metrovancouver

Greater Vancouver Water District

2021 Water Quality Annual Report

Volume 1 of 2

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EXECUTIVE SUMMARY

Source Water Quality

- In 2021, the turbidity levels of the delivered water met the requirements of the Guidelines for Canadian Drinking Water Quality (GCDWQ).
- The Capilano supply was in service for the entire year. Heavy rainfall events in November resulted in Capilano source water turbidity peaking just over 21 Nephelometric Turbidity Unit (NTU). Even with the higher turbidity, the delivered filtered Capilano water was less than 0.30 NTU as measured by online instruments for the entire year.
- The Seymour supply was in service for the entire year. Heavy rainfall events in November resulted in Seymour source water turbidity peaking at 11 NTU. The delivered filtered Seymour water was less than 0.30 NTU as measured by online instruments for the entire year.
- The Coquitlam supply was in service for the entire year. The unfiltered Coquitlam source water was greater than 1 NTU for 22 days in 2021 and did not exceed 5 NTU throughout the year in accordance with GVWD's Permit to Operate.
- The microbiological quality of the three source waters was excellent in 2021. 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 avoiding filtration outlined in the turbidity section of the 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.

Water Treatment

- The Seymour Capilano Filtration Plant (SCFP) performance, as measured by the quality of the delivered water, was excellent in 2021. The daily average turbidity of water leaving the clearwells to enter the Greater Vancouver Water District (GVWD) transmission system was an average of 0.15 NTU in 2021.
- Turbidity levels for Individual Filter Effluent (IFE) met the turbidity requirements of the GCDWQ.
- Filtration consistently removed iron, colour and organics from the Capilano and Seymour source water.
- Levels of total aluminum in filtered water were consistently below the GCDWQ operational guideline value of 0.2 mg/L for direct filtration plants using aluminum-based coagulants. The maximum value for 2021 was 0.03 mg/L.
- There were no outages of ultraviolet treatment at the SCFP and the Coquitlam Water Treatment Plant (CWTP).
- The SCFP and CWTP operated the full year using sodium hypochlorite for chlorination.
- The secondary disinfection stations boosted chlorine when required.

Transmission/Distribution System Water Quality

- Bacteriological water quality was excellent in the GVWD transmission mains and in-system storage reservoirs.
- Of the approximate 6,600 samples collected from the regional system for testing in 2021, none were positive for *E. coli*. The detection of an *E. coli* triggers a protocol which involves immediate notification to health and member jurisdiction officials, re-sampling, and a thorough investigation into the possible causes.
- Bacteriological water quality was excellent in the distribution systems of the member jurisdictions. Of the approximate 20,800 samples collected from member jurisdictions for

testing in 2021, a high percentage (99.8%) were free of total coliforms, and one sample tested positive for *E. coli*.

- The running average levels of the Trihalomethane (THM) group of chlorine disinfection by-products detected in the delivered water in the GVWD and member jurisdiction systems were below the Maximum Acceptable Concentration (MAC) in the GCDWQ of 100 µg/L (0.1 mg/L). The running average levels for the Haloacetic Acid (HAA) group of chlorine disinfection by-products were below the GCDWQ Maximum Acceptable Concentration (MAC) of 80 µg/L (0.08 mg/L).

ACRONYMS

ACU	Apparent Color Unit
AO	Aesthetic Objective (characteristics such as taste, colour, appearance, temperature that are not health related)
BCDWPR	*British Columbia Drinking Water Protection Regulation*
BHT	Break Head Tank
BTEX	Benzene, Ethylbenzene, Toluene, Xylene
CALA	Canadian Association for Laboratory Accreditation
CRWPS	Capilano Raw Water Pump Station
CFE	Combined Filter Effluent
CFU	Colony Forming Units
CO_2	Carbon Dioxide
CTD	Conductivity, Temperature, Depth
CWTP	Coquitlam Water Treatment Plant
DS	Distribution System
DBP	Disinfection By-product
DOC	Dissolved Organic Carbon
DWTP	*Drinking Water Treatment Program*
DWTO	*Drinking Water Treatment Objectives (Microbiological) for Surface Water Supplies in British Columbia*
E. coli	*Escherichia coli*
ERF	Energy Recovery Facility
EPA	Environmental Protection Agency (USA)
ESWTR	*Enhanced Surface Water Treatment Rule* (USA)
GCDWQ	*Guidelines for Canadian Drinking Water Quality*
GVWD	Greater Vancouver Water District
HAA	Haloacetic Acid
HPC	Heterotrophic Plate Count
IFE	Individual Filter Effluent
MAC	Maximum Acceptable Concentration
MCL	Maximum Contaminant Level
MDA	Minimum Detectable Activity
MDL	Method Detection Limit
mg/L	Milligram per litre (0.001 g/L)
µg/L	Microgram per litre (0.000001 g/L)
mL	Milliliter
MF	Membrane Filtration
mJ/cm^2	Millijoule per centimeter squared
MPN	Most Probable Number
N/A	Not Available
NTU	Nephelometric Turbidity Unit
PAH	Polycyclic Aromatic Hydrocarbons
PFOA	Perfluorooactanoic Acid
PFOS	Perfluorooctane Sulfonate
pH	Measure of acidity or basicity of water; pH 7 is neutral

ppb	Parts per Billion (Equivalent of microgram per litre)
ppm	Parts per Million (Equivalent of microgram per litre)
RCW	Recycled Clarified Water
RWT	Raw Water Tunnel
SCADA	Supervisory Control and Data Acquisition
SCFP	Seymour Capilano Filtration Plant
TS	Transmission System
$THAA_5$	Total $Haloacetic_5$ Acids
THM	Trihalomethane
TOC	Total Organic Carbon
TTHM	Total Trihalomethane
TWT	Treated Water Tunnel
UV_{254}	Ultraviolet Absorbance at 254 nm
WHO	World Health Organization
WQMRP	*Water Quality Monitoring and Reporting Plan for Metro Vancouver (GVWD) and Local Government Members*

WATER SAMPLING AND TESTING PROGRAM

Water Type	Parameter	Frequency
Untreated, Source Water	Total coliform and *E. coli*	Daily
	Turbidity	Daily
	Giardia and *Cryptosporidium*	Monthly at Capilano and Coquitlam
	Ammonia, colour, iron, organic carbon, pH	Weekly
	Alkalinity, chloride, calcium, hardness, magnesium, manganese, nitrate, potassium, phosphate, sulphate	Monthly
	Aluminum, copper, sodium, total and suspended solids	Bi-monthly
	Trihalomethanes, haloacetic acids	Quarterly
	Antimony, arsenic, barium, boron, cadmium, cyanide, chromium, lead, mercury, nickel, phenols, selenium, silver, zinc	Semi-annually
	Pesticides and herbicides	Annually
	PAHs, BTEXs	Annually
	VOC	Annually
	Radioisotopes	Annually
Treated water	Total coliform and *E. coli*	Daily
	Turbidity	Daily
	Temperature	Daily
	Ammonia, colour, iron, organic carbon, pH, aluminum at SCFP	Weekly
	Aluminum, copper, sodium, total and suspended solids	Bi-Monthly
	Trihalomethanes, haloacetic acids	Quarterly at selected sites
	Antimony, arsenic, barium, boron, cadmium, cyanide, chromium, lead, mercury, nickel, phenols, selenium, silver, zinc	Semi-annually
GVWD Water Mains	Total coliform and *E. coli*	Weekly per site
	Heterotrophic plate count	Weekly per site
	Free chlorine	Weekly per site
	Trihalomethanes, haloacetic acids, pH	Quarterly at selected sites
	PAHs, BTEXs	Semi-annually at selected sites
GVWD Reservoirs	Total coliform and *E. coli*	Weekly per site
	Heterotrophic plate count	Weekly per site
	Free chlorine	Weekly per site
Member Jurisdiction Distribution Systems	Total coliform and *E. coli*	Weekly per site
	Heterotrophic plate count	Weekly per site
	Free chlorine	Weekly per site
	Turbidity	Weekly per site
	Trihalomethanes, haloacetic acids, pH	Quarterly at selected sites

1.0 SOURCE WATER QUALITY

The first barrier in place to protect the quality of drinking water supply is the protection of the Water Supply Area to ensure the best quality source water. 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 that is in place. Regular monitoring of the water sources is also a requirement of the *Water Quality Monitoring and Reporting Plan for Metro Vancouver (GVWD) and Local Government Members (WQMRP)*.

1.1. Bacteriological Quality of the Source Water

The bacteriological quality of the source water is an important indicator of the degree of 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 turbidity guideline.

	Percent of samples (daily) in a six month period ending on the last day of the month named where *E. coli* greater than 20/100 mL		
Month	**Capilano**	**Seymour**	**Coquitlam**
Jan	4.4%	8.7%	3.8%
Feb	4.4%	9.1%	3.9%
Mar	1.1%	5.1%	0.6%
Apr	0.0%	0.0%	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	3.8%	4.4%	3.3%
Oct	3.8%	7.6%	3.8%
Nov	3.8%	7.7%	3.8%
Dec	3.8%	7.7%	3.8%

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

Figure 1 shows the results of the analysis of the source water from 2017 to 2021 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 in previous years, 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.

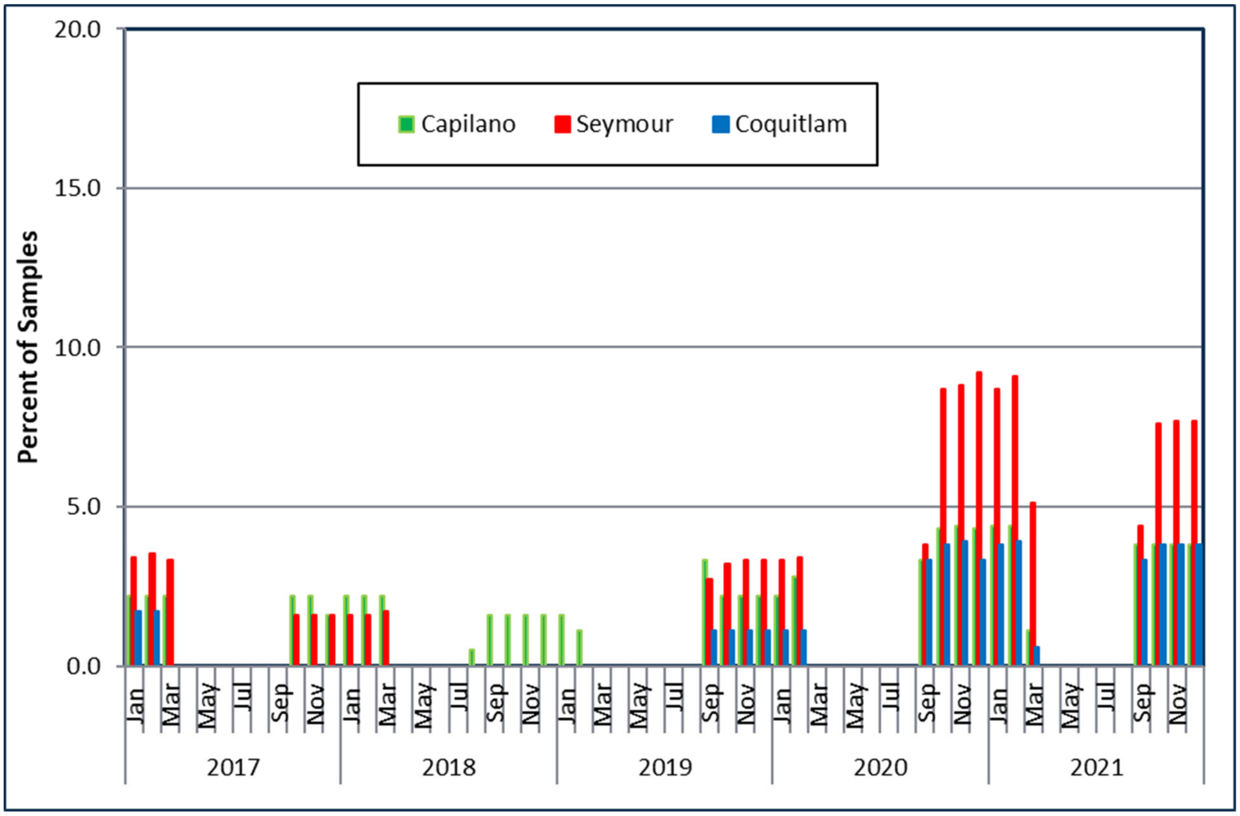


Figure 1: Percent of Samples Exceeding 20 E. coli/100 mL at all Three Sources (2017 to 2021)

Note: Metro Vancouver has protected Water Supply Areas and therefore the source of *E. coli* is most likely originating from endemic animals in the Water Supply Areas.

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 raw water for *Giardia* since 1987. Since 1992, Metro Vancouver has participated in a program with the BC Centre of Disease Control Enhanced Water Testing Laboratory, to gather more information about the number and nature of cysts found in the GVWD water supplies. The program involves collecting samples from the Capilano and Coquitlam supplies upstream of disinfection.

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.

The results of the 2021 testing program are contained in the "Metro Vancouver Detection of Waterborne *Cryptosporidium* and *Giardia* January - December, 2021 Annual Report", which was prepared by the BC Public Health Microbiology & Reference Laboratories, Environmental Microbiology, and can be found in Appendix D. Three of twelve (25%) samples collected at Capilano and three of the twelve (25%) collected at Coquitlam were positive for *Giardia* (Table 2).

Seymour samples are all process control samples and not Seymour source water (shown as N/A in the table).

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Capilano	75	50	18	18	50	58	33	33	33	25
Seymour	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Coquitlam	50	23	8	0	17	67	8	25	25	25

Table 2: Percent of Samples Positive for Giardia

Zero of twelve (0%) samples collected at Capilano were positive for *Cryptosporidium*, and zero of twelve (0%) were positive at Coquitlam (Table 3). Seymour samples are all process control samples and not Seymour source water (shown as N/A in the table).

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Capilano	16	9	9	9	25	17	8	0	0	0
Seymour	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Coquitlam	8	9	0	0	0	0	0	0	0	0

Table 3: Percent of Samples Positive of Cryptosporidium

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

1.3. Turbidity

As shown in Figure 2, GVWD water sources have been susceptible to turbidity upsets 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 the turbidity does not exceed specific water quality parameters requirements and provided that a number of other provisions, including source water protection and two forms of water treatment requirements, are in place. Historically the turbidity levels on both the Capilano and Seymour sources would not meet these criteria, therefore plans were developed and implemented to filter both supplies.

Filtration of 100% of the Seymour supply began in December 2009, and filtration and distribution of the Capilano supply through the Twin Tunnels connecting the Capilano and Seymour source supplies commenced in February 2015. Both the raw and treated water tunnels were fully operational in April 2015.

Section 4.4 of the DWTO (Version 1.1, 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 so these source water criteria don't apply to the delivered water. Coquitlam, which is unfiltered, was in service for all of 2021 in accordance with the DWTO.

