2021 City of Kelowna Annual Water and Filtration Deferral Report

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Introduction

As required by the *British Columbia Drinking Water Protection Act*, the City of Kelowna (COK) provides the following annual report in accordance with our conditions on permit and conditions on filtration treatment deferral.

This report provides an overview of our service area, water quality monitoring program, water sustainability initiatives, distribution system maintenance, capital works projects, cross connection program, staff certification program, water source protection activities, emergency response plan, and water services provided.

The City of Kelowna's primary focus is to reliably provide sustainable, quality drinking water from source to tap for the customers of the Kelowna Water Utility. For further details on the content of this report or to request additional information, please contact the City of Kelowna Utility at 250-469-8502 or email watersmart@kelowna.ca.

Water System Overview

The City of Kelowna water utility is one of four large water providers operating within the municipal boundary and services approximately 86,000 residents. Within the water boundary, there is one main potable water distribution system that services over 99% of the utility customers that includes the Poplar Point, Eldorado, and Cedar Creek pump stations and one small water system that services approximately 300 residents via the Swick Road pump station.

The Utility operates a dedicated non-potable irrigation distribution network for the agricultural farming community and most of the residential properties in Southeast Kelowna. Water is supplied through a series of upland water reservoirs and funneled through Hydraulic Creek.

The northern industrial area of the city boundary, bordering Lake Country, is supplied with water from Okanagan Lake by the District of Lake Country Water Utility through infrastructure maintained by the Kelowna Water Utility.

Service Area

The defined geographical service area for Water Utility customers is bordered by Lake Okanagan to the West and three water districts to the East as presented in Figure 1.

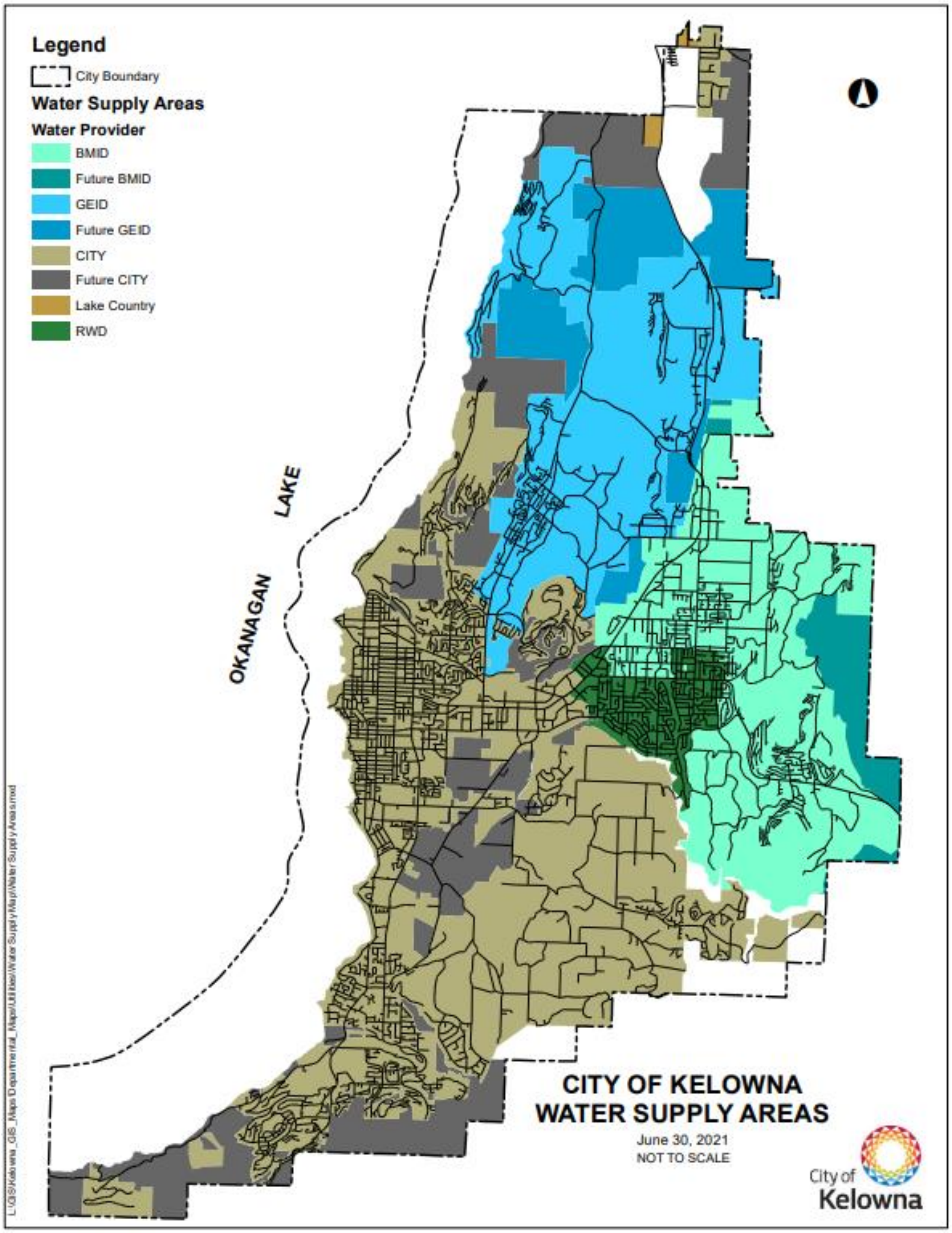


Figure 1. Water Supply area for the City of Kelowna Water Utility and surrounding water districts

Domestic Water Source and Treatment

Okanagan Lake is considered a fjord lake of glacial origin and is used as a water source by several communities in the North, Central, and South Okanagan. The lake is 135 km long, between 4-5 km in width, surface area of 348 km^2 and has a maximum depth of 232 meters. Major inflows primarily consist of Mission, Vernon, Trout, Penticton, Equesis, Kelowna, Peachland, and Powers Creeks and is drained at the south end by the Okanagan River and continues through to a series of lake chains until it reaches its confluence with the Columbia River in the Unites States.

COK is licensed to draw water from Okanagan Lake through 3 primary intakes (Poplar Point, Cedar Creek, and Swick) and 1 seasonal intake (Eldorado) that is typically only utilized during peak water demand periods. Intake locations have been designed and constructed to draw water at designated lake depths to minimize impact of suspended material, microorganisms, and chemical influences.

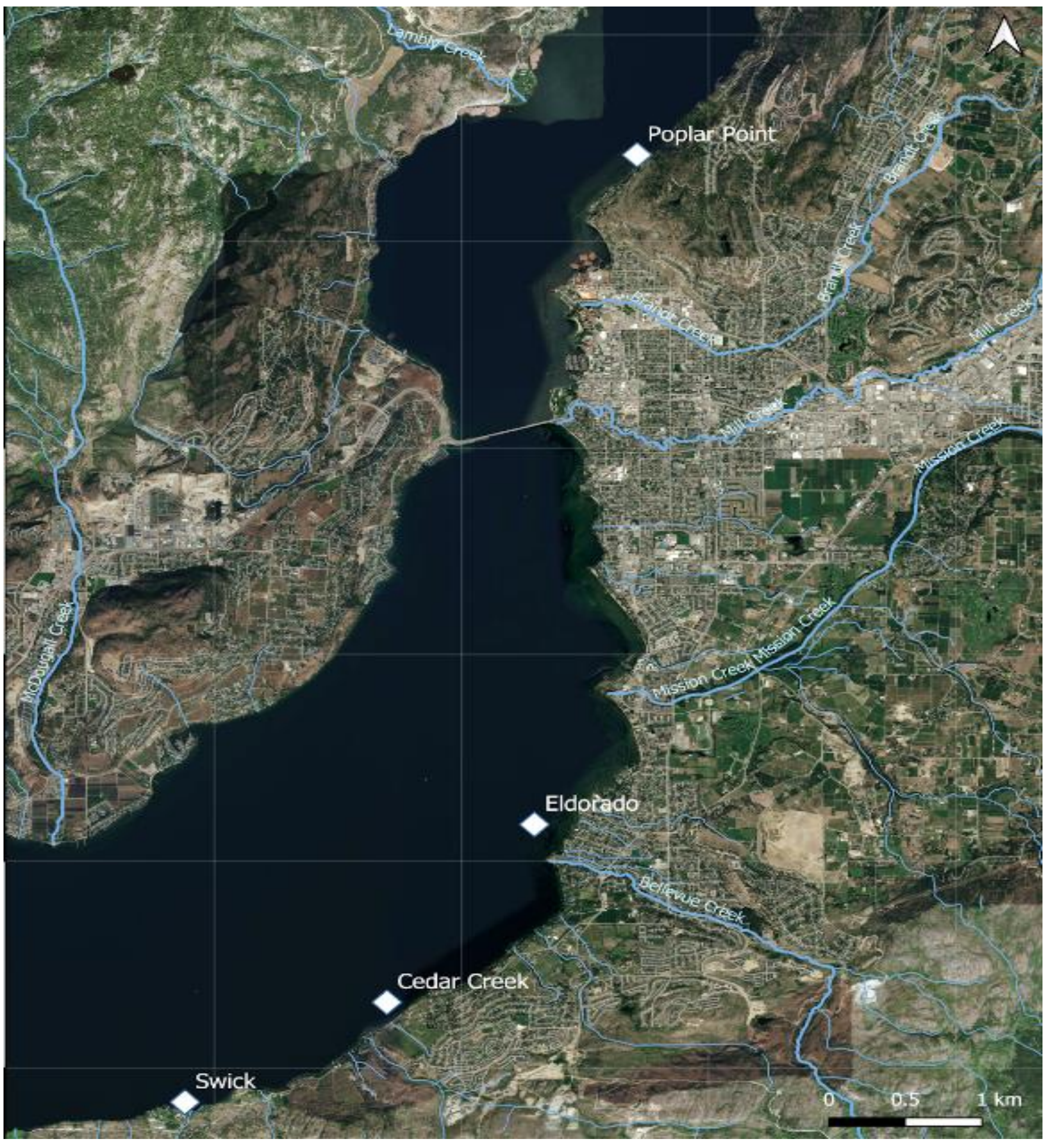


Figure 2. City of Kelowna Water Utility Intake locations

The city water treatment and supply system is classified as an EOCP Level 2 and employs a multi-barrier treatment approach that consists of UV dosing and chlorination disinfection prior to the water entering the distribution system. This aligns and complies with the "Drinking Water Treatment Objectives (Microbiological) for Surface Water Supplies in BC" as established and adopted by the Ministry of Health – Health Protection Branch.

Utilizing multiple intakes insures that there is water source redundancy in the event that an intake needs to be taken off-line due to water quality issues in localized areas, and provides some flexibility to redirect water volume to meet demand. The Swick System remains the only independently connected intake due to the remote geographical location. Cedar Creek intake had upgrades completed in 2020 that increased the pump capacity from 15,000,000 L/day to 38,000,000 L/day (Table 1).

Intake	On-site Treatment	Depth (m)	Intake Clearance (m)	Pump Capacity (L/day)	Date Commissioned	Modifications
Poplar Point	UV, Chlorine	26	1	75,000,000	1985	UV Treatment (2005)
Eldorado	UV, Chlorine	14	0.3	25,000,000	1972	UV Treatment (2005)
Cedar Creek	UV, Chlorine	20	1.5	38,000,000	2020	UV Treatment (2015)
Swick	UV, Chlorine	16	1.2	1,200,000	1984	UV Treatment (2005)

Table 1. City of Kelowna Water Utility intake specifications

Intakes are annually inspected to ensure the integrity of the screens are maintained, intake clearance is adequate, and any buildup of material on the screens is noted and cleaned as necessary.

Domestic (Potable) Distribution System

The Poplar Point, Cedar Creek, and Eldorado water distribution systems are classified as EOCP level IV based on population served, water storage capacity, flow, and pumping ability, whereas the Swick system distribution is classified as a Small Water System. Utility accounts consists of approximately 20,400 service connections, of which 18,000 connections are residential, 1,800 commercial businesses, and 600 are farm or agricultural.

Capital Assets

The COK potable distribution system consists of 4 pump stations, 19 booster stations, 26 balancing reservoirs, 48 pressure reducing stations, and delivered over 15 million cubic meters of water to customers in 2021. Over 600km of pipe make up the distribution network and consists of various materials and sizes (Table 2). The Utility asset replacement program prioritizes the replacement of Cast Iron and similar type of material that was used prior to 1978. This is typically done in conjunction with road improvement projects in those areas.

Pipe Material	Length in Service (km)	Comments
Asbestos Cement	195.6	Majority installed prior to 1978
Cast Iron	9.6	Majority installed prior to 1978
Concrete - RCCP	14.0	Majority installed prior to 1978, used in larger diameter applications
Copper	1.5	Used in smaller applications
Ductile Iron	24.0	Ductile Iron still used in some applications
Galvanized	0.21	Galvanized still used is some applications
High Density Polyethylene	14.5	Used for specialized applications
PVC	352.0	Used in most applications since 1979
PVCO	1.5	Used for specialized applications
Steel	7.3	Used for specialized or larger applications
Thermal Lined Ductile Iron	0.7	Used for specialized applications
Total	**620.9**	

Table 2. Water distribution system pipe material in use for the Kelowna Utility

The age, condition, and value of the infrastructure assets are reviewed annually and tracked through Cityworks asset management system to ensure that sufficient funding is set aside for the repair or replacement of the assets over the lifespan.

Asset Category	Dimension	Replacement Value (millions)
Water main	671 km	$646
Booster Stations	46	$37
PRV Stations	21	$23
Meters	18,626	$12
Reservoirs	26	$62
Source Water Pump Stations	4	$76
UV Reactors	4	$6
Total		**$862**

Table 3. City of Kelowna Potable Water System Asset inventory value

Maintenance

The Utility has a goal of flushing all high impact pipes and checking all hydrants in a calendar year to reduce sediment, scaling build-up, and maintain optimum water quality. A total of 539 km of pipes were flushed (84% completed) and 2453 hydrant checks (99% attendance rate) in 2021. Residents may notice slight discoloration in their water after flushing, but is still considered potable. Residents are encouraged to run their taps until water runs clear.

Irrigation (non-potable) Water Source and Treatment


McCulloch Reservoir

Although not part of the potable domestic water system, the Southeast Kelowna Irrigation system plays an important role in the supply of water to the Agricultural community. The water source primarily comes from a series of upland reservoirs in the Hydraulic Lake Watershed that covers approximately 140 km² and relies predominantly on snowpack for replenishing annual water supply. The reservoirs feed tributary streams that converge to supply the water intake located on Hydraulic Creek, which employs a single-barrier water treatment consisting of course mechanical screening and chlorine dosing. Chlorine residual will continue to be seasonally maintained in the future as it plays a vital role to minimize the growth of bacteria and pipe slime which can clog pipes, fittings, and coat sensor equipment. It is also necessary to maintain the City's goal of having irrigation water meet Canadian Agricultural Water Quality guidelines.

Reservoir and Dam Inspections

The McCulloch Reservoir system, located approximately 20 km south east of Kelowna, is the non-potable water source for Southeast Kelowna. The system is a series of lakes and dams storing water for approximately five hundred agricultural producers along with commercial and residential irrigation customers.

In addition to regular dam monitoring there are regulated reporting requirements for each dam structure depending on the classification of the dam. This reporting requires annual inspections and periodic safety reviews to ensure effective, safe, and reliable operation of the system. Monitoring and inspections are critical elements of operation that identify areas of required maintenance or improvements. While there is significant work to be completed on the system, it continues to provide reliable service for the city and its customers.

Irrigation Distribution System

The bulk of the current irrigation distribution system was installed in the late 1960's and consists of a gravity fed intake system, 4 reservoirs, a chlorine dosing station, a debris clearing screen, 5 diversion channels, 36 pressure reducing stations, and over 50km of distribution pipe. Due to the age and technical limitations of the Irrigation water meters, a full replacement program was initiated in 2021 with the goal of having all meter exchanged for ultrasonic models equipped with AMI endpoint transmitters by end of 2022.

System Control

The operation of the pumps, reservoirs, PRV's, chlorine and UV treatment systems are controlled w through the use of a Supervisory Control and Data Acquisition Software (SCADA) program. Connected by wireless links, the SCADA software remotely collects information from sensors at all of the pump stations and reservoirs and other points in the distribution system. The SCADA system also monitors and controls chemical feed systems and records water quality in the system. The software interprets the receiving data and automatically adjusts pumps and system settings to maintain pre-defined operating requirements. When an issue is detected within the system, the SCADA system issues alerts and alarms to water system operators who then respond to the concerns.

Staffing

Section 12 of the *Drinking Water Protection Regulations* (DWPR) refers to the qualification standards for water system operators. In this section, the "Environmental Operators Certification Program" (EOCP) is required for certification of operators to maintain, operate, or repair a water system. The qualification levels required for operators are determined by the class of the system under the EOCP. Current list of water system operators and certification levels are listed in Table 4, which now include Dam Inspection and Maintenance.

Name	Job Title	Water Treatment		Water Distribution				Chlorine Handling	Dam Inspection & Maintenance
		I	II	I	II	III	IV		
B. Stuart	Water Supply & Pump Stations Supervisor								
S. Saran	Water Supply Foreman								
J. Hilstob	Water Supply Operator II								
D. Sharpe	Water Supply Operator II								
D. Enns	Water Supply Operator II								
R. Hogan	Water Supply Operator II								
B. Mandryk	Control Systems Specialist								
R. Day	Electrical Foreman								
M. Hughes	Water Supply Millwright								
S. Morane	Instrument Technician								
T. Hall	Water Supply Operator II								
D. Allingham	Water Supply Operator II								
D. Van Asseldonk	Water Supply Operator II								
C. Jensen	Maintenance Foreman								

Name	Job Title	Water Distribution I	Water Distribution II	Water Distribution III	Water Distribution IV	Chlorine Handling
D. Schwarz	Water Distribution Supervisor					
D. Francis	Water Distribution Foreman					
A. Bernardin	Water Operator in Training					
D. Seneshen	Water Distribution Operator II					
D. King	Utility Services Operator					
A. Cossacchi	Water Distribution Operator I					
M. Scheidl	Water Equipment Operator					
C. Roth	Water Distribution Operator II					
J. Melrose	Utility Services Operator					
C. Van Steinburg	Hydrant and Valve Operator					
J. Daoust	Water Operator in Training					
B. Callioux	Hydrant and Valve Operator					

Table 4. City of Kelowna Water System Operators certification levels

COK employs a diverse and experienced team who are responsible for managing all aspects of the Water Utility operations. This includes managers, supervisors, operators, technicians, electricians, millwrights, technical engineers, and support staff.

Staff	Role
K. Van Vliet, P.Eng., M.Eng.	Utility Services Manager
A. Weremy, P.Eng.	Water Operations Manager
B. Stuart, WQT	Water Supply and Pump Stations Supervisor. Designated Chief Operator
M. Logan, P.Eng., MBA	Infrastructure General Manager
C. Bolt	Communications Advisor
R. MacLean, P.Eng.	Utilities Planning Manager
E. Hoppe, B.Sc., P.Chem.	Water Quality and Customer Care Supervisor
C. Moody	Cross Connection Control Program Coordinator
L. Jablonski, WQT	Water and Wastewater Quality Technician
D. Bachmann, WQT	Water and Wastewater Quality Technician

Table 5. City of Kelowna Water System Managers and Support Staff

Capital Works Projects

A number of capital projects were scheduled and completed in 2021 that involved upgrades and improvements to existing water infrastructure and drainage systems that totaled over $11 million. A large portion of these funds were directed to the completion of the SEKID water integration phase 1 project. Projects were initiated and completed according to government grant funding stipulations, priority, contractor pricing, conjunction with other road construction projects, and long term development planning.

Water Capital Projects 2021	Description	2021 Budget Spent	Level of Completion
Infrastructure Upgrade	Ellis Street, Cawston to Clement	$ 692,000	Complete
Infrastructure Replacement	Cadder Avenue, Richter to Ethel	$ 563,000	Complete
Infrastructure Upgrade	SEKID Water Integration Phase 1	$ 2,045,000	Complete
Infrastructure Upgrade	South End Water Upgrades (inc. SOMID Decommissioning)	$ 726,000	Construction in Progress
Infrastructure Upgrade	WestPoint Transmission Main	$ 202,000	Complete
Infrastructure Upgrade	Adams Reservoir Expansion	$ 901,000	Complete
Infrastructure Upgrade	Westridge Transmission Main	$ 934,000	Complete
Infrastructure Replacement	Ethel Street, Rose to Raymer	$ 459,000	Complete
Infrastructure Upgrade	Lakeshore Road, McClure to Collett	$ 351,000	Complete
Infrastructure Upgrade	Raymer Avenue, Ethel to Richter	$ 535,000	Complete
Infrastructure Upgrade	Poplar Point UV System Modifications	$ 61,000	Construction in Progress
Infrastructure Upgrade	Skyline Pump Station Repairs and Safety Upgrades	$ 610,000	Construction in Progress
Infrastructure Upgrade	Skyline Pump Station DCC - Electrical Building Upgrades	$ 671,000	Construction in Progress
Infrastructure Upgrade	Meter installations	$ 235,000	Ongoing Program
Infrastructure Replacement	Chemical Storage Tank Replacement - Kettle Valley UV Facility	$ 27,000	In Progress
Infrastructure Replacement	Data Radio Replacement - Water	$ 16,000	Complete
Infrastructure Replacement	Water Meter Replacement - Stage 1	$ 2,185,000	In Progress
Non-potable Water Capital Projects 2021	**Description**	**2021 Budget Spent**	**Level of Completion**
Infrastructure Upgrade	Dam Repairs - Irrigation Intake	$ 84,000	In Progress
Infrastructure Upgrade	Irrigation System Upgrades	$ 22,000	In Progress
	2021 Total Investment	**$ 11,320,000**	

Table 6. Drinking Water capital projects

The installation of water meters throughout Southeast Kelowna was a notable project that fundamentally changed the way residents monitored and paid for water services. The addition of cellular endpoints to all new meters allows for remote and real time access to water use data and is available to the Utility and the residents through the use of a free, on-line application. The ability to have residents easily monitor and manage their water use as well as receive automated notification in the event of potential water leak, provides a critical tool to reduce water demand and waste.

