardness as CaCO ₃ (mg/L)	3.7	21.4	18.1-24.8	N/A	None	N/A
Iron Dissolved (µg/L)	43	<5	<5	N/A	None	N/A
Iron Total (µg/L)	131	<10	<5-19	0	≤ 300	Aesthetic
Lead Total (µg/L)	<0.5	<0.5	<0.5	0	5 (ALARA)	Health
Magnesium Total (µg/L)	174	240	202-363	N/A	None	N/A
Manganese Dissolved (µg/L)	5.5	2.2	1.0-3.5	N/A	None	N/A
Manganese Total (µg/L)	7.4	5.7	3.4-9.6	0	120/20	Health/Aesthetic
Mercury Total (µg/L)	<0.05	<0.05	<0.05	0	1	Health
Molybdenum Total (µg/L)	<0.5	<0.5	<0.5	N/A	None	N/A
Nickel Total (µg/L)	<0.5	<0.5	<0.5	N/A	None	N/A
Nitrogen - Ammonia as N (mg/L)	<0.02	<0.02	<0.02	N/A	None	N/A
Nitrogen - Nitrate as N (mg/L)	0.09	0.08	0.03-0.14	0	10	Health
Nitrogen - Nitrite as N (mg/L)	<0.01	<0.01	<0.01	0	1	Health
pH (pH units)	6.5	8.1	7.8-8.5	0	7.0-10.5	Aesthetic
Phenol (mg/L)	<0.005	<0.005	<0.005	N/A	None	N/A
Potassium Total (µg/L)	182	177	144-212	N/A	None	N/A
Residue Total (mg/L)	16	34	32-37	N/A	None	N/A
Residue Total Dissolved (TDS) (mg/L)	10	30	30-40	0	≤ 500	Aesthetic
Residue Total Fixed (mg/L)	7	24	16-29	N/A	None	N/A
Residue Total Volatile (mg/L)	8	10	6-16	N/A	None	N/A
Selenium Total (µg/L)	<0.5	<0.5	<0.5	0	50	Health
Silica as SiO ₂ (mg/L)	3.3	3.3	2.6-4.0	N/A	None	N/A
Silver Total (µg/L)	<0.5	<0.5	<0.5	N/A	None	N/A
Sodium Total (µg/L)	590	1,690	1,420-2,040	0	≤ 200,000	Aesthetic
Trihalomethanes Total (µg/L)	<4	23	18-35	0	100	Health
Turbidity (NTU)	1.2	0.20	0.09-0.65	N/A	None ⁴	N/A
Uranium Total (µg/L)	0.0294	N/A	N/A	0	50	Health
UV Absorbance 254 nm (Abs/cm)	0.067	0.011	0.008-0.016	N/A	None	N/A
Zinc Total (µg/L)	<3	<3	<3	0	≤ 5,000	Aesthetic

¹Untreated water is sampled from the source intake.

²Treated water is sampled prior to entering the Capilano transmission system.

³Limits are from the *Guidelines for Canadian Drinking Water Quality*.

⁴*Guidelines for Canadian Drinking Water Quality* recommends that water entering the distribution system does not have turbidity levels exceeding 1.0 NTU.

Physical and Chemical Analysis of Water Supply

2023 – Seymour Water System

Parameter	Untreated ¹	Treated ²		Canadian Guideline		
	Average	Average	Range	Days Exceeded	Limit ³	Reason Established
Alkalinity as CaCO ₃ (mg/L)	3.6	21	17-26	N/A	None	N/A
Aluminum Dissolved (µg/L)	57	34	18-68	N/A	None	N/A
Aluminum Total (µg/L)	106	40	17-120	0	2,900	Health
Antimony Total (µg/L)	<0.5	<0.5	<0.5	0	6	Health
Arsenic Total (µg/L)	<0.5	<0.5	<0.5	0	10 (ALARA)	Health
Barium Total (µg/L)	3.4	2.8	2.5-3.3	0	2,000	Health
Boron Total (µg/L)	<10	<10	<10	0	5,000	Health
Bromate (µg/L)	<10	<10	<10	0	10	Health
Bromide (µg/L)	<10	<10	<10	N/A	None	N/A
Cadmium Total (µg/L)	<0.2	<0.2	<0.2	0	7	Health
Calcium Total (µg/L)	1,650	8,180	7,220-9,490	N/A	None	N/A
Carbon Organic - Dissolved (mg/L)	1.4	0.7	0.5-1.0	N/A	None	N/A
Carbon Organic - Total (mg/L)	1.5	0.7	0.5-1.0	N/A	None	N/A
Chlorate (µg/L)	<10	31	14-75	0	1,000	Health
Chloride (mg/L)	<0.5	2.6	2.2-3.3	0	≤ 250	Aesthetic
Chromium Total (µg/L)	<0.06	<0.06	<0.05-0.07	0	50	Health
Cobalt Total (µg/L)	<0.5	<0.5	<0.5	N/A	None	N/A
Colour - Apparent (ACU)	16	<2	<2-3	N/A	None	N/A
Colour - True (TCU)	10	<1	<1-2	0	≤ 15	Aesthetic
Conductivity (µmhos/cm)	13	51	41-58	N/A	None	N/A
Copper Total (µg/L)	18.5	<0.5	<0.5	0	2,000/1,000	Health/Aesthetic
Cyanide Total (mg/L)	<0.02	<0.02	<0.02	0	0.2	Health
Cyanobacterial Toxins - Microcystin - LR (µg/L)	<0.20	N/A	N/A	0	1.5	Health
Fluoride (mg/L)	<0.05	<0.05	<0.05	0	1.5	Health
Haloacetic Acids Total (µg/L)	<1	9	8-11	0	80 (ALARA)	Health
Hardness as CaCO ₃ (mg/L)	4.8	21.6	19.1-24.7	N/A	None	N/A
Iron Dissolved (µg/L)	83	<5	<5	N/A	None	N/A
Iron Total (µg/L)	182	15	5-58	0	≤ 300	Aesthetic
Lead Total (µg/L)	<0.5	<0.5	<0.5	0	5 (ALARA)	Health
Magnesium Total (µg/L)	160	246	204-341	N/A	None	N/A
Manganese Dissolved (µg/L)	4.8	3.0	1.3-4.2	N/A	None	N/A
Manganese Total (µg/L)	8.9	6.3	3.5-9.8	0	120/20	Health/Aesthetic
Mercury Total (µg/L)	<0.05	<0.05	<0.05	0	1	Health
Molybdenum Total (µg/L)	<0.5	<0.5	<0.5	N/A	None	N/A
Nickel Total (µg/L)	<0.5	<0.5	<0.5	N/A	None	N/A
Nitrogen - Ammonia as N (mg/L)	<0.02	<0.02	<0.02	N/A	None	N/A
Nitrogen - Nitrate as N (mg/L)	0.08	0.08	0.03-0.14	0	10	Health
Nitrogen - Nitrite as N (mg/L)	<0.01	<0.01	<0.01	0	1	Health
pH (pH units)	6.6	8.0	7.7-8.4	0	7.0-10.5	Aesthetic
Phenol (mg/L)	<0.005	<0.005	<0.005	N/A	None	N/A
Potassium Total (µg/L)	192	184	169-209	N/A	None	N/A
Residue Total (mg/L)	16	34	31-36	N/A	None	N/A
Residue Total Dissolved (TDS) (mg/L)	10	30	30-40	0	≤ 500	Aesthetic
Residue Total Fixed (mg/L)	8	25	18-28	N/A	None	N/A
Residue Total Volatile (mg/L)	8	8	6-13	N/A	None	N/A
Selenium Total (µg/L)	<0.5	<0.5	<0.5	0	50	Health
Silica as SiO ₂ (mg/L)	3.3	3.3	2.6-3.9	N/A	None	N/A
Silver Total (µg/L)	<0.5	<0.5	<0.5	N/A	None	N/A
Sodium Total (µg/L)	558	1,680	1,430-1,930	0	≤ 200,000	Aesthetic
Trihalomethanes Total (µg/L)	<4	21	16-35	0	100	Health
Turbidity (NTU)	0.80	0.22	0.09-1.1	N/A	None ⁴	N/A
Uranium Total (µg/L)	0.0224	N/A	N/A	0	50	Health
UV Absorbance 254 nm (Abs/cm)	0.063	0.011	0.008-0.016	N/A	None	N/A
Zinc Total (µg/L)	<4	<3	<3	0	≤ 5,000	Aesthetic

¹Untreated water is sampled prior to the Seymour Capilano Filtration Plant.