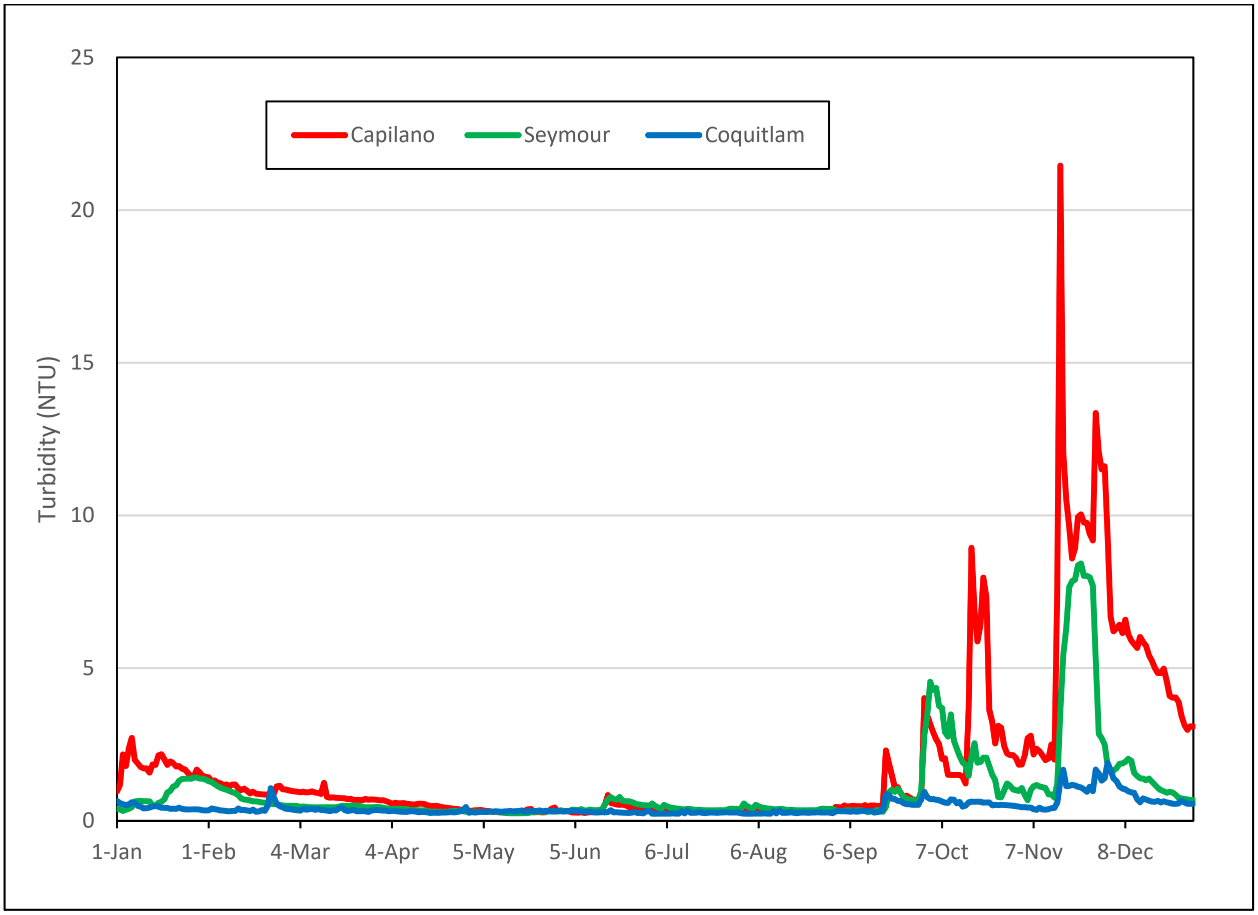


Figure 2: Average Daily Turbidity of Source Water (From In-line Readings)

1.4. Chemistry

1.4.1. Chemical and Physical Characteristics of Source Water

The chemical and physical characteristics of the GVWD source water are summarized in Appendix A of this report; detailed analytical results are provided in Volume II. The results from the chemical and physical analyses of the source water in 2021 were similar to those for other years.

1.4.2. Herbicides, Pesticides, Volatile Organic Compounds, Radioactivity and Uranium

Analyses of the source water for a variety of organic compounds, including all of the compounds with an specified MAC in the *Guidelines for Canadian Drinking Water Quality* (GCDWQ), is carried out on an annual basis in accordance with the WQMRP. The results are contained in Appendix B of this report and in Volume II. No parameters were detected above the applicable GCDWQ health based limits.

1.4.3. PFOS and PFAS

The GCDWQ have added the parameters of Perfluorooctane Sulfonate (PFOS) and Perfluorooactanoic Acid (PFAS) for testing of the source and treated waters. The results are in Appendix B of this report and in Volume II. None of the chemicals in these categories were detected. Common sources of these synthetic chemicals are from consumer products and fire-fighting foam for their water and oil repellant properties.

1.4.4. Limnology

The Reservoir Water Quality Monitoring Program started in 2014 collects limnology data (physical, chemical and biological parameters) for the Capilano, Seymour and Coquitlam 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 rivers is conducted between April and November each year. Biological productivity that can influence water quality is the highest during this time of year, making it an important time for sampling and measurements. Monthly sampling of the source water is conducted by staff and sample analysis undertaken by accredited labs. More frequent water quality measurements are compiled by arrays of scientific instruments in each reservoir.

Metro Vancouver employs the services of a limnology consultant to review the annual program data, interpret physical, chemical, and biological conditions and examine long term trends. Results in 2021, as in previous years, confirmed the three reservoirs are ultra-oligotrophic (see Appendix C), which means they have low levels of available nutrients and low levels of biological production. A single value called the Trophic State Index (TSI) is used to infer time course change in water quality based on the amount of algal biomass in the water column of each reservoir. TSI values have remained consistently low since measurements began (see Appendix C), which shows low biological production. The ultra-oligotrophic classification and low TSI values are highly desirable for source drinking water supply and shows that the GVWD Water Supply Areas and reservoirs continue to supply high quality water.

There is worldwide interest in blue green algae (also known as cyanobacteria) in 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 well below levels known to affect human health and are far below the GCDWQ. This desirable condition is due to the ultra-oligotrophic status of the reservoirs. Metro Vancouver continues to monitor cyanobacteria, including Merismopedia species as well as processes in the 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 reservoir management strategies.

2.0 QUALITY CONTROL ASSESSMENT OF WATER TREATMENT

Water treatment is the second barrier (after source water protection) relied on to assure the quality of the water supply.

Completion of the Twin Tunnels Project in 2015 successfully concluded GVWD's regional long-range water treatment enhancement plans which spanned more than ten years. Each tunnel is 3.8 metres in diameter, 7.1 kilometres long, and 160 to 640 meters below ground level, running beneath Grouse Mountain and Mount Fromme. The water from the Raw Water Tunnel (RWT) is filtered and treated alongside the Seymour source water at the Seymour Capilano Filtration Plant (SCFP). Both treated sources enter the Clearwell at the SCFP for further treatment before the blended water is distributed to the region. Blended treated water returns to Capilano through the Treated Water Tunnel (TWT) and provides high quality drinking water to the Capilano area while the remainder is distributed through the Seymour system.

2.1. Seymour Capilano Filtration Plant

The SCFP is a chemically assisted direct filtration plant which uses poly aluminum 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 ultraviolet light as the water exits each filter. The final processes are the addition of sodium hypochlorite (chlorine) and hydrated lime before the water enters the Clearwells. The West and East Clearwells are large water storage reservoirs that store and allow controlled passage of water with mixing (or blending) of the injected chlorine and hydrated lime. The Clearwells provide sufficient retention (or contact time) with chlorine to provide any further disinfection required after filtration and ultraviolet light treatment. Carbon dioxide (CO_2) in solution is added to trim pH once the desired alkalinity is reached. After the Clearwells, the finished water enters the transmission system at the Seymour Treated Water Valve Chamber. The SCFP has been operational since December 2009 and the quality of the water produced has been excellent.

2.1.1. Filtration

As a result of filtration treatment of the Capilano and Seymour water sources, there have been a number of changes to the characteristics of the delivered water. Some of these changes are visible, and some are not. The most obvious visible change in the water is the decrease in colour and increase in clarity. There is a total loss of brown hue that can sometimes characterize Capilano and Seymour waters before filtration. This improvement in colour is a result of removal of the naturally occurring parameters that cause the brown hue by the filtration process. Suspended particles in water that cause light to scatter (turbidity) are also removed. The end product is water that is very clear. Due to the purity of the water, it may have a slight bluish tinge.

Figure 3 compares the apparent colour of SCFP filtered water and Capilano and Seymour source waters for 2021. During the fall rainfall events, the apparent colour of the Seymour source water feeding the SCFP had a reading over 25 ACU. After the removal of the organic material through filtration, the colour of the filtered water delivered to the public was never greater than 3 ACU.

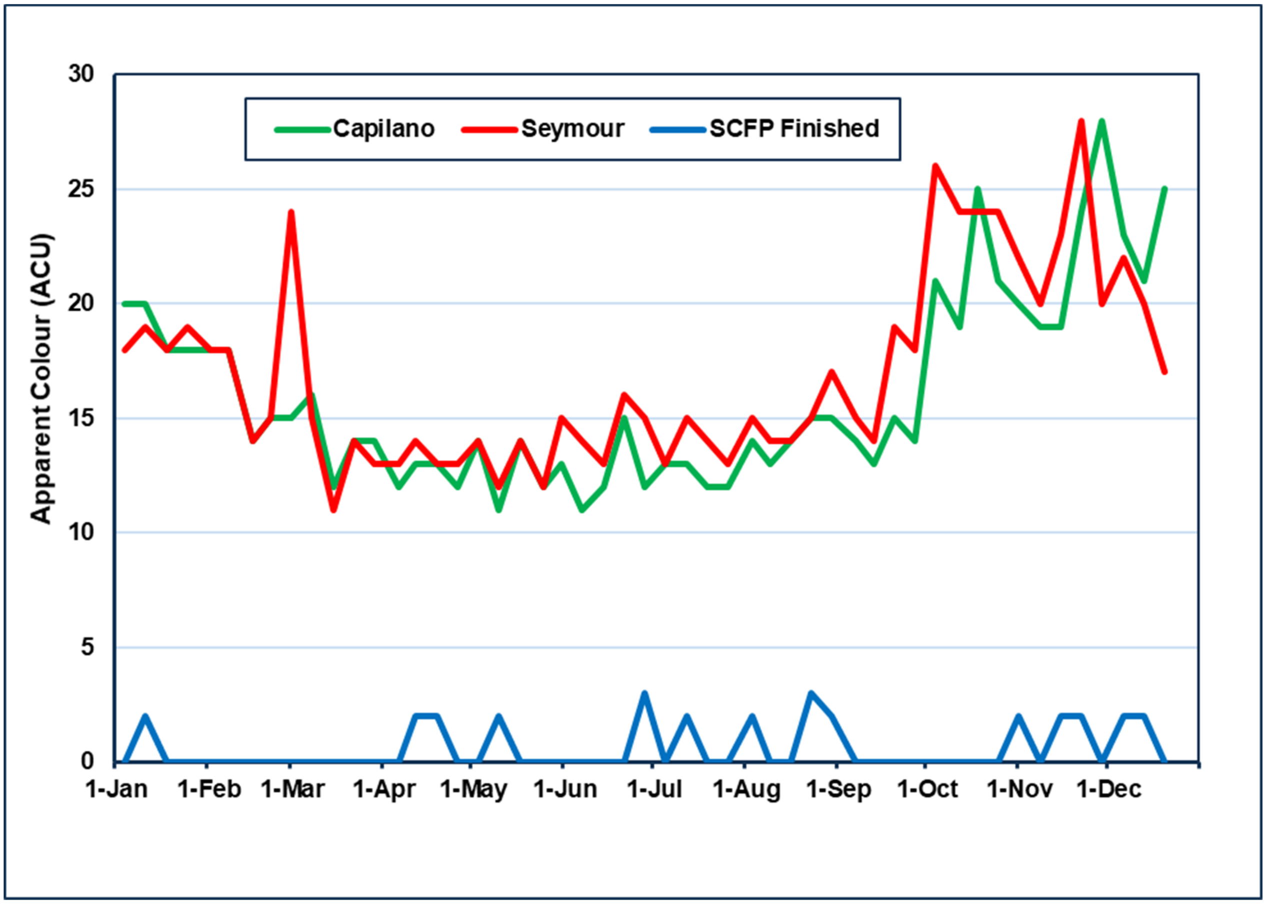


Figure 3: Apparent Colour Levels Before and After Filtration

Figure 4 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 NTU for 106 days. The Capilano source exceeded 1 NTU on 127 days. Since both sources were filtered at the SCFP, the maximum average daily turbidity of the delivered water was 0.22 NTU and the average was 0.15 NTU.

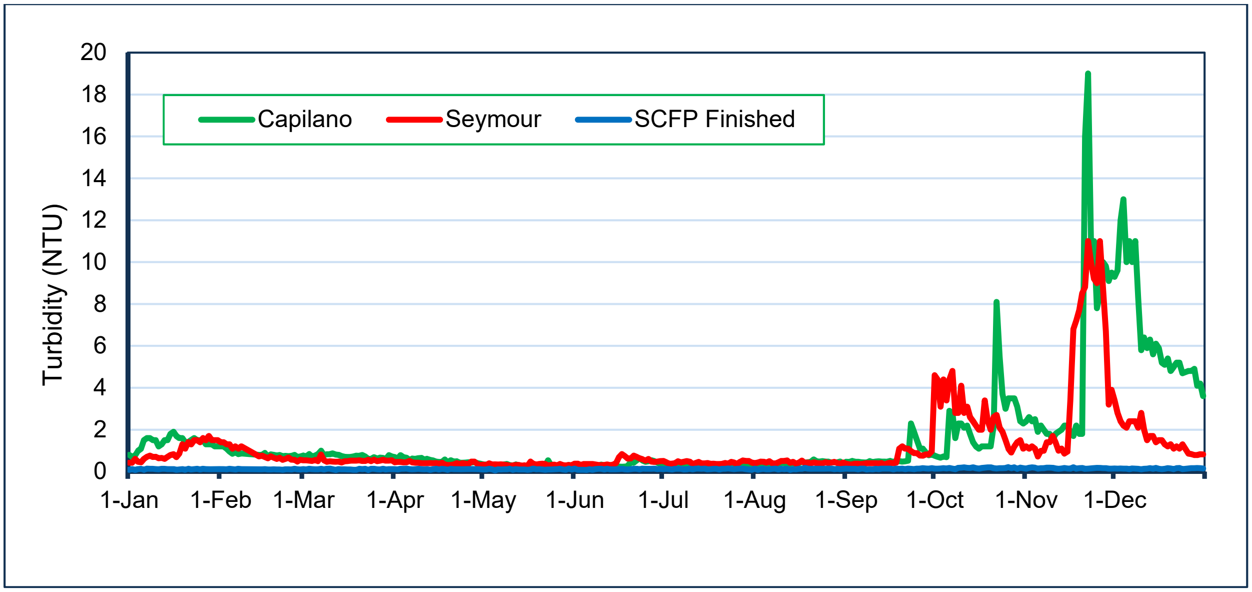


Figure 4: Average Daily Turbidity Levels Before and After Filtration

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 SCFP 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 (2020) 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.*"

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 time less than 0.3 NTU. This is summarized in Table 4. In 2021, 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.

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	100%
February	0	100%
March	0	99.99%
April	0	99.99%
May	0	100%
June	0	99.99%
July	0	100%
August	0	100%
September	0	100%
October	0	100%
November	0	100%
December	0	99.99%

Table 4: Monthly Filter Effluent Turbidity Summary

Under normal operating conditions the average turbidity of the filtered water at SCFP was 0.15 NTU.

All water that flows through the filters immediately passes through the ultraviolet units. The intensity of the ultraviolet lamps automatically increases when there is an increase in turbidity of the water exiting each filter. After ultraviolet treatment, the water is chlorinated as it enters the clearwell, where more than one hour of contact time is provided.