Cross Connection Control Program

The City of Kelowna Water Utility implemented a comprehensive Cross Connection Control (CCC) program in 1998. The CCC program is designed to protect water quality in the distribution system from backflow and any subsequent contaminants that could be carried from point of use sources. Our program has been strategically implemented to include the 4 distinct water district purveyors in Kelowna and tracked 6337 testable backflow prevention assemblies in approximately 2900 facilities throughout the city in 2021.

Program Scope

The Cross Connection Control program applies to all water customers within the city regardless of their water purveyor. The City of Kelowna manages the program on behalf of all four major Kelowna water providers. Although the program applies to all customers, it is focused on Industrial, Commercial, Institutional, and Agricultural customers. There are standard backflow prevention requirements that apply to single family dwellings, but these requirements don't usually involve testable Back Flow Preventer (BFP) assemblies. Occasionally single family homeowners will install a commercial type of system or appliance in their home and in these instances appropriate backflow prevention assemblies may be installed. The program utilizes field inspections and review of construction plans and building permit applications to identify cross-connection hazards and risk of backflow. When a cross-connection hazard is identified, a backflow prevention assembly (BFP) is required to be installed to isolate and contain the hazard and to prevent backflow into the public water system.

Annual Testing

Consumers connected to the public water supply in the city share the responsibility of protecting the water system from the backflow of contaminants. The assembly owners are required to contact the services of a qualified tester and submit a passing test report for the assembly(s) annually.

The City of Kelowna strives to achieve total compliance with the annual testing component of our program and is successful within 2% year after year (Table 7).

Premise Protection	In-Service	New Installs	Failures	Cleaned	Repairs	Tests Completed
Double Check Detector Assembly	11	1	0	0	0	10
Double Check Valve Assembly	2970	1	70	0	0	3080
Pressure Vacuum Breaker Assembly	2	0	0	0	0	2
Reduced Pressure Backflow Assembly	1595	164	74	1	0	1736
Total	**4578**	**166**	**144**	**1**	**0**	**4828**
Double Check Detector Assembly	1	0	0	0	0	2
Double Check Valve Assembly	1479	84	29	0	0	1541
Reduced Pressure Backflow Assembly	272	33	17	0	0	302
Total	**1757**	**117**	**46**	**0**	**0**	**1845**
Grand Total	**6337**	**283**	**190**	**1**	**0**	**6673**

Table 7. Summary of 2021 Cross Connection Backflow Devices and compliance tested

2021 Progress

The Utility has taken ownership and testing responsibility of approximately 625 DCVA backflow preventors in Southeast Kelowna. These backflow preventers are a requirement to protect domestic water services installed on properties that have access to the non-potable irrigation water or are engaged in an agricultural activity.

The backflow preventers are in freeze protected pits on the public side of the property line. This is a departure from the normal cross connection control program operation, as it is the drinking water utility protecting itself from the irrigation water utility.

Water Quality Monitoring

The COK Water Quality Program references the following regulations and guidelines to develop a formal reporting and monitoring program:

- *Guidelines for Canadian Drinking Water Quality (GCDWQ)*
- *British Columbia Approved Water Quality Guidelines*
- *British Columbia Drinking Water Protection Act and Regulation (DWPA)*
- *Drinking Water Treatment Objectives for Surface Water in BC*
- *IHA Decision Tree for Responding to Turbidity Events in Unfiltered Water*

The *Guidelines for Canadian Drinking Water Quality* are based on the current, published scientific research related to the health effects, aesthetic effects, and operational considerations. Health based guidelines are established on the basis of comprehensive review of the known health effects associated with each contaminant, on exposure levels and on the availability of treatment and analytical techniques. The highest priority guidelines are those dealing with microbiological contaminants such as bacteria, protozoa, and viruses.

Sample Collection and Frequency

A source to tap drinking water quality monitoring program is a function of source water quality, water treatment, and water quality through the distribution system. As a result, the monitoring of drinking water quality consists of 4 main sampling and information collection components:

- Source Water Monitoring
- Monitoring of the Pump Intakes and Distribution System
- Monitoring at the outflow of Wastewater Treatment Plant
- Customer Concerns and Service Requests

The sampling location, frequency, and water quality parameters required at each of the source to tap sites are reviewed yearly, approved by IHA, and samples collected as per frequency referenced in the COK Water Utility Water Quality Sampling Guidelines (Appendix A). Qualified field and lab technicians perform more than 500 monthly tests on source and distribution water at over 80 sites throughout the system. Sampling sites include various locations from Okanagan Lake, tributary creeks, pump stations, reservoirs, booster stations, valve chambers, and final tap source points.

Data collection consists of SCADA monitoring, field measurements, in-lab testing, and submission of samples to a third party, accredited laboratory as part of the quality assurance program. Analytical results are entered into the WaterTrax software database, which has the ability to alert water operation staff and utility management in the event that specific parameters exceed operational or water quality guidelines as outlined in the CDWQG.

Source Water Quality Monitoring

Over 2,000 combined source water samples were tested from Okanagan Lake drawn from each of the four intake locations. The samples are taken prior to both UV and Chlorine treatment and analyzed for a variety of water quality parameters either on-site at the COK laboratory or at the certified lab as per monthly sampling schedule. Detailed chemical and biological parameter descriptions, graphical trends, and related WQ objectives are listed in Appendix B and include the following:

- Turbidity (Table 11, Figures 10-11)
- Total Coliform (Table 12, Figures 12-13)
- Escherichia coli (E. Coli.) (Table 13, Figures 14-15)
- pH (Table 14, Figures 16-17)
- Color (Table 15, Figures 18-19)
- Temperature (Table 16, Figures 20-21)
- UV Transmittance (Table 17, Figures 22-23)

2021 Source Water Quality Observations

- Turbidity never exceeded 0.76 NTU, well below the CDWQG and continued to trend lower over 5 years
- Both Total Coliform and E.coli. counts remained consistently low
- pH, algae, and yearly average temperature demonstrated an increase in concentrations
- UVT and color remained consistent year over year
- Particle size analysis over 1 year period indicated particles predominantly less than 50 micron

Overall Lake Okanagan Water Quality Health

In addition to internal testing program, the COK is part of an annual *Collaborative Okanagan Lake Water Quality Study* that is generated annually by Larratt Aquatic Consultants on behalf of various municipalities and districts that discharge into Okanagan Lake. This report is submitted to the Ministry of Environment as part of the condition on permit for wastewater operations. The report examines the general physical, chemical, and biological health of Lake Okanagan and water quality trends that may be influenced by tributaries as well as outfalls from treatment plants. Parameters in the Central Okanagan area generally all fell within water quality objectives published (Nordin, 2005) and accepted by the Ministry of Environment.

Physical Properties

Okanagan Lake is usually stratified from May to November, it mixes in mid-November and then freely mixes over the winter. Secchi depth was highest in late winter and decreased each spring in response to increased phytoplankton activity. Water clarity was typical for Okanagan Lake in 2021. Only the Armstrong Arm failed to meet the Secchi depth objective in 2021, as it did in every year to date.

Chemical Properties

Dissolved oxygen (DO) is essential for all aquatic animals and is high throughout Okanagan Lake at all times except in the hypolimnion of the Armstrong Arm where DO fell below the water quality objective each summer including 2021. Silica, an important micronutrient, had stable concentrations in Okanagan Lake over the past 20 years.

Total nitrogen (TN) exceeded the objective at all sites during 2021 as it did in most years. There were significant increasing trends in TN from 2011-2021 at Okanagan Centre and Armstrong Arm, driven in part by decades of increasing nitrate concentrations in the deep water of Okanagan Lake. This increasing nitrate trend has continued through multiple wet-dry climate cycles and is likely caused by increasing human impacts within the Okanagan region and possibly also climate change.

Total phosphorus (TP) had a year-over-year increasing trend at all sites from 2011-2021, and forms part of a longer-term trend since the mid-2000s. TP includes phosphorus associated with suspended sediment carried into the lake. It increased in Okanagan Lake during wet years such as 2017-2018 and decreased during dry years such as 2019 and 2021. Dissolved phosphorus is less affected by freshets than TP and was stable over the past 20 years at all sites, averaging much lower than the 1970s.

The ratio of total nitrogen to total phosphorus (N:P) available to phytoplankton will play a major role in which types of phytoplankton proliferate in a lake. A lower N:P ratio (abundant phosphorus relative to nitrogen) will favor the growth of cyanobacteria. The N:P ratio failed to meet the objective in the Armstrong Arm in 2021 with a downwards trend (farther from meeting objective).

Biological Properties

Chlorophyll-a was used as a measure of photosynthetic activity in Okanagan Lake. A decreasing north to south trend in the chlorophyll-a data occurred over the course of this study. All sites met the chlorophyll-a objectives during 2021. Chlorophyll-a was lower during 2019-2021 compared to the very high 2018 values because of the drier conditions and lower freshet nutrient inputs after 2018. However, a significant increasing trend occurred at all sites from 2011-2020, part of a trend since the mid-2000s.

Phytoplankton abundance during 2021 was elevated compared to 2020. All sites met the phytoplankton biovolume objective but failed to meet the phytoplankton taxonomy objective during 2021 because of elevated cyanobacteria densities, particularly the Armstrong Arm.

Zooplankton biomass met the objective at Kelowna and Summerland in 2021 and was high compared to previous years. All sites failed to meet the objective of >5% cladocerans in some samples during 2021. No significant trends in zooplankton data occurred to date.

Treated Water Quality Monitoring

Similar to the source water sampling program, over 2,750 combined treated water samples were tested from each of the four intake location immediately post UV and Chlorine treatment. The purpose of this monitoring program is to establish that the treatment is effectively removing or neutralizing any microbiological threat, improving, or at least not deteriorating the chemical and physical quality of the drinking water, and complying with the established *GCDWQ* health and aesthetic guidelines.

Detailed chemical and biological parameter descriptions, graphical trends, and related water quality objectives are listed in Appendix C and include:

- Turbidity (Table 18, Figures 24-25)
- Free Chlorine (Table 19, Figures 26-27)
- Total Coliform (Table 20)
- Escherichia coli (E. Coli.) (Table 21)
- pH (Table 22, Figures 28-29)
- Color (Table 23, Figures 30-31)
- Temperature (Table 24, Figures 32-33)
- UV Transmittance (Table 25, Figures 34-35)

2021 Treated Water Quality Observations

- Turbidity remained consistently below the CDWQG of 1 NTU
- Treatment remained effective through complete deactivation of Total Coliform and E. coli. bacteria
- pH, color, chlorine residual, temperature, and UVT results were acceptable and remained consistent with previous year

Annual Physical, Chemical and Biological Analysis

In addition to the on-site and in-lab analytical testing program, the COK submits treated water samples to an external accredited laboratory for full comprehensive physical, chemical, and microbiological analysis from each of the Intake sites. The purpose of utilizing an external lab is to verify internal test results as a quality control check and evaluate a broader range of compounds and highlight any water quality health concerns.

The 2021 analytical results validated the data generated by internal lab testing and did not indicate any significant year over year trend. There were no exceedances of aesthetic or health maximum guideline of any parameters listed and no significant trends relative to previous years of historical comprehensive analysis (Table 26).

Pesticides and Herbicides

The Okanagan valley is renowned for its long standing agricultural industry and continues to be a hallmark of the BC interior region. Farming practices have commonly included the application of a variety of pesticides and herbicides over the past 80 years. Although much of the hazardous compounds have been phased or legislated out, there are still some legacy chemical compounds that are monitored due to its lifespan in the environment. Due to the proximity of the agricultural land to Okanagan Lake, Herbicides and Pesticides are tested on a four-year cycle. Since the beginning of the quadrennial screening practice in 2000, none of the scanned Pesticides or Herbicides has been detected in any of the samples to date (Table 27). Testing was completed in 2021 and is next scheduled for 2025.

Radiological

Radionuclides are naturally present in the environment and have been surveyed in various regions throughout British Columbia of which Uranium is the most common isotope identified in the Okanagan. Leaching of these radionuclides into ground water is of concern and therefore are measured against health standards. Maximum acceptable concentrations in drinking water have been established for three natural isotopes (210-Pb, 226-Ra, and 236-U) and four artificial isotopes (90-Sr, 131-I, 137-Cs, and H3-Tritium). To date, there has not been any significant Gross Alpha or Gross Beta radionuclides found in the drinking water (Table 28). Testing was last completed in 2018 and is scheduled again in 2022.

Distribution System Testing Program

To maintain potable water service, bacteria, chlorine residual, and chlorination byproducts are routinely monitored and reported to Interior Health for compliance to *BC Drinking Water Regulations* and *Guidelines for Canadian Drinking Water Quality*. Representative distribution sampling sites and testing frequencies are determined by COK and approved by IHA on an annual basis. The sampling plan includes taking samples at the beginning, midpoint, and at the end of the main distribution pipes to ensure free chlorine residual is maintained and chlorination byproducts can be tested. Specific parameters that are monitored are listed in Appendix D and include:

- Free Chlorine (Table 29, Figures 36-37)
- Total Coliform (Table 30)
- Escherichia coli (E. Coli) (Table 31)
- Trihalomethanes (THM) (Table 32, Figures 38-39)
- Haloacetic Acids (HAA) (Table 33, Figures 40-41)

As per established GCDWQ guidelines, the following microbiological criteria for drinking water distribution systems are referenced:

- No sample should contain more than one Escherichia Coli organisms per 100mL
- No two consecutive samples from the same site should show the positive presence of Total Coliform organisms per 100mL
- At least 90% of the samples must have zero Total Coliform per 100mL

COK demonstrated that the treated drinking water met the guideline criteria for both Total Coliform and E. Coli. throughout 2021 with no recorded exceedances (Table 8).

Criteria – Total Coliform	City System	Swick System	Airport System
Number of microbiological tests - Total Coliform	1377	176	56
Number of samples containing positive Total Coliform/100mL	0	0	0
Samples with >10 Total Coliform / 100mL	0	0	0
Occasions with consecutive positive Total Coliform / 100mL	0	0	0
Criteria – Escherichia coli			
Number of microbiological tests - E. Coli.	1377	176	56
Number of samples containing positive E. Coli. /100mL	0	0	0

Table 8: Summary drinking water Bacterial tests

2021 Distribution Water Quality Observations

- Total Coliform and E. coli. counts all met drinking water quality objectives with no positive counts
- Chlorine disinfection was maintained but challenging in remote areas of the system
- Annual running average THM and HAA concentrations were below the drinking water guidelines

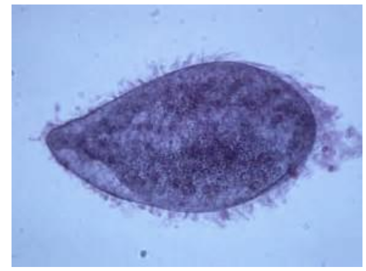
Filtration Deferral Requirements

The City of Kelowna applied for filtration treatment exclusion in 2010 and was approved in 2011 based on the proviso that several treatment and water quality objectives be adopted, monitored, and reported to Interior Health on an annual basis. Since obtaining filtration exclusion, COK has continually met or exceeded the seven requirements outlined by Interior Health and approved by the provincial Medical Health Officer.

Dual Disinfection

In accordance with the IHA dual barrier approach for drinking water, all of the Kelowna intake systems are equipped and utilize both Ultra Violet (UV) and chlorine disinfection prior to the water entering the distribution system. UV disinfection is currently applied at a minimal dose of 40 MJ/cm through the reactor cells and chlorine (Hypochlorite) dosed to maintain a minimum free chlorine residual of 0.2 mg/L in the distribution system.

Protozoa Sampling



Protozoa was analyzed extensively between 1996 and 2013 on raw and treated water samples throughout the COK water system. After consultation and review of the data with IHA, this requirement was removed from the scope in 2014 as it was demonstrated that the UV treatment adequately accounted for the deactivation and neutralization of all protozoa entering the water system.

Source Water Protection

The COK relies on Federal and Provincial Acts, Regulations, Stewardship Plans, Best Management Practices and Local Government bylaws and policies to protect water resources from the impacts of land use in the watershed. As a condition on Permit to Operate, COK contracted an external Environmental consultant with the purpose of conducting and documenting a Source Water Protection Plan (SWPP) assessment. This was formally completed in 2011 with the intent that the resulting recommendations would trigger an assessment action response plan that would be annually reviewed and updated in accordance with the risks identified. Six main risk categories were identified as influential to the water quality for the COK and include:

1) Creek Flow
2) In-Lake Algal Production
3) Wastewater Treatment Plant Discharge
4) Transportation Corridor Spills
5) Boating Activities
6) Impact of Lake Physics

A formal source water protection plan was developed that addresses these risks through planning, mitigation, education, testing, and reporting.

- Assessing the performance and frequency of the city water quality monitoring program
  - Water Quality is analyzed continuously on-line through field and laboratory analysis for both drinking water and stormwater. Frequency of reportable lab data is increased during freshet.
- Upgrades to protect against invasive mussels
  - COK partners with the Okanagan Basin Water Boards (OBWB) "Don't Move a Mussel" program
- Establishing an intake protection zone (IPZ)
  - The IPZs around the City's four intakes has been added to the City's GIS mapping and now can be coordinated with the City's new OCP to help better protect the sensitive areas surrounding the drinking water intakes.
- Stormwater management
  - Utility has developed a 10-year plan to install a new oil and grease (O&G) separator every year over the next 10 years in high impact areas. In 2021, a new O&G separator was installed at the inflow of Chichester Pond.
  - Six new aerators were installed into Redlich Pond to replace aging infrastructure and improve oxygenation and nutrient balancing.

    - Incorporating the use of Green Infrastructure into City and new development projects through our new OCP and existing bylaws
- Public education
    - The city has two 'Clean water volunteer programs' that have been on a 2 year hiatus due to COVID-19 safety measures, in fall of 2021 both programs have been re-initiated and will resume in spring 2022
- Utility long range planning
    - A collaborative committee between the COK, OBWB, Regional District of Central Okanagan (RDCO), and Interior Health was established to develop a comprehensive and long range plan for all aspects of water quality and use in the Okanagan. Work is in progress and will be reported to the public
    - In 2021 the city completed a Natural Asset Inventory in partnership with Municipal Natural Assets Initiative (MNAI), resulting in a dashboard for all of the City's natural assets to be used in planning and development and environmental protection.
- Climate change
    - 10-year plan to restore and improve upstream water storage and mitigate flooding risk
    - OCP amended to include an updated 'Hazardous Condition Development Permit' to help protect certain areas at risk from flooding
    - The new OCP now includes the requirement for planting indigenous, drought tolerant vegetation and buffers in new developments and city properties

Drainage Water Quality Program

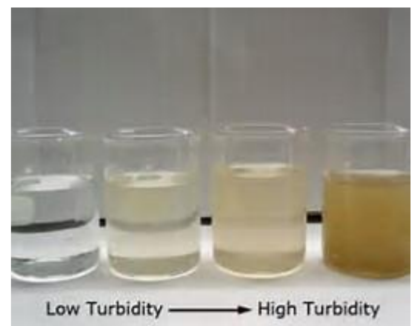
As part of the COK *Source Water Protection Assessment Plan*, there are number of chemical and biological parameters that are tested and monitored at storm water outfalls and local tributaries that enter Okanagan Lake. Contaminants carried through the drainage system have the potential to impact the water quality at the intakes and therefore have been categorically assessed, recommendations made, and actions taken to mitigate and monitor the risks. Yearly assessments include correlating elevated Turbidity and E. Coli. levels in tributaries to the same parameters at intakes, recording water quality changes during rain and flushing events through the storm water system, summer beach sampling for E. Coli., and testing of routine water quality parameters in creeks at a minimum of 5 times a month to determine the level of nutrient and pathogen contribution to the lake water quality. Details of each category are listed with commentary in Appendix E

Raw Water Bacteria

As per the annual COK water quality sampling program, source (raw) water was monitored for Total and E. Coli. Bacteria throughout the year at each intake. Results were collected and reviewed through the WaterTrax software system that allows for alert levels to flag and notify utility operators of elevated levels.