²Treated water is sampled prior to entering the Seymour transmission system.

³Limits are taken from the *Guidelines for Canadian Drinking Water Quality*.

⁴*Guidelines for Canadian Drinking Water Quality* recommends that water entering the distribution system have turbidity levels of 1.0 NTU or less.

Physical and Chemical Analysis of Water Supply

2023 – Coquitlam Water System

Parameter	Untreated ¹	Treated ²		Canadian Guideline		
	Average	Average	Range	Days Exceeded	Limit ³	Reason Established
Alkalinity as CaCO ₃ (mg/L)	1.9	21	18-24	N/A	None	N/A
Aluminum Dissolved (µg/L)	55	59	45-65	N/A	None	N/A
Aluminum Total (µg/L)	75	76	61-85	0	2,900	Health
Antimony Total (µg/L)	<0.5	<0.5	<0.5	0	6	Health
Arsenic Total (µg/L)	<0.5	<0.5	<0.5	0	10 (ALARA)	Health
Barium Total (µg/L)	2.2	2.2	2.0-2.4	0	2,000	Health
Boron Total (µg/L)	<10	<10	<10	0	5,000	Health
Bromate (µg/L)	<10	<10	<10	0	10	Health
Bromide (µg/L)	<10	<10	<10	N/A	None	N/A
Cadmium Total (µg/L)	<0.2	<0.2	<0.2	0	7	Health
Calcium Total (µg/L)	838	838	790-905	N/A	None	N/A
Carbon Organic - Dissolved (mg/L)	1.4	1.4	1.1-1.8	N/A	None	N/A
Carbon Organic - Total (mg/L)	1.5	1.4	1.0-1.8	N/A	None	N/A
Chlorate (µg/L)	<10	49	36-73	0	1,000	Health
Chloride (mg/L)	<0.5	2.2	2.0-2.7	0	≤ 250	Aesthetic
Chromium Total (µg/L)	<0.06	<0.05	<0.05-0.05	0	50	Health
Cobalt Total (µg/L)	<0.5	<0.5	<0.5	N/A	None	N/A
Colour - Apparent (ACU)	11	<3	<2-5	N/A	None	N/A
Colour - True (TCU)	7	<1	<1-2	0	≤ 15	Aesthetic
Conductivity (µmhos/cm)	8	48	42-54	N/A	None	N/A
Copper Total (µg/L)	5.1	<0.5	<0.5	0	2,000/1,000	Health/Aesthetic
Cyanide Total (mg/L)	<0.02	<0.02	<0.02	0	0.2	Health
Cyanobacterial Toxins – Microcystin – LR (µg/L)	<0.20	N/A	N/A	0	1.5	Health
Fluoride (mg/L)	<0.05	<0.05	<0.05	0	1.5	Health
Haloacetic Acids Total (µg/L)	<1	5	4-6	0	80 (ALARA)	Health
Hardness as CaCO ₃ (mg/L)	2.5	2.5	2.3-2.7	N/A	None	N/A
Iron Dissolved (µg/L)	18	19	14-31	N/A	None	N/A
Iron Total (µg/L)	49	49	32-91	0	≤ 300	Aesthetic
Lead Total (µg/L)	<0.5	<0.5	<0.5	0	5 (ALARA)	Health
Magnesium Total (µg/L)	98	98	86-112	N/A	None	N/A
Manganese Dissolved (µg/L)	3.8	2.4	1.7-3.2	N/A	None	N/A
Manganese Total (µg/L)	4.2	3.5	2.5-6.6	0	120/20	Health/Aesthetic
Mercury Total (µg/L)	<0.05	<0.05	<0.05	0	1	Health
Molybdenum Total (µg/L)	<0.5	<0.5	<0.5	N/A	None	N/A
Nickel Total (µg/L)	<0.5	<0.5	<0.5	N/A	None	N/A
Nitrogen - Ammonia as N (mg/L)	<0.02	<0.02	<0.02	N/A	None	N/A
Nitrogen - Nitrate as N (mg/L)	0.08	0.08	0.04-0.10	0	10	Health
Nitrogen - Nitrite as N (mg/L)	<0.01	<0.01	<0.01	0	1	Health
pH (pH units)	6.4	8.2	7.7-8.7	0	7.0-10.5	Aesthetic
Phenol (mg/L)	<0.006	<0.005	<0.005	N/A	None	N/A
Potassium Total (µg/L)	122	124	113-138	N/A	None	N/A
Residue Total (mg/L)	12	35	32-40	N/A	None	N/A
Residue Total Dissolved (TDS) (mg/L)	10	30	30-40	0	≤ 500	Aesthetic
Residue Total Fixed (mg/L)	<5	22	20-24	N/A	None	N/A
Residue Total Volatile (mg/L)	7	13	11-19	N/A	None	N/A
Selenium Total (µg/L)	<0.5	<0.5	<0.5	0	50	Health
Silica as SiO ₂ (mg/L)	2.5	2.5	2.3-2.6	N/A	None	N/A
Silver Total (µg/L)	<0.5	<0.5	<0.5	N/A	None	N/A
Sodium Total (µg/L)	470	10,300	9,600-10,900	0	≤ 200,000	Aesthetic
Trihalomethanes Total (µg/L)	<4	8	6-12	0	100	Health
Turbidity (NTU)	0.46	0.39	0.19-2.9	N/A	None ⁴	N/A
Uranium Total (µg/L)	0.0482	N/A	N/A	0	50	Health
UV 254 - Apparent (Abs/cm)	0.062	0.022	0.014-0.052	N/A	None	N/A
UV Absorbance 254 nm (Abs/cm)	0.055	0.017	0.010-0.022	N/A	None	N/A
Zinc Total (µg/L)	<3	<3	<3	0	≤ 5,000	Aesthetic

¹Untreated water is sampled from the source intake.

²Treated water is sampled prior to entering the Coquitlam transmission system.

³Limits are taken from the *Guidelines for Canadian Drinking Water Quality*.

⁴ *Guidelines for Canadian Drinking Water Quality* recommends that water entering the distribution system have turbidity levels of 1.0 NTU or less.

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Appendix C — Analysis of Water for Organic Components and Radionuclides

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Analysis of Source Waters for Herbicides, Pesticides, and other Organic Compounds

Parameter	Capilano (µg/L)	Seymour (µg/L)	Coquitlam (µg/L)	MAC (µg/L)	AO (µg/L)
	May 29	May 29	May 29		
Herbicides					
2,4-Dichlorophenoxyacetic acid (2,4-D)	<1.0	<1.0	<1.0	100	None
Bromoxynil	<0.50	<0.50	<0.50	30	None
Dicamba	<1.0	<1.0	<1.0	110	None
Diclofop-methyl	<0.90	<0.90	<0.90	None	None
Diquat	<14	<14	<14	50	None
Diuron	<10	<10	<10	None	None
Glyphosate	<10	<10	<10	280	None
4-Chloro-2-methylphenoxyacetic acid (MCPA)	<10	<10	<10	350	None
Metribuzin (Sencor)	<5.0	<5.0	<5.0	80	None
Paraquat	<2.0	<2.0	<2.0	None	None
Picloram	<5.0	<5.0	<5.0	None	None
Pesticides					
Atrazine	<0.50	<0.50	<0.50	5	None
Carbaryl	<5.0	<5.0	<5.0	None	None
Carbofuran	<5.0	<5.0	<5.0	None	None
Chlorpyrifos (Dursban)	<1.0	<1.0	<1.0	90	None
Diazinon	<1.0	<1.0	<1.0	None	None
Dimethoate	<2.5	<2.5	<2.5	20	None
Guthion (Azinphos-methyl)	<2.0	<2.0	<2.0	None	None
Malathion	<5.0	<5.0	<5.0	190	None
Metolachlor	<0.50	<0.50	<0.50	None	None
Phorate (Thimet)	<0.50	<0.50	<0.50	None	None
Simazine	<1.0	<1.0	<1.0	None	None
Terbufos	<0.50	<0.50	<0.50	None	None
Trifluralin	<1.0	<1.0	<1.0	None	None
Other Organic Compounds					
Phenolics					
2,3,4,6-tetrachlorophenol	<0.50	<0.50	<0.50	None	None
2,4,6-trichlorophenol	<0.50	<0.50	<0.50	5	≤2
2,4-dichlorophenol	<0.25	<0.25	<0.25	None	None
Pentachlorophenol	<0.50	<0.50	<0.50	60	≤30

Analysis of Source Waters for Herbicides, Pesticides, and other Organic Compounds Con't.