2.1.2. Ultraviolet Treatment

The effluent from each filter is treated with ultraviolet light as the water exits the filter. Ultraviolet 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, ultraviolet light is present to render any parasites that may be present as non-infectious. Oocysts are not able to proliferate inside the intestines of human hosts to cause illness after a sufficient dose of ultraviolet light. The target dosage for ultraviolet light is to achieve 2-Log (99%) *Giardia* and *Cryptosporidium* inactivation is 21 mJ/cm^2.

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

Table 5 summarizes the performance of the SCFP ultraviolet system in 2021.

Month	Percent of Monthly Volume ≥ 2-log of *Giardia* and *Cryptosporidium* Inactivation (95% of monthly volume required)
January	99.83%
February	99.92%
March	99.87%
April	99.95%
May	99.95%
June	99.95%
July	99.93%
August	99.86%
September	99.94%
October	99.88%
November	99.92%
December	99.93%

Table 5: Percent of Volume Meeting Ultraviolet Dosage Requirements at SCFP

2.1.3. Chlorination

Chlorination is used for disinfection at the source as well as at secondary disinfection stations to minimize bacterial regrowth in the GVWD transmission and member jurisdiction distribution systems. Chlorination provides 4-log virus inactivation with liquid sodium hypochlorite.

2.2. Coquitlam Water Treatment Plant

The Coquitlam Water Treatment Plant (CWTP) uses ozonation, ultraviolet treatment, soda ash and chlorination to treat water from the Coquitlam source.

Ozonation provides pre-treatment and helps remove micro-organisms from the water, reduces disinfection by-products and improves water clarity, which increases the efficiency of the subsequent ultraviolet process. Ozonation provides an additional 4-log virus inactivation to chlorination. Soda ash is then added for pH and alkalinity adjustment for corrosion control, followed by chlorination.

2.2.1. Ultraviolet Treatment

Ultraviolet treatment (operational since 2014) provides for primary disinfection, and achieves 3-log inactivation of chlorine-resistant micro-organisms for *Giardia* and *Cryptosporidium*. The water is directed into 8 ultraviolet units, each containing 40 ultraviolet lamps encased in protective sleeves. Ultraviolet light emitted from the lamps passes through the water. The US Environmental Protection Agency (USEPA) 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 6. The USEPA standard is used because there is no Canadian standard.

Month	Percent of Monthly Volume ≥ 3-log *Giardia* and *Cryptosporidium* Inactivation (Minimum 95% Required)
January	99.86%
February	99.87%
March	99.88%
April	99.84%
May	99.87%
June	99.83%
July	99.91%
August	99.90%
September	99.90%
October	99.85%
November	99.88%
December	99.90%

Table 6: Percent of Volume Meeting Ultraviolet Dosage Requirements at CWTP

2.2.2. Chlorination

Chlorination is used for disinfection at the source as well as at secondary disinfection stations to minimize bacterial regrowth in the GVWD transmission and member jurisdiction distribution systems. Chlorination provides 4-log virus inactivation with liquid sodium hypochlorite, which replaced the compressed chlorine gas system in 2017. Table 7 summarizes the performance of all the Coquitlam disinfection systems in 2021.

Facility	Performance	Discussion
Ozonation	Operated 99.7% of time	Acts as a pre-treatment, enhancing the removal of organics and increasing the UV Transmittance making Ultraviolet treatment more effective. Ozone outages were due to electrical or instrument maintenance, ozone outage test, or ozone generator faults.
Ultraviolet	No loss of ultraviolet in 2021. 99.87 % of volume was treated to ultraviolet specifications	UV performance met USEPA requirements. (95% of monthly volume required).
Chlorination	100% of water was chlorinated	This facility uses chlorine as a secondary disinfectant except during an outage of the ultraviolet system when it is used for primary disinfection.

Table 7: Performance of Coquitlam Disinfection Facilities

2.3. Secondary Disinfection

There are 8 secondary disinfection stations operated by Metro Vancouver. The purpose of these stations is to increase the chlorine residual in the water transmission and distribution systems to meet a target residual based on a number of factors, including source water turbidity, the amount of bacterial regrowth detected in member jurisdiction 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 dose leaving the secondary facilities receiving SCFP water is 0.8 mg/L. These facilities frequently have an incoming chlorine residual high enough that boosting is not required. The target chlorine dose leaving the secondary facilities receiving CWTP water ranges from 1.20 to 1.50 mg/L.

Table 8 summarizes the performance of the secondary disinfection facilities in 2021.

Facility	Branch Main	Average Free Chlorine (mg/L)	Range of Free Chlorine (mg/L)	Discussion
Clayton	Whalley/Clayton	1.21	1.02 – 1.54	Supplied by Coquitlam water. Station was shut down for one day to replace existing connection to City of Surrey.
	Jericho/Clayton	1.23	0.95 – 1.61	
Chilco/Alberni	Capilano No. 4 and No.5	0.74	0.61 – 0.83	Supplied by SCFP water. Station was out of service periodically throughout the year due to power outages and water main isolations.
Pitt River	Haney Main No.2	1.23	0.88 – 1.52	Supplied by Coquitlam water. Station was out of service periodically throughout the year due to power issues and piping breaks.
	Haney Main No.3	1.23	1.01 – 1.53	
Newton	Surrey Hickleton Main	0.99	0.38 – 1.34	Primarily supplied by SCFP water. Power loss for a few hours caused both metering pumps to fault.
Kersland	Capilano No. 4 and No.5	0.89	0.67 – 1.10	Supplied by SCFP water. The Sodium Hypochlorite Solution injection piping was replaced in May. Station was off for 2 weeks.
Central Park	South Burnaby Main No.1	0.77	0.70 – 1.04	Primarily supplied by SCFP water. Station was off for 2 days in March for main repairs.
	South Burnaby Main No.2	0.90	0.65 – 1.39	
Cape Horn	Coquitlam Main No.2	1.24	0.93 – 1.53	Supplied by Coquitlam water. Station was out of service for 1.5 hours after a loss of power in March. Main No. 2 was dosed using Main No. 3 system after a break in piping. Repairs made and systems returned to normal after 2 days.
	Coquitlam Main No.3	1.24	0.79 – 1.51	
Vancouver Heights	Boundary Road Main No. 5	0.84	0.69 – 1.19	Supplied by SCFP water. No operational issues.

Table 8: Performance of Secondary Disinfection Facilities

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.

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 hydrated lime (calcium bicarbonate) to raise its pH and alkalinity before it enters the clearwells. To achieve the desired alkalinity, the resultant pH is trimmed using CO_2 to bring it down to target levels

At the Coquitlam source, the commissioning of the CO_2 system at the CWTP began in 2019 and was fully operational in 2021. The CO_2 system with the addition of soda ash allows the GVWD to meet new target pH and alkalinity values across the entire system. Similar to the SCFP, the CO_2 system is used to trim the resultant pH to desired target levels.

The average pH of the treated water leaving Seymour Capilano and Coquitlam Water Treatment Plants was 8.2 and 8.1, respectively, during 2021.

Performance of the corrosion control facilities is summarized in Table 9.

Facility	Performance	Discussion
SCFP Corrosion Control	pH ranged from 7.4 – 8.9	The annual average pH was 8.2 and was continually monitored with online instrumentation. The pH target changed from 7.7 to 8.4 in June 2021 to enhance corrosion control.
CWTP Corrosion Control	pH ranged from 6.7 – 9.4	The annual average pH was 8.1. On a couple of occasions in January the pH was <7.0 for a short period due to a soda ash equipment fault. In April and December, the pH was > 9 for a short period. In April it was due to complications with the carbon dioxide dosing. In December it was related to a failure with the soda ash system.

Table 9: Performance of Corrosion Control Facilities

The chemical and physical characteristics of the GVWD treated water are summarized in Appendix A of this report and detailed analytical results are provided in Volume II.

3.0 TRANSMISSION/DISTRIBUTION SYSTEM WATER QUALITY

Schedule A of the *BC Drinking Water Protection Regulation* (BCDWPR) 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 its member jursidictions. 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 1 sample is collected.

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

The BCDWPR 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 distribution system itself (regrowth).

The number of *E. coli* detected in both GVWD and member jurisdiction drinking water samples is typically very low. Out of more than 26,000 samples collected from GVWD and member jurisdiction systems analyzed in 2021, one sample was positive for *E. coli*. The detection of a positive *E. coli* sample triggers a protocol which involves immediate notification to health and member jurisdiction officials, re-sampling, and a thorough investigation into the possible causes.

In the GVWD transmission system, only 11 out of the approximately 6,600 samples collected, tested positive for total coliforms. Only 30 of the approximately 20,000 samples collected from the member jurisdiction distribution systems tested positive for total coliforms in 2021. The majority of the coliforms (67%) in the member jurisdiction systems appeared in the warmer water months of June through October.

The most likely source of these organisms can be attributed to bacterial regrowth. It should be emphasized that 99.8% of the samples in 2021 had no coliforms present, 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 2021, 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, well below the 10% standard. Of the approximately 4,400 samples processed, only 9 samples tested positive for total coliforms and no samples were positive for *E. coli* bacteria. The compliance of monitoring results from GVWD water mains with the criteria in the BCDWPR is shown in Figure 5.

There were another 540 samples collected from stations where only chlorine residuals are measured. In addition, there are inline stations collecting data every 10-minutes after chlorination at each source, but these samples are not included in the calculations for compliance monitoring.

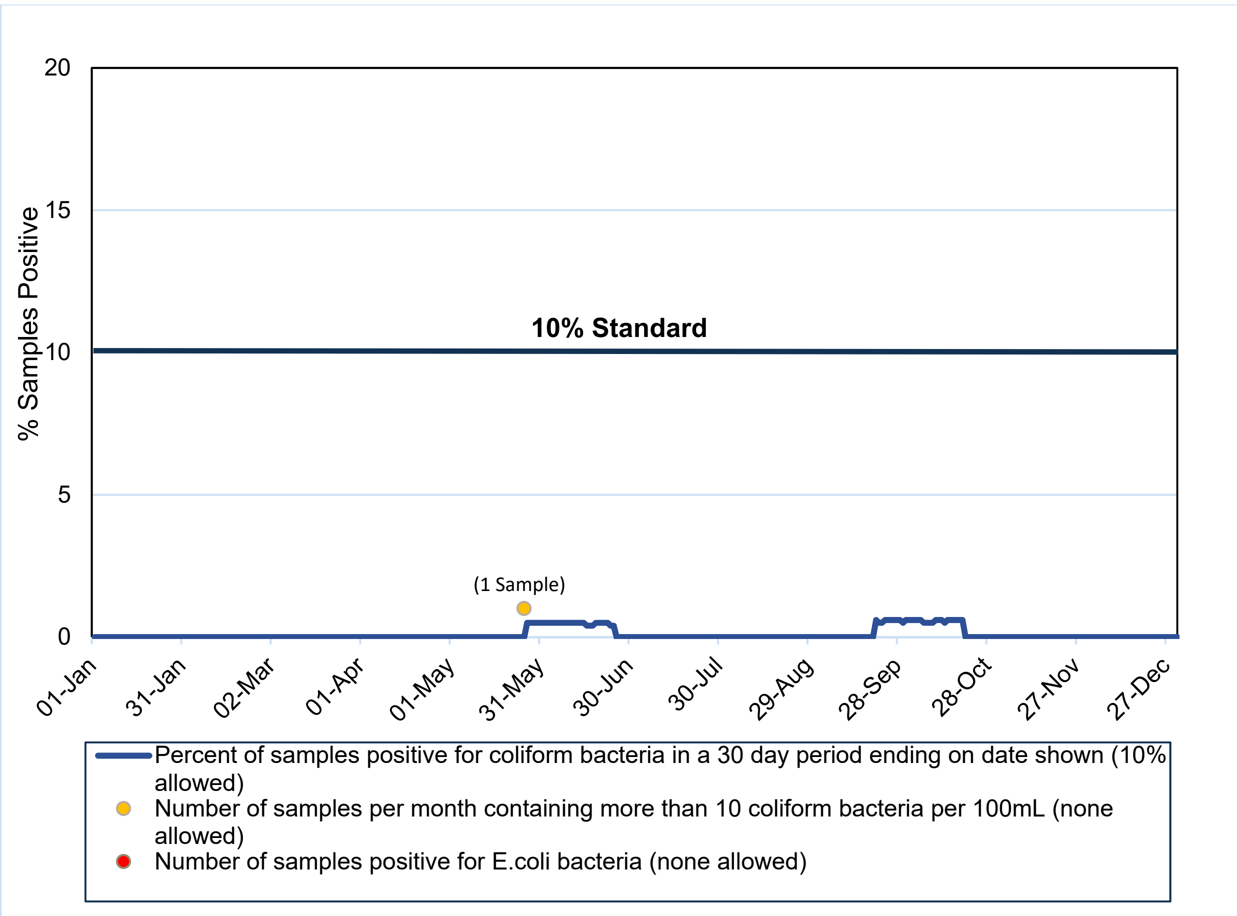


Figure 5: Bacteriological Quality of Water in GVWD Water Mains

3.1.2. GVWD Reservoirs

In 2021, over 2,200 samples were collected from 21 reservoirs and tanks that are located throughout the GVWD water system. Only 2 samples were positive for total coliforms. No sample from a reservoir was positive for *E. coli*.

The compliance of 2021 monitoring results from GVWD reservoirs with the criteria in the BCDWPR is shown in Figure 6.

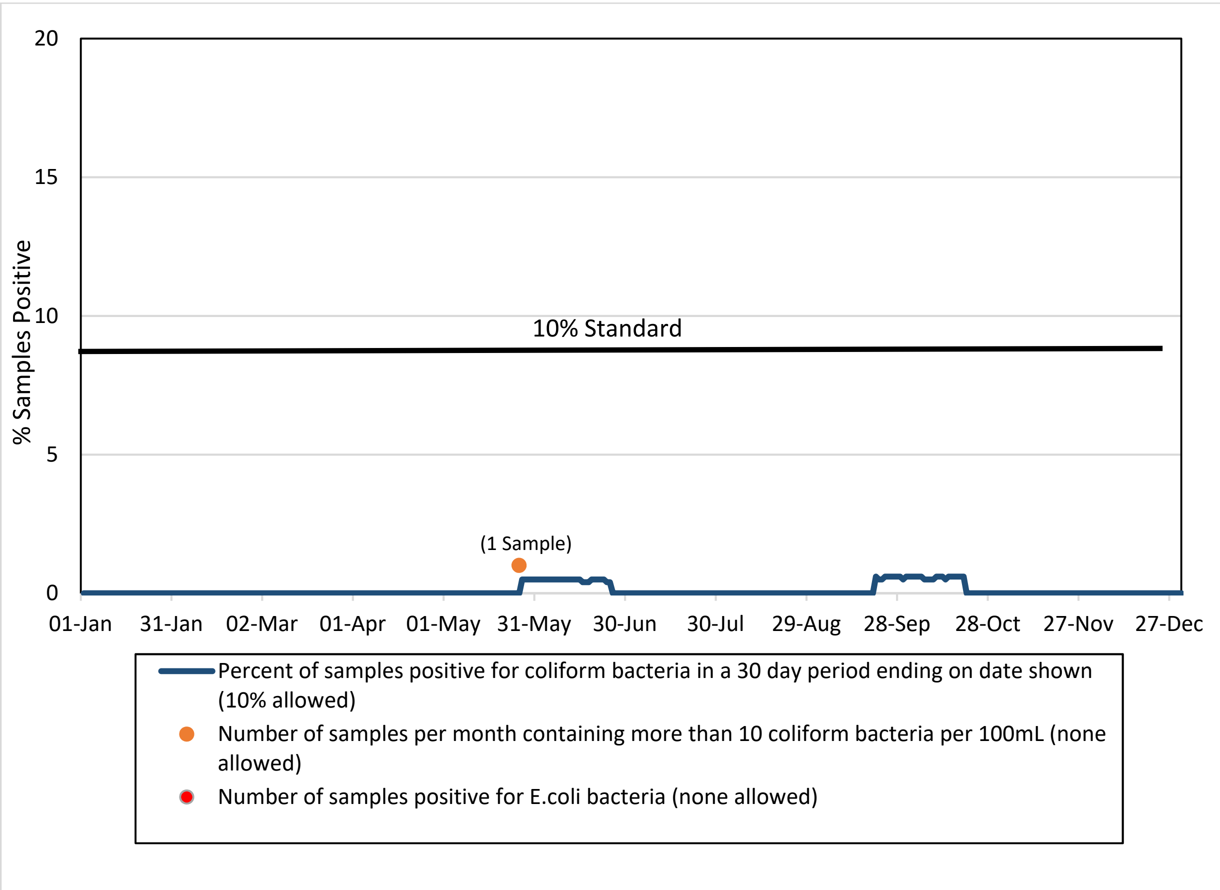


Figure 6: Bacteriological Quality of Water in GVWD Reservoirs

Reservoir water quality is optimized by the use of secondary disinfection coupled with an active reservoir exercising program that includes a minimum of weekly monitoring of chlorine residuals and bacteriology results, which can result in changes to filling levels, if necessary.