Corresponding monthly summary reports were issued to Interior Health as part of the Condition on Permit to operate and to assess if the water treatment is sufficiently neutralizing the raw water bacterial counts at the intake. For the 2021 calendar year, all samples from poplar Point, Cedar Creek, Eldorado, or Swick Road intakes met the Filtration Deferral criteria of having no more than 10% of the source water E. Coli. samples exceed 20/100ml in any 6-month period (Table 15 in Appendix B)

Raw Water Physical Parameters



In 2006, Interior Health introduced the Turbidity Education and Notification Campaign for unfiltered water systems to inform customers that health risks increase as Turbidity rises and to notify customers (particularly for at-risk populations with weakened immune systems) for levels higher than one (1) Nephelometric Turbidity Units (NTU). None of the four COK intakes currently are equipped with filtration and therefore routine testing and reporting of Turbidity levels to Interior Health are required to demonstrate that source water levels meet the 1 NTU target.

The onset of freshet and subsequent increase in Turbidity at the intakes alligned with similar historical averages at all of the intakes (Figure 3-6). In contrast to 2018, at no point did the turbidity measurements exceed the CDWQ guidelines and subsequently, no water quality advisory related to freshet had to be issued within the City Utility boundary. In order to better understand the relationship and impact of these tributaries, the COK has implemented a sampling program that cross references the freshet as well as timely weather events with water quality tested at the intakes. Summary and commentary on these relationships can be found in the drainage report (Appendix E).

Turbidity is continuously measured at all water supply sources via on-line Turbidity meters through SCADA and is primarily used as a screening or trending indicator for water quality. Grab samples are tested by City lab staff at regular intervals and with increased frequency if in-line monitors indicate that turbidity is approaching or exceeding the 1 NTU threshold. Using 2019-2021 SCADA Turbidity values for each of the intakes are plotted in Figures 3-6 with weekly averages and associated guidelines. The year over year comparison highlights a very mild, moderate freshet in 2021 with minimal Turbidity fluctuations.

In addition to regular intake sampling, weekly depth sampling is conducted during freshet to capture high Turbidity plumes that may be emanating from some of the major tributaries. This provides insite as to conditions in and around the intake and allows for operation decisions and adjustments as needed.

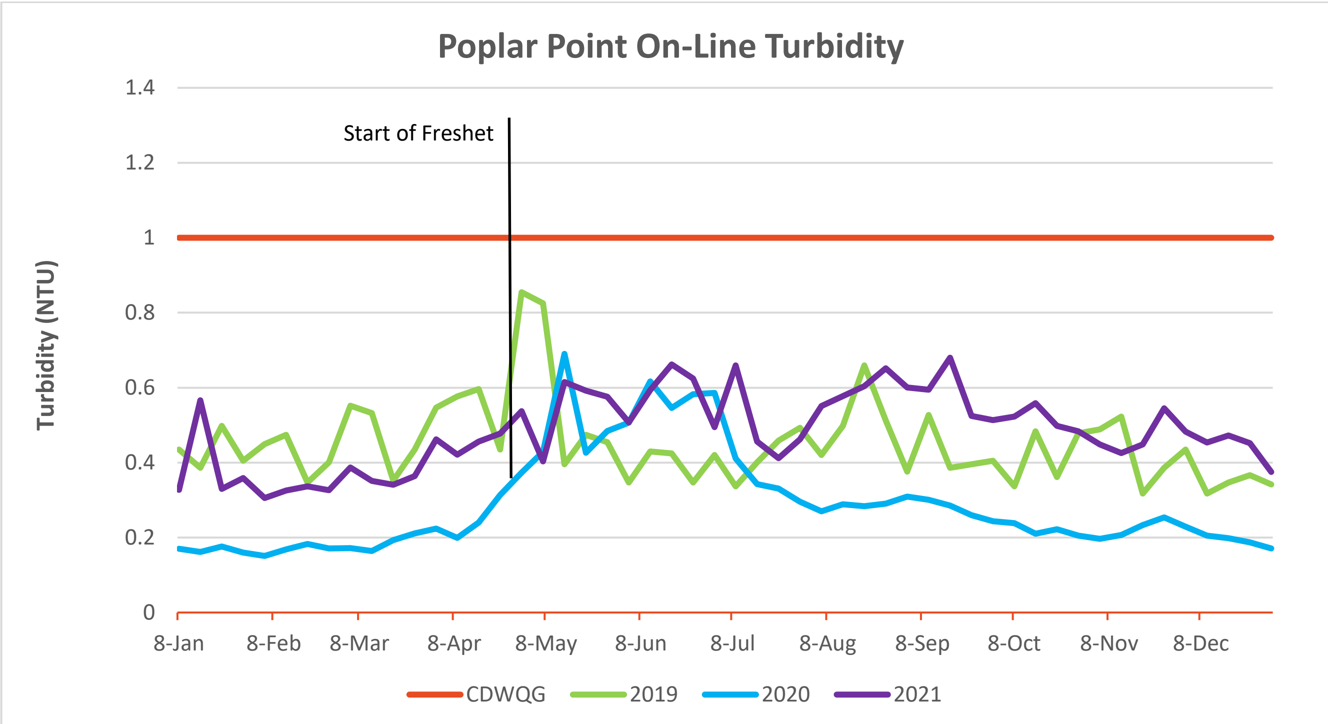


Figure 3. On-line Turbidity values at Poplar Point intake

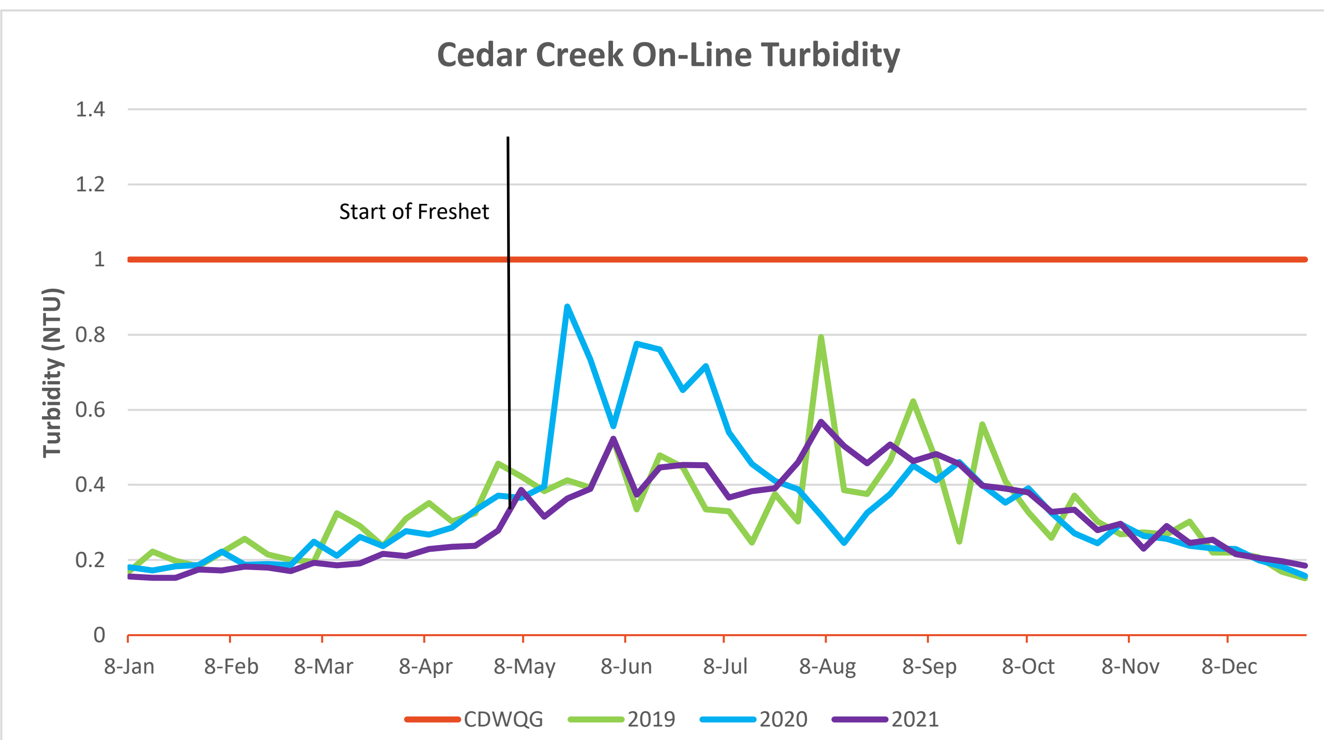


Figure 4. On-line Turbidity values at Cedar Creek intake

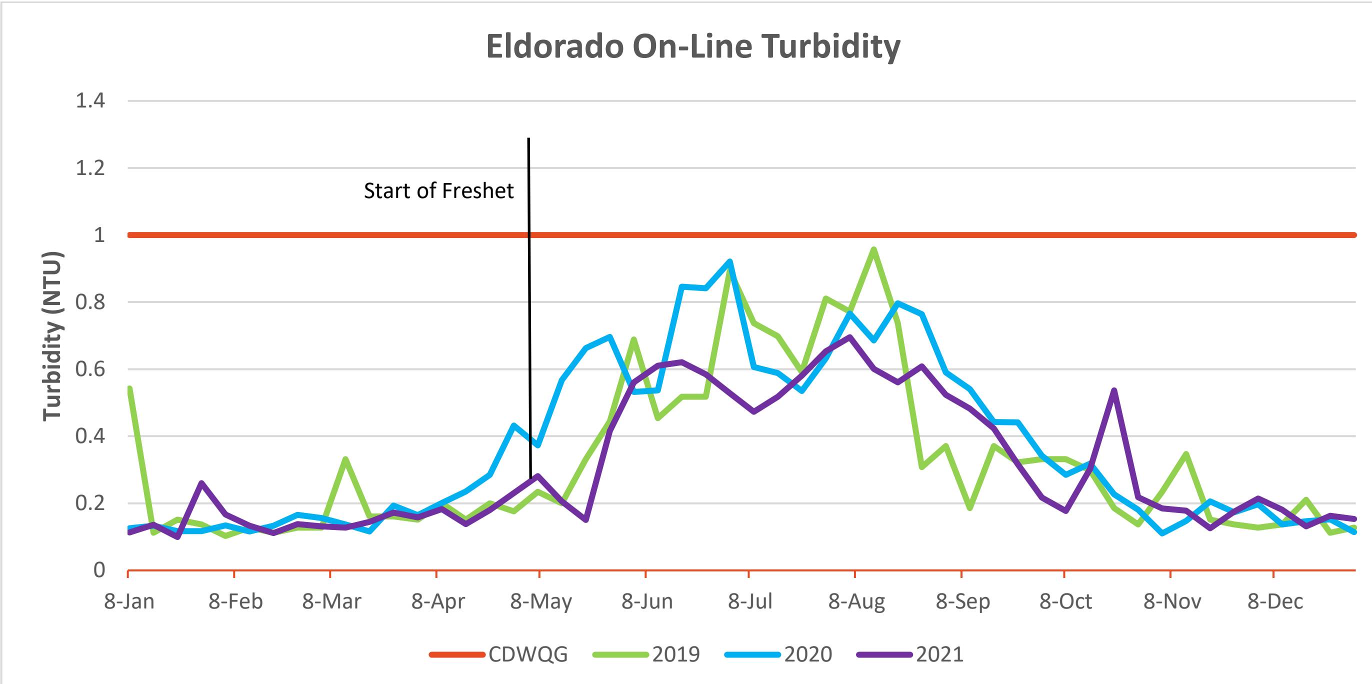


Figure 5. On-line Turbidity values at Eldorado intake

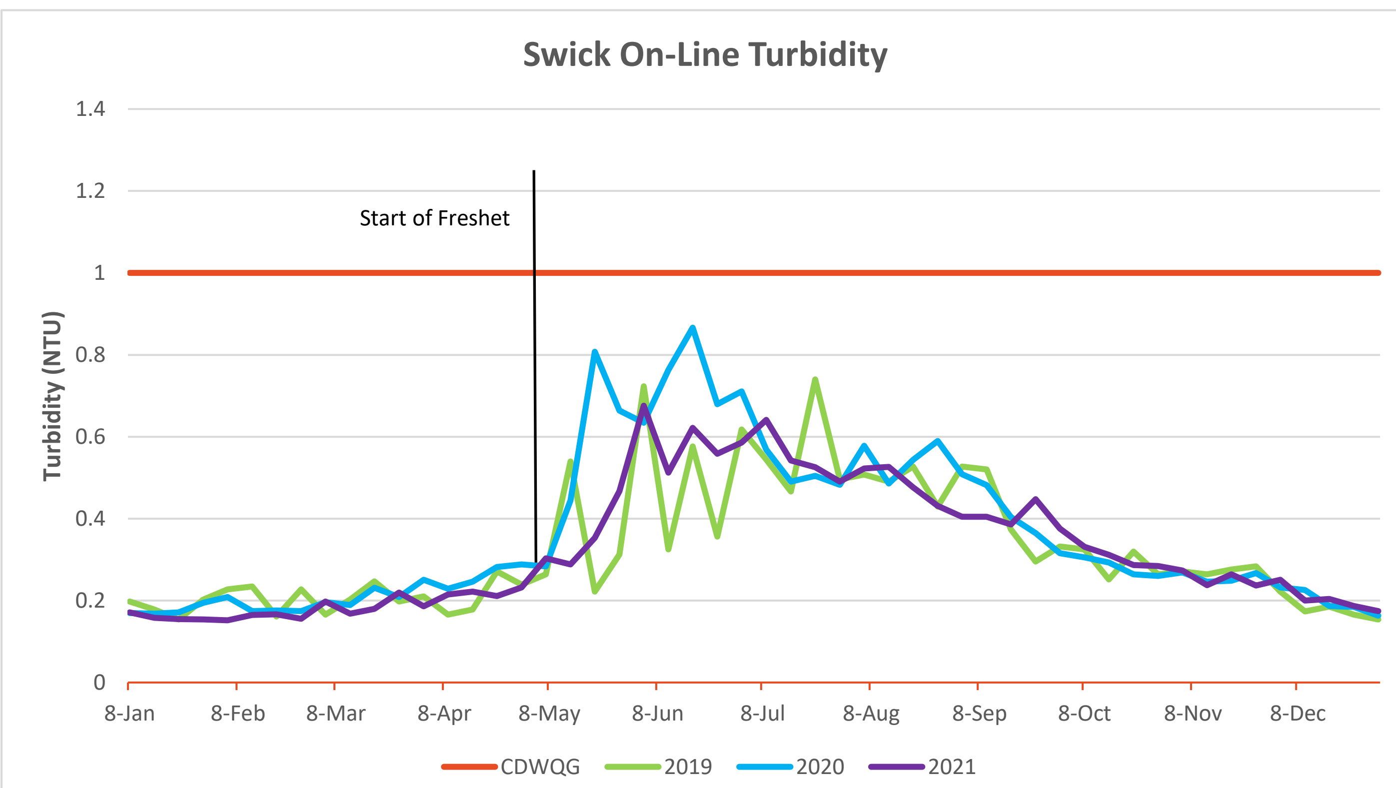


Figure 6. On-line Turbidity values at Swick intake

Water Production

Water production within the COK service area is monitored at each pump station prior to treatment. The Poplar Point system accounts for 70% of the total annual domestic water production with the remaining 30% between Cedar Creek, Eldorado and Swick (Figure 7).

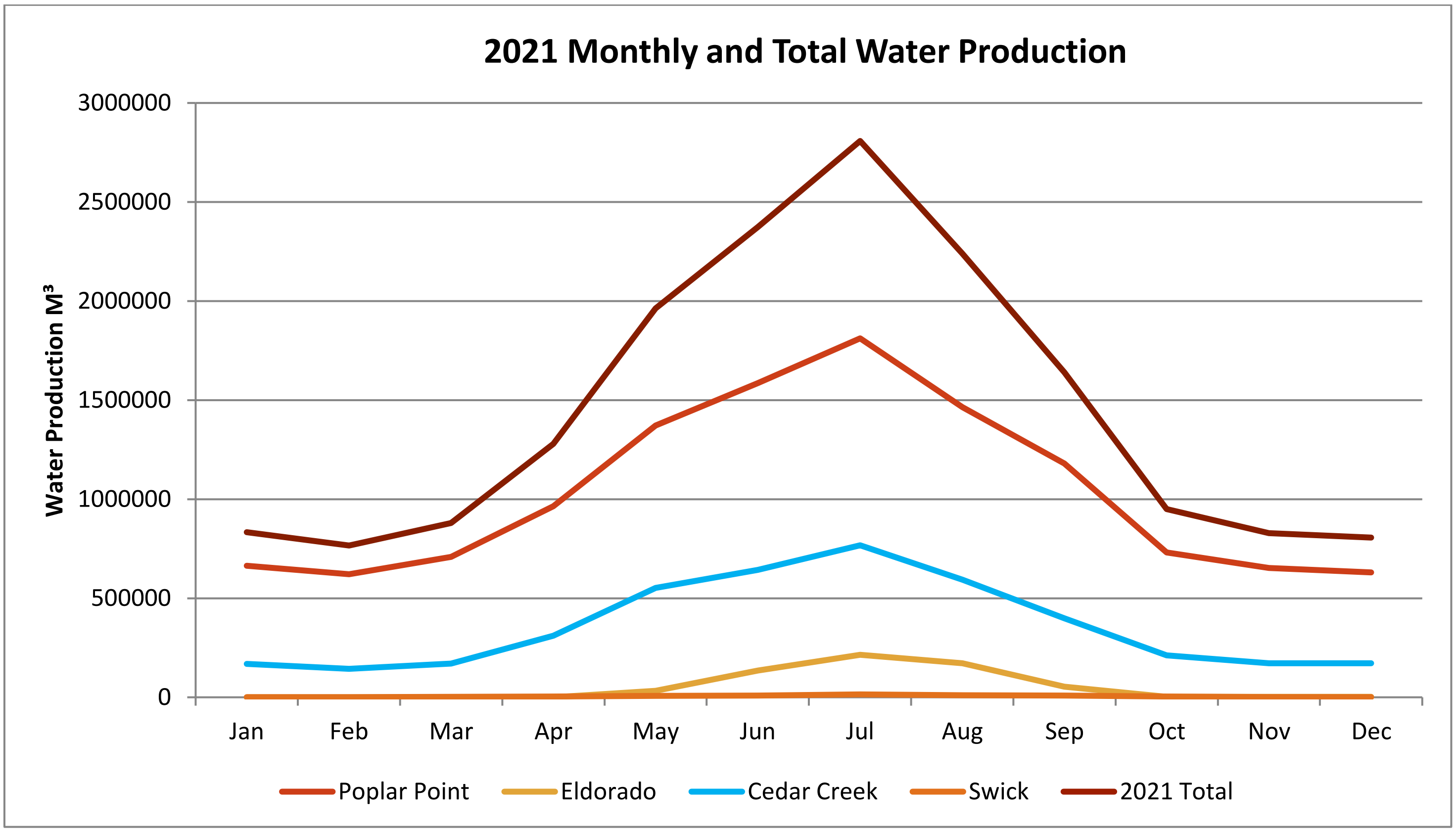


Figure 7. Monthly and Year over Year water production at each COK pump station

Production demand typically increases in April, peaks in late July or early August due to agriculture and irrigation demand and drops through October. However, June through July had a very pronounced heat wave which saw peak water demands a month earlier then previously experienced. In 2021 the highest ever water production daily demand was experienced on July 1st at 98,462m³ and reaffirms the upward trajectory over the past 4 years (Figure 8).