Parameter	Capilano (µg/L)	Seymour (µg/L)	Coquitlam (µg/L)	MAC (µg/L)	AO (µg/L)
	Oct 12	Oct 12	Oct 12		
Volatile Organics					
1,1-dichloroethene	<0.50	<0.50	<0.50	14	None
1,2-dichlorobenzene	<0.50	<0.50	<0.50	None	None
1,2-dichloroethane	<0.50	<0.50	<0.50	5	None
1,4-dichlorobenzene	<0.50	<0.50	<0.50	5	≤1
Benzene	<0.40	<0.40	<0.40	5	None
Carbon tetrachloride	<0.50	<0.50	<0.50	2	None
Chlorobenzene	<0.50	<0.50	<0.50	None	None
Dibromomethane	<0.90	<0.90	<0.90	None	None
Dichloromethane	<2.0	<2.0	<2.0	50	None
Ethylbenzene	<0.40	<0.40	<0.40	140	1.6
Methyl-tert-butylether (MTBE)	<4.0	<4.0	<4.0	None	≤15
Tetrachloroethene	<0.50	<0.50	<0.50	10	None
Toluene	<0.40	<0.40	<0.40	60	24
Trichloroethene	<0.50	<0.50	<0.50	5	None
Vinyl chloride	<0.50	<0.50	<0.50	2 (ALARA)	None
m & p-Xylene	<0.40	<0.40	<0.40	None	None
o-Xylene	<0.40	<0.40	<0.40	None	None
Xylenes (Total)	<0.40	<0.40	<0.40	90	20
Miscellaneous					
Nitrilotriacetic acid (NTA) (mg/L)	<0.050	<0.050	<0.050	0.4 mg/L	None
N-Nitrosodimethylamine (NDMA) (ng/L)	<1.9	<1.9	<1.9	40 ng/L	None

Monitoring of Selected GVWD Water Mains for BTEX

Parameter	Maple Ridge Main		Barnston Island Main at Willoughby Pump Station		Jericho Clayton Main		South Burnaby Main No. 2		MAC (µg/L)	AO (µg/L)
	(µg/L)		(µg/L)		(µg/L)		(µg/L)			
	Jun 22	Dec 7	Jun 28	Dec 5	Jun 28	Dec 7	Jun 20	Dec 7		
Benzene	<0.5	<0.5	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	5	None
Ethyl Benzene	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	140	1.6
Toluene	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	60	24
m & p-Xylene	<1	<1	<1	<1	<1	<1	<1	<1	None	None
o-Xylene	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	None	None
Total Xylenes	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	90	20
Total BTEX	<1.4	<1.4	<1.4	<1.4	<1.4	<1.4	<1.4	<1.4	None	None

Analysis of Source Water for PAHs

Parameter	Capilano (µg/L)			Seymour (µg/L)			Coquitlam (µg/L)		
	May 24	May 29	Dec 5	May 25	May 29	Dec 4	May 25	May 29	Dec 5
1-Methylnaphthalene	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
2-Methylnaphthalene	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Acenaphthene	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Acenaphthylene	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Acridine	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Anthracene	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Benzo(a)anthracene	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Benzo(a)pyrene ¹	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Benzo(b&j)fluoranthene	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
Benzo(g,h,i)perylene	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Benzo(k)fluoranthene	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Chrysene	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Dibenz(a,h)anthracene	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030
Fluoranthene	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Fluorene	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Indeno(1,2,3-cd)pyrene	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Naphthalene	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Phenanthrene	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Pyrene	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Quinoline	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Total PAHs	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10

¹Benzo(a)pyrene is the only PAH compound that has a GCDWQ limit. Maximum Acceptable Concentration of Benzo(a)pyrene is 0.04 µg/L.

Analysis of Selected GVWD Mains for PAHs

Parameters	Coquitlam Main No. 2		Westburnco Reservoir		Barnston Island Main		Annacis Main No. 4		Whalley - Kennedy Link Main		Haney Main No. 2		36 Ave. Main	
	(µg/L)		(µg/L)		(µg/L)		(µg/L)		(µg/L)		(µg/L)		(µg/L)	
	Jun 2	Dec 7	May 24	Dec 7	May 24	Dec 5	Jun 9	Dec 6	May 25	Dec 7	May 23	Dec 7	May 24	Dec 7
1-Methylnaphthalene	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
2-Methylnaphthalene	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Acenaphthene	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Acenaphthylene	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Acridine	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Anthracene	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Benz[a]anthracene	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Benzo[a]pyrene	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Benzo[b+j]fluoranthene	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
Benzo[g,h,i]perylene	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Benzo[k]fluoranthene	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Chrysene	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Dibenz[a,h]anthracene	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030
Fluoranthene	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Fluorene	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Indeno[1,2,3-c,d]pyrene	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Naphthalene	<0.10	<0.10	<0.10	0.13	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Phenanthrene	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Pyrene	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Quinoline	<0.020	<0.020	<0.020	0.047	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Total PAHs	<0.10	<0.10	<0.10	0.18	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10

¹Benzo(a)pyrene is the only PAH compound that has a GCDWQ limit. Maximum Acceptable Concentration of Benzo(a)pyrene is 0.04 µg/L.

Analysis of Source Water for Radionuclides

Parameter	Capilano (Bq/L)	Seymour (Bq/L)	Coquitlam (Bq/L)	MAC (Bq/L)
	Jun 15*	Jun 15*	Jun 15*	
Gross Alpha	<0.10	<0.10	<0.10	0.5
Gross Beta	<0.10	<0.10	<0.10	1
Cesium-134	<1	<1	<1	None
Cesium-137	<1	<1	<1	10
Iodine-131	<1	<1	<1	6
Lead-210	<0.10	<0.10	<0.10	0.2
Manganese-54	<1	<1	<1	None
Radium-226	<0.010	<0.010	<0.010	0.5
Radon-222*	<10	<10	<10	None
Strontium-90	<0.10	<0.10	<0.10	5
Tritium	<20	<20	<20	7,000
Zinc-65	<1	<1	<1	None

*All parameters except Radon-222 were sampled on June 15, 2023. Only Radon-222 was sampled on September 13, 2023.

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Appendix D — Metro Vancouver Detection of Waterborne *Cryptosporidium* and *Giardia* January – December 2023 Annual Report

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Metro Vancouver

Detection of Waterborne *Cryptosporidium* and *Giardia*

Annual Report

January - December, 2023

February 2024

Dr. Natalie Prystajecky, Program Head
Christine Tchao, Team Lead
Tracy Chan, Technical Coordinator
Daisy Yu, Technical Coordinator
Jenny Jeong, Technical Coordinator

Environmental Microbiology
BCCDC Public Health Laboratory
Provincial Health Services Authority

Metro Vancouver

Detection of Waterborne *Cryptosporidium* and *Giardia*

Annual Report, January - December 2023

Purpose

To detect and quantify *Cryptosporidium* oocysts and *Giardia* cysts from Metro Vancouver reservoirs (Capilano, Coquitlam and Seymour), as well as from the Recycled Clarified Water (RCW) from Seymour-Capilano Filtration Plant (SCFP).