In 2021, the first of two cells of the new Jericho Reservoir was commissioned and placed into service on August 30. The reservoir will service the growing needs of the Township of Langley. The second cell is expected to be commissioned in 2022. Total storage at this facility will be 20 million litres.

Table 10 provides an overview of the status of the GVWD reservoirs from 2018 to 2021. During certain times of the year, it is not possible to cycle reservoirs as much as would be desired due to operational constraints. Despite these constraints, water quality as determined by coliform bacteria was satisfactory in all reservoirs.

Reservoir (Capacity in Million Litres)	Average Free Chlorine (mg/L)				Discussion
	2018	2019	2020	2021	
Burnaby Mountain Reservoir (13.2)	0.49	0.53	0.57	0.53	Inspection by divers for conditions in April. Remained in operation.
Burnaby Tank (2.3)	0.54	0.58	0.60	0.57	No operational issues
Cape Horn Reservoir (40.0)	0.78	0.61	0.78	0.71	No operational issues
Central Park Reservoir (35.0)	0.53	0.51	0.66	0.54	No operational issues
Clayton Reservoir (21.6)	1.1	1.02	1.08	1.1	Cell 1 was out of service January 1 to May 10. Cell 2 removed from service October 12 to maintain water quality due to seasonal low demand.
Glenmore Tanks (1.0)	0.66	0.68	0.77	0.73	No operational issues
Grandview Reservoir (13.5)	0.71	0.73	0.80	0.85	No operational issues
Greenwood Reservoir (8.8)	0.66	0.68	0.75	0.70	No operational issues
Hellings Tank (4.3)	0.47	0.48	0.54	0.56	No operational issues
Jericho Reservoir (20.0)	NA	NA	NA	1.10	New reservoir. Cell 1 was disinfected and was in operation starting on August 30.
Kennedy Reservoir (16.3)	0.56	0.52	0.58	0.65	No operational issues
Kersland Reservoir (73.7)	0.55	0.55	0.66	0.65	Reservoir No.1 removed from service in October for upgrades until Spring 2022. No Operational issues with other cell.
Little Mountain Reservoir (171.0)	0.64	0.67	0.72	0.69	No operational issues
Maple Ridge Reservoir (20.0)	0.53	0.52	0.44	0.46	No operational issues
Newton Reservoir (32.0)	0.45	0.46	0.55	0.44	No operational issues
Pebble Hill Reservoir (42.2)	0.63	0.60	0.66	0.54	Cell 1 was out of service January 1 to July 12. Cell 1 was out of service October 17 to maintain water quality due to seasonal low demand and for seismic upgrade work. No Operational issues with other cells.
Prospect Reservoir (4.4)	0.64	0.66	0.76	0.73	No operational issues
Sasamat Reservoir (26.0)	0.54	0.54	0.65	0.62	No operational issues
Sunnyside Reservoir (22.7)	0.58	0.47	0.73	0.85	Cell 1 was investigated by divers in March. Cell 2 was cleaned, inspected, and disinfected in November.
Vancouver Heights Reservoir (43.0)	0.66	0.75	0.82	0.78	The reservoir was cleaned by divers in February while remaining in service.
Westburnco Reservoir (73.0)	0.58	0.58	0.64	0.60	No operational issues
Whalley Reservoir (33.4)	0.60	0.59	0.73	0.71	No operational issues

Table 10: Status of GVWD Reservoirs (2018-2021)

3.2. Microbiological Water Quality in Member Jurisdiction Systems

For samples collected from member jurisdiction systems, the percent positive per month for total coliform bacteria from 2018-2021 is shown in Figure 7.

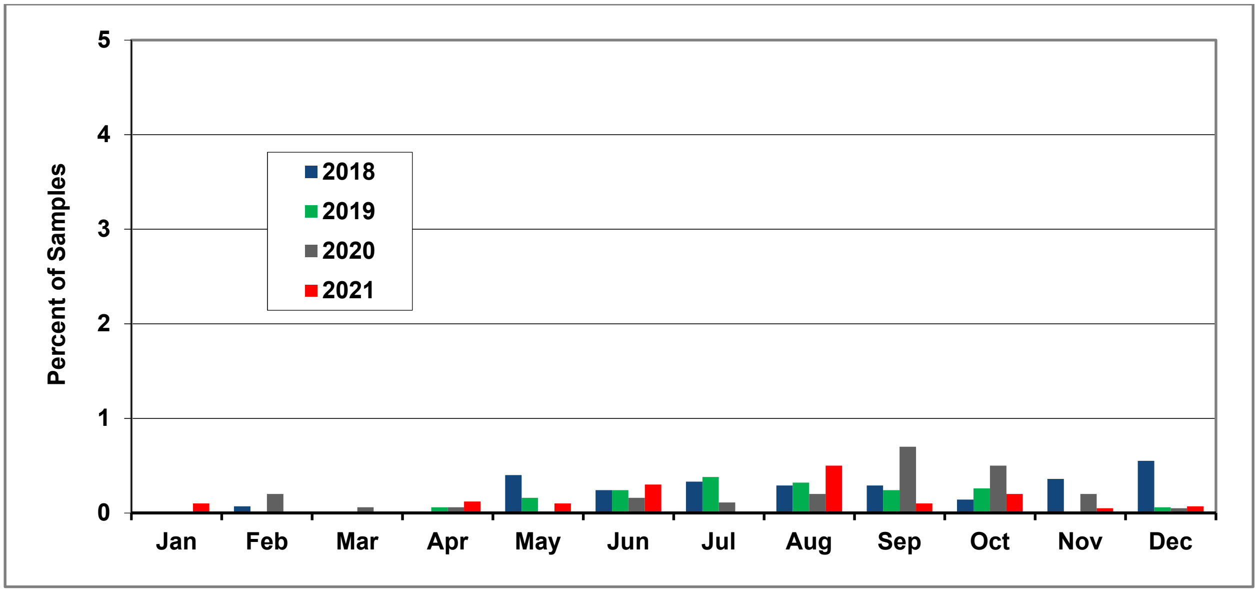


Figure 7: Percent of Samples per Month Positive for Total Coliform Bacteria (2018 to 2021)

The percentage of samples positive for total coliform bacteria in 2021 remained relatively similar as compared to 2020.

Schedule A of the BCDWPR contains standards for the bacteriological quality of potable water in the Province. There are three components of this standard that apply to local governments:

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 1 sample is collected.

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

For samples from member jurisdiction systems, this requirement was met in 2021 with the following exceptions:

- One sample in January contained more than 10 total coliform bacteria.
- One sample in June contained more than 10 total coliform bacteria.
- One sample in October was positive for *E. coli.*

Table 11 shows the compliance with the bacteriological standards (3 parts) in the BCDWPR for samples taken within the distribution systems of the 20 member jurisdictions that are supplied with GVWD water.

Month	Number that met Part 1	Number that met Part 2	Number that met Part 3	Number that met all requirements
January	20	20	19	19
February	20	20	20	20
March	20	20	20	20
April	20	20	20	20
May	20	20	20	20
June	20	20	19	19
July	20	20	20	20
August	20	20	20	20
September	20	20	20	20
October	19	20	20	19
November	20	20	20	20
December	20	20	20	20

Table 11: Member Jurisdiction Water Quality Compared to the Provincial Bacteriological Standards

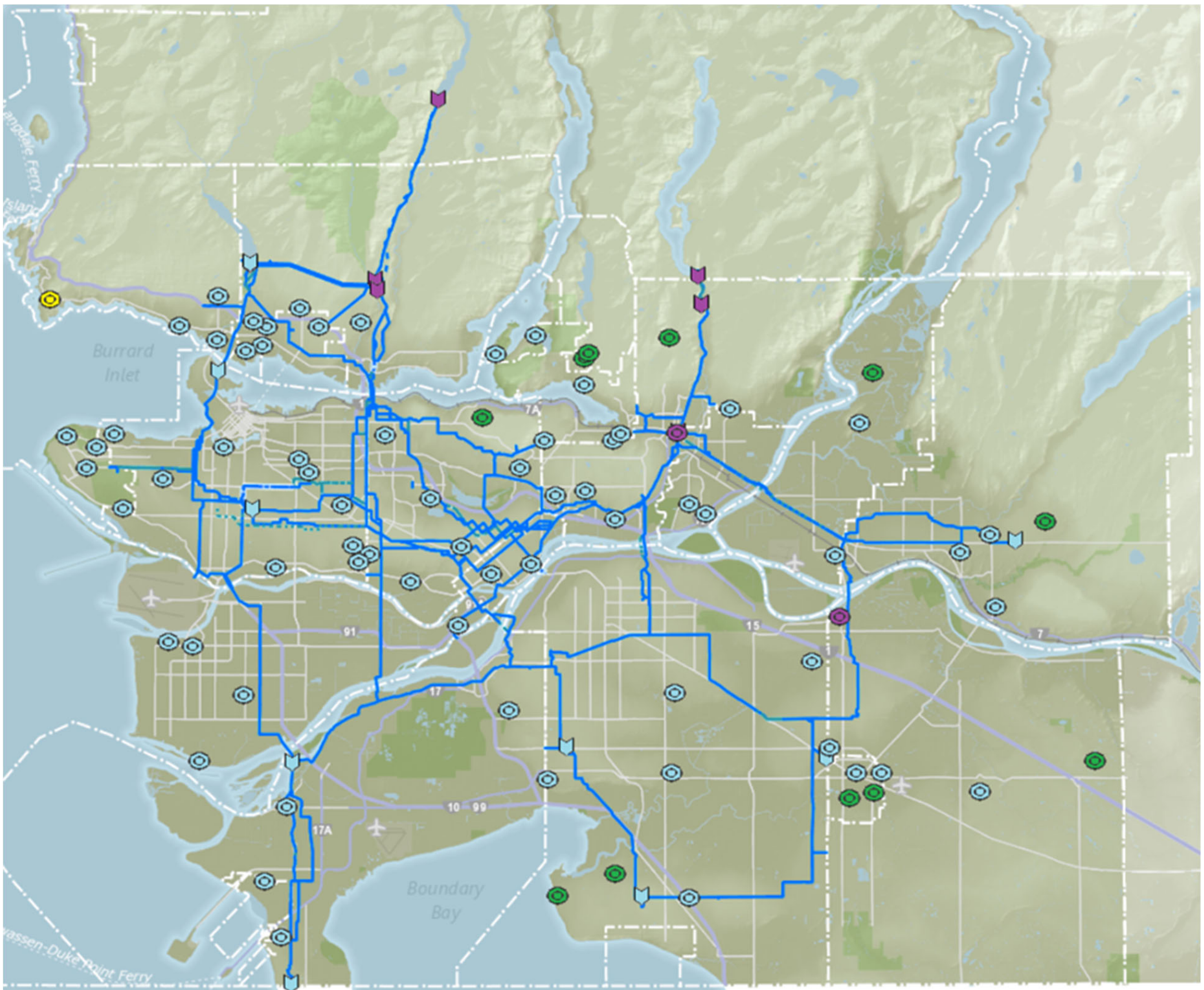
3.3. Disinfection By-Products in the Transmission/Distribution Systems

As the treated water moves through the GVWD Transmission system and into the member jurisdiction distribution system's infrastructure of pipes and reservoirs, changes in water quality occur. This is mainly due to the reaction between the chlorine in the water (added during primary and secondary disinfection) and 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: Total Trihalomethanes (TTHMs) and Total Haloacetic Acids ($THAA_5$). 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 Maximum Acceptable Concentration (MAC) in the GCDWQ for TTHMs is a locational yearly running average of 100 ppb (0.1 mg/L) based on quarterly samples. A comparison of TTHM levels in the GVWD and member jurisdiction systems in 2021 is shown in Figure 8. All THM results from GVWD water mains and member jurisdiction systems were below the MAC of 100 ppb.

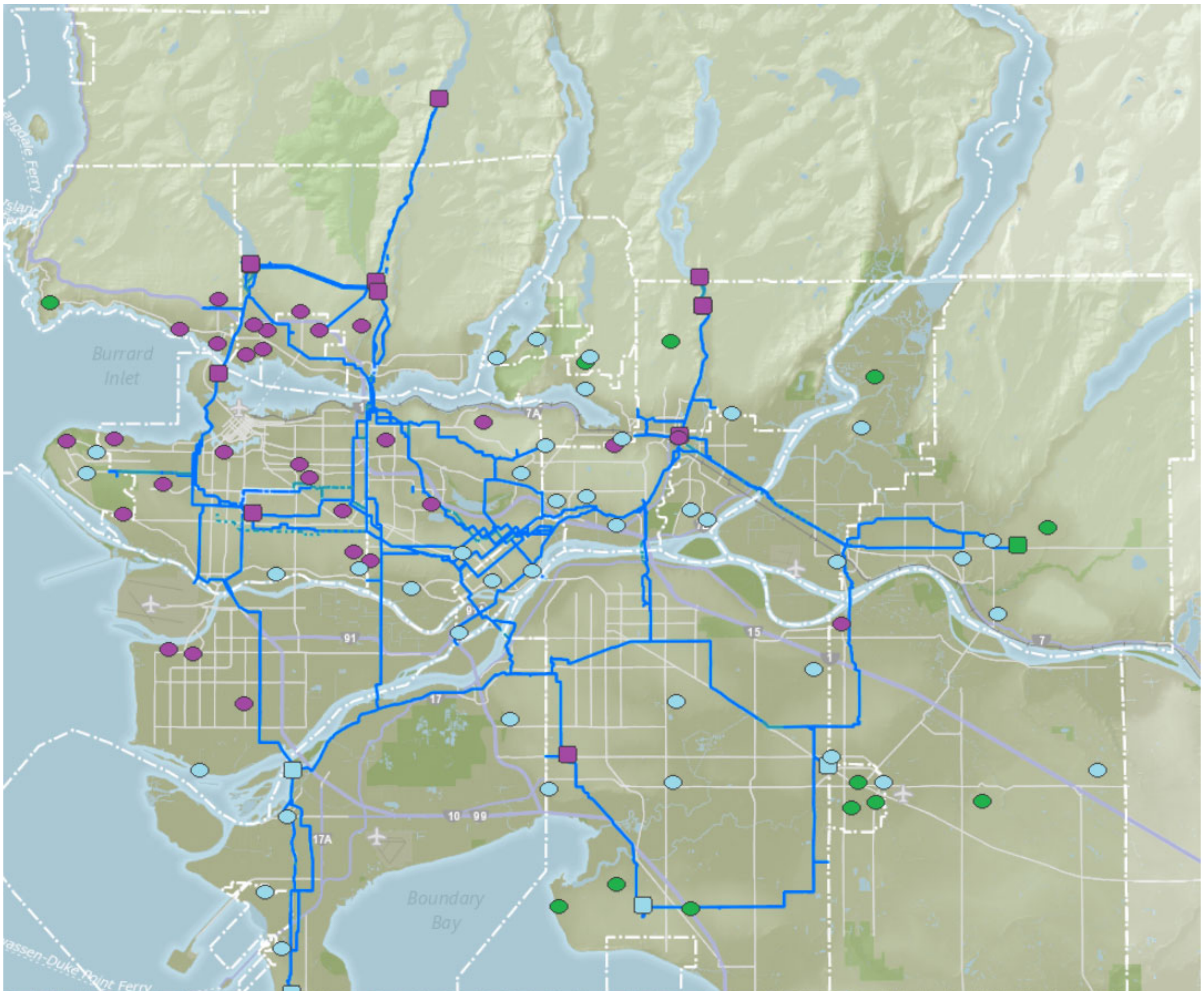


2021 Average GVWD TTHM = 22 ppb
2021 Average Member Jurisdictions TTHM = 31 ppb

Total Trihalomethane Levels for GVWD Sites	Total Trihalomethane Levels for Local Government 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 Total Trihalomethane values is 100 µg/L (or ppb)	

Figure 8: Average Total Trihalomethane Levels

The other group of disinfection by-products of interest is the Total Haloacetic Acid ($THAA_5$) group. Comparison of $THAA_5$ in the GVWD and member jurisdiction systems in 2021 is shown in Figure 9. In 2021, all HAA results from GVWD water mains and member jurisdiction systems were below the MAC of 80 ppb.