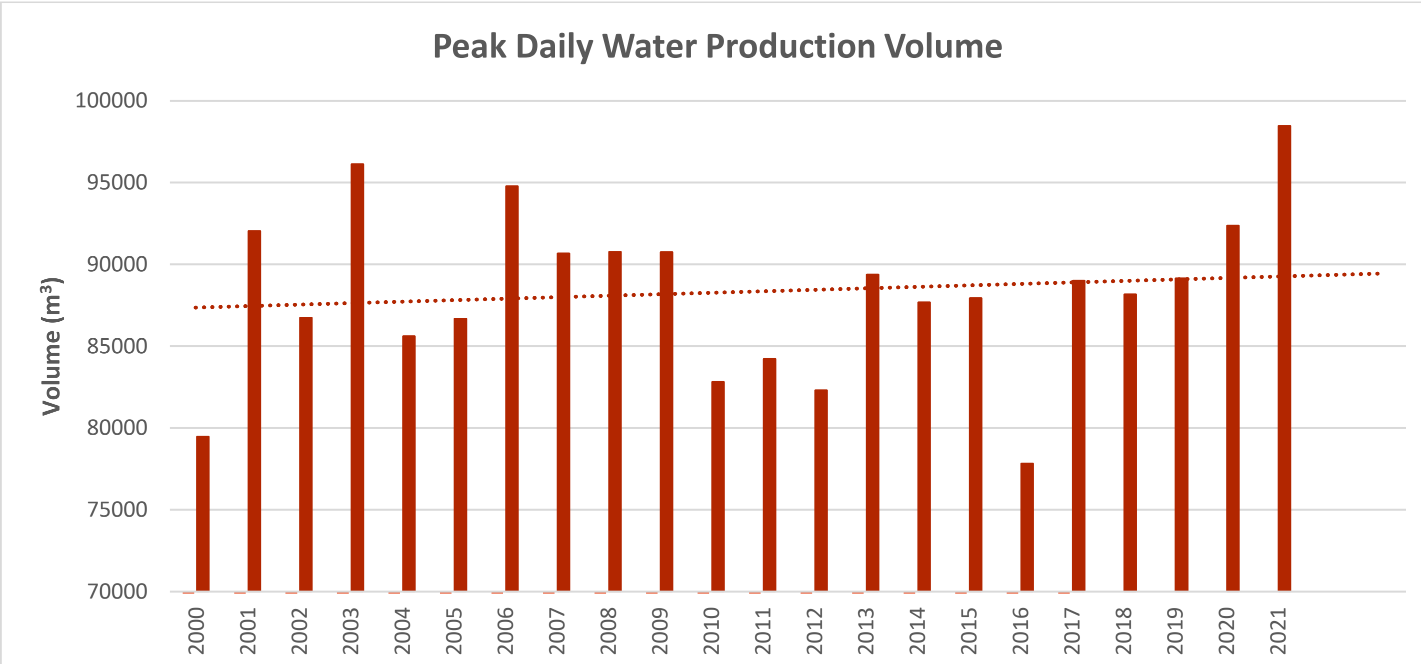


Figure 8. Peak daily water production volume trending

Similarly, the total water production has been tracked relative to the Utility area population over the past 15 years (Figure 9). Water volume production trend had remained relatively consistent up until 2020-2021 that had Southeast Kelowna demand added as well as unprecedented heat and dry summer conditions.

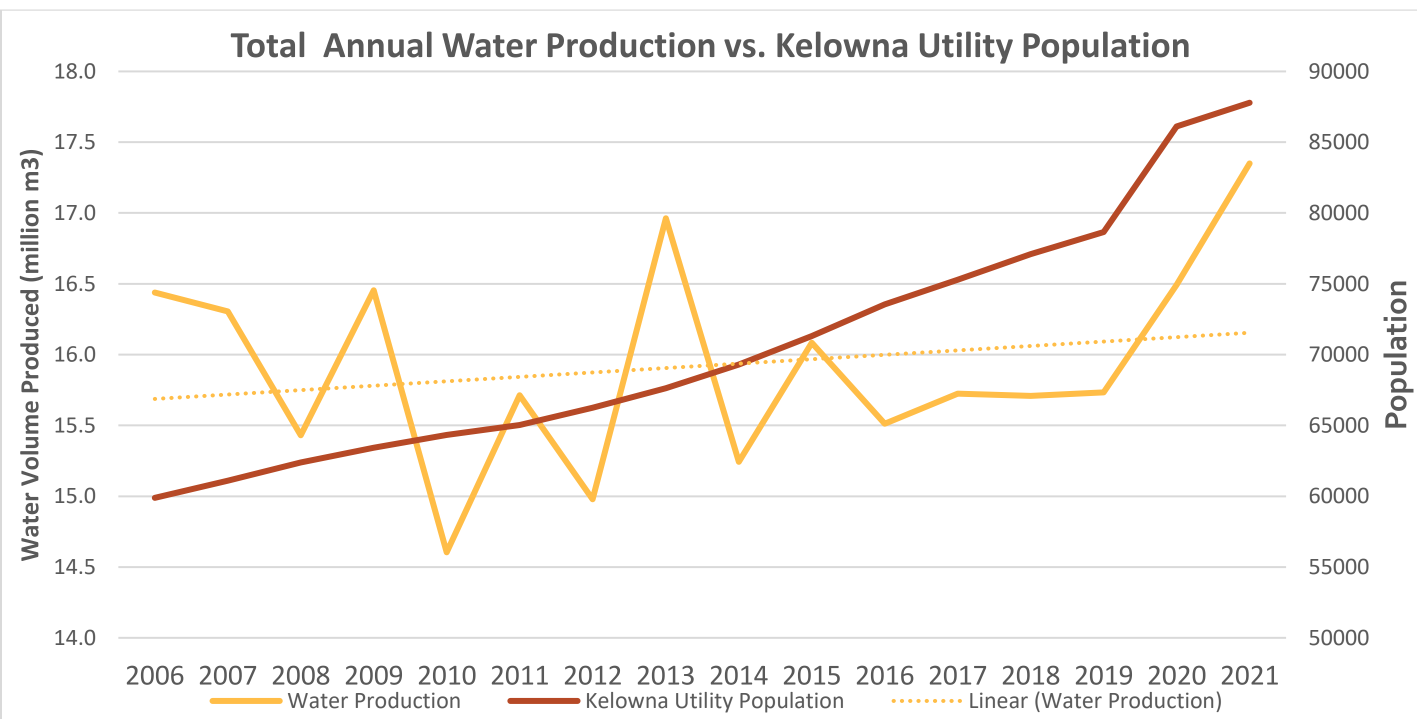


Figure 9. Total water production relative to Utility population growth

Consumption is also tracked by service type and metered accounts and provides a correlation between what is produced and what is consumed. Discrepancies between the two values indicate potential water loss due to leakage or line flushing or as a result of unmetered accounts.

The number of metered service connections increased for most categories as has water demand in line with population growth. 2021 saw one of the lowest precipitation rates over the summer in the past 20 years which lead to the high demand observed. Water consumption per person in the Okanagan remains one of the highest in any region through Canada.

	2015	2016	2017	2018	2019	2020	2021	Unit
Production								
Total Pumped	16,083.60	15,512.80	15,833.28	15,712.41	15,650.00	16,503.87	17,346.75	1000 m^3
Population								
COK Water Utility Boundary	69,679	70,694	73,542	74,679	75,370	83,529	85,238	people
Climate								
Precipitation (April-September) (Normal: 209 mm)	153	148	99	134	146	183	73	mm
Number of Services (active and inactive)								
Residential	14,084	14,365	14,313	14,480	14,565	15,477	15,609	services
Multifamily	342	351	356	416	434	465	508	services
Strata	648	657	661	663	665	1165	1163	services
Commercial	1,361	1,367	966	954	966	1,371	1,367	services
Parks	167	167	52	176	175	175	195	services
Total	16,910	16,907	16,348	16,689	16,805	18,653	18,842	services
Consumption (Metered)								
Residential	6,052.00	5,647.60	5,981.80	5,733.70	5,486.10	5,633.06	6,779.92	1000 m^3
Multifamily	2,542.70	2,443.00	2,502.20	2,703.30	2,804.65	2,917.17	3,161.28	1000 m^3
Strata	735.5	717	736.2	768.3	658.82	679.32	941.03	1000 m^3
Commercial	3,666.00	3,867.80	3,903.20	3,754.20	3,717.21	3,476.98	3,794.90	1000 m^3
Parks	585.3	498	499.8	578	564.7	517.56	676.6	1000 m^3
Total	13,599.50	13,173.40	13,699.00	13,537.50	13,231.48	13,224.08	15,353.78	1000 m^3
Indicator								
Other Use*	2,421.50	2,201.10	2,134.28	2,174.91	2,418.52	3,279.79	1,992.97	1000 m^3
Max Day Demand	87.9	77.8	89	88.2	89.2	99.5	107.5	1000 m^3
Average Day Demand	44.1	42.4	43.4	43	42.9	42.5	47.5	1000 m^3
Utility wide Peak Day Demand	1,261	989	1210	1182	1183	1067	1259	L/capita/day
Utility wide Average Day Demand	633	539	590	576	569	513	507	L/capita/day
Single Family Dwelling Demand	436	403	418	402	382	369	441	L/capita/day
Average Monthly Residential Consumption per Service	36	33	35	33	31	30	36	m^3/month

*Includes water sold through filling stations, hydrant carts, utility use, fire department, and apparent losses

Table 9. Summary of potable water production and consumption trends

Water Sustainability Management

The COK demand management programs are focused on reducing water demand both internally (such as the Parks department) and the customer point of use in order to achieve sustainable use. High level water demand management strategies have been implemented including the mandatory installment of water meters for residential, commercial, and agriculture customers, tiered consumption-based water rates, and water conservation education programs. As climate change continues to accelerate, the message and mindset of water sustainability will need to take a high priority. The Utility has undertaken a number of initiatives that all contribute towards the efficient use of our shared water resource.

Water Conservation

Landscape Water Conservation Reports (LWCR)

Submission of Landscape Water Conservation Report is a bylaw requirement within Utility boundary for any irrigation installation or retrofit that covers an area greater than 100m^2 in order to confirm that acceptable watering systems and landscape materials are utilized. While the LWC report is a bylaw requirement by the homeowner, the majority of the reports are submitted by private contractors. Participation rates have historically been quite low (18%), but doubled in 2021 over 2020. Water Smart walk through follow up visits occurred at more than 20% of the sites in order to verify the water use efficiency and workmanship in relation to the submitted reports. The attributed water savings from this initiative were estimated at over 82,000 m^3.

Water Restrictions

Year round watering restrictions remain in place since first introduced in 2016. Allowable irrigation times for residential customers are limited to 3 days per week and specific times during the allowable day to minimize evaporation waste and maximize plant material uptake. Restrictions are intended to make residents cognoscente of their water usage and to reduce the daily water production peak demand. As with previous years, neighborhoods were patrolled for violations to the restrictions with notifications provided on compliance where needed. Water restrictions were set to Stage 1 in early July and has become an annual declaration for several years based on Okanagan Lake levels and demands put on the distribution system.

Water Rebates

In order to assist residents to reduce water consumption, two rebates were offered in 2021: $40 towards qualifying irrigation controller purchases and a matching rebate towards retrofitting residential and commercial landscapes and irrigation systems to more water efficient options. Estimated water savings for both rebates totaled 2 million liters and will be carried over into 2021 for promotion.

Eye-On-Water (EOW)

Residents receiving a new or retro-fitted water meter are given the opportunity to have their meter paired with new cellular meter reading technology that safely and securely collects and transmits water use data daily to the Utility. The added benefit of these devices is that property owners are given access to this information through a free downloadable application to track and manage their own water use as well as the option to be notified in the event that water is used on a continual basis for more than 24 hours. This allows the owner to investigate to determine if there is a potential leak and make necessary repairs before significant water damage and avoid substantial water bills.

QWEL

The importance of proper planning, design and workmanship of irrigation systems and landscape selection is paramount to an effective water conservation program. Irrigation professionals significantly contribute to each of those stages and as such is vital that they apply water smart principles when designing and installing water systems and landscape materials. In order to accomplish this, the City of Kelowna became the first Canadian Professional Certifying Organization (PCO) to sponsor and endorse a Qualified Water Efficient Landscaper (QWEL) certification program. This training, testing, and on-site follow up inspection program provides an elevated level of contractor accountability. This ensures that knowledge and workmanship of these contractors are in line with water conservation in mind and suitable to our local climate. The city will promote this program and use this in the future as the benchmark for irrigation qualifications in the city along with the various Irrigation Industry Association of BC (IIABC) CIT, CIT2, and CID designations.

Irrigation Inquiries / Service Requests / Community Events

The COK offers a number of services to assist residents with inspection, operation, and scheduling of their irrigation systems. Due to on-going Covid restrictions, the number of service requests were significantly reduced, and community events were cancelled in 2021. However, residents were encouraged to take advantage of the City's on-going free residential and commercial irrigation audits by a qualified professional. For more information on this program, please visit www.kelowna.ca/watersmart

Educational Outreach

Watersmart, in conjunction with a grant from the Okanagan Basin Water Board (OBWB), produced an interactive water conservation video and corresponding classroom curriculum for middle school aged students. The media material is designed to be integrated into water teaching topics geared specifically towards the Okanagan region.

Water Disruption Events

As with all water utilities, there are certain events throughout the year that interrupt water services – either planned or unplanned. These include pipe breaks, seized valves, leaking hydrants, and power outages. Regardless of cause, the COK strives to quickly correct the deficiencies with minimal disruption to water service as per AWWA standard C651-14. Summary of 2021 infrastructure replacement and repairs are captured in Table 10 relative to previous years.

	2017	2018	2019	2020	2021
Water Main break repairs	8	7	17	9	20
Water service leak repairs	121	103	123	116	80
Fire Hydrant replacements	3	4	5	2	4
Water Main Blow off replacements	3	5	4	12	4
Water Disruption Events	104	46	77	52	68

Table 10. 2017-2021 Water disruption events

Emergency Response and Notifications

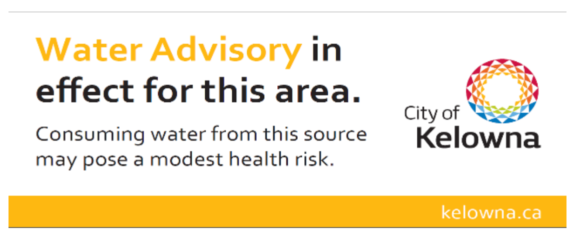
The COK Water Utility and Communications department have developed a series of emergency protocol documents that are consulted in the event of water quality deviations or emergencies:

- Water Utility Emergency Preparedness and Response Plan
- Public Notification Protocol
- Turbidity Response Plan
- Drought Trigger Response Plan (OBWB developed plan)

These documents contain information on course of actions, list of appropriate contacts, and procedure necessary to assist operators and staff to make timely and informed decisions.

Residents and businesses are reminded to sign up on the City of Kelowna e-subscribe system, found on the city website at www.kelowna.ca, that allows the selection and automatic notification delivery of a number of service updates, including water quality changes and advisories.

Water Quality Notifications



Water Quality Advisories (WQA) and Boil Water Notices (BWN) are typically issued in conjunction with Interior Health for water systems that cannot meet the Canadian Water Quality Guidelines for either chemical and/or bacteriological parameters. The areas affected and length of the advisories are determined by the conditions and containment at the time of water main breaks, source water quality, effectiveness of disinfection, and subsequent water quality test results.

Notifications are typically issued in the form of media releases, electronic sign boards, social media outlets, radio messages, automated email notifications for those registered on a sensitive customer list (hospitals, care homes, daycare, and schools). If a substantial number of customers are affected, additional notification includes website updates and links with specific instructions for food establishments, signage at public water fountains, washrooms, and facilities, and if logistical conditions allow door to door hangers are distributed by staff.

The existing SEKID water system, supplied by the Hydraulic Creek intake, was designated as a permanent non-potable irrigation water system in 2021 under a Boil Water Notice status. All customers throughout Southeast Kelowna were notified of this condition and advised to physically disconnect any on-property water connections between the potable drinking water pipes and non-potable irrigation system. Low winter irrigation demand resulted in the non-potable chlorination system being temporarily turned off in October through May.

Service Requests and Responses

The COK provides residents a number of open and transparent options to report water and water quality related issues to the utility. These include a phone-in number as well as on-line service request form to submit electronically through the COK website. These are all documented and responded to in a timely fashion by related utility staff that are equipped to address the public concerns or comments.

There was a total of 135 service requests submitted and responded to by staff in 2021:

- Water Restrictions: 49
- Dirty/cloudy water: 14
- Taste and Odor: 5
- Drinking Water information: 12
- Pool discharge: 3
- Miscellaneous: 10
- Catch Basin discharge: 11
- Source water protection: 4
- Water Smart – Water Conservation: 27

This represents a 40% increase in the number of requests received over the previous year, primarily connected to water restriction notices and water conservation messaging.

Long Term Improvements

The COK has a dedicated Utility Planning department that works in conjunction with Utility Operations in determining the design, implementation, and funding requirements for long term water service improvements. This requires reliable development forecasts, environmental considerations, government grant funding opportunities, and strategies that chart the path for future growth while balancing the sustainability of existing capital assets. The COK continues to charge an annual Water Quality Enhancement (WQE) fee to residents and businesses that is set aside to fund water quality capital improvement initiatives and future water filtration. A total of $2.7M was contributed to the reserve fund for a total balance of $10 million as of Dec 31, 2021.

Current and future initiatives include:

- Interconnections or Integration with surrounding water districts to improve water supply resiliency for all COK residents
- Upgrade of the Cedar Creek pump station and transmission main to increase capacity and decrease dependency on the seasonal Eldorado pump station
- Comprehensive Kelowna Area Based Water Management Plan that incorporates a full overview and guidance on water quality, quantity and use in the Kelowna and surrounding area
- Utility / Water Quality Performance metrics for internal measurement and public reporting
- A Utility wide water meter replacement / cellular endpoint upgrade through 2026.

Conclusion

The COK is committed to continually improving water quality and services to its residents, commercial users, and agriculture stakeholders. Protecting our water source is not an option – it is a requirement, for our current generation and those to come. To that end, the city has created a list of priorities of which providing safe and reliable drinking water is at the heart of leadership decisions. This requires extensive planning, funding, collaboration, vision, and leadership from City Council all the way through to the water utility staff and operators working diligently to support the Kelowna vision statement:

"Kelowna, a City of the Future"

City of Kelowna is pleased to present the 2021 Annual Water Quality Report, detailing the health and direction of our water system. If you have any questions about this report or wish to have additional information provided, please contact the COK Water Utility at 250-469-8502 or email watersmart@kelowna.ca

Appendix A

2021 Water Quality Sampling and Reporting Guidelines

City of Kelowna Water Utility - Water Quality Sampling Program 2021

Kelowna Water Utility (KWU) currently operates three distinct water systems, under two permits, within the water Utility boundary. They consist of a primary City of Kelowna System, Swick Road Water System, and South East Kelowna (SEK) Non-potable System. The Utility also routinely monitors the Kelowna Airport drinking water system.

1. **City of Kelowna System** – fed by Poplar Point intake and Cedar Creek intake supplemented by Eldorado intake when operationally required. The Poplar Point System is interconnected to the Cedar Creek System via a booster pump at Steele Road Reservoir. This system now supplies water to South East Kelowna domestic connections as of 2020 and is supplemented by O'Reilly Well when operationally required.

2. **Swick System** – small water system (~300 connections) fed by Swick Road intake off Okanagan Lake.

3. **Airport Water System** –Glenmore Ellison Irrigation District supplies treated water from Okanagan Lake to the airport and when required is further treated using point of use filtration.

4. **South East Kelowna Non-Potable System** – formerly utilized as drinking water distribution system for SEK. Water source originates from a series of upland water reservoirs that is channeled through Hydraulic Creek and is designated for irrigation and fire protection use only in this region. Chlorination treatment is only implemented seasonally.

Water quality sampling is to be conducted in accordance with the BC Drinking Water Protection Regulation, 2005, Section 15 Schedule B, which states that the number of bacteriological samples taken per month is to be 1 per 1,000 of population. Based on population estimate of 86,122 in 2020, the 2021 water quality routine sampling plan meets and exceeds the representative sampling requirements. Additional testing is completed in the event of water main breaks, re-tests, water advisories, or other irregular activities.

City of Kelowna and Swick Systems:

Daily On-line Data Monitoring

- Source Water
  - pH, Turbidity, UVT, Conductivity, Temperature
- Treated Water
  - Free Chlorine, pH, and Turbidity

Weekly

- Source Water
  - Total Coliform and E. Coli., Turbidity, Color, Temperature, UVT, pH
- Treated Water (Distribution)
  - Total Coliform and E. Coli., Turbidity, Color, Temperature, UVT, Total/Free Chlorine, Odor

Quarterly (Treated Water)

- Trihalomethanes, Haloacetic Acids, Total Organic Carbon (TOC)
- Ammonia and Algae (Cyanobacteria)

Annual (Treated Water)

- Comprehensive Chemical scan

Quadrennial (Source Water)

- Pesticide and Herbicide scan, Radiological parameters

Airport System:

Daily On-line Data Monitoring (Treated Water)

- Turbidity, Chlorine residual

Monthly (Treated Water)

- Total Coliform and E. Coli., Turbidity, Temperature, U.V, Free and Total Chlorine, Color, Odor

Quarterly (Treated Water)

- Trihalomethanes, Haloacetic Acids, Ammonia, Total Organic Carbon (TOC)

South East Kelowna Non-Potable System:

Daily On-line Data Monitoring

- Turbidity, Chlorine residual, pH

Monthly

- Total Coliform and E. Coli., Turbidity, Temperature, Free and Total Chlorine, Color, Odor

Annually

- Comprehensive Chemical Scan, Total Organic Carbon (TOC)

Quadrennial

- Pesticide and Herbicide scan, Radiological parameters

Reporting

All Drinking Water Quality and Drainage Water Quality data will be reported to the Watertrax data base. Summary reports of the Drinking Water quality will be reported to IHA monthly and is to include:

Drinking Water Quality

- Turbidity, Free & total Chlorine - max, min, mean, number of tests
- Total Coliform and E. Coli, number of sites. Only positives will be location specific
- UVT on-line and grab samples tested in lab – max, min, mean, number of tests
- Operational activities, distribution events, and customer complaints
- Water production data, volume off spec water distributed, and any relevant events and activities
- THM and HAA quarterly

***Note**-During the winter months (November – March) there is a decrease in the number of sites sampled due to some sample stations not being compatible with the colder weather and freezing. Sampling frequency may also change relative to distribution events, construction, or necessary water advisories.