Introduction

On behalf of Metro Vancouver, the Environmental Microbiology Laboratory at BCCDC Public Health Laboratory (BCCDC PHL) examined the source water of Capilano, Coquitlam and Seymour reservoirs, as well as Recycled Clarified Water (RCW) at the Seymour-Capilano Filtration Plant (SCFP) for the presence of *Cryptosporidium* oocysts and *Giardia* cysts under the waterborne parasite surveillance program. All sample collection, testing, analysis and reporting occurred on a monthly basis using a validated method.

Methods

All testing was performed at the Environmental Microbiology Laboratory at BCCDC PHL, conforming to the United States Environmental Protection Agency (USEPA) Method 1623.1: *Cryptosporidium* and *Giardia* in Water by Filtration/IMS/FA (4) for the detection of oocysts and cysts in water. As stated by Method 1623.1, the performance is based on the method applicable for the quantification of *Cryptosporidium* and *Giardia* in aqueous matrices. It requires the filtration of a large volume of water, elution off the filter, and immunomagnetic separation (IMS) to concentrate and purify the oocysts and cysts from sample material captured. After the IMS purification, immunofluorescence microscopy was performed to identify and enumerate oocysts and cysts. 4'-6-diamidino-2-phenylindole staining (DAPI) and differential interference contrast microscopy (DIC) are used to confirm internal structures of the cysts and oocysts.

Raw water samples were collected by Metro Vancouver at specific sampling sites at the reservoirs and filtration plants on the scheduled date each month. Water samples were filtered in the field using Pall Life Science Envirochek high volume (HV) filters. After collection/filtration, the Envirochek HV filters were transported to the Environmental Microbiology Laboratory at BCCDC PHL, where they were processed and analysed within 96 hours. Positive and negative controls were included for the entire process to assess the performance of the method. Matrix spike testing was also performed at scheduled collection periods, annually for baseline assessment.

Results & Discussions

In 2023, 48 sample filters (excluding matrix spikes) were examined in total. These include:

- 12 Envirochek HV filters from Capilano reservoir
- 12 Envirochek HV filters from Coquitlam reservoir
- 12 Envirochek HV filters from SCFP-RCW
- 12 Envirocheck HV filters from Seymour reservoir

Table 1 and Figures 1 to 4 show the summary of all results. Detailed results per collection site can be found in Tables A1-A4 in Appendix A

	Capilano Reservoir		Coquitlam Reservoir		Seymour Capilano Filtration Plant – Recycled Clarified Water		Seymour Reservoir	
# of Filter Tested	12		12		12		12	
Average volume (L) Filtered per Month	50.0		50.0		150.4		44.2	
Average Detection Limit (oo)cysts per 100 L	2.17		2.02		0.94		2.82	
	<i>Cryptosporidium</i>	<i>Giardia</i>	<i>Cryptosporidium</i>	<i>Giardia</i>	<i>Cryptosporidium</i>	<i>Giardia</i>	<i>Cryptosporidium</i>	<i>Giardia</i>
# Positive Filters	0	6	0	1	0	0	1	1
% Positive Filters	0%	50%	0%	8%	0%	0%	8%	8%
Max Count (oo)cysts per 100 L	0	4	0	2	0	0	10	2

Table 1. Metro Vancouver Filter Result Summary in 2023

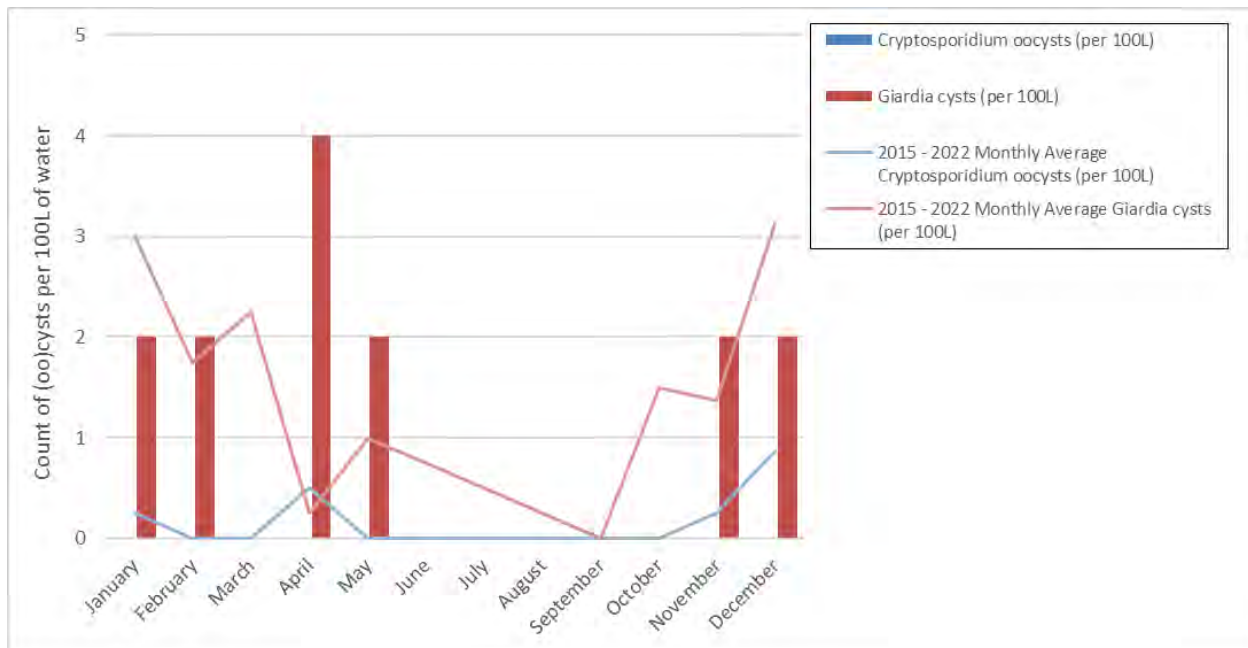


Figure 1. Capilano Reservoir *Cryptosporidium* Oocysts and *Giardia* Cysts Counts per 100 Litres of Raw Water in 2023

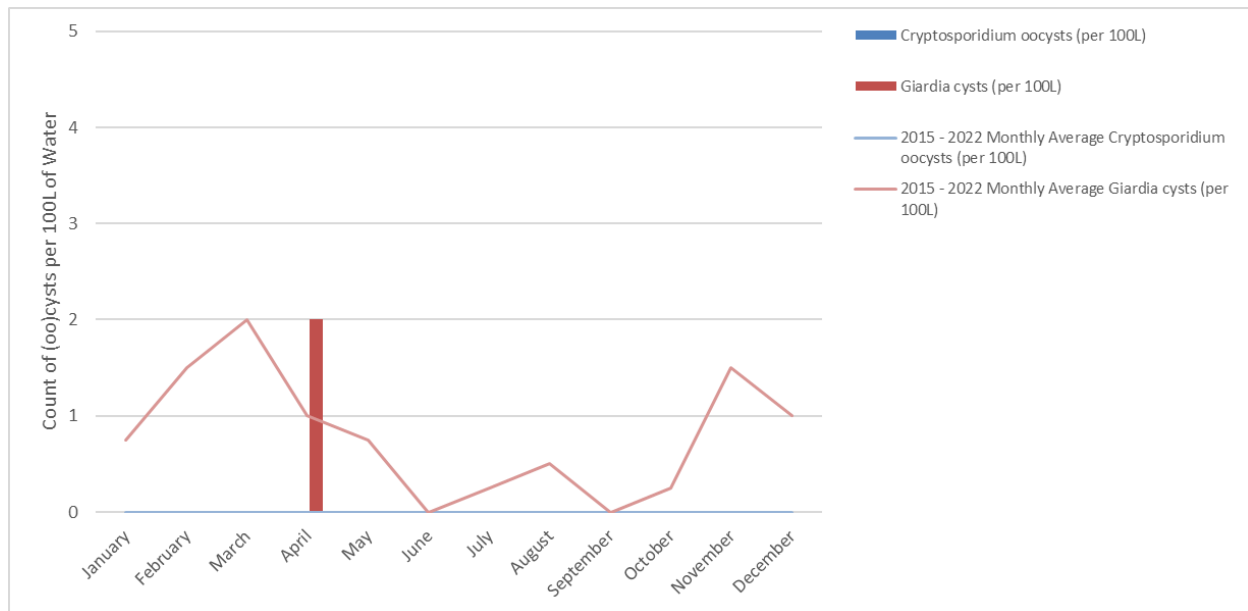


Figure 2: Coquitlam Reservoir *Cryptosporidium* Oocysts and *Giardia* Cysts Counts per 100 Litres of Raw Water in 2023