2021 Average GVWD THAA = 22 ppb
2021 Average Member Jurisdictions THAA = 26 ppb

Total Haloacetic Acid Levels for GVWD Sites	Total Haloacetic Acid Levels for Local Government 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 Total Haloacetic Acid values is 80 μg/L (or ppb)	

Figure 9: Average Total Haloacetic Acid Levels

4.0 QUALITY CONTROL/QUALITY ASSURANCE

In 1994, as required by a new BC Ministry of Health program, the bacteriology section of the GVWD Laboratory received approval from the Provincial Medical Health Officer to perform bacteriological analysis of potable water as required in the BCDWPR. 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 have carried out an inspection of the GVWD Laboratory facilities at the Lake City Operations Centre in February 2019 as part of the process leading up to approval of the laboratory by the Provincial Health Officer. The next inspection is scheduled for 2022.

In addition to the approval process discussed above, the GVWD Laboratory is accredited by the Canadian Association for Laboratory Accreditation (CALA) for the analysis of parameters for which the laboratory has requested certification. The GVWD Laboratory has been inspected by representatives from CALA bi-annually since 1995.

Accreditation for the laboratory from the Standards Council of Canada was first received early in 1996 and continued until the middle of 2005, when accreditation was granted by CALA directly.

The most recent on-site audit took place in September 2021, and CALA is expected to issue accreditation approval in Spring 2022. The next CALA inspection will take place in the fall of 2023.

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APPENDIX A — CHEMICAL AND PHYSICAL ANALYSIS SUMMARIES

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Physical and Chemical Analysis of Water Supply

2021 – Capilano Water System

	Untreated	Treated		Canadian Guideline		
Parameter	Average	Average	Range	Days Exceeded	Limit	Reason Established
Alkalinity as CaCO3 (mg/L)	2.8	16	9.0-25		**none**	
Aluminum Dissolved (µg/L)	76	34	19-63		none	
Aluminum Total (µg/L)	164	35	19-81		none	
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	Health
Barium Total (µg/L)	2.9	2.5	1.8-2.9	0	1000	Health
Boron Total (µg/L)	<10	<10	<10	0	5000	Health
Bromate (mg/L)	<0.01	<0.01	<0.01	0	0.1	Health
Bromide (mg/L)	<0.01	<0.01	<0.01		none	
Cadmium Total (µg/L)	<0.2	<0.2	<0.2	0	5	Health
Calcium Total (µg/L)	1140	6210	3980-9320		none	
Carbon Organic - Dissolved (mg/L)	1.8	0.7	0.5-1.0		none	
Carbon Organic - Total (mg/L)	1.8	0.7	0.5-1.0		none	
Chlorate (mg/L)	<0.01	0.03	0.02-0.04	0	1	Health
Chloride (mg/L)	<0.5	2.4	2.0-3.1	0	=250	Aesthetic
Chromium Total (µg/L)	<0.1	<0.05	<0.05	0	50	Health
Cobalt Total (µg/L)	<0.5	<0.5	<0.5		none	
Color - Apparent (ACU)	16	<2	<2-3		none	
Color - True (TCU)	11	<1	<1-2	0	=15	Aesthetic
Conductivity (µmhos/cm)	10	41	30-55		none	
Copper Total (µg/L)	2.1	<0.5	<0.5	0	=1000	Aesthetic
Cyanide Total (mg/L)	<0.02	<0.02	<0.02	0	0.2	Health
Fluoride (mg/L)	<0.05	<0.05	<0.05	0	1.5	Health
Hardness as CaCO3 (mg/L)	3.5	16.6	10.5-24.3		none	
Iron Dissolved (µg/L)	34	<5	<5-5		none	
Iron Total (µg/L)	121	<6	<5-13	0	=300	Aesthetic
Lead Total (µg/L)	<0.5	<0.5	<0.5	0	5	Health
Magnesium Total (µg/L)	166	185	147-241		none	
Manganese Dissolved (µg/L)	3.9	1.6	0.7-3.3		none	
Manganese Total (µg/L)	5.4	3.6	1.4-7.0	0	=50	Aesthetic
Mercury Total (µg/L)	<0.05	<0.05	<0.05	0	1	Health
Molybdenum Total (µg/L)	<0.5	<0.5	<0.5		none	
Nickel Total (µg/L)	<0.5	<0.5	<0.5		none	
Nitrogen - Ammonia as N (mg/L)	<0.02	<0.02	<0.02		none	
Nitrogen - Nitrate as N (mg/L)	0.07	0.06	0.04-0.10	0	45	Health
Nitrogen - Nitrite as N (mg/L)	<0.01	<0.01	<0.01	0	1	Health
pH (pH units)	6.5	7.7	7.4-8.2	0	7.0 to 10.5	Aesthetic
Phenol (mg/L)	<0.005	<0.005	<0.005		none	
Phosphorus Dissolved (µg/L)	<10	<10	<10		none	
Phosphorus Total (µg/L)	<10	<10	<10		none	
Potassium Total (µg/L)	150	150	124-169		none	
Residue Total (mg/L)	15	28	21-37		none	
Residue Total Dissolved (mg/L)	10	30	20-40	0	=500	Aesthetic
Residue Total Fixed (mg/L)	9	22	15-31		none	
Residue Total Volatile (mg/L)	6	6	4-9		none	
Selenium Total (µg/L)	<0.5	<0.5	<0.5	0	50	Health
Silica as SiO2 (mg/L)	3.2	3.2	2.3-3.8		none	
Silver Total (µg/L)	<0.5	<0.5	<0.5		none	
Sodium Total (µg/L)	564	1570	1420-1760	0	=200000	Aesthetic
Sulphate (mg/L)	<0.6	1.0	0.7-1.3	0	=500	Aesthetic
Turbidity (NTU)	1.7	0.13	0.06-0.24		none	
Turbidity IFE (NTU)	-	-	-	-	-	-
UV Absorbance 254 nm (Abs/cm)	0.073	0.011	0.007-0.017		none	
Zinc Total (µg/L)	<3	<3	<3	0	=5000	Aesthetic

These figures are averaged values from a number of laboratory analyses done throughout the year. Where the range is a single value no variation was measured for the samples analyzed. Average values containing one or more results below the detection limit are preceded with "<" symbol. Minimum range values than "<" denotes not detectable with the technique used for determination. Methods and terms are based on those of the most current on-line version of "Standard Methods for the Examination of Water and Waste Water". Untreated water is from the intake prior to the raw water tunnel, treated water is from a single site in the GVWD distribution system after the treated water tunnel and before the breakhead tank. Guidelines are taken from the most current Guidelines for Canadian Drinking Water Quality summary table updated in September 2020. Capilano Source was operational for 365 days in 2021.
[1]Treated turbidity guideline and the number of exceedances applies to Individual Filter Effluent readings; measured in events and not days.

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Physical and Chemical Analysis of Water Supply

2021 – Seymour Water System

Parameter	Untreated	Treated		Canadian Guideline		
	Average	Average	Range	Days Exceeded	Limit	Reason Established
Alkalinity as CaCO3 (mg/L)	3.3	16	8.3-24		none	
Aluminum Dissolved (µg/L)	69	34	19-63		none	
Aluminum Total (µg/L)	130	35	20-76		none	
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	Health
Barium Total (µg/L)	3.1	2.5	2.0-2.9	0	1000	Health
Boron Total (µg/L)	<10	<10	<10	0	5000	Health
Bromate (mg/L)	<0.01	<0.01	<0.01	0	0.1	Health
Bromide (mg/L)	<0.01	<0.01	<0.01		none	
Cadmium Total (µg/L)	<0.2	<0.2	<0.2	0	5	Health
Calcium Total (µg/L)	1550	6320	3980-9180		none	
Carbon Organic - Dissolved (mg/L)	1.6	0.7	0.5-1.0		none	
Carbon Organic - Total (mg/L)	1.7	0.7	0.5-1.0		none	
Chlorate (mg/L)	<0.01	0.03	0.02-0.04	0	1	Health
Chloride (mg/L)	<0.5	2.4	2.0-3.1	0	=250	Aesthetic
Chromium Total (µg/L)	<0.07	<0.05	<0.05	0	50	Health
Cobalt Total (µg/L)	<0.5	<0.5	<0.5		none	
Color - Apparent (ACU)	17	<2	<2-3		none	
Color - True (TCU)	11	<1	<1-1	0	=15	Aesthetic
Conductivity (µmhos/cm)	12	41	29-55		none	
Copper Total (µg/L)	29.4	<0.6	<0.5-1.1	0	=1000	Aesthetic
Cyanide Total (mg/L)	<0.02	<0.02	<0.02	0	0.2	Health
Fluoride (mg/L)	<0.05	<0.05	<0.05	0	1.5	Health
Hardness as CaCO3 (mg/L)	4.5	16.7	10.6-23.9		none	
Iron Dissolved (µg/L)	63	<6	<5-29		none	
Iron Total (µg/L)	162	<8	<5-29	0	=300	Aesthetic
Lead Total (µg/L)	<0.5	<0.5	<0.5	0	5	Health
Magnesium Total (µg/L)	154	186	148-238		none	
Manganese Dissolved (µg/L)	4.2	3.0	1.9-4.6		none	
Manganese Total (µg/L)	6.2	4.0	2.2-6.2	0	=50	Aesthetic
Mercury Total (µg/L)	<0.05	<0.05	<0.05	0	1	Health
Molybdenum Total (µg/L)	<0.5	<0.5	<0.5		none	
Nickel Total (µg/L)	<0.5	<0.5	<0.5		none	
Nitrogen - Ammonia as N (mg/L)	<0.02	<0.02	<0.02		none	
Nitrogen - Nitrate as N (mg/L)	0.06	0.06	0.03-0.10	0	45	Health
Nitrogen - Nitrite as N (mg/L)	<0.01	<0.01	<0.01	0	1	Health
pH (pH units)	6.5	7.7	7.3-8.1	0	7.0 to 10.5	Aesthetic
Phenol (mg/L)	<0.005	<0.005	<0.005		none	
Phosphorus Dissolved (µg/L)	<10	<10	<10		none	
Phosphorus Total (µg/L)	<10	<10	<10		none	
Potassium Total (µg/L)	150	142	123-169		none	
Residue Total (mg/L)	16	28	22-37		none	
Residue Total Dissolved (mg/L)	10	30	20-40	0	=500	Aesthetic
Residue Total Fixed (mg/L)	9	21	12-32		none	
Residue Total Volatile (mg/L)	7	7	5-11		none	
Selenium Total (µg/L)	<0.5	<0.5	<0.5	0	50	Health
Silica as SiO2 (mg/L)	3.1	3.1	2.3-3.8		none	
Silver Total (µg/L)	<0.5	<0.5	<0.5		none	
Sodium Total (µg/L)	534	1550	1400-1720	0	=200000	Aesthetic
Sulphate (mg/L)	1.1	1.0	0.7-1.3	0	=500	Aesthetic
Turbidity (NTU)	1.1	0.13	0.06-0.21		none	
Turbidity IFE (NTU)	-	-	-	-	-	-
UV Absorbance 254 nm (Abs/cm)	0.070	0.011	0.008-0.017		none	
Zinc Total (µg/L)	<4	<3	<3	0	=5000	Aesthetic

These figures are averaged values from a number of laboratory analyses done throughout the year. Where the range is a single value no variation was measured for the samples analyzed. Average values containing one or more results below the detection limit are preceded with "<" symbol. Minimum range values than "<" denotes not detectable with the technique used for determination. Methods and terms are based on those of the most current on-line version of "Standard Methods for the Examination of Water and Waste Water". Untreated water is from a sample site prior to coagulation, treated water is from a sample site downstream of the SCFP clearwell. Guidelines are taken from the most current Guidelines for Canadian Drinking Water Quality summary table updated in September 2020. Seymour Source was operational for 365 days in 2021.

[1]Treated turbidity guideline and the number of exceedances applies to Individual Filter Effluent readings; measured in events and not days.