Water Quality Analyst will inform Water operators in the event that elevated bacterial counts or turbidity are noted during source water quality monitoring for operational adjustments.

Protocol for notification of positive E Coli. result in distribution system

- ➢ KWU lab staff will provide immediate notification of positive E. Coli results to Chief Water Operator (CWO)
- ➢ CWO or designate will immediately contact IH Environmental Health Officer or designate and provide written copy of test results within 24 hours
- ➢ All positive E. Coli will be immediately resampled for confirmation
- ➢ Appropriate corrective actions will be determined in collaboration with IHA

Protocol for notification of positive Total Coliform result in distribution system

- All positive Total Coliform results will be reported to CWO and will be resampled immediately
- If the following criteria is met, KWU will immediate contact the IH Environmental Health Officer:
  1. Result is greater than 10 MPN or CFU per 100mL or if more than one sample is TC positive in a sampling period.
  2. Consecutives resample result is positive
  3. Positive result is under anomalous or suspicious conditions
- Appropriate corrective actions will be determined in collaboration with IHA

Protocol for reporting of abnormal sampling conditions or results in distribution system and raw water

- If abnormal conditions are noted by the sampler (low chlorine residual for the area, sample station damage, flooding, conditions preventing sampling collection (frozen tap), or increased raw water bacteria) will be recorded on the field data record sheet. Related qualifiers will be put on the monthly report as required.

Storm Water Quality

- **Regular Sampling**- the standard drainage water quality scan (SDWQS) includes ammonia, chloride, color, conductivity, dissolved oxygen, *E. Coli,* pH, suspended solids, temperature, and turbidity will be analyzed in-house. Site number may change due to seasonal variations
- **5/30 (A- Creek Water)**- for filtration exclusion, the mouths of Mission Creek, Mill Creek, and Brandt's Creek are sampled 5 times in 30 days from April 15th to September 15th, analyzed for the SDWQS and included in the annual report
- **Water Quality at Intakes (B- Creek Water)**- for filtration exclusion, the mouths of Mission Creek, Mill Creek, and Brandt's Creek are sampled when decreased water quality of raw water at the intakes occurs, analyzed for the SDWQS and included in the annual report
- **Storm Water-** for filtration exclusion, the first flush samples are collected at selected outfalls on Mill Creek and Brandt's Creek, analyzed for the SDWQS and included in the annual report
- **Storm / Sanitary interconnect-** for filtration exclusion, Fascieux Creek is sampled approximately 3 times per year at 3 locations during rain events, analyzed for the SDWQS and included in the annual report
- **Irregular events**- may be analyzed for parameters in the SDWQS suite (samples may be sent to a private lab for further analysis if the situation dictates). Discretion of either Tech analyst or IHA relative to circumstance.

Appendix B

Source Water Quality Monitoring Parameters

Source Water Quality Parameters

Turbidity

Turbidity measurements are related to the optical properties of water. Suspended materials such as clay, silt, organic and inorganic particles, plankton, and other microscopic organisms all contribute to Turbidity and can have a negative effect on disinfection techniques.

As expected with a mild freshet, Turbidity remained under 1.0 NTU. The YOY average and maximum values decreased as did the number of exceedances over 1 NTU (Table 11). Both the monthly and 5-year Turbidity trend indicated a decrease after several years of elevated concentrations (Figure 10 and 11).

Intake	Average (NTU)	Minimum (NTU)	Maximum (NTU)	Guideline (NTU)	Number of Exceedances	Number of Tests in 2021
Poplar Point	0.295	0.14	0.586	<1.0	0	172
Eldorado	0.569	0.373	0.759	<1.0	0	7
Cedar Creek	0.403	0.177	0.696	<1.0	0	64
Swick	0.346	0.123	0.721	<1.0	0	91

Table 11. Source Water Turbidity annual summary

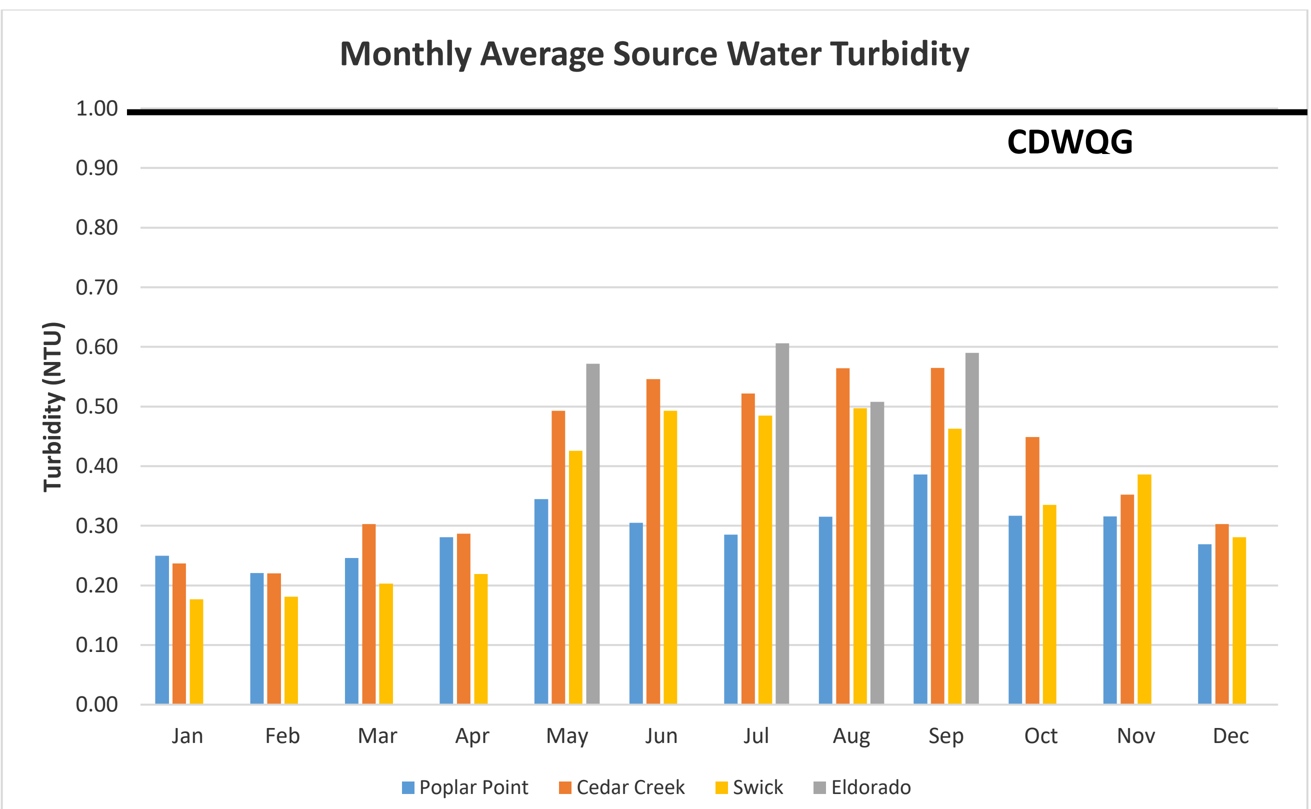


Figure 10. Monthly Turbidity average at Intake source

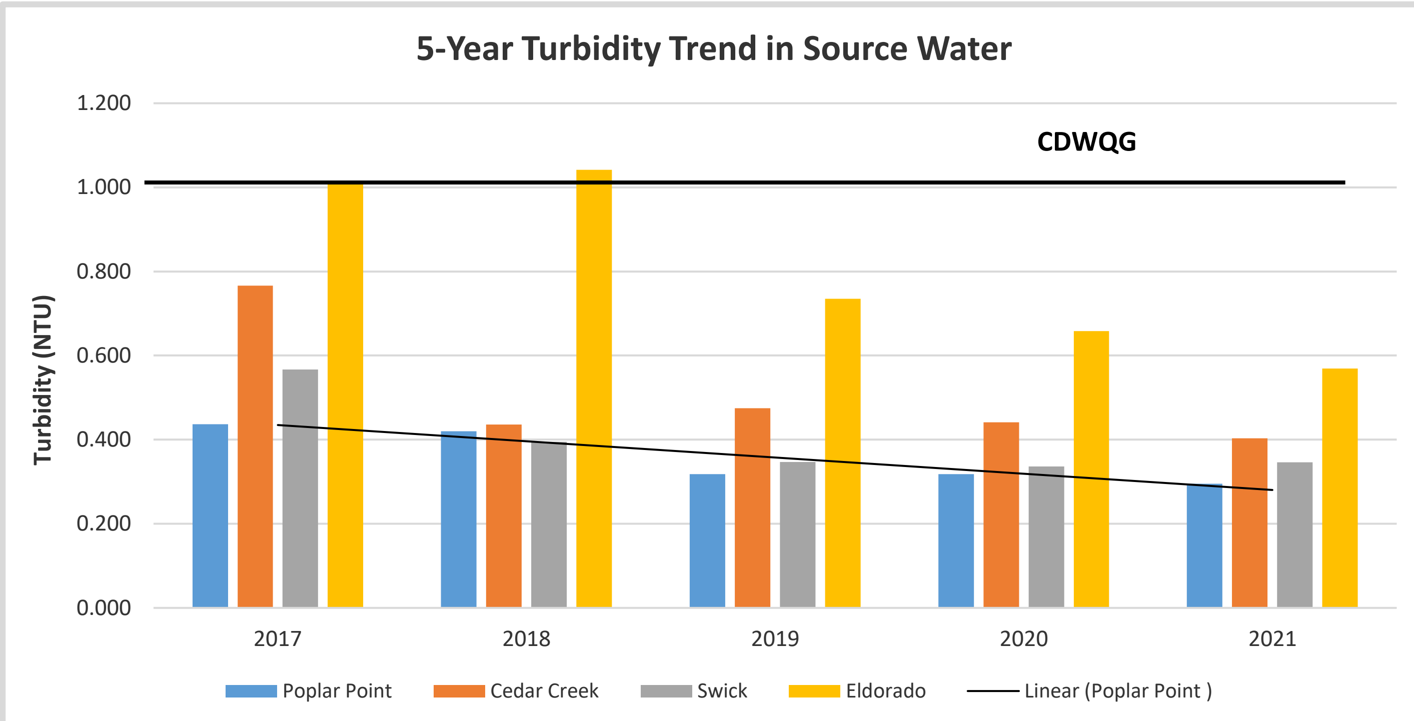


Figure 11. 5-Year Turbidity trend in Source Water

Total Coliform

The coliform group consists of several genera of bacteria belonging to the Enterobacteriaceae family. The detection of these bacteria can be determined with a variety of analytical techniques including membrane filtration and lactose fermentation. The COK utilizes the Quanti-tray method which is based on the fermentation technique which involves a reaction with an enzymatic substrate. The water sample reacts with the enzymes in multiple wells or tubes over 18-24 hours and generates a detectable yellow color for positive Total Coliform. The replicate wells are reported in terms of the Most Probable Number (MPN) which is statistically derived number to determine the presence of the coliform.

The average coliform concentrations in 2021 was lower than 2020 as well as the 5-year average for all intake sites (Figure 13). The predominant number of positive counts were measured in the month of August, 2 months earlier than the previous year (Figure 12).

Intake	Average (MPN/100ml)	Minimum (MPN/100ml)	Maximum (MPN/100ml)	Number of Tests in 2021	# of Tests >100 MPN	2021 % of Tests >100MPN	2020 % of Tests >100MPN
Poplar Point	2	0	25.3	171	0	0	1
Eldorado	7	2	18.7	7	0	0	0
Cedar Creek	3	0	33.6	63	0	0	0
Swick	2	0	77.1	91	0	0	0

Table 12. Source Water Total Coliform annual summary

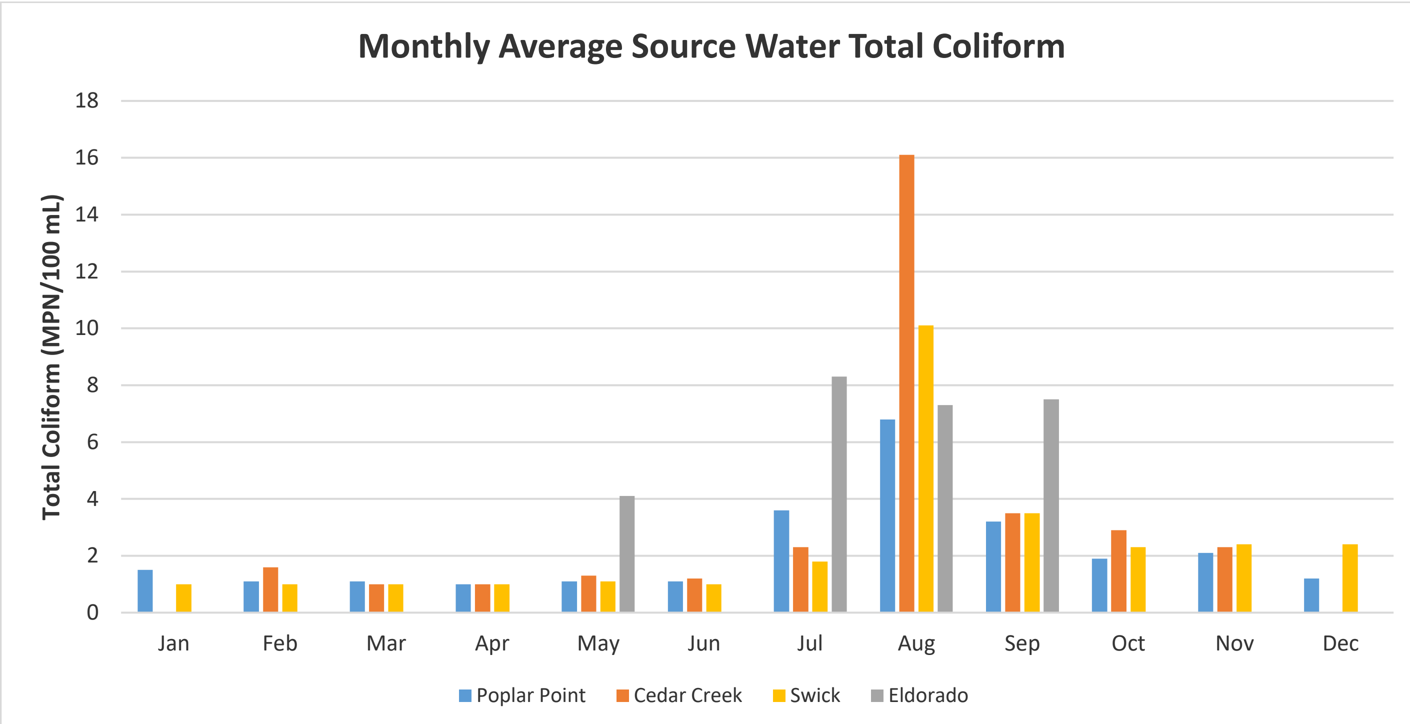


Figure 12. Monthly Total Coliform average at Intake source

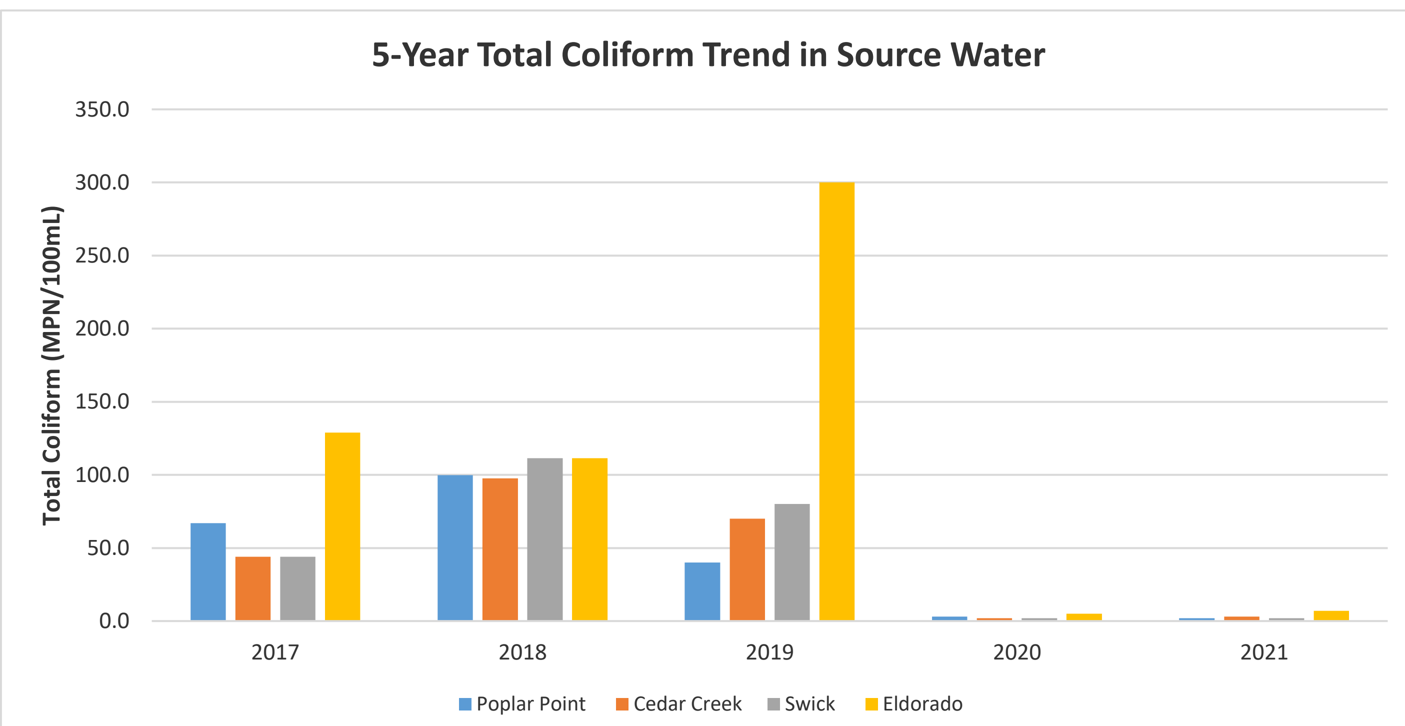


Figure 13. 5-Year Total Coliform trend in Source Water

E. Coli.

Escherichia coli (E. Coli.) is a sub-category within the coliform family and is used as a high risk indicator of harmful pathogens derived from human or animal fecal matter. The principle behind the methodology to detect E. Coli. is identical to the Total Coliform method in that an enzymatic reaction and subsequent fermentation is used to produce a detectable presence of the pathogen. The unique characteristic of E. Coli. using this technique is that in the presence of a long wave UV lamp (365nm), the resulting sample wells fluoresce. The number of wells that fluoresce are counted and calculated and reported as MPN values.

Similar to Total Coliform, the levels of E. Coli. remained relatively and consistently low relatively low in term of average and maximum number of counts compared to previous years. All results were within the filtration exclusion guideline of no more than 10% of E. coli. counts to exceed 20 MPN/100mL (Table 13, Figure 14-15).

Intake	Average (MPN/100ml)	Minimum (MPN/100ml)	Maximum (MPN/100ml)	Number of Tests in 2021	# of Tests >20 MPN	% of Tests >20MPN
Poplar Point	0.7	0	4.1	171	0	0
Eldorado	0.3	0	2	7	0	0
Cedar Creek	0.4	0	2	63	0	0
Swick	1.3	0	10.9	91	0	0

Table 13. Source Water E. Coli.