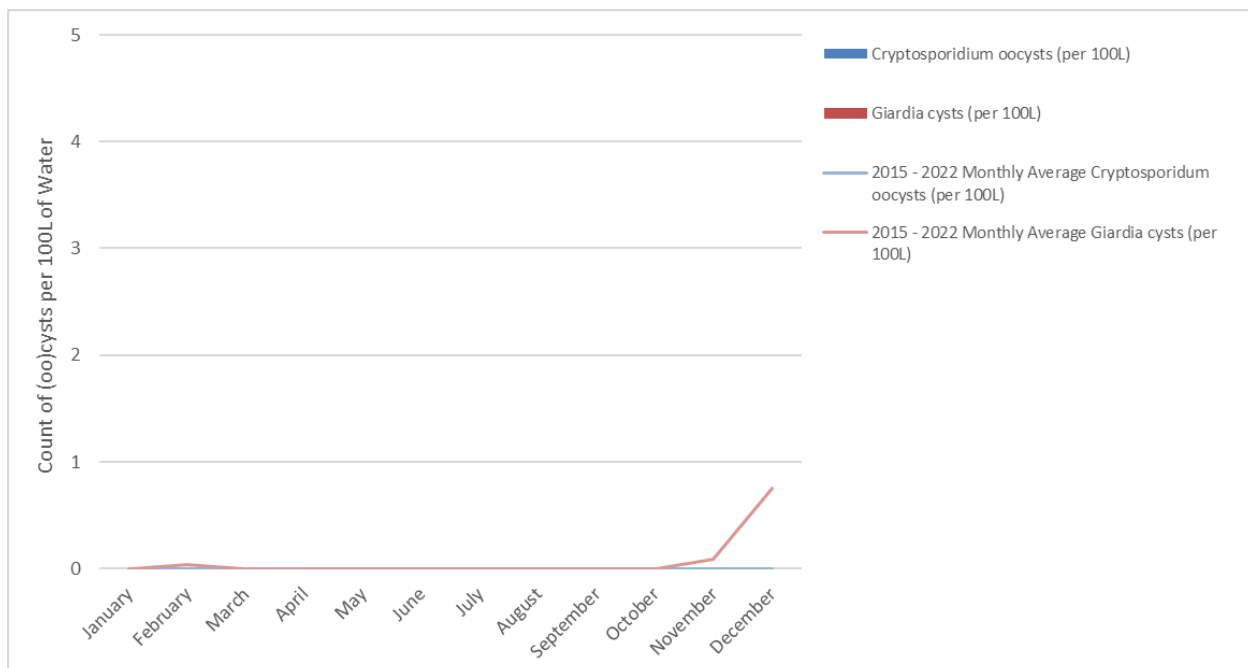


Figure 3: Seymour Capilano Filtration Plant - Recycled Clarified Water *Cryptosporidium* Oocysts and *Giardia* Cysts Counts per 100 Litres of Raw Water in 2023

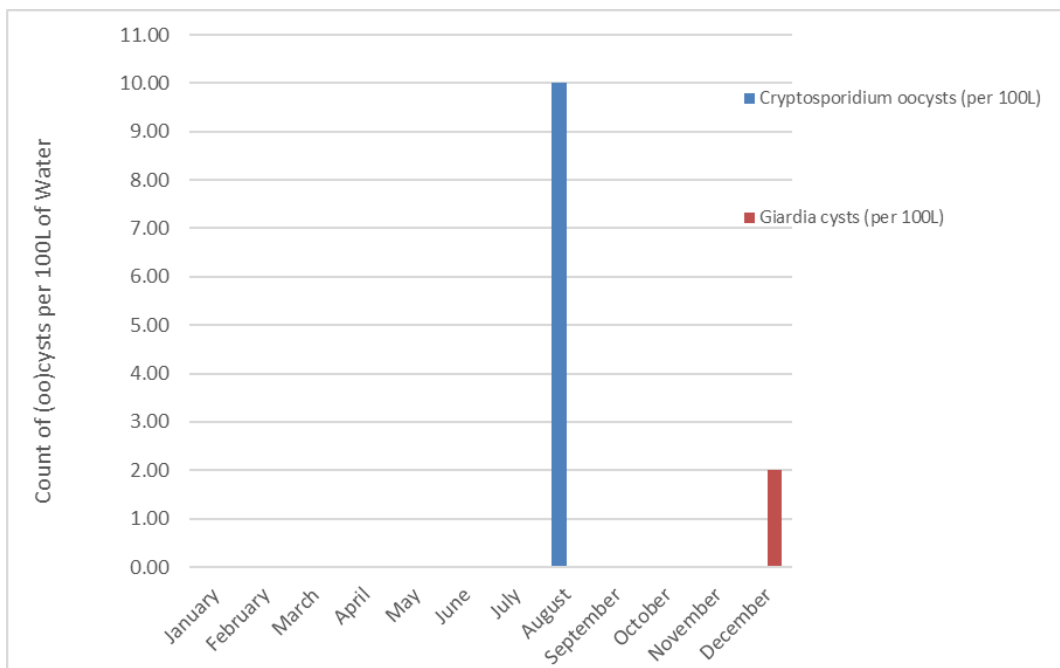


Figure 4: Seymour Reservoir *Cryptosporidium* Oocysts and *Giardia* Cysts Counts per 100 Litres of Raw Water in 2023
Note: Monthly averages for pervious years are not available for this site due to limited data as collection started in July 2022.

Overall, similar trends were observed for both *Cryptosporidium* and *Giardia* in 2023, in comparison to historical data in 2015-2022.

DAPI staining is used as part of the confirmation of the internal structure of *Cryptosporidium* oocysts and *Giardia* cysts. DIC microscopy is used primarily for *Cryptosporidium* oocyst and *Giardia* cyst confirmation, but it can also serve as an indicator of oocysts/cysts cytoplasm and cell wall integrity. While no median body (or axoneme) was observed for all *Giardia* cysts detected, the cytoplasm was observed indicating that the cysts were not empty and could be viable.

Summary of morphological results are listed in Tables 2 and 3. Detailed results for staining by IFA, DAPI and internal morphology, as determined through DIC microscopy, for every identified cyst and oocyst were recorded in Tables A5-A12 in Appendix A.

Site	Count of oocysts	DAPI -	DAPI +		DIC		
		Light blue internal staining, no distinct nuclei, green rim	Intense blue internal staining	Nuclei stained sky blue	Empty oocysts	Oocysts with amorphous structure	Oocysts with internal structure, sporozoites
Capilano	0	0	0	0	0	0	0
		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Coquitlam	0	0	0	0	0	0	0
		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
SCFP-RCW	0	0	0	0	0	0	0
		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Seymour	1	1	0	0	0	1	0
		0.0%	0.0%	0.0%	0.0%	100.0%	0.0%

Table 2. 2023 Summary of morphological results for *Cryptosporidium* oocysts observed under fluorescence microscope

Site	Count of cysts	DAPI -	DAPI +		DIC				
		Light blue internal staining, no distinct	Intense blue internal staining	Nuclei stained sky blue	Empty cysts	Cysts with amorphous structure	Cysts with internal structure		
							Nuclei	Median Body	Axoneme
Capilano	7	4	0	3	2	4	1	0	0
		57.1%	0.0%	42.9%	28.6%	57.1%	14.3%	0.0%	0.0%
Coquitlam	1	1	0	0	1	0	0	0	0
		100.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%
SCFP-RCW	0	0	0	0	0	0	0	0	0
		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Seymour	1	0	0	1	0	1	0	0	0
		0.0%	0.0%	100.0%	0.0%	100.0%	0.0%	0.0%	0.0%

Table 3: 2023 Summary of morphological results for *Giardia* cysts observed under fluorescence microscope

DAPI staining is used as an indicator of nuclei integrity by staining the DNA. It can also approximate oocysts/cysts integrity; the absence of nuclei is indicative of an aged, damaged or non-infective cell. A number of oocysts and cysts observed across all sites had no visible nuclei indicating that they were aged and likely subjected to environmental degradation (Table 4). However, they were likely in previous infective state.