Physical and Chemical Analysis of Water Supply

2021 – Coquitlam Water System

Parameter	Untreated	Treated		Canadian Guideline		
	Average	Average	Range	Days Exceeded	Limit	Reason Established
Alkalinity as $CaCO_3$ (mg/L)	1.9	16	7.1-23		**none**	
Aluminum Dissolved (µg/L)	68	70	61-85		none	
Aluminum Total (µg/L)	94	94	77-141		none	
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	Health
Barium Total (µg/L)	2.2	2.2	1.9-2.4	0	1000	Health
Boron Total (µg/L)	<10	<10	<10	0	5000	Health
Bromate (mg/L)	<0.01	<0.01	<0.01	0	0.1	Health
Bromide (mg/L)	<0.01	<0.01	<0.01		none	
Cadmium Total (µg/L)	<0.2	<0.2	<0.2	0	5	Health
Calcium Total (µg/L)	836	836	752-899		none	
Carbon Organic - Dissolved (mg/L)	1.6	1.5	1.2-2.0		none	
Carbon Organic - Total (mg/L)	1.7	1.5	1.2-2.0		none	
Chlorate (mg/L)	<0.01	0.06	0.03-0.10	0	1	Health
Chloride (mg/L)	<0.5	2.2	1.8-2.7	0	=250	Aesthetic
Chromium Total (µg/L)	<0.05	<0.05	<0.05-0.06	0	50	Health
Cobalt Total (µg/L)	<0.5	<0.5	<0.5		none	
Color - Apparent (ACU)	13	<2	<2-3		none	
Color - True (TCU)	9	<1	<1-1	0	=15	Aesthetic
Conductivity (µmhos/cm)	8	37	24-50		none	
Copper Total (µg/L)	4.7	<0.5	<0.5-0.6	0	=1000	Aesthetic
Cyanide Total (mg/L)	<0.02	<0.02	<0.02	0	0.2	Health
Fluoride (mg/L)	<0.05	<0.05	<0.05	0	1.5	Health
Hardness as $CaCO_3$ (mg/L)	2.5	2.5	2.3-2.6		none	
Iron Dissolved (µg/L)	22	24	12-64		none	
Iron Total (µg/L)	57	58	31-150	0	=300	Aesthetic
Lead Total (µg/L)	<0.5	<0.5	<0.5	0	5	Health
Magnesium Total (µg/L)	97	98	86-110		none	
Manganese Dissolved (µg/L)	4.2	2.6	1.5-4.2		none	
Manganese Total (µg/L)	4.5	3.8	2.0-7.4	0	=50	Aesthetic
Mercury Total (µg/L)	<0.05	<0.05	<0.05	0	1	Health
Molybdenum Total (µg/L)	<0.5	<0.5	<0.5		none	
Nickel Total (µg/L)	<0.5	<0.5	<0.5		none	
Nitrogen - Ammonia as N (mg/L)	<0.02	<0.02	<0.02		none	
Nitrogen - Nitrate as N (mg/L)	0.07	0.08	0.04-0.10	0	45	Health
Nitrogen - Nitrite as N (mg/L)	<0.01	<0.01	<0.01	0	1	Health
pH (pH units)	6.3	7.9	7.1-8.7	0	7.0 to 10.5	Aesthetic
Phenol (mg/L)	<0.005	<0.005	<0.005		none	
Phosphorus Dissolved (µg/L)	<10	<10	<10		none	
Phosphorus Total (µg/L)	<10	<10	<10		none	
Potassium Total (µg/L)	108	109	106-112		none	
Residue Total (mg/L)	12	30	21-36		none	
Residue Total Dissolved (mg/L)	10	30	20-40	0	=500	Aesthetic
Residue Total Fixed (mg/L)	6	20	12-26		none	
Residue Total Volatile (mg/L)	6	10	7-13		none	
Selenium Total (µg/L)	<0.5	<0.5	<0.5	0	50	Health
Silica as SiO_2 (mg/L)	2.5	2.5	2.2-2.8		none	
Silver Total (µg/L)	<0.5	<0.5	<0.5		none	
Sodium Total (µg/L)	462	8010	5110-10600	0	=200000	Aesthetic
Sulphate (mg/L)	<0.5	<0.6	<0.5-0.7	0	=500	Aesthetic
Turbidity (NTU)	0.50	0.43	0.18-1.9		none	
UV 254 - Apparent (Abs/cm)	0.071	0.023	0.015-0.060		none	
UV Absorbance 254 nm (Abs/cm)	0.065	0.019	0.013-0.022		none	
Zinc Total (µg/L)	<3	<3	<3	0	=5000	Aesthetic

These figures are averaged values from a number of laboratory analyses done throughout the year. Where the range is a single value no variation was measured for the samples analyzed. Average values containing one or more results below the detection limit are preceded with "<" symbol. Minimum range values than "<" denotes not detectable with the technique used for determination. Methods and terms are based on those of the most current on-line version of "Standard Methods for the Examination of Water and Waste Water". Untreated water is from the intake prior to treatment, treated water is from a single site in the GVWD distribution system downstream of CWTP. Guidelines are taken from the most current Guidelines for Canadian Drinking Water Quality summary table updated in September 2020. Recommended turbidity guidelines applies to finished treated water from an un-filtered source. Coquitlam source was operational for 365 days in 2021.

APPENDIX B — ANALYSIS OF WATER FOR ORGANIC/INORGANIC COMPONENTS AND RADIONUCLIDES

Analysis of Source Waters for Herbicides, Pesticides, Volatile Organic Compounds and Uranium

Parameter	Units	Date Sampled	MAC	AO	Capilano	Seymour	Coquitlam
Atrazine	µg/L	06/23/21	5		<1.0	<1.0	<1.0
Azinphos-Methyl	µg/L	06/23/21	20		<1.0	<1.0	<1.0
benzene	µg/L	09/24/21	5		<0.50	<0.50	<0.50
Benzo(a)pyrene	µg/L	12/07/21	0.04		<0.0050	<0.0050	<0.0050
Bromoxynil	µg/L	06/23/21	5		<0.50	<0.50	<0.50
Carbaryl	µg/L	06/23/21	90		<5.0	<5.0	<5.0
Carbofuran	µg/L	06/23/21	90		<5.0	<5.0	<5.0
Carbon tetrachloride	µg/L	09/24/21	2		<0.50	<0.50	<0.50
Chlorpyrifos (Dursban)	µg/L	06/23/21	90		<2.0	<2.0	<2.0
Cyanobacterial toxins- Microcystin-LR	µg/L	April – Nov 2021	1.5		<0.20	<0.20	<0.20
Diazinon	µg/L	06/23/21	20		<2.0	<2.0	<2.0
Dicamba	µg/L	06/23/21	120		<0.50	<0.50	<0.50
Dichlorobenzene, 1,2-	µg/L	09/24/21	200	≤ 3	<0.50	<0.50	<0.50
Dichlorobenzene, 1,4-	µg/L	09/24/21	5	≤ 1	<0.50	<0.50	<0.50
Dichloroethane, 1,2-	µg/L	09/24/21	5		<0.50	<0.50	<0.50
Dichloroethylene, 1,1-	µg/L	09/24/21	14		<0.50	<0.50	<0.50
Dichloromethane	µg/L	09/24/21	50		<1.0	<1.0	<1.0
Dichlorophenol, 2,4-	µg/L	06/23/21	900	≤ 0.3	<0.10	<0.10	<0.10
Dichlorophenoxyacetic acid,2,4-(2,4-D)	µg/L	06/23/21	100		<0.50	<0.50	<0.50
Diclofop-methyl	µg/L	06/23/21	9		<0.90	<0.90	<0.90
Dimethoate	µg/L	06/23/21	20		<2.0	<2.0	<2.0
Diquat	µg/L	06/23/21	70		<7.0	<7.0	<7.0
Diuron	µg/L	06/23/21	150		<10	<10	<10
Ethylbenzene	µg/L	09/24/21	140	≤ 1.6	<0.50	<0.50	<0.50
Glyphosate	µg/L	06/23/21	280		<10	<10	<10
Malathion	µg/L	06/23/21	190		<2.0	<2.0	<2.0
2-Methyl-4-chlorophenoxyacetic acid (MCPA)	µg/L	06/23/21	100		<0.50	<0.50	<0.50
Methyl-tert-butyl ether [MTBE]	µg/L	09/24/21	None	≤ 15	<0.50	<0.50	<0.50
Metolachlor	µg/L	06/23/21	50		<5.0	<5.0	<5.0
Metribuzin (Sencor)	µg/L	06/23/21	80		<5.0	<5.0	<5.0
Monochlorobenzene	µg/L	09/24/21	80	≤ 30	<0.50	<0.50	<0.50
N-Nitrosodimethylamine (NDMA)	ng/L	06/23/21	0.04		<1.9	<1.9	<2.0
Nitrilotriacetic acid (NTA)	mg/L	06/23/21	400		<0.050	<0.050	<0.050
Paraquat	µg/L	06/23/21	10		<1.0	<1.0	<1.0

Analysis of Source Waters for Herbicides, Pesticides, Volatile Organic Compounds and Uranium Con't

Parameter	Units	Date Sampled	MAC	AO	Capilano	Seymour	Coquitlam
Pentachlorophenol	µg/L	06/23/21	60		<0.10	<0.10	<0.10
Phorate	µg/L	06/23/21	2		<1.0	<1.0	<1.0
Picloram	µg/L	06/23/21	190		<0.50	<0.50	<0.50
Simazine	µg/L	06/23/21	10		<2.0	<2.0	<2.0
Terbufos	µg/L	06/23/21	1		<1.0	<1.0	<1.0
tetrachloroethylene	µg/L	09/24/21	10		<0.50	<0.50	<0.50
Tetrachlorophenol, 2,3,4,6-	µg/L	06/23/21	100	≤ 1	<0.10	<0.10	<0.10
Toluene	µg/L	09/24/21	60	24	<0.40	<0.40	<0.40
Trichloroethylene	µg/L	09/24/21	5		<0.50	<0.50	<0.50
Trichlorophenol, 2,4,6-	µg/L	06/23/21	5	≤ 2	<0.10	<0.10	<0.10
Trifluralin	µg/L	06/23/21	45		<5.0	<5.0	<5.0
Uranium (Total)	µg/L	06/21/21	20		0.0323	0.0230	0.0460
Vinyl chloride	µg/L	09/24/21	2		<0.40	<0.40	<0.40
Xylenes, total	µg/L	09/24/21	90	≤ 20	<0.50	<0.50	<0.50

Monitoring of Selected GVWD Water Mains for BTEXs

Parameters	Units	MAC	AO	Maple Ridge Main at Reservoir		Barnston Island Main at Willoughby PS		Jericho-Clayton Main		South Burnaby Main #2	
				10-Dec	18-May	17-May	7-Dec	19-May	10-Dec	18-May	7-Dec
Benzene	ppb	5	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Ethyl Benzene	ppb	140	1.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Toluene	ppb	60	24	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Xylene Total	ppb	90	20	1	<1	<1	1	1	1	<1	1

Analysis of Source Water for PAH's

Parameters	Units	Capilano		Seymour		Coquitlam	
		19-May	07-Dec	07-Dec	17-May	19-May	07-Dec
acenaphthene	µg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
acenaphthylene	µg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
acridine	µg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
anthracene	µg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
benz(a)anthracene	µg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
benzo(a)pyrene	µg/L	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
benzo(b+j)fluoranthene	µg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
benzo(b+j+k)fluoranthene	µg/L	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015
benzo(g,h,i)perylene	µg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
benzo(k)fluoranthene	µg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
chrysene	µg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
dibenz(a,h)anthracene	µg/L	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
fluoranthene	µg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
fluorene	µg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
indeno(1,2,3-c,d)pyrene	µg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
methylnaphthalene, 1-	µg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
methylnaphthalene, 2-	µg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
naphthalene	µg/L	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
phenanthrene	µg/L	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
pyrene	µg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
quinoline	µg/L	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050

Analysis of Selected GVWD Mains for PAHs

Parameters	Units	Coquitlam Main #2	Westburnco Reservoir		Barnston Island		Queensborough		Whalley Kennedy Link Main		Haney Main #2		36th Ave Main
		19-May	9-Dec	18-May	7-Dec	18-May	9-Dec	19-May	9-Dec	19-May	9-Dec	17-May	7-Dec
acenaphthene	µg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
acenaphthylene	µg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
acridine	µg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
anthracene	µg/L	<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	µg/L	<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	µg/L	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0076	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
benzo(b+j)fluoranthene	µg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.012	<0.010	<0.010	<0.010	<0.010	<0.010
benzo(b+j+k)fluoranthene	µg/L	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015
benzo(g,h,i)perylene	µg/L	<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(k)fluoranthene	µg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
chrysene	µg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.016	<0.010	<0.010	<0.010	<0.010	<0.010
dibenz(a,h)anthracene	µg/L	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
fluoranthene	µg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
fluorene	µg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
indeno(1,2,3-c,d)pyrene	µg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
methylnaphthalene, 1-	µg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
methylnaphthalene, 2-	µg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
naphthalene	µg/L	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
phenanthrene	µg/L	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
pyrene	µg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
quinoline	µg/L	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050

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

Monitoring of Source Waters for PFOS and PFOA

Parameter	Sampling Date	Units	MAC	Capilano	Seymour	Coquitlam
PFOS	07/30/2021	µg/L	600	<0.010	<0.010	<0.010
PFOA	07/30/2021	µg/L	200	<0.010	<0.010	<0.010

Parameter	Sampling Date	Units	Capilano	Seymour	Coquitlam
PFBA	07/30/2021	µg/L	<0.10	<0.10	<0.10
PFPeA	07/30/2021	µg/L	<0.10	<0.10	<0.10
PFHxA	07/30/2021	µg/L	<0.010	<0.010	<0.010
PFHpA	07/30/2021	µg/L	<0.010	<0.010	<0.010
PFOA	07/30/2021	µg/L	<0.010	<0.010	<0.010
PFNA	07/30/2021	µg/L	<0.010	<0.010	<0.010
PFDA	07/30/2021	µg/L	<0.010	<0.010	<0.010
PFUnA	07/30/2021	µg/L	<0.010	<0.010	<0.010
PFDoA	07/30/2021	µg/L	<0.010	<0.010	<0.010
PFTrDA	07/30/2021	µg/L	<0.0250	<0.0250	<0.0250
PFTeDA	07/30/2021	µg/L	<0.025	<0.025	<0.025
PFBS	07/30/2021	µg/L	<0.010	<0.010	<0.010
PFPeS	07/30/2021	µg/L	<0.010	<0.010	<0.010
PFHxS	07/30/2021	µg/L	<0.010	<0.010	<0.010
PFHpS	07/30/2021	µg/L	<0.010	<0.010	<0.010
PFOS	07/30/2021	µg/L	<0.010	<0.010	<0.010
PFNS	07/30/2021	µg/L	<0.010	<0.010	<0.010
PFDS	07/30/2021	µg/L	<0.010	<0.010	<0.010
PFDoS	07/30/2021	µg/L	<0.010	<0.010	<0.010
4:2 FTS	07/30/2021	µg/L	<0.010	<0.010	<0.010
6:2 FTS	07/30/2021	µg/L	<0.010	<0.010	<0.010
8:2 FTS	07/30/2021	µg/L	<0.010	<0.010	<0.010
PFOSA	07/30/2021	µg/L	<0.010	<0.010	<0.010
N-MeFOSA	07/30/2021	µg/L	<0.025	<0.025	<0.025
N-EtFOSA	07/30/2021	µg/L	<0.025	<0.025	<0.025
MeFOSAA	07/30/2021	µg/L	<0.010	<0.010	<0.010
EtFOSAA	07/30/2021	µg/L	<0.010	<0.010	<0.010
N-MeFOSE	07/30/2021	µg/L	<0.030	<0.030	<0.030
N-EtFOSE	07/30/2021	µg/L	<0.030	<0.030	<0.030
HFPO-DA	07/30/2021	µg/L	<0.20	<0.20	<0.20
ADONA	07/30/2021	µg/L	<0.010	<0.010	<0.010
9Cl-PF3ONS	07/30/2021	µg/L	<0.020	<0.020	<0.020
11Cl-PF3OUdS	07/30/2021	µg/L	<0.020	<0.020	<0.020

Analysis of Source Water for Radioactivity

Radioactivity	Units	Date Sampled	MAC[1]	Capilano	Seymour	Coquitlam
				Activity	Activity	Activity
Cesium-134	Bq/L	09/22/21	7	<0.33	<0.37	<0.42
Cesium-137	Bq/L	09/22/21	10	<0.37	<0.35	<0.34
Cobalt-60	Bq/L	09/22/21	2	<0.36	<0.45	<0.45
Gross Alpha	Bq/L	09/22/21	<0.5	<0.05	<0.045	<0.056
Gross Beta	Bq/L	09/22/21	<1.0	<0.097	<0.097	<0.093
Iodine-131	Bq/L	09/22/21	6	<1	<1.1	<0.97
Lead-210	Bq/L	09/22/21	0.2	<0.019	<0.019	<0.02
Radium 226	Bq/L	09/22/21	0.5	<0.0061	<0.0081	<0.0066
Radon-222	Bq/L	11/22/21	None	<4	<3.9	<3.9
Strontium-90	Bq/L	09/22/21	5	<0.0095	<0.01	<0.011
Tritium	Bq/L	09/22/21	7000	<12	<12	<12
Cesium-134	Bq/L	09/22/21	7	<0.33	<0.37	<0.42