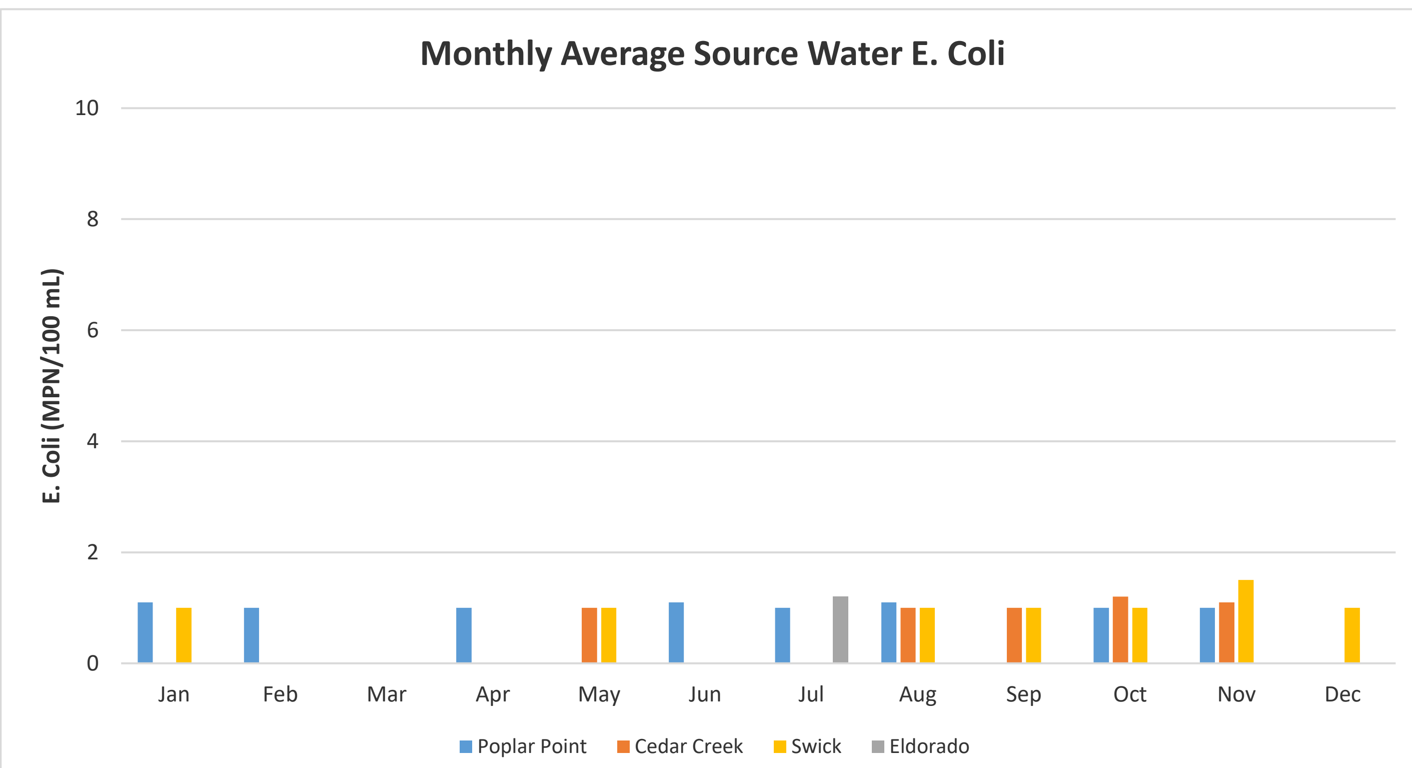


Figure 14. Monthly E. Coli. average at Intake source

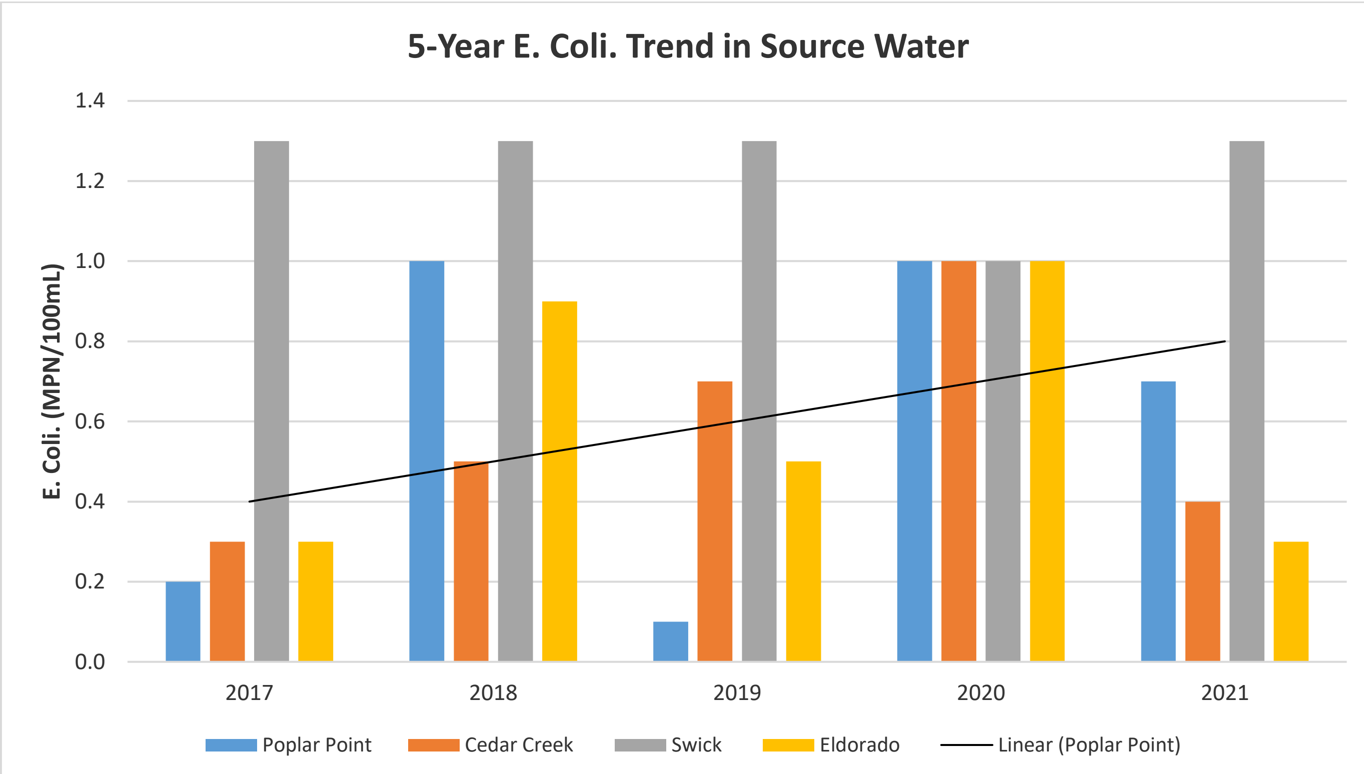


Figure 15. 5-Year E. Coli. trend in Source Water

pH

Measurement of pH is one of the most import and frequently used tests in water chemistry. Practically every aspect of water supply and treatment is pH dependent such as acid-base neutralization, water softening, precipitation, coagulation, disinfection, and corrosion control. At a given temperature, the intensity of the acidic or basic character of a solution is indicated by pH or hydrogen ion activity. Natural waters tend to have a pH value in the range of 4-9, and most are slightly basic (7.5-9) due to the presence of bicarbonates and carbonates of the alkali and alkaline earth metals in the environment.

The pH remained firmly alkaline for each of the intakes and within the objective range of 7.5-10 with no instances of exceedance (Table 14). The 5-year trend indicates a gradual increase in contrast to the lower pH experienced during the 2017-2018 flooding event years (Figure 17).

Intake	Average	Minimum	Maximum	Guideline	Number of Exceedances	Number of Tests in 2021
Poplar Point	8.08	7.74	8.43	7.0 - 10.5	0	171
Eldorado	8.33	8.18	8.54	7.0 - 10.5	0	7
Cedar Creek	8.07	7.64	8.36	7.0 - 10.5	0	64
Swick	8.09	7.74	8.56	7.0 - 10.5	0	91

Table 14. Source Water pH annual summary

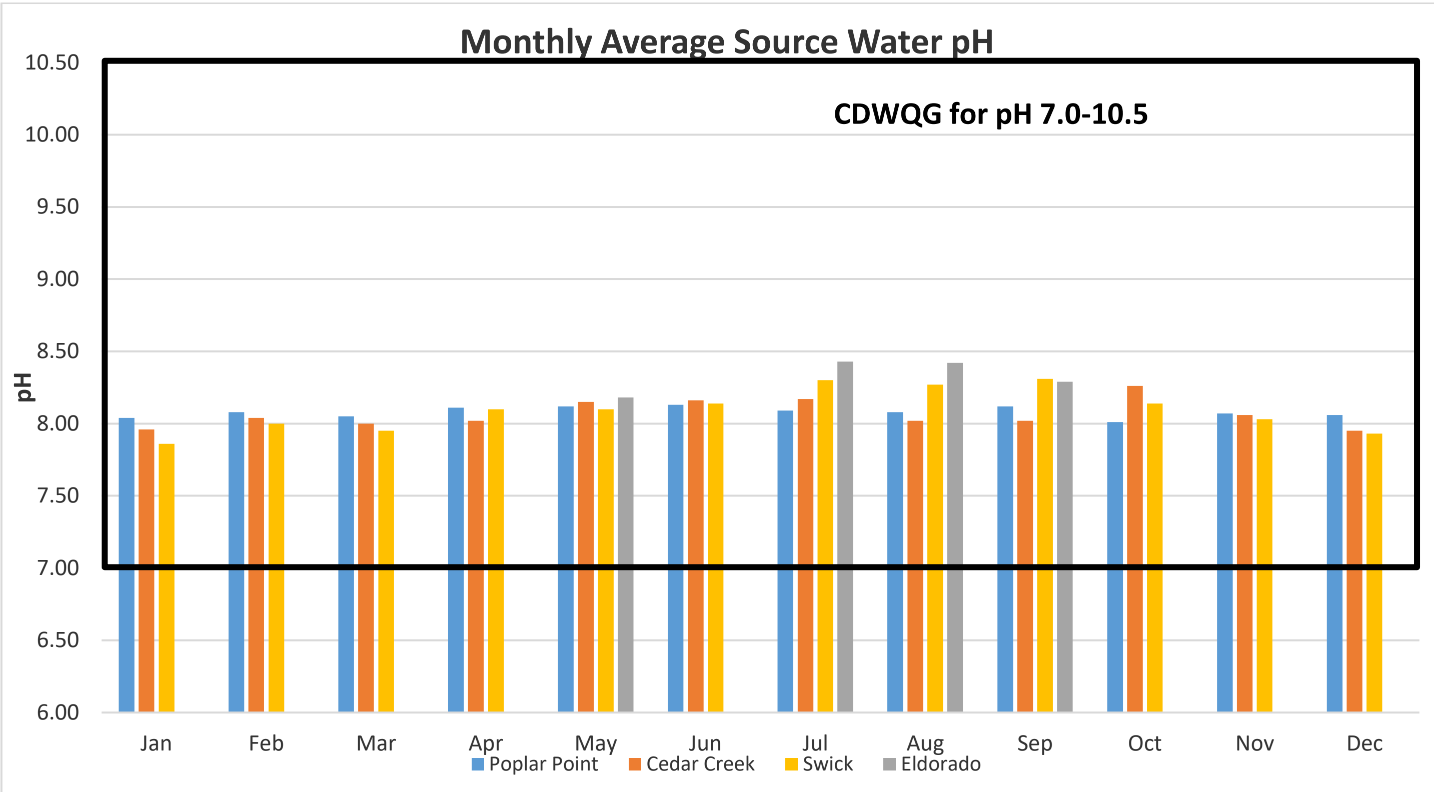


Figure 16. Monthly pH average at Intake source

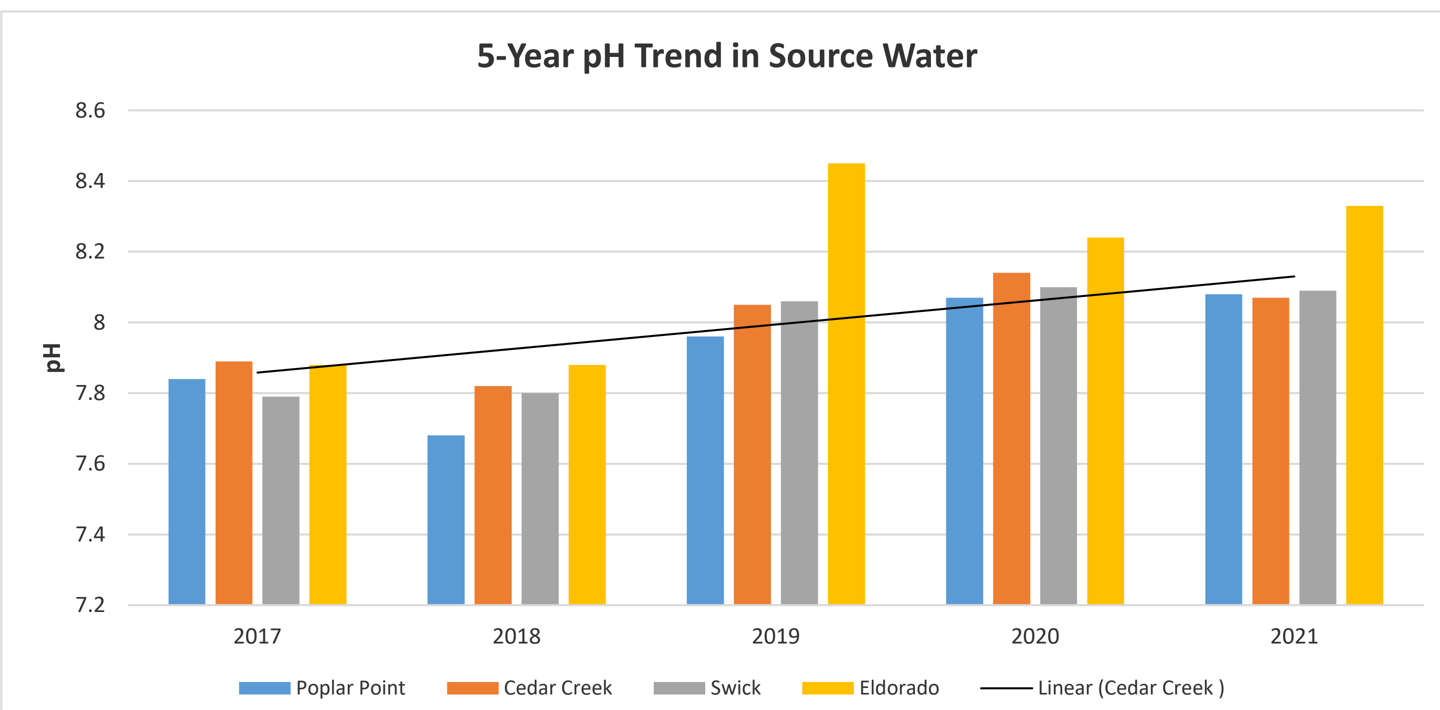


Figure 17. 5-Year pH trend in Source Water

Color

Color in surface waters result primarily from the presence of natural organic humic matter. Humic matter consists of humic and fulvic acids; both of which cause a yellow-brown color that can be measured by spectrophotometer wavelength. Color is preferred to be kept to a minimum as those compounds are considered precursors in the formation of chlorine disinfection byproducts such as chloroform. Assessment of color data is primarily gauged against an aesthetic objective of 15 color units.

With the exception of Cedar Creek, color remained consistent or below historical averages with a decrease in the number of samples exceeding the Aesthetic objective of 15 ACU during the summer months (Table 15, Figure 18, 19).

Intake	Average (ACU)	Minimum (ACU)	Maximum (ACU)	Guideline (ACU)	Number of Exceedances	Number of Tests in 2021
Poplar Point	8	5	12	AO:≤15	0	171
Eldorado	13	11	18	AO: ≤15	1	7
Cedar Creek	10	7	18	AO:≤15	1	63
Swick	9	5	18	AO:<15	1	91

Table 15. Source Water Color annual summary

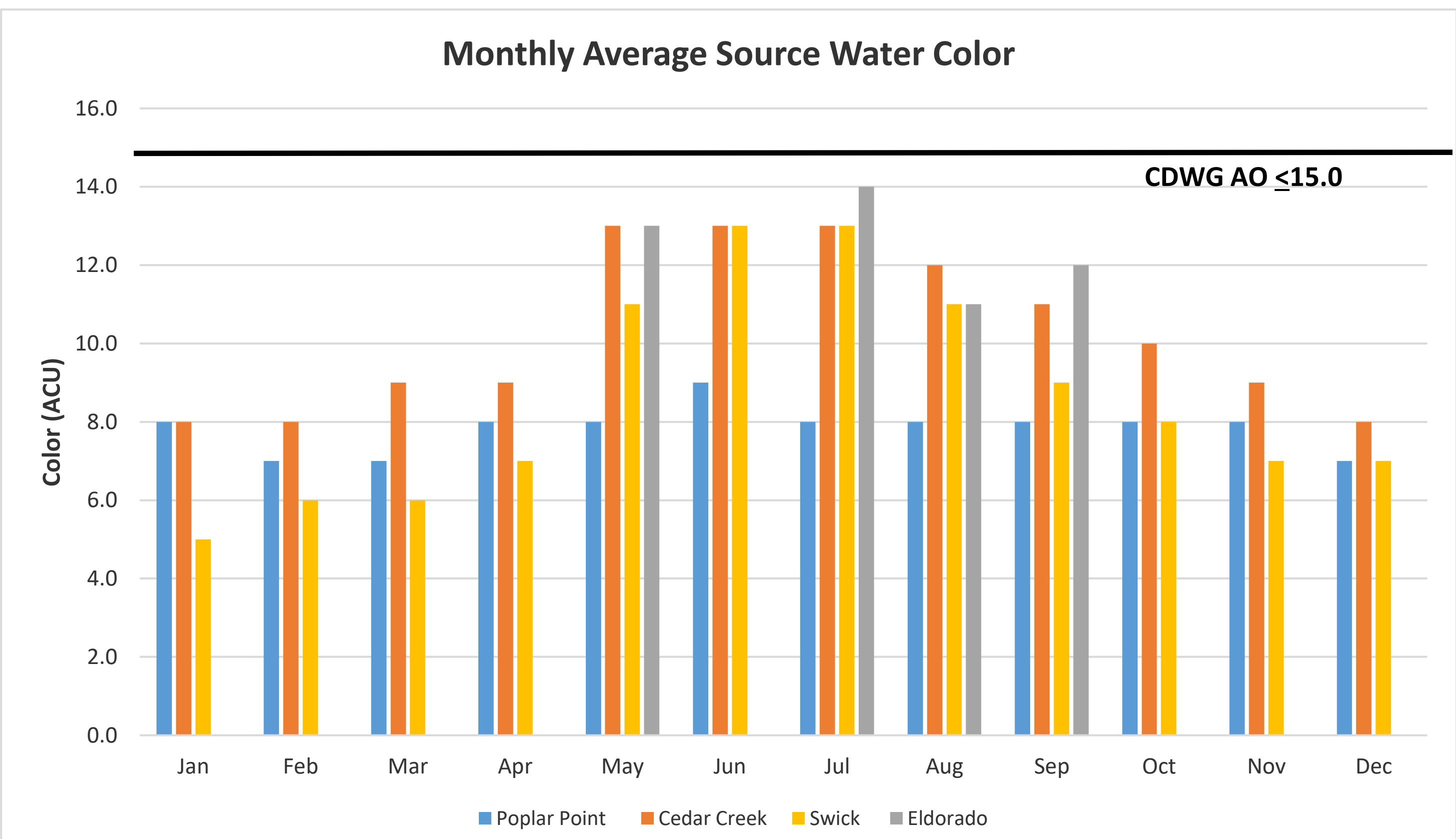


Figure 18. Monthly Apparent Color average at Intake source

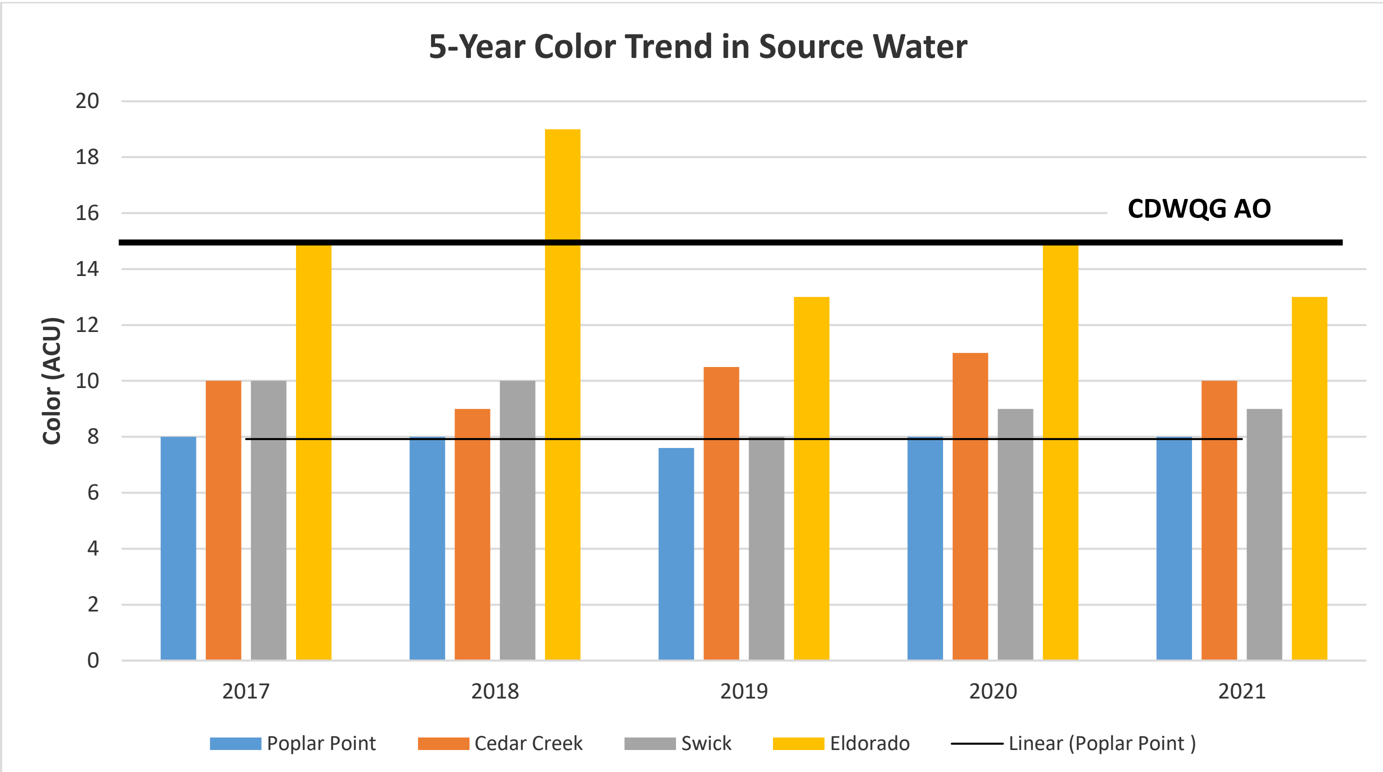


Figure 19. 5-Year Apparent Color trend in Source Water

Temperature

Temperature is an important factor to consider in water quality as it has influences on several other parameters and can alter the physical and chemical properties of water. Water temperature is considered when determining:

- Metabolic rates of aquatic life
- Dissolved Oxygen
- Conductivity and Salinity
- pH
- Water Density

Temperature fluctuations also plays an important role in the lake limnology which can transport nutrients and potential contaminants to the water intake sources. The COK operational objective is to consistently draw from water source at <15°C, which was maintained 98% of the time at the intake sites (Table 16). Over trend indicated a marginal 0.1-0.6°C increase at the intakes above 2018 (Figure 21).