Number of Nuclei per (oo)cyst	0*	1	2	3	4	Total # of (oo)cysts
<i>Cryptosporidium</i> oocysts						
Capilano	0	0	0	0	0	0
Coquitlam	0	0	0	0	0	0
SCFP-RCW	0	0	0	0	0	0
Seymour	1	0	0	0	0	1
<i>Giardia</i> cysts						
Capilano	4	0	0	1	2	7
Coquitlam	1	0	0	0	0	1
SCFP-RCW	0	0	0	0	0	0
Seymour	0	0	0	1	0	1

Table 4: 2023 Number of nuclei in each *Cryptosporidium* oocysts and *Giardia* cysts. *DAPI negative or only intense blue internal staining.

Due to the variations of water chemistry and organic matters between geographical area and temporally within each sampling sites, a matrix spike is performed annually to provide recovery rate estimation from each site. The results of the matrix spike recovery (2007-2023) are compiled in Table 5. Matrix recovery rates fluctuate from year-to-year, even within each site. This variation is not uncommon for the test and has been noted in USEPA's Method 1623.1.

Matrix testing in 2023 was only completed in fall/ winter at each site. 50L were provided from each site and the percentage recovery for *Cryptosporidium* oocysts and *Giardia* cysts and were noted in Table 5.

Year	Capilano		Coquitlam		SCFP - Recycled Clarified Water		Seymour	
	<i>Cryptosporidium</i> % Recovery	<i>Giardia</i> % Recovery	<i>Cryptosporidium</i> % Recovery	<i>Giardia</i> % Recovery	<i>Cryptosporidium</i> % Recovery	<i>Giardia</i> % Recovery	<i>Cryptosporidium</i> % Recovery	<i>Giardia</i> % Recovery
2007	27.6%	37.4%	28.0%	54.0%	not collected		not collected	
2008	25.0%	55.0%	28.0%	39.0%	not collected		not collected	
2009	10.0%	40.0%	16.0%	37.0%	not collected		not collected	
2010	28.0%	43.0%	26.0%	49.0%	17.0%	13.0%	not collected	
2011	27.0%	44.0%	22.0%	47.0%	1.0%	0.0%	not collected	
2012	38.4%	76.5%	35.0%	49.0%	7.0%	13.7%	not collected	
2013	22.4%	59.4%	16.3%	64.4%	6.1%	14.9%	not collected	
2014	not collected		55.0%	39.4%	18.0%	14.1%	not collected	
2015	26.3%	40.4%	2.0%	60.6%	9.1%	26.5%	not collected	
2016	35.4%	47.5%	22.2%	50.5%	9.1%	14.0%	not collected	
2017	20.2%	38.4%	22.2%	21.2%	0.0%	2.0%	not collected	
2018	43.4%	75.8%	17.1%	59.6%	1.0%	11.1%	not collected	
2019	0.0%	43.0%	1.0%	55.0%	0.0%	4.1%	not collected	
2020	5.1%	37.4%	8.1%	59.8%	0.0%	4.0%	not collected	
2021 June	2.0%	53.0%	0.0%	35.0%	5.1%	38.0%	not collected	
2021 November	11.1%	52.0%	15.2%	80.0%	0.0%	8.0%	not collected	
2022 Summer	12.1%	17.0%	4.0%	13.0%	0.0%	11.0%	0.0%	19.0%
2022 Fall/Winter	0.0%	12.2%	5.1%	49.0%	1.0%	36.7%	not collected	
2023 Fall/Winter	0.0%	32.0%	0.0%	41.4%	0.0%	6.1%	1%	59.6%

Table 5: Matrix recovery results from 2007 – 2023.

Summary

In brief, we reported:

1. Overall, a low but consistent positivity rate was observed across all sites this year, except for SCFP-RCW, for both *Cryptosporidium* oocysts and *Giardia* cysts.
2. *Cryptosporidium* oocysts were detected from Seymour reservoir, but not from Capilano reservoir, Coquitlam reservoir and SCFP-RCW. 1 of 12 filters (8%) from Seymour reservoir was positive for *Cryptosporidium*.
3. *Giardia* cysts were detected from Capilano, Coquitlam and Seymour reservoirs, but not from SCFP-RCW. 6 of 12 filters (50%) from Capilano, and 1 of 12 filters (8%) from Coquitlam and Seymour were positive for *Giardia*.
4. The highest concentration of *Cryptosporidium* oocysts detected in 2023 was 10 oocysts per 100 L from Seymour reservoir in August.
5. The highest concentration of *Giardia* cysts detected in 2023 was 4 cysts per 100 L from Capilano reservoir in March.
6. Most of the *Giardia* cysts detected showed evidence of environmental degradation, based on microscopic examination. *Giardia* is more susceptible to environmental stresses in comparison to *Cryptosporidium*.
7. Matrix recovery for *Cryptosporidium* oocyst continued to be low, which is consistent with previous years. Although previous additional matrix collections in the summer did not confirm suspected seasonality variabilities, further summer matrix collections are recommended to continue this investigation.

These *semi-quantitative* data (reported oocyst and cyst levels) should be interpreted in the context of, and with the understanding that the current standard laboratory method, USEPA Method 1623.1, used for detecting and analysing parasites in water matrices has its limitations, with variable recovery rates depending on the water matrix and environmental conditions.

Acknowledgements

The BCCDC Public Health Laboratory thanks Metro Vancouver for their ongoing support of this program and other related projects. In particular, the assistance of Vila Goh, Eileen Butler, Melody Sato, and Rick Zolkiewski of the Metro Vancouver, Water Quality Department are greatly appreciated.

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Appendix A

Lab #	Site Sampled	Month	Date Sampled	Volume filtered (L)	Detection Limit (per 100L)	Cryptosporidium oocysts (per 100L)	Giardia cysts (per 100L)	2015 - 2022 Monthly Average	
								Cryptosporidium oocysts (per 100L)	Giardia cysts (per 100L)
8314	Capilano Reservoir	January 15, 2023	January 16, 2023	50	<2.0	0	2	0.3	3.0
8321	Capilano Reservoir	February 12, 2023	February 13, 2023	50	<2.0	0	2	0.0	1.8
8328	Capilano Reservoir	March 19, 2023	March 20, 2023	50	<2.0	0	0	0.0	2.3
8345	Capilano Reservoir	April 23, 2023	April 24, 2023	50	<2.0	0	4	0.5	0.3
8351	Capilano Reservoir	May 14, 2023	May 15, 2023	50	<2.0	0	2	0.0	1.0
8357	Capilano Reservoir	June 18, 2023	June 19, 2023	50	<4.0	0	0	0.0	0.8
8363	Capilano Reservoir	July 16, 2023	July 17, 2023	50	<2.0	0	0	0.0	0.5
8369	Capilano Reservoir	August 20, 2023	August 21, 2023	50	<2.0	0	0	0.0	0.3
8375	Capilano Reservoir	September 17, 2023	September 18, 2023	50	<2.0	0	0	0.0	0.0
8381	Capilano Reservoir	October 15, 2023	October 16, 2023	50	<2.0	0	0	0.0	1.5
8389	Capilano Reservoir	November 19, 2023	November 20, 2023	50	<2.0	0	2	0.3	1.4
8399	Capilano Reservoir	December 10, 2023	December 11, 2023	50	<2.0	0	2	0.9	3.1
2023 Average				50.0	2.17	0	1.2		