APPENDIX C — ANALYSIS OF SOURCE WATERS FOR THE RESERVOIR MONITORING PROGRAM

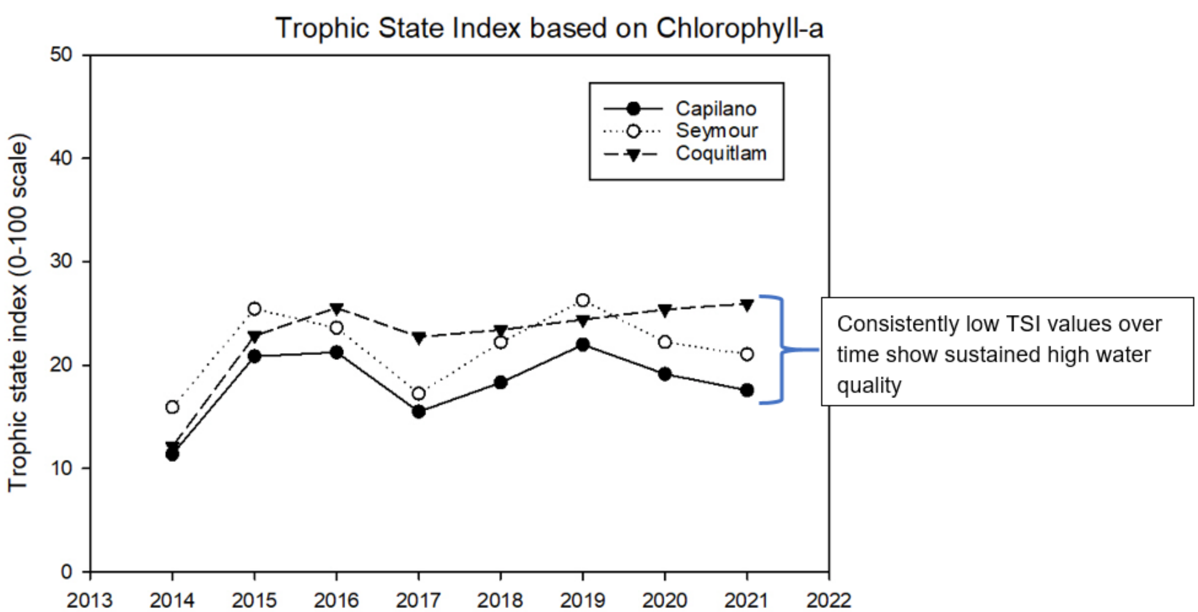
Comparison of Water Quality in GVWD Water Supply Sources to Standard Water Quality Classifications

Chemical measurement[2]	Average value[3]					Status of Reservoirs
	Ultra-oligotrophic status defined in the scientific literature[1]	Oligotrophic status defined in the scientific literature[1]	Capilano Reservoir 2014 – 2021 (2021 only in brackets)	Seymour Reservoir 2014 – 2021 (2021 only in brackets)	Coquitlam Reservoir 2014 – 2021 (2021 only in brackets)	
Total phosphorus (parts per billion)	5	8.0	3.0 (4.0)	3.0 (4.0)	3.0 (4.0)	Ultraoligotrophic (very high water quality)
Total Nitrogen (parts per billion)	250	661	125 (117)	124 (96)	129 (131)	Ultraoligotrophic (very high water quality)
Phytoplankton biomass (parts per billion of chlorophyll-a)	0.5	1.7	0.41 (0.36)	0.55 (0.46)	0.54 (0.68)	Ultraoligotrophic (very high water quality)

[1]e.g. Wetzel, R.G. 2001 River Ecosystems. 3rd edition. Academic Press. New York.
Ultraoligotrophic means very low nutrient content and very low biological production: very high water quality
Oligotrophic means low nutrient content and low biological production (low risk of algal blooms): high water quality
[2]Chemical measurements are defined as follows:

- Phosphorus and nitrogen are nutrients that primarily control the growth of algae, including cyanobacteria.
- Phytoplankton biomass includes cells of all algae and cyanobacteria species in a reservoir.

[3]Values are averages from all water depths during April through November of all years. Values in brackets are average values only from 2021.



APPENDIX D — REPORT TO METRO VANCOUVER ON *CRYPTOSPORIDIUM* AND *GIARDIA* STUDY

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Metro Vancouver
Detection of Waterborne *Cryptosporidium* and *Giardia*

January - December, 2021
Annual Report

January 2022

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

Environmental Microbiology
BCCDC Public Health Laboratory
Provincial Health Services Authority

Metro Vancouver
Detection of Waterborne *Cryptosporidium and Giardia*
January - December, 2021 Annual Report

Purpose

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

Introduction

Cryptosporidium and *Giardia* species are parasites that infect the intestinal tracts of a wide range of warm-blooded animals. In humans, infection with *Cryptosporidium* species or *Giardia lamblia* can cause gastroenteritis. Since *Cryptosporidium* oocysts and *Giardia* cysts are resistant to chlorination, they are of great concern for drinking water purveyors (1-3). On behalf of Metro Vancouver, the Environmental Microbiology Laboratory at BCCDC Public Health Laboratory (BCCDC PHL) examined the source water of Capilano and Coquitlam reservoirs, as well as Recycled Clarified Water (RCW) at the Seymour-Capilano Filtration Plant (SCFP) for the presence of *Cryptosporidium* oocysts and *Giardia* cysts. All sample collection, testing, analysis and reporting occurred on a monthly basis using a validated method.

Methods

The Environmental Microbiology Laboratory at BCCDC PHL follows 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 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 the Metro Vancouver staff at specific sampling sites at the reservoirs and filtration plants on the scheduled date each month. A desired volume of samples were filtered in the field using Pall Life Science Envirochek HV filters. After collection and 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 2021, 36 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

Table 1 and Figures 1-3 show the summary of all results. Detailed results per collection site can be found in Tables A1-A3 in Appendix A.

	Capilano Reservoir		**Coquitlam Reservoir**		**Seymour Capilano Filtration Plant – Recycled Clarified Water**	
# of Filters Tested	12		12		12	
Average volume (L) Filtered per Month	50		50		770.9	
Average Detection Limit (oo)cysts per 100 L	<2.0		<2.0		0.31	
	Cryptosporidium	**Giardia**	**Cryptosporidium**	**Giardia**	**Cryptosporidium**	**Giardia**
# Positive Filters	0	3	0	3	0	0
% Positive Filters	0%	25%	0%	25%	0%	0%
Max Count (oo)cysts per 100 L	0	2	0	4	0	0

Table 1. Metro Vancouver Filter Result Summary in 2021

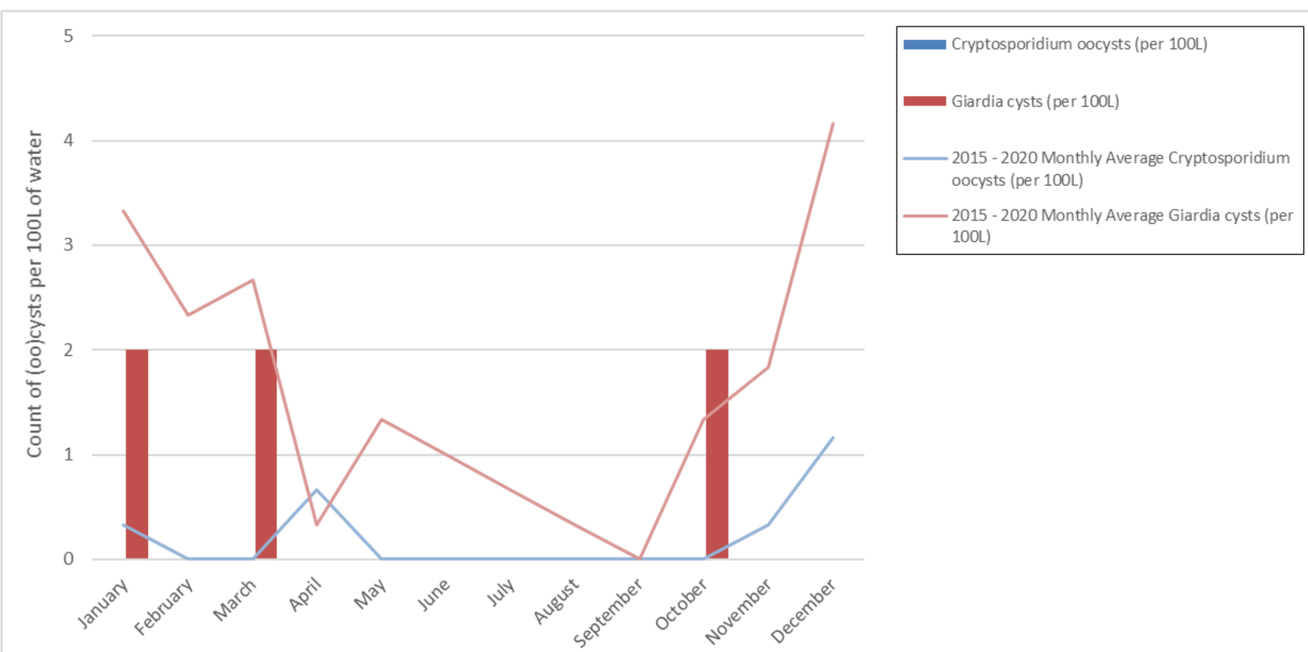

Figure 1. Capilano Reservoir *Cryptosporidium* Oocysts and *Giardia* Cysts Counts per 100 Litres of Raw Water in 2021

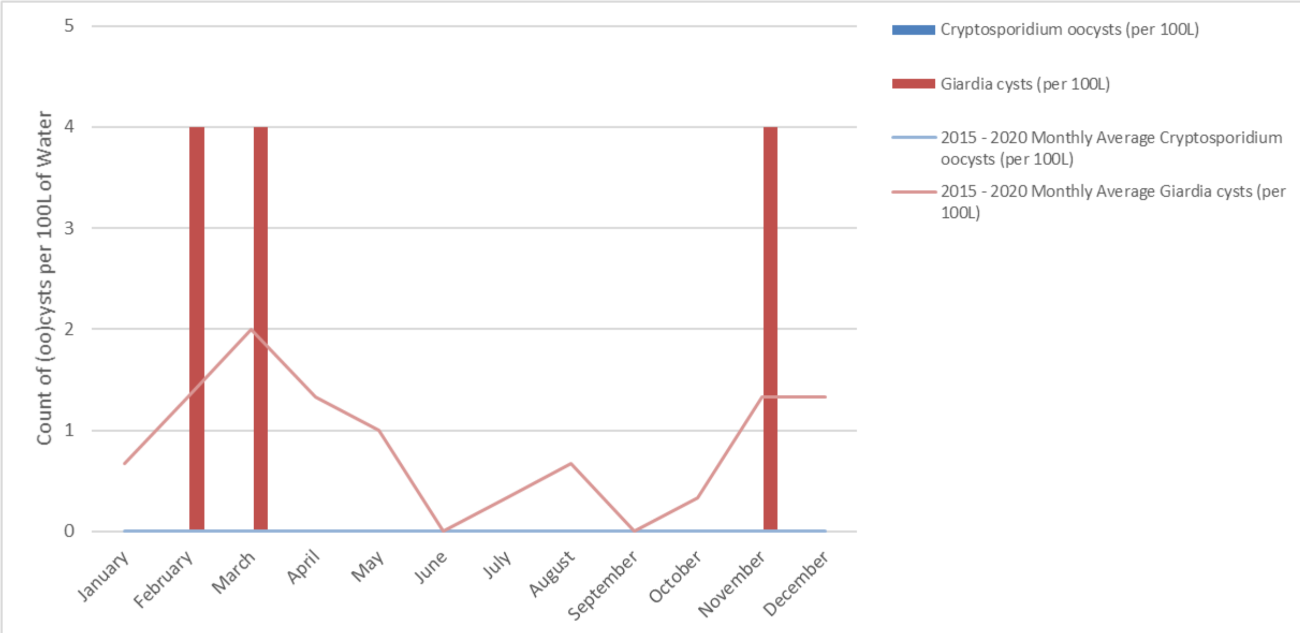

Figure 2: Coquitlam Reservoir *Cryptosporidium* Oocysts and *Giardia* Cysts Counts per 100 Litres of Raw Water in 2021

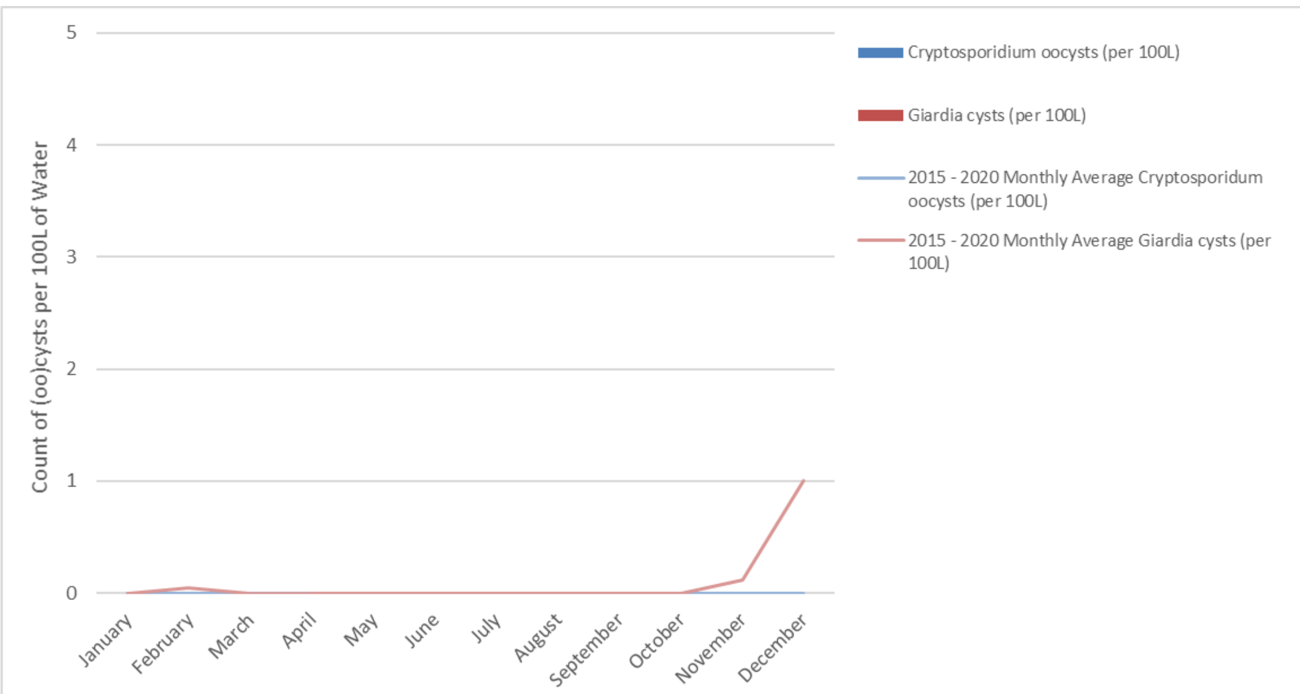

Figure 3: Seymour Capilano Filtration Plant - Recycled Clarified Water *Cryptosporidium* Oocysts and *Giardia* Cysts Counts per 100 Litres of Raw Water in 2021

Overall, similar trends were observed for both *Cryptosporidium* and *Giardia* in 2021, in comparison to historical data in 2015-2020.