Intake	Average (°C)	Minimum (°C)	Maximum (°C)	Guideline (°C)	Number of Exceedances	Number of Tests in 2021
Poplar Point	6.7	4.0	10.5	AO:≤15	0	171
Eldorado	15.4	8.0	21	AO:≤15	4	7
Cedar Creek	8.2	4.0	13	AO:≤15	0	63
Swick	10.1	4.5	19.5	AO:≤15	10	91

Table 16. Source Water Temperature annual summary

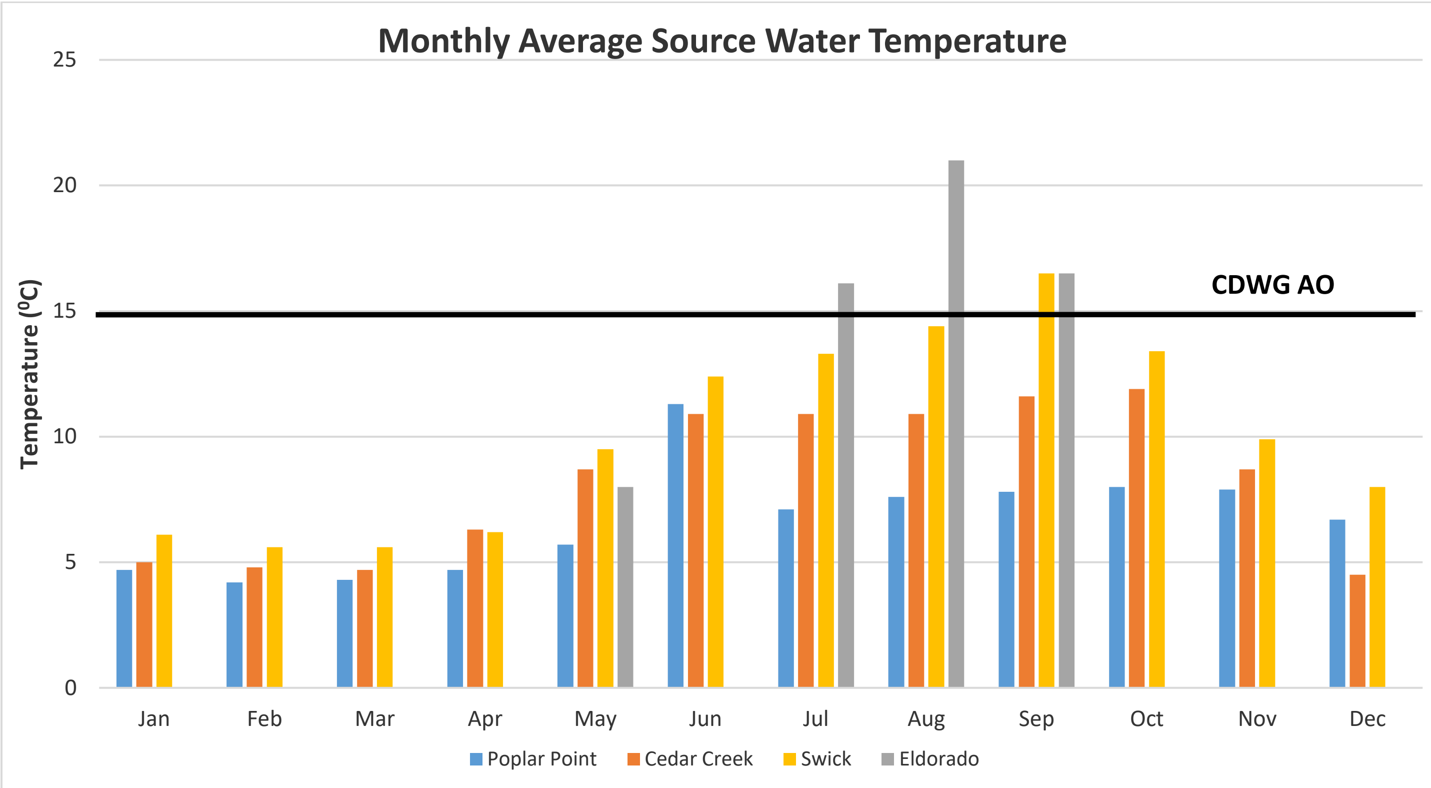


Figure 20. Monthly Water Temperature average at Intake source

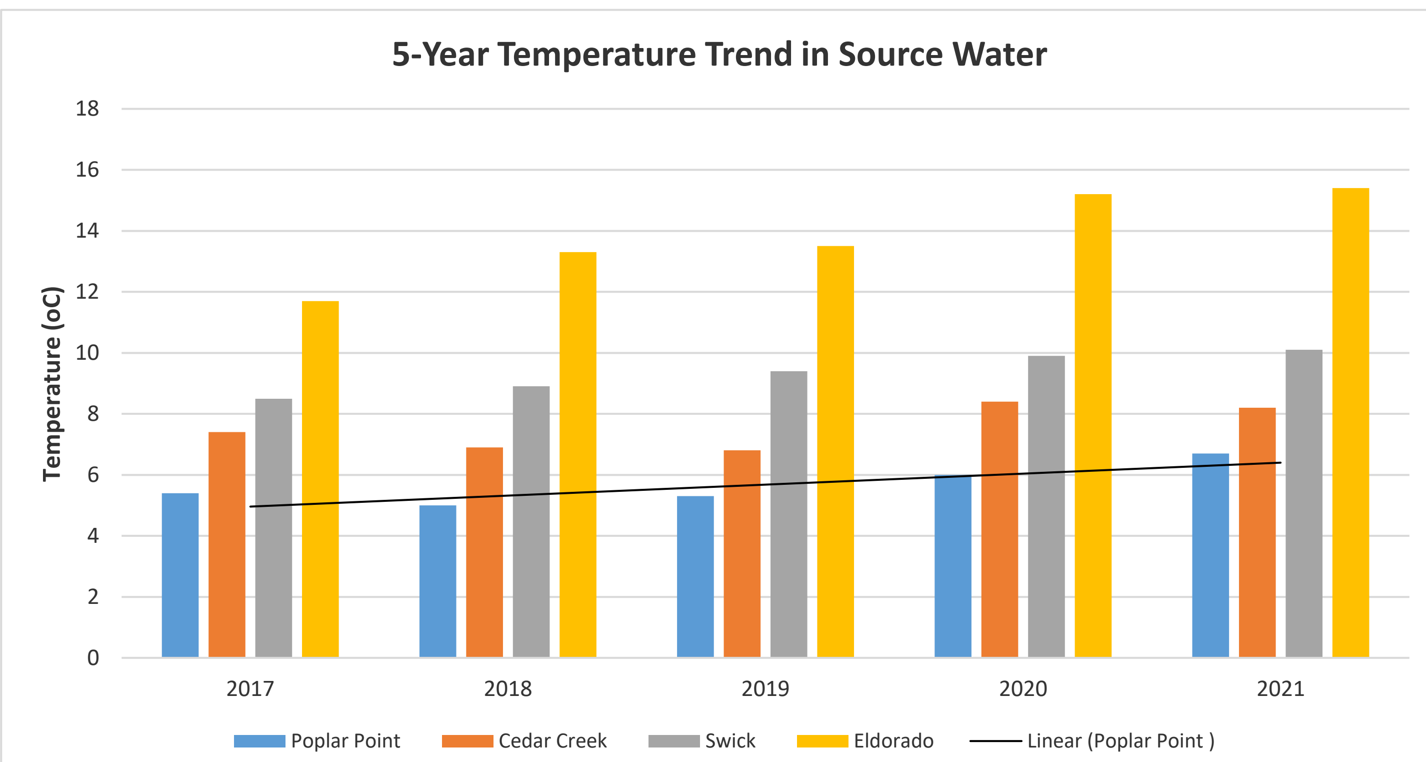


Figure 21. 5-Year Temperature trend in Source Water

UV Transmittance

Ultra Violet transmittance (UVT) represents the amount of light transmitted through water and is used to gauge the effectiveness of the UV light will be on the disinfection of the drinking water. The higher the Transmittance, the less UV dosing, in theory, is required to treat the sample. It is important to note that both solid and dissolved compounds have the ability to absorb UV light, which in turn has a negative impact on UVT.

UVT is measured on unfiltered samples (representative of treatment type) at a wavelength of 254nm and reported as a percentage. All source water samples remained above the UVT operational >80% objective with a minimal number of samples measuring just below that threshold (Table 17, Figure 22). A marginal decrease in UVT was noted overall in the 5-year trend (Figure 23).

Intake	Average (%T)	Minimum (%T)	Maximum (%T)	Objective (%T)	Number of Exceedances	Number of Tests in 2021
Poplar Point	85.3	83.8	88.0	>80	0	171
Eldorado	83.9	83.2	84.5	>80	0	7
Cedar Creek	84.8	82.3	86.8	>80	0	63
Swick	85.1	82.3	87.6	>80	0	91

Table 17. Source Water UV Transmittance annual summary

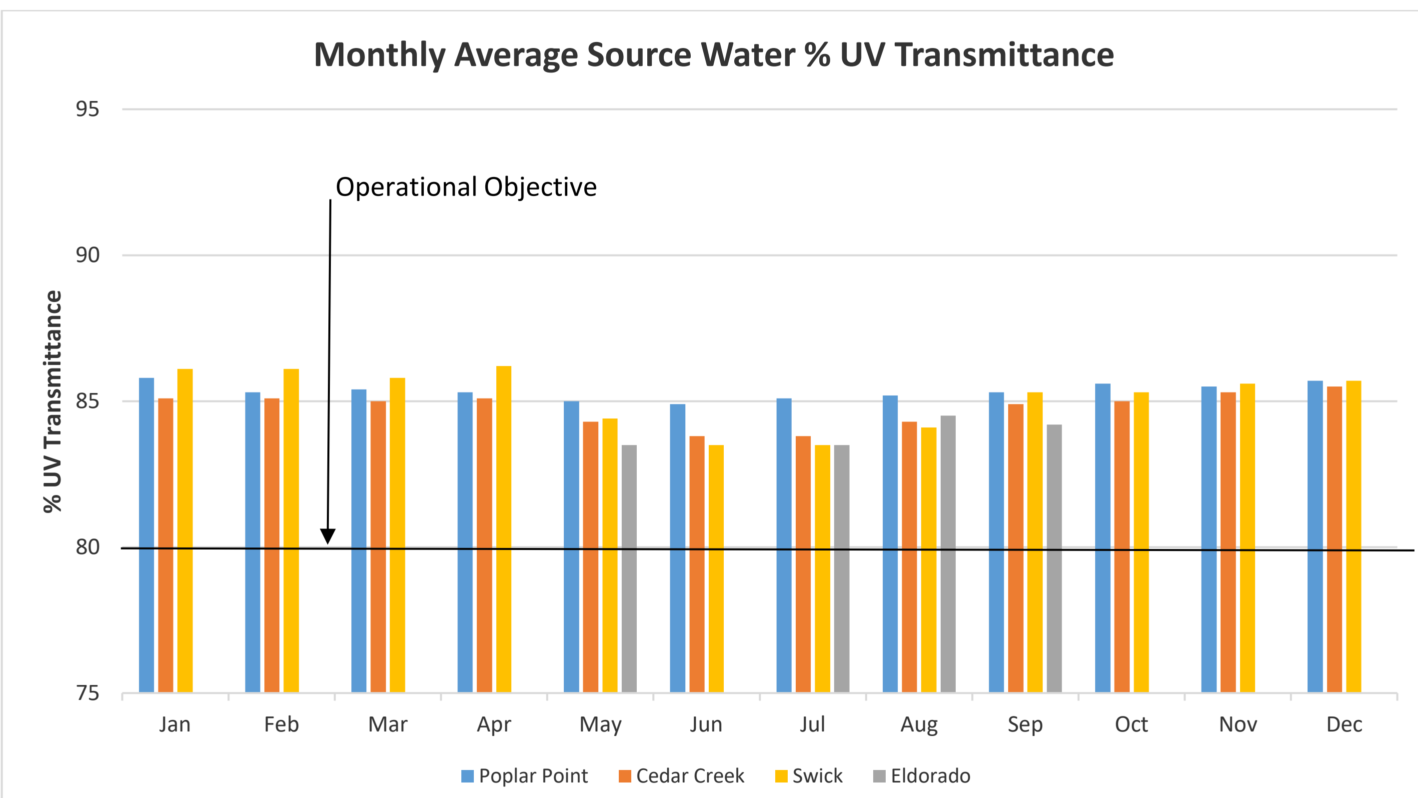


Figure 22. Monthly UVT average at Intake source

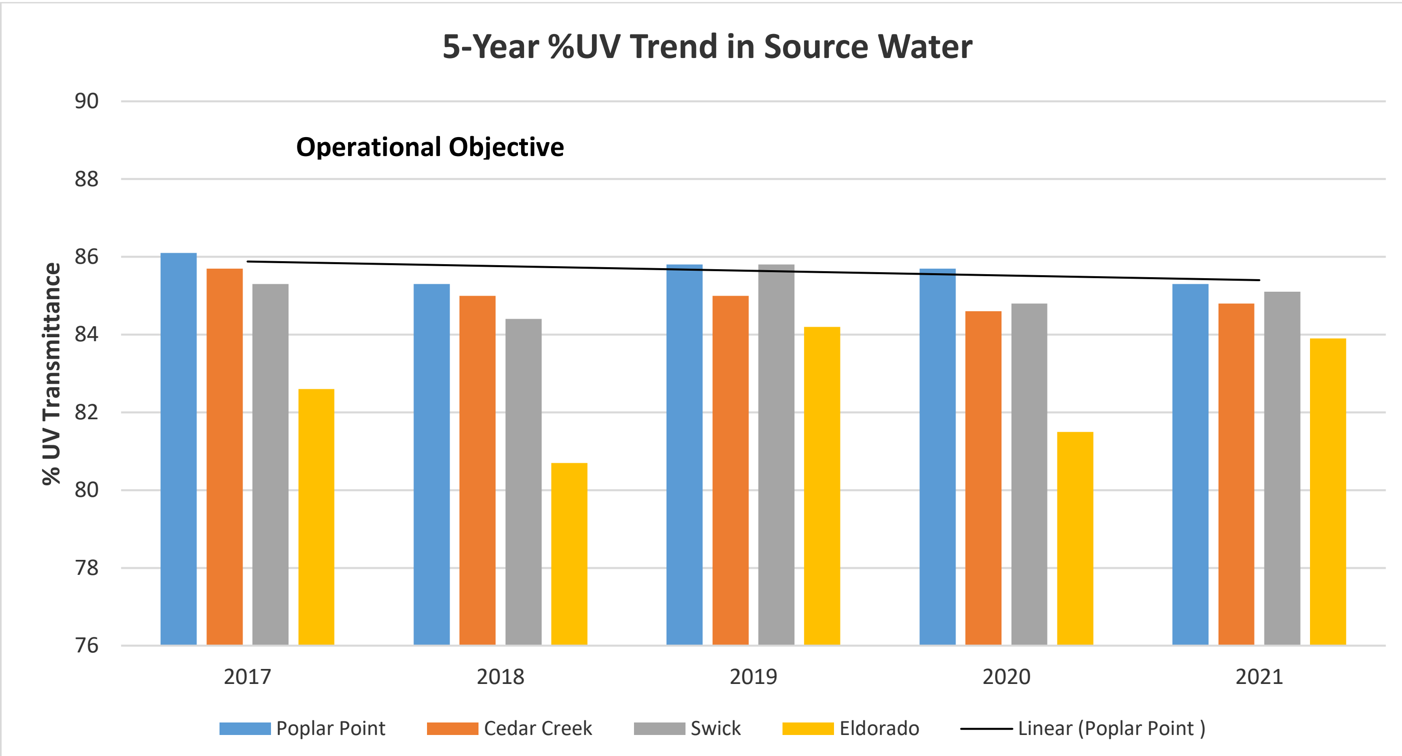


Figure 23. 5-Year UVT trend in Source Water

Algae

The number and types of algae present in Okanagan Lake provide excellent water quality for most of the year. In the surface water, peak algae growth follows the spring overturn, followed by a lull during late July and August as key nutrients and vitamins are exhausted, and finally a smaller peak in cyanobacteria (blue-green algae) near the fall overturn. Cyanobacteria counts in intake samples often include species that inhabit deep water or grow along the substrate. Cyanobacteria are a problematic group of organisms in which some types can generate toxins, and all types contain BMAA, and they readily form THM's (Trihalomethanes) after disinfection with chlorine. Okanagan Lake has been dominated by cyanobacteria for at least 70 years. Since 2006, the COK has contracted Larratt Aquatic Environmental consultants to conduct quarterly Microcystin sampling and analysis to determine concentrations of Cyanobacteria and general Algal biomass that would have an impact on water quality at the intake systems.

The last three years of algae monitoring have revealed increasing algae activity. The CoK 2021 algae counts were high for Okanagan Lake and set new records for total algal counts and cyanobacteria. 2021 was also the first-year cyanobacterial counts exceeded 4000 cells/mL. High counts may be attributed to the large freshets and flooding events during 2017, 2018 and 2020, but may have also been affected by regional wildfire activity.

Over the years, average algae densities were moderate with algae spikes resulting in deep and/or bottom-dwelling cyanobacteria counts exceeding 2000 cells/mL. Turbidity also spiked during some of these events, suggesting that seiches were involved. Correlations between algae counts and turbidity indicate that most turbidity was caused by fine silt particles, primarily from creek plumes.

Intake depth in Okanagan Lake is an important determinant of the types and density of algae that will be drawn into the distribution system. The deepest intake, Poplar Point, contained the lowest 2021 average algal count (925 ± 586 cells/mL) while the shallowest had the highest (4841 ± 6072 cells/mL). Intake algae sampling undertaken by City of Kelowna from 2010 through 2021 showed regular seasonal trends and was consistent with historical sampling.

Appendix C

Treated Water Quality Monitoring Parameters

Treated Water Quality Parameters

Turbidity

The primary function of monitoring the Turbidity post treatment is to ensure that the chlorination and UV dosing has not detrimentally affected the water quality and meets operational objective targets. Relative to the source water Turbidity, the level of treated water concentrations and exceedances remained relatively consistent (Table 18). Overall Turbidity trend for 2021 indicated a general increase over the past 3 years, but lower than experienced in 2017-2018 flooding years(Figure 25).