Table A1. Capilano Reservoir Monthly Filter Results in 2023

Lab #	Site Sampled	Month	Date Sampled	Volume filtered (L)	Detection Limit (per 100L)	Cryptosporidium oocysts (per 100L)	Giardia cysts (per 100L)	2015 - 2022 Monthly Average	
								Cryptosporidium oocysts (per 100L)	Giardia cysts (per 100L)
8315	Coquitlam Reservoir	January 15, 2023	January 16, 2023	50	<2.0	0	0	0.0	0.8
8322	Coquitlam Reservoir	February 12, 2023	February 13, 2023	50	<2.0	0	0	0.0	1.5
8329	Coquitlam Reservoir	March 19, 2023	March 20, 2023	50	<2.0	0	0	0.0	2.0
8346	Coquitlam Reservoir	April 23, 2023	April 24, 2023	50	<2.0	0	2	0.0	1.0
8352	Coquitlam Reservoir	May 14, 2023	May 15, 2023	50	<2.0	0	0	0.0	0.8
8358	Coquitlam Reservoir	June 18, 2023	June 19, 2023	50	<2.0	0	0	0.0	0.0
8364	Coquitlam Reservoir	July 16, 2023	July 17, 2023	50	<2.0	0	0	0.0	0.3
8370	Coquitlam Reservoir	August 20, 2023	August 21, 2023	50	<2.0	0	0	0.0	0.5
8376	Coquitlam Reservoir	September 17, 2023	September 18, 2023	50	<2.2	0	0	0.0	0.0
8382	Coquitlam Reservoir	October 15, 2023	October 16, 2023	50	<2.0	0	0	0.0	0.3
8390	Coquitlam Reservoir	November 19, 2023	November 20, 2023	50	<2.0	0	0	0.0	1.5
8400	Coquitlam Reservoir	December 10, 2023	December 11, 2023	50	<2.0	0	0	0.0	1.0
2023 Average				50.0	2.02	0	0		

Table A2. Coquitlam Reservoir Monthly Filter Results in 2023

Lab #	Site Sampled	Month	Date Sampled	Volume filtered (L)	Detection Limit (per 100L)	Cryptosporidium oocysts (per 100L)	Giardia cysts (per 100L)	2015 - 2022 Monthly Average	
								Cryptosporidium oocysts (per 100L)	Giardia cysts (per 100L)
8317	SCFP - Recycled Clarified Water	January 17, 2023	January 17, 2023	128.4	<0.78	0	0	0.0	0.0
8324	SCFP - Recycled Clarified Water	February 14, 2023	February 14, 2023	293.7	<0.34	0	0	0.0	0.0
8331	SCFP - Recycled Clarified Water	March 21, 2023	March 21, 2023	415.8	<0.24	0	0	0.0	0.0
8348	SCFP - Recycled Clarified Water	April 25, 2023	April 25, 2023	152.6	<0.66	0	0	0.0	0.0
8354	SCFP - Recycled Clarified Water	May 16, 2023	May 16, 2023	63.6	<1.57	0	0	0.0	0.0
8360	SCFP - Recycled Clarified Water	June 20, 2023	June 20, 2023	90.4	<1.11	0	0	0.0	0.0
8366	SCFP - Recycled Clarified Water	July 18, 2023	July 19, 2023	94.1	<1.1	0	0	0.0	0.0
8372	SCFP - Recycled Clarified Water	August 22, 2023	August 22, 2023	87.8	<1.1	0	0	0.0	0.0
8378	SCFP - Recycled Clarified Water	September 19, 2023	September 19, 2023	207.4	<0.48	0	0	0.0	0.0
8384	SCFP - Recycled Clarified Water	October 17, 2023	October 17, 2023	70.4	<1.42	0	0	0.0	0.0
8391	SCFP - Recycled Clarified Water	November 21, 2023	November 21, 2023	144.6	<0.69	0	0	0.0	0.1
8402	SCFP - Recycled Clarified Water	December 12, 2023	December 12, 2023	55.5	<1.8	0	0	0.0	0.8
2022 Average				150.4	0.94	0	0		

Table A3. Seymour Capilano Filtration Plant - Recycled Clarified Water (SCFP-RCW) Monthly Filter Results in 2023

Lab #	Site Sampled	Month	Date Sampled	Volume filtered (L)	Detection Limit (per 100L)	<i>Cryptosporidium</i> oocysts (per 100L)	<i>Giardia</i> cysts (per 100L)
8316	Seymour Reservoir	January	January 15, 2023	50	<2.0	0	0
8323	Seymour Reservoir	February	February 12, 2023	50	<2.0	0	0
8330	Seymour Reservoir	March	March 19, 2023	40	<2.5	0	0
8347	Seymour Reservoir	April	April 23, 2023	30	<3.3	0	0
8353	Seymour Reservoir	May	May 14, 2023	50	<2.0	0	0
8359	Seymour Reservoir	June	June 18, 2023	50	<2.0	0	0
8365	Seymour Reservoir	July	July 16, 2023	50	<2.0	0	0
8371	Seymour Reservoir	August	August 20, 2023	10	<10.0	10	0
8377	Seymour Reservoir	September	September 17, 2023	50	<2.0	0	0
8383	Seymour Reservoir	October	October 15, 2023	50	<2.0	0	0
8395	Seymour Reservoir	November	November 26, 2023	50	<2.0	0	0
8401	Seymour Reservoir	December	December 10, 2023	50	<2.0	0	2
2023 Average				44.2	2.82	0.8	0.2

Table A4. Seymour Reservoir Monthly Filter Results in 2023. Note: Historical monthly average is not available due to limited data.

			Cryptosporidium									
Lab #	Site name	Date sampled	Cryptosporidium			DAPI -		DAPI +		DIC		
			Object located by FA	Shape (oval or round)	Size L x W (µm)	Light blue internal staining, no distinct nuclei, green rim		Intense blue internal staining	Number of nuclei stained sky blue	Empty oocysts	Oocysts with amorphous structure	Oocysts with internal structure, Number of sporozoites
8314	Capilano Reservoir	January 15, 2023	0									
8321	Capilano Reservoir	February 12, 2023	0									
8328	Capilano Reservoir	March 19, 2023	0									
8345	Capilano Reservoir	April 23, 2023	0									
8351	Capilano Reservoir	May 14, 2023	0									
8357	Capilano Reservoir	June 18, 2023	0									
8363	Capilano Reservoir	July 16, 2023	0									
8369	Capilano Reservoir	August 20, 2023	0									
8375	Capilano Reservoir	September 17, 2023	0									
8381	Capilano Reservoir	October 15, 2023	0									
8389	Capilano Reservoir	November 19, 2023	0									
8399	Capilano Reservoir	December 10, 2023	0									

Table A5. Capilano Reservoir Slide Examination Results - *Cryptosporidium* 2023

			Cryptosporidium								
Lab #	Site name	Date sampled	Cryptosporidium			DAPI -	DAPI +		DIC		
			Object located by FA	Shape (oval or round)	Size L x W (µm)	Light blue internal staining, no distinct nuclei, green rim	Intense blue internal staining	Number of nuclei stained sky blue	Empty oocysts	Oocysts with amorphous structure	Oocysts with internal structure, Number of sporozoites
8315	Coquitlam Reservoir	January 15, 2023	0								
8322	Coquitlam Reservoir	February 12, 2023	0								
8329	Coquitlam Reservoir	March 19, 2023	0								
8346	Coquitlam Reservoir	April 23, 2023	0								
8352	Coquitlam Reservoir	May 14, 2023	0								
8358	Coquitlam Reservoir	June 18, 2023	0								
8364	Coquitlam Reservoir	July 16, 2023	0								
8370	Coquitlam Reservoir	August 20, 2023	0								
8376	Coquitlam Reservoir	September 17, 2023	0								
8382	Coquitlam Reservoir	October 15, 2023	0								
8390	Coquitlam Reservoir	November 19, 2023	0								
8400	Coquitlam Reservoir	December 10, 2023	0								