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 A4-A9 in Appendix A.

Site	Count	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%

Table 2. 2021 Summary of morphological results for *Cryptosporidium* oocysts observed under fluorescence microscope

Site	Count	DAPI -	DAPI +		DIC				
							Cysts with internal structure		
		Light blue internal staining, no distinct nuclei, green rim	Intense blue internal staining	Nuclei stained sky blue	Empty cysts	Cysts with amorphous structure	Nuclei	Median Body	Axoneme
Capilano	3	1 33.3%	0 0.0%	2 66.7%	0 0.0%	3 100.0%	0 0.0%	0 0.0%	0 0.0%
Coquitlam	6	6 100.0%	0 0.0%	0 0.0%	0 0.0%	6 100.0%	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%	0 0.0%	0 0.0%

Table 3: 2021 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
Cryptosporidium oocysts						
Capilano	0	0	0	0	0	**0**
Coquitlam	0	0	0	0	0	**0**
SCFP-RCW	0	0	0	0	0	**0**
Giardia cysts						
Capilano	1	0	1	0	1	**3**
Coquitlam	6	0	0	0	0	**6**
SCFP-RCW	0	0	0	0	0	**0**

Table 4: 2021 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 (2007-2021) 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 2021 was completed in both summer and winter on two separate sampling events at each site. 50L were filtered 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	
	Cryptosporidium % Recovery	Giardia % Recovery	Cryptosporidium % Recovery	Giardia % Recovery	Cryptosporidium % Recovery	Giardia % 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%
2011	27.0%	44.0%	22.0%	47.0%	1.0%	0.0%
2012	38.4%	76.5%	35.0%	49.0%	7.0%	13.7%
2013	22.4%	59.4%	16.3%	64.4%	6.1%	14.9%
2014	Not collected	Not collected	55.0%	39.4%	18.0%	14.1%
2015	26.3%	40.4%	2.0%	60.6%	9.1%	26.5%
2016	35.4%	47.5%	22.2%	50.5%	9.1%	14.0%
2017	20.2%	38.4%	22.2%	21.2%	0.0%	2.0%
2018	43.4%	75.8%	17.1%	59.6%	1.0%	11.1%
2019	0.0%	43.0%	1.0%	55.0%	0.0%	4.1%
2020	5.1%	37.4%	8.1%	59.8%	0.0%	4.0%
2021 Summer	2.0%	53.0%	0.0%	35.0%	5.1%	38.0%
2021 Winter	11.1%	52.0%	15.2%	80.0%	0.0%	8.0%

Table 5: Matrix Results from 2007 - 2021

Summary

In brief, we reported:

1. Overall, a steady positivity rate was observed across all sites for both *Cryptosporidium* oocysts and *Giardia* cysts.

2. *Cryptosporidium* oocysts were not detected in Capilano reservoir, Coquitlam reservoir and SCFP-RCW.

3. *Giardia* cysts were detected in filters from Capilano and Coquitlam but not from SCFP-RCW. 25% of all filters received from Capilano were positive for *Giardia*, and 25% of all filters received from Coquitlam were positive for *Giardia*, and there were no *Giardia* cysts detected for SCFP-RCW.

4. The highest concentration of *Giardia* cysts detected in 2021 was from Coquitlam reservoir in February, March, and November (4 cysts per 100 L).

5. Most of the *Giardia* cysts detected showed evidence of environmental degradation.

6. Matrix recovery for *Cryptosporidium* oocyst continued to be low, which is consistent with previous years. The additional matrix collection in the summer did not confirm suspected seasonality variabilities for this year. 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 Larry Chow, Vila Goh, Eileen Butler, and Melody Sato 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 - 2020 Monthly Average	
								Cryptosporidium oocysts (per 100L)	Giardia cysts (per 100L)
8150	Capilano Reservoir	January	January 17, 2021	50	<2.0	0	2	0.3	3.3
8155	Capilano Reservoir	February	February 21, 2021	50	<2.0	0	0	0.0	2.3
8160	Capilano Reservoir	March	March 14, 2021	50	<2.0	0	2	0.0	2.7
8165	Capilano Reservoir	April	April 18, 2021	50	<2.0	0	0	0.7	0.3
8173	Capilano Reservoir	May	May 16, 2021	50	<2.0	0	0	0.0	1.3
8178	Capilano Reservoir	June	June 20, 2021	50	<2.0	0	0	0.0	1.0
8185	Capilano Reservoir	July	July 18, 2021	50	<2.0	0	0	0.0	0.7
8191	Capilano Reservoir	August	August 15, 2021	50	<2.0	0	0	0.0	0.3
8196	Capilano Reservoir	September	September 19, 2021	50	<2.0	0	0	0.0	0.0
8201	Capilano Reservoir	October	October 3, 2021	50	<2.0	0	2	0.0	1.3
8211	Capilano Reservoir	November	November 14, 2021	50	<2.0	0	0	0.3	1.8
8218	Capilano Reservoir	December	December 12, 2021	50	<2.0	0	0	1.2	4.2
			2021 Average	50	<2.0	0	0.5		

Table A1. Capilano Reservoir Monthly Filter Results in 2021

Lab #	Site Sampled	Month	Date Sampled	Volume filtered (L)	Detection Limit (per 100L)	Cryptosporidium oocysts (per 100L)	Giardia cysts (per 100L)	2015 - 2020 Monthly Average	
								Cryptosporidium oocysts (per 100L)	Giardia cysts (per 100L)
8151	Coquitlam Reservoir	January	January 17, 2021	50	<2.0	0	0	0.0	0.7
8156	Coquitlam Reservoir	February	February 21, 2021	50	<2.0	0	4	0.0	1.3
8161	Coquitlam Reservoir	March	March 14, 2021	50	<2.0	0	4	0.0	2.0
8166	Coquitlam Reservoir	April	April 18, 2021	50	<2.0	0	0	0.0	1.3
8174	Coquitlam Reservoir	May	May 16, 2021	50	<2.0	0	0	0.0	1.0
8179	Coquitlam Reservoir	June	June 20, 2021	50	<2.0	0	0	0.0	0.0
8186	Coquitlam Reservoir	July	July 18, 2021	50	<2.0	0	0	0.0	0.3
8192	Coquitlam Reservoir	August	August 15, 2021	50	<2.0	0	0	0.0	0.7
8197	Coquitlam Reservoir	September	September 19, 2021	50	<2.0	0	0	0.0	0.0
8202	Coquitlam Reservoir	October	October 3, 2021	50	<2.0	0	0	0.0	0.3
8212	Coquitlam Reservoir	November	November 14, 2021	50	<2.0	0	4	0.0	1.3
8219	Coquitlam Reservoir	December	December 12, 2021	50	<2.0	0	0	0.0	1.3
			2021 Average	50	<2.0	0	1		

Table A2. Coquitlam Reservoir Monthly Filter Results in 2021

Lab #	Site Sampled	Month	Date Sampled	Volume filtered (L)	Detection Limit (per 100L)	Cryptosporidium oocysts (per 100L)	Giardia cysts (per 100L)	2015 - 2020 Monthly Average	
								Cryptosporidium oocysts (per 100L)	Giardia cysts (per 100L)
8152	SCFP - Recycled Clarified Water	January	January 19, 2021	3793.2	<0.03	0	0	0.0	0.0
8157	SCFP - Recycled Clarified Water	February	February 23, 2021	254.5	<0.39	0	0	0.0	0.1
8162	SCFP - Recycled Clarified Water	March	March 16, 2021	426	<0.23	0	0	0.0	0.0
8167	SCFP - Recycled Clarified Water	April	April 20, 2021	244.9	<0.41	0	0	0.0	0.0
8175	SCFP - Recycled Clarified Water	May	May 18, 2021	201.3	<0.497	0	0	0.0	0.0
8180	SCFP - Recycled Clarified Water	June	June 22, 2021	252.7	<0.396	0	0	0.0	0.0
8187	SCFP - Recycled Clarified Water	July	July 20, 2021	297.3	<0.336	0	0	0.0	0.0
8193	SCFP - Recycled Clarified Water	August	August 17, 2021	1716.8	<0.058	0	0	0.0	0.0
8198	SCFP - Recycled Clarified Water	September	September 21, 2021	296.5	<0.337	0	0	0.0	0.0
8203	SCFP - Recycled Clarified Water	October	October 5, 2021	1318	<0.076	0	0	0.0	0.0
8213	SCFP - Recycled Clarified Water	November	November 16, 2021	187	<0.53	0	0	0.0	0.1
8220	SCFP - Recycled Clarified Water	December	December 14, 2021	263	<0.380	0	0	0.0	1.0
			2021 Average	770.9	0.31	0	0		

Table A3. Seymour Capilano Filtration Plant - Recycled Clarified Water (SCFP-RCW) Monthly Filter Results in 2021

			Giardia										
			Giardia			DAPI -	DAPI +		DIC				
Lab #	Site name	Date sampled	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
8150	Capilano Reservoir	January 17, 2021	1	Oval	12x9			4		P			
8155	Capilano Reservoir	February 21, 2021	0										
8160	Capilano Reservoir	March 14, 2021	1	Oval	13x9	P				P			
8165	Capilano Reservoir	April 18, 2021	0										
8173	Capilano Reservoir	May 16, 2021	0										
8178	Capilano Reservoir	June 20, 2021	0										
8185	Capilano Reservoir	July 18, 2021	0										
8191	Capilano Reservoir	August 15, 2021	0										
8196	Capilano Reservoir	September 19, 2021	0										
8201	Capilano Reservoir	October 3, 2021	#1	Oval	12x5			2		P			
8211	Capilano Reservoir	November 14, 2021	0										
8218	Capilano Reservoir	December 12, 2021	0										

Table A4. Capilano Reservoir Slide Examination Results - *Giardia* 2021 (P = present)

			Giardia										
			Giardia			DAPI -	DAPI +		DIC				
Lab #	Site name	Date sampled	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
8151	Coquitlam Reservoir	January 17, 2021	0										
8156	Coquitlam Reservoir	February 21, 2021	1	Oval	13x9	P				P			
8156	Coquitlam Reservoir	February 21, 2021	2	Oval	15x10	P				P			
8161	Coquitlam Reservoir	March 14, 2021	1	Oval	13X7	P				P			
8161	Coquitlam Reservoir	March 14, 2021	2	Oval	10X5	P				P			
8166	Coquitlam Reservoir	April 18, 2021	0										
8174	Coquitlam Reservoir	May 16, 2021	0										
8179	Coquitlam Reservoir	June 20, 2021	0										
8186	Coquitlam Reservoir	July 18, 2021	0										
8192	Coquitlam Reservoir	August 15, 2021	0										
8197	Coquitlam Reservoir	September 19, 2021	0										
8202	Coquitlam Reservoir	October 3, 2021	0										
8212	Coquitlam Reservoir	November 14, 2021	#1	Oval	15x9	P				P			
8212	Coquitlam Reservoir	November 14, 2021	#2	Oval	10x7	P				P			
8219	Coquitlam Reservoir	December 12, 2021	0										

Table A5. Coquitlam Reservoir Slide Examination Results - *Giardia* 2021 (P = present)

			Giardia										
			Giardia			DAPI -	DAPI +		DIC				
Lab #	Site name	Date sampled	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
8152	SCFP - Recycled Clarified Water	January 19, 2021	0										
8162	SCFP - Recycled Clarified Water	March 16, 2021	0										
8167	SCFP - Recycled Clarified Water	April 20, 2021	0										
8175	SCFP - Recycled Clarified Water	May 18, 2021	0										
8180	SCFP - Recycled Clarified Water	June 22, 2021	0										
8187	SCFP - Recycled Clarified Water	July 20, 2021	0										
8193	SCFP - Recycled Clarified Water	August 17, 2021	0										
8198	SCFP - Recycled Clarified Water	September 21, 2021	0										
8203	SCFP - Recycled Clarified Water	October 5, 2021	0										
8213	SCFP - Recycled Clarified Water	November 16, 2021	0										
8220	SCFP - Recycled Clarified Water	December 14, 2021	0										

Table A6. Seymour Capilano Filtration Plant – Recycled Clarified Water Slide Examination Results - *Giardia* 2021

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			Cryptosporidium								
			Cryptosporidium			DAPI -	DAPI +		DIC		
Lab #	Site name	Date sampled	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
8150	Capilano Reservoir	January 17, 2021	0								
8155	Capilano Reservoir	February 21, 2021	0								
8160	Capilano Reservoir	March 14, 2021	0								
8165	Capilano Reservoir	April 18, 2021	0								
8173	Capilano Reservoir	May 16, 2021	0								
8178	Capilano Reservoir	June 20, 2021	0								
8185	Capilano Reservoir	July 18, 2021	0								
8191	Capilano Reservoir	August 15, 2021	0								
8196	Capilano Reservoir	September 19, 2021	0								
8201	Capilano Reservoir	October 3, 2021	0								
8211	Capilano Reservoir	November 14, 2021	0								
8218	Capilano Reservoir	December 12, 2021	0								

Table A7. Capilano Reservoir Slide Examination Results - *Cryptosporidium* 2021

			Cryptosporidium			DAPI -	DAPI +		DIC		
Lab #	Site name	Date sampled	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
8151	Coquitlam Reservoir	January 17, 2021	0								
8156	Coquitlam Reservoir	February 21, 2021	0								
8161	Coquitlam Reservoir	March 14, 2021	0								
8166	Coquitlam Reservoir	April 18, 2021	0								
8174	Coquitlam Reservoir	May 16, 2021	0								
8179	Coquitlam Reservoir	June 20, 2021	0								
8186	Coquitlam Reservoir	July 18, 2021	0								
8192	Coquitlam Reservoir	August 15, 2021	0								
8197	Coquitlam Reservoir	September 19, 2021	0								
8202	Coquitlam Reservoir	October 3, 2021	0								
8212	Coquitlam Reservoir	November 14, 2021	0								
8219	Coquitlam Reservoir	December 12, 2021	0								

Table A8. Coquitlam Reservoir Slide Examination Results - *Cryptosporidium* 2021

			Cryptosporidium								
			Cryptosporidium			DAPI -	DAPI +		DIC		
Lab #	Site name	Date sampled	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
8152	SCFP - Recycled Clarified Water	January 19, 2021	0								
8157	SCFP - Recycled Clarified Water	February 23, 2021	0								
8162	SCFP - Recycled Clarified Water	March 16, 2021	0								
8167	SCFP - Recycled Clarified Water	April 20, 2021	0								
8175	SCFP - Recycled Clarified Water	May 18, 2021	0								
8180	SCFP - Recycled Clarified Water	June 22, 2021	0								
8187	SCFP - Recycled Clarified Water	July 20, 2021	0								
8193	SCFP - Recycled Clarified Water	August 17, 2021	0								
8198	SCFP - Recycled Clarified Water	September 21, 2021	0								
8203	SCFP - Recycled Clarified Water	October 5, 2021	0								
8213	SCFP - Recycled Clarified Water	November 16, 2021	0								
8220	SCFP - Recycled Clarified Water	December 14, 2021	0								

Table A9. Seymour Capilano Filtration Plant – Recycled Clarified Water Slide Examination Results - *Cryptosporidium* 2021

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