Intake	Average (NTU)	Minimum (NTU)	Maximum (NTU)	Guideline (NTU)	Number of Exceedances	Number of Tests in 2021
Poplar Point	0.329	0.154	0.773	<1.0	0	173
Eldorado	0.593	0.397	0.916	<1.0	0	24
Cedar Creek	0.369	0.178	0.762	<1.0	0	92
Swick	0.369	0.159	0.766	<1.0	0	92

Table 18. Annual Treated Water Turbidity summary

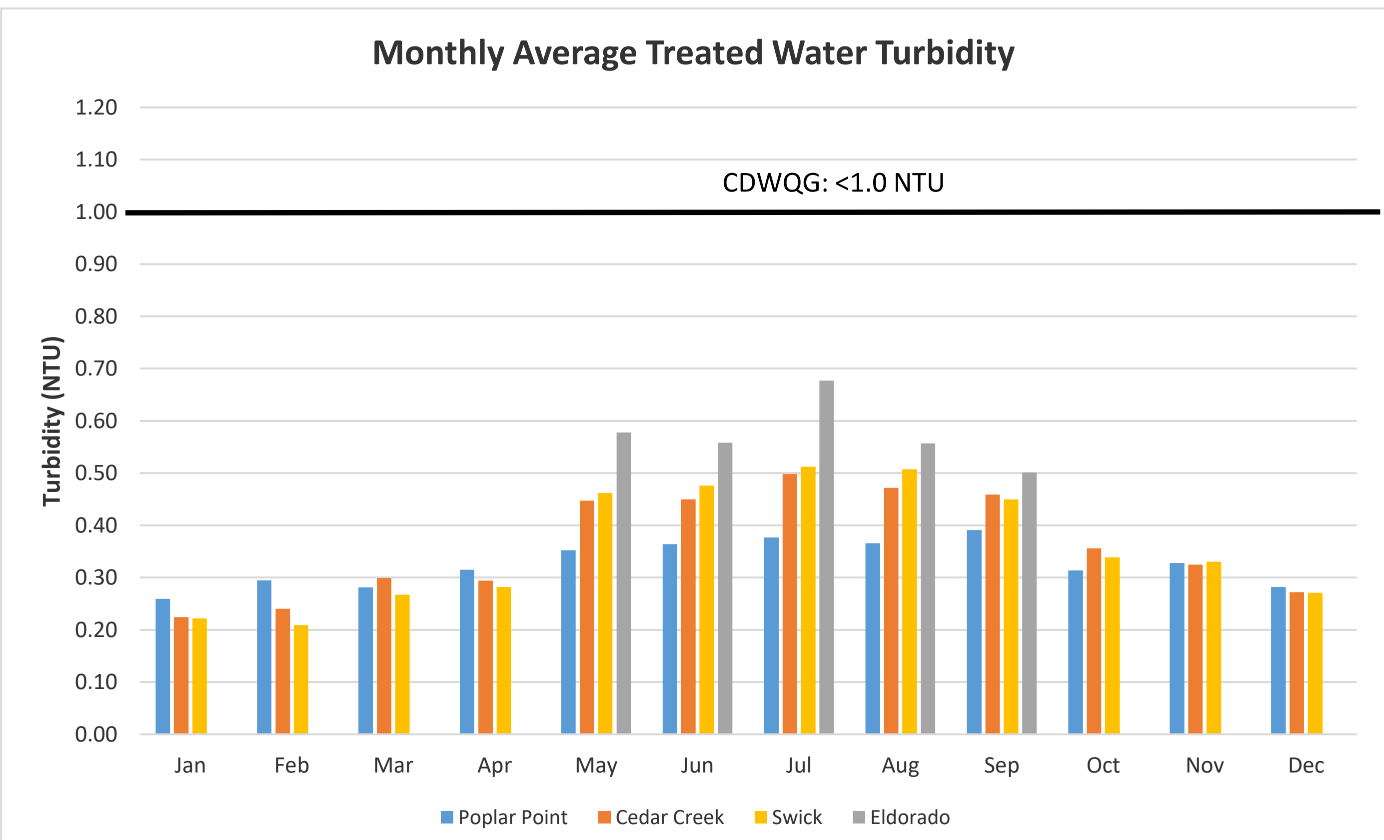


Figure 24. Monthly average Turbidity of Treated Water

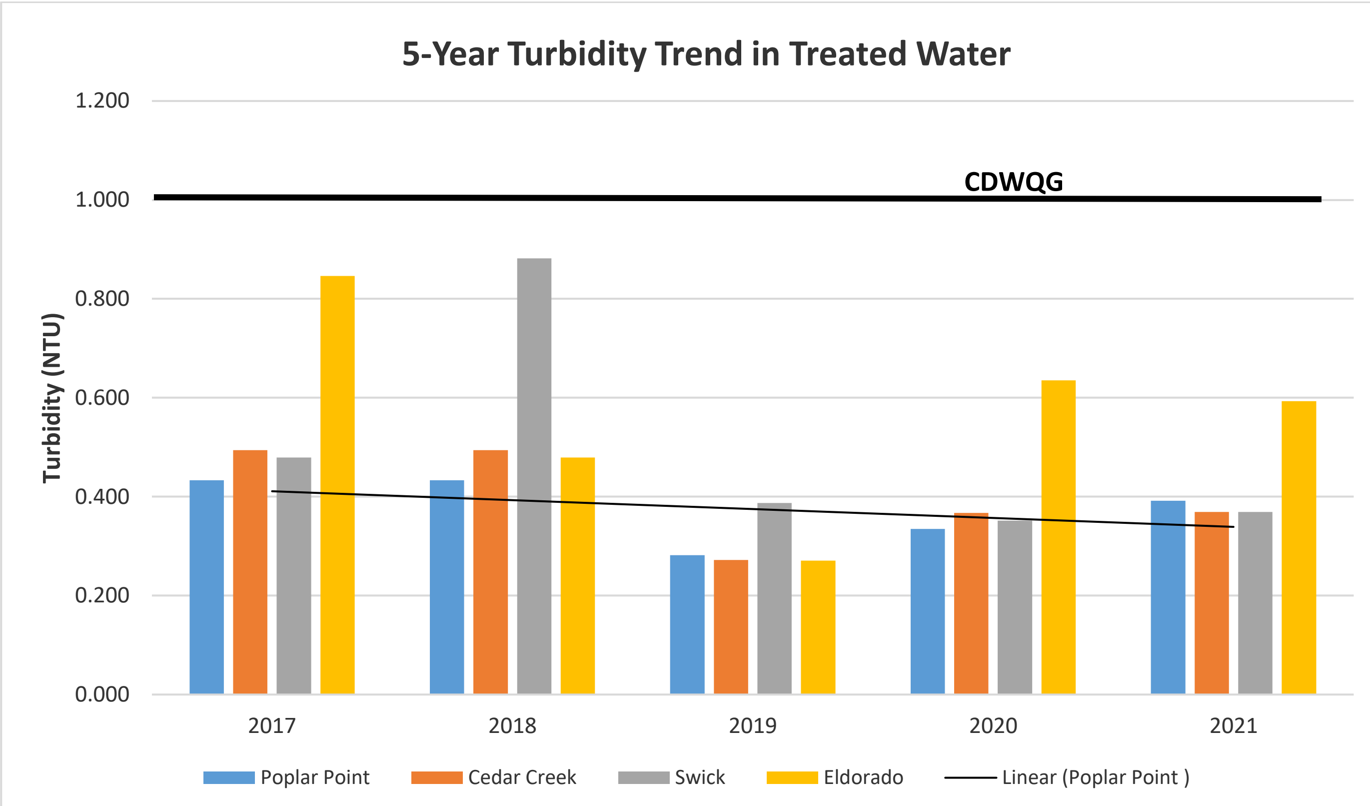


Figure 25. 5-Year Turbidity trend in Treated Water

Chlorine – Free

Chlorine is introduced to source water at each pump house through exposure and mixing with either chlorine gas or commercial hypochlorite at set time levels and concentrations that meet the criteria of 3 and 4-log reduction of bacteria and pathogens. Both Total and Free Chlorine are measured to ensure that the initial chlorine demand does not exceed the dosing applied and is at appropriate levels to maintain a residual throughout the entire length of the distribution system. Free Chlorine is primarily monitored as that is the form of chlorine available to neutralize pathogens beyond the initial dosing point.

The average Free Chlorine value at each intake immediately post treatment met the operational objectives in 2021 (Table 19, Figure 26). Overall, there is a marginal increase in free chlorine over the past 5 years (Figure 27).

Intake	Average (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Objective (mg/L)	Number of Tests in 2021
Poplar Point	1.63	0.77	2.04	0.20	172
Eldorado	1.50	0.92	1.92	0.20	23
Cedar Creek	1.41	0.64	2.20	0.20	90
Swick	0.99	0.25	1.77	0.20	91

Table 19. Treated Water Free Chlorine annual summary

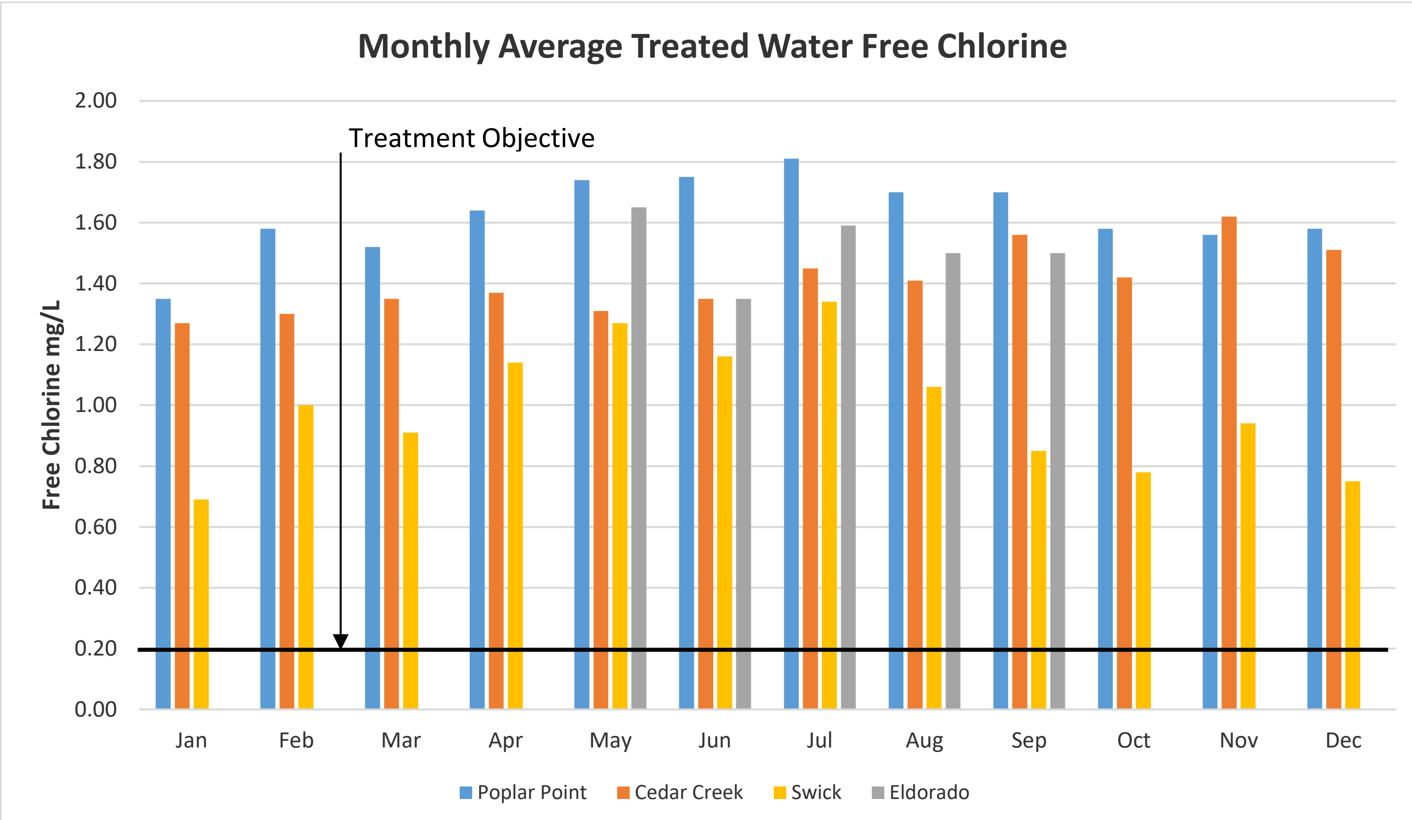


Figure 26. Monthly average Free Chlorine of Treated Water

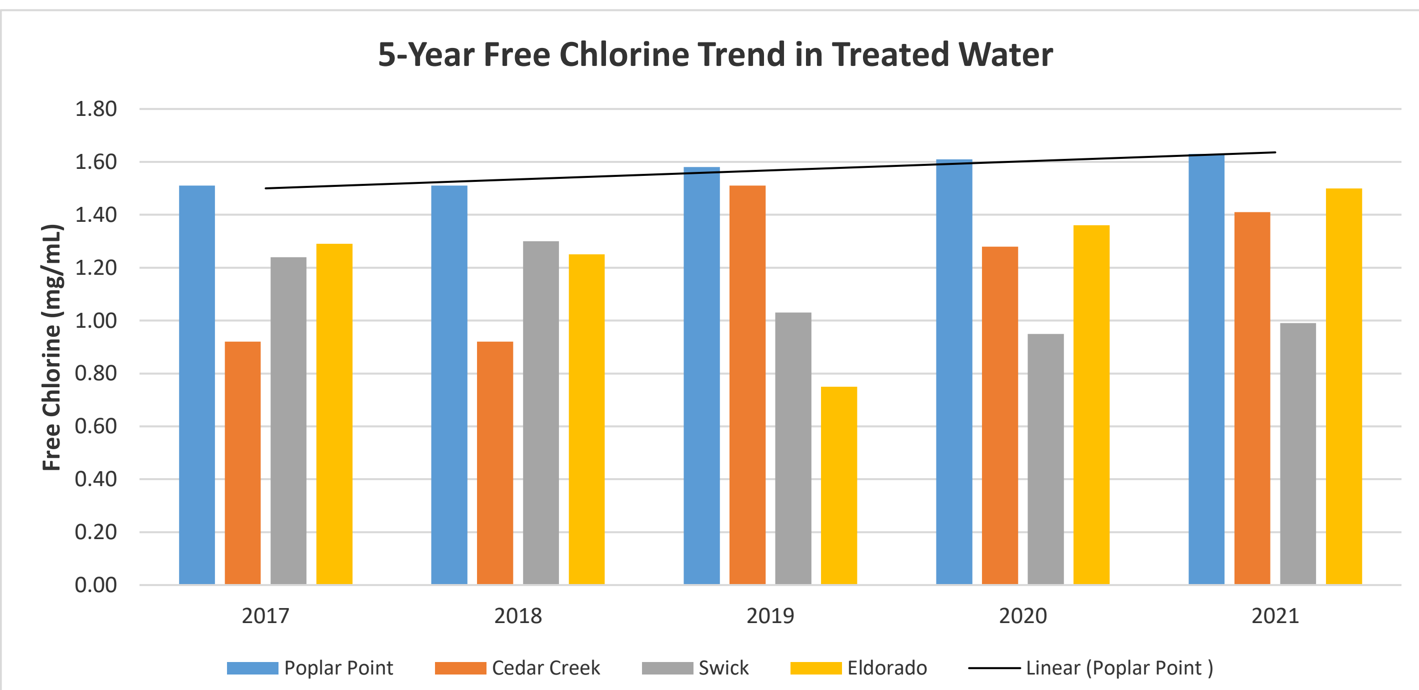


Figure 27. 5-Year Free Chlorine trend in Treated Water

Total Coliform

Effectiveness of water treatment is measured by the viable presence of both Total Coliform and E. Coli. bacteria. At no point throughout 2020 was there any positive Total Coliform detected immediately post treatment. This is in line with the 5-year trend and the CDWQ guideline requirement of <1 MPN/100mL. (Table 20). Important to note that the reporting requirement of the MPN Quanti-tray method produces a minimum value of <1 MPN/100mL, which is essentially equivalent to the CDWQ guideline of zero CFU/100mL.

Intake	Average (MPN/100ml)	Minimum (MPN/100ml)	Maximum (MPN/100ml)	Guideline (MPN/100ml)	Number of Exceedances	Number of Tests in 2021
Poplar Point	<1.0	<1.0	<1.0	<1.0	0	172
Eldorado	<1.0	<1.0	<1.0	<1.0	0	23
Cedar Creek	<1.0	<1.0	<1.0	<1.0	0	91
Swick	<1.0	<1.0	<1.0	<1.0	0	91

Table 20. Total Coliform in Treated Water annual summary

E. Coli.

The guideline objective for E. Coli. are identical to that of Total Coliform in that all viable bacteria related to Fecal matter requires complete and full inactivation (<1 MPN/100mL). The objective was achieved at all treatment points throughout 2021 (Table 21) with no requirement for the issue of any Boil Water Notices (BWN).

Intake	Average (MPN/100ml)	Minimum (MPN/100ml)	Maximum (MPN/100ml)	Guideline (MPN/100ml)	Number of Exceedances	Number of Tests in 2021
Poplar Point	<1.0	<1.0	<1.0	<1.0	0	172
Eldorado	<1.0	<1.0	<1.0	<1.0	0	23
Cedar Creek	<1.0	<1.0	<1.0	<1.0	0	91
Swick	<1.0	<1.0	<1.0	<1.0	0	91

Table 21. E.coli. in Treated Water annual summary

pH

The pH level of the water has a direct influence on the effectiveness and efficiency of the chlorine treatment applied as well as impact on the rate of infrastructure corrosion. Ideal range of pH for maximum chlorine disinfection (Hypochlorous acid) is between 6-7, but corrosion is a concern at levels <7.5. The pH of treated water is similar to the source water and is not significantly altered in any fashion. Levels were consistently within the target guideline range at all treatment points (Table 22). The 5-year trend indicates a rebound of recent pH values to a more alkaline condition in the lake (Figure 29).

Intake	Average	Minimum	Maximum	Guideline (AO)	Number of Exceedances	Number of Tests in 2021
Poplar Point	7.94	7.63	8.26	7.0 - 10.5	0	171
Eldorado	8.12	7.84	8.33	7.0 - 10.5	0	22
Cedar Creek	8.11	7.87	8.40	7.0 - 10.5	0	92
Swick	8.15	7.78	8.62	7.0 - 10.5	0	92

Table 22. Treated Water pH annual summary

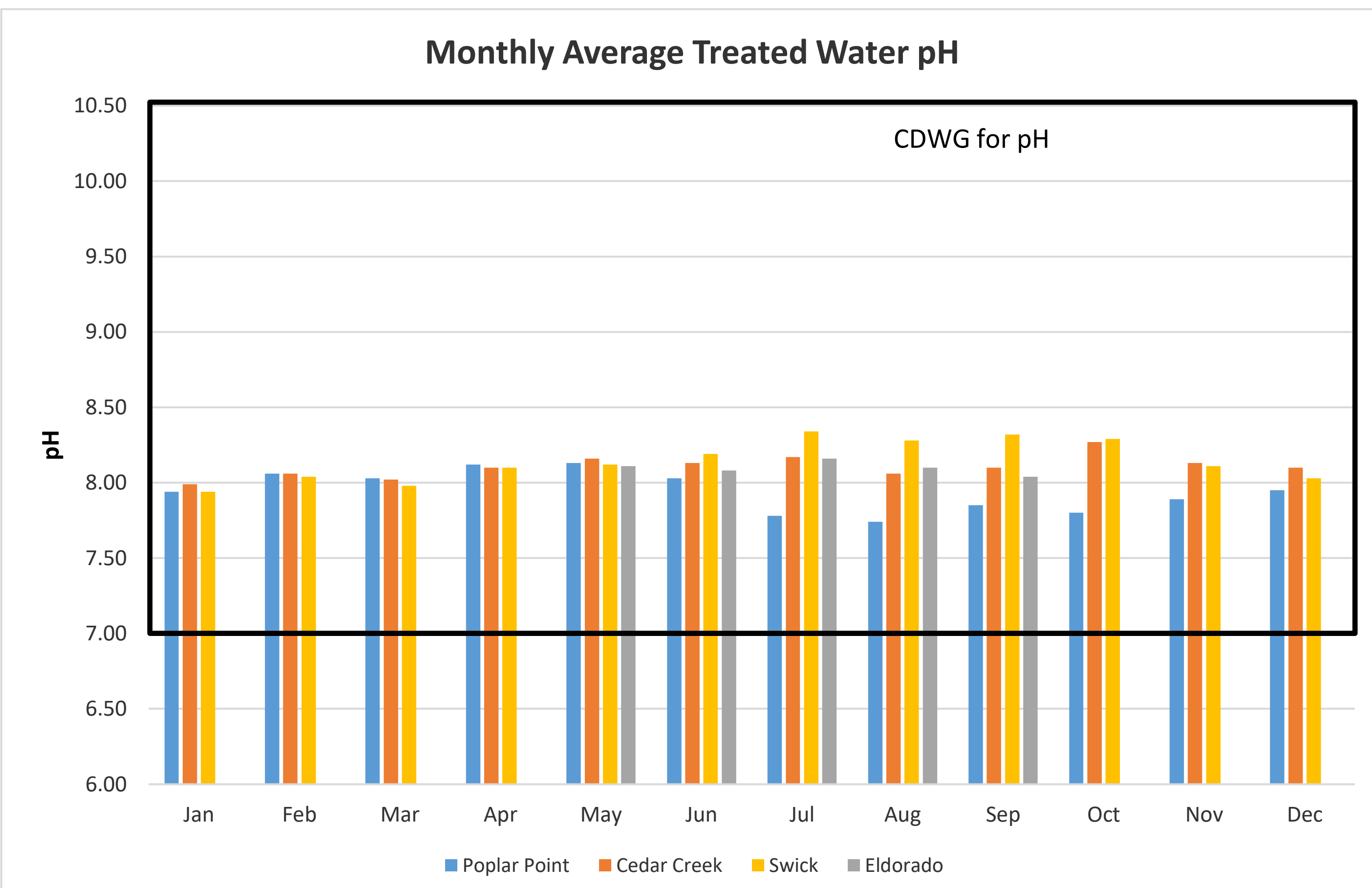


Figure 28. Monthly average pH of Treated Water