Table A6. Coquitlam Reservoir Slide Examination Results - *Cryptosporidium* 2023

			Cryptosporidium									
Lab #	Site name	Date sampled	Cryptosporidium			DAPI -		DAPI +		DIC		
			Object located by FA	Shape (oval or round)	Size L x W (µm)	Light blue internal staining, no distinct nuclei, green rim	Intense blue internal staining	Number of nuclei stained sky blue	Empty oocysts	Oocysts with amorphous structure	Oocysts with internal structure, Number of sporozoites	
8317	SCFP - Recycled Clarified Water	January 17, 2023	0									
8324	SCFP - Recycled Clarified Water	February 14, 2023	0									
8331	SCFP - Recycled Clarified Water	March 21, 2023	0									
8348	SCFP - Recycled Clarified Water	April 25, 2023	0									
8354	SCFP - Recycled Clarified Water	May 16, 2023	0									
8360	SCFP - Recycled Clarified Water	June 20, 2023	0									
8366	SCFP - Recycled Clarified Water	July 18, 2023	0									
8372	SCFP - Recycled Clarified Water	August 22, 2023	0									
8378	SCFP - Recycled Clarified Water	September 19, 2023	0									
8384	SCFP - Recycled Clarified Water	October 17, 2023	0									
8391	SCFP - Recycled Clarified Water	November 21, 2023	0									
8402	SCFP - Recycled Clarified Water	December 12, 2023	0									

Table A7. Seymour Capilano Filtration Plant – Recycled Clarified Water Slide Examination Results - *Cryptosporidium* 2023

			Cryptosporidium									
Lab #	Site name	Date sampled	Cryptosporidium			DAPI -		DAPI +		DIC		
			Object located by FA	Shape (oval or round)	Size L x W (µm)	Light blue internal staining, no distinct nuclei, green rim	Intense blue internal staining	Number of nuclei stained sky blue	Empty oocysts	Oocysts with amorphous structure	Oocysts with internal structure, Number of sporozoites	
8316	Seymour Reservoir	January 15, 2023	0									
8323	Seymour Reservoir	February 12, 2023	0									
8330	Seymour Reservoir	March 19, 2023	0									
8347	Seymour Reservoir	April 23, 2023	0									
8353	Seymour Reservoir	May 14, 2023	0									
8359	Seymour Reservoir	June 18, 2023	0									
8365	Seymour Reservoir	July 16, 2023	0									
8371	Seymour Reservoir	August 20, 2023	#1	Round	4.5	P				P		
8377	Seymour Reservoir	September 17, 2023	0									
8383	Seymour Reservoir	October 15, 2023	0									
8395	Seymour Reservoir	November 26, 2023	0									
8401	Seymour Reservoir	December 10, 2023	0									

Table A8. Seymour Reservoir Slide Examination Results - *Cryptosporidium* 2023

			Giardia											
Lab #	Site name	Date sampled	Giardia			DAPI -	DAPI +		DIC					
			Object located by FA	Shape (oval or round)	Size L x W (µm)	Light blue internal staining, no distinct nuclei, green rim	Intense blue internal staining	Number of nuclei stained sky blue	Empty cysts	Cysts with amorphous structure	Number of nuclei	Median Body	Axoneme	
▼		▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼
8314	Capilano Reservoir	January 15, 2023	#1	Oval	14x9			4		P				
8321	Capilano Reservoir	February 12, 2023	#1	Oval	11x10			3		P				
8328	Capilano Reservoir	March 19, 2023	0											
8345	Capilano Reservoir	April 23, 2023	#1	Oval	12x9	P				P				
8345	Capilano Reservoir	April 23, 2023	#2	Oval	13x10									
8351	Capilano Reservoir	May 14, 2023	#1	oval	12x7			4				4		
8357	Capilano Reservoir	June 18, 2023	0											
8363	Capilano Reservoir	July 16, 2023	0											
8369	Capilano Reservoir	August 20, 2023	0											
8375	Capilano Reservoir	September 17, 2023	0											
8381	Capilano Reservoir	October 15, 2023	0											
8389	Capilano Reservoir	November 19, 2023	#1	oval	13X10	P			P					
8399	Capilano Reservoir	December 10, 2023	#1	oval	16X8	p				p				

Table A9. Capilano Reservoir Slide Examination Results - *Giardia* 2023 (P = present)

Lab #	Site name	Date sampled	Giardia											
			Giardia			DAPI -	DAPI +		DIC					
			Object located by FA	Shape (oval or round)	Size L x W (µm)	Light blue internal staining, no distinct nuclei, green rim	Intense blue internal staining	Number of nuclei stained sky blue	Empty cysts	Cysts with amorphous structure	Number of nuclei	Median Body	Axoneme	
▼		▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼
8315	Coquitlam Reservoir	January 15, 2023	0											
8322	Coquitlam Reservoir	February 12, 2023	0											
8329	Coquitlam Reservoir	March 19, 2023	0											
8346	Coquitlam Reservoir	April 23, 2023	#1	Oval	13x10	P				P				
8352	Coquitlam Reservoir	May 14, 2023	0											
8358	Coquitlam Reservoir	June 18, 2023	0											
8364	Coquitlam Reservoir	July 16, 2023	0											
8370	Coquitlam Reservoir	August 20, 2023	0											
8376	Coquitlam Reservoir	September 17, 2023	0											
8382	Coquitlam Reservoir	October 15, 2023	0											
8390	Coquitlam Reservoir	November 19, 2023	0											
8400	Coquitlam Reservoir	December 10, 2023	0											

Table A10. Coquitlam Reservoir Slide Examination Results - *Giardia* 2023 (P = present)

Lab #	Site name	Date sampled	Giardia										
			Giardia			DAPI -	DAPI +		DIC				
			Object located by FA	Shape (oval or round)	Size L x W (µm)	Light blue internal staining, no distinct nuclei, green rim	Intense blue internal staining	Number of nuclei stained sky blue	Empty cysts	Cysts with amorphous structure	Number of nuclei	Median Body	Axoneme
▼		▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼
8317	SCFP - Recycled Clarified Water	January 17, 2023	0										
8324	SCFP - Recycled Clarified Water	February 14, 2023	0										
8331	SCFP - Recycled Clarified Water	March 21, 2023	0										
8348	SCFP - Recycled Clarified Water	April 25, 2023	0										
8354	SCFP - Recycled Clarified Water	May 16, 2023	0										
8360	SCFP - Recycled Clarified Water	June 20, 2023	0										
8366	SCFP - Recycled Clarified Water	July 18, 2023	0										
8372	SCFP - Recycled Clarified Water	August 22, 2023	0										
8378	SCFP - Recycled Clarified Water	September 19, 2023	0										
8384	SCFP - Recycled Clarified Water	October 17, 2023	0										
8391	SCFP - Recycled Clarified Water	November 21, 2023	0										
8402	SCFP - Recycled Clarified Water	December 12, 2023	0										

Table A11. Seymour Capilano Filtration Plant – Recycled Clarified Water Slide Examination Results - *Giardia* 2023

			Giardia										
Lab #	Site name	Date sampled	Giardia			DAPI -	DAPI +		DIC				
			Object located by FA	Shape (oval or round)	Size L x W (µm)	Light blue internal staining, no distinct nuclei, green rim	Intense blue internal staining	Number of nuclei stained sky blue	Empty cysts	Cysts with amorphous structure	Number of nuclei	Median Body	Axoneme
▼		▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼
8316	Seymour Reservoir	January 15, 2023	0										
8323	Seymour Reservoir	February 12, 2023	0										
8330	Seymour Reservoir	March 19, 2023	0										
8347	Seymour Reservoir	April 23, 2023	0										
8353	Seymour Reservoir	May 14, 2023	0										
8359	Seymour Reservoir	June 18, 2023	0										
8365	Seymour Reservoir	July 16, 2023	0										
8371	Seymour Reservoir	August 20, 2023	0										
8377	Seymour Reservoir	September 17, 2023	0										
8383	Seymour Reservoir	October 15, 2023	0										
8395	Seymour Reservoir	November 26, 2023	0										
8401	Seymour Reservoir	December 10, 2023	#1	oval	14x9			3		P			

Table A12. Seymour Reservoir Slide Examination Results - *Giardia* 2023

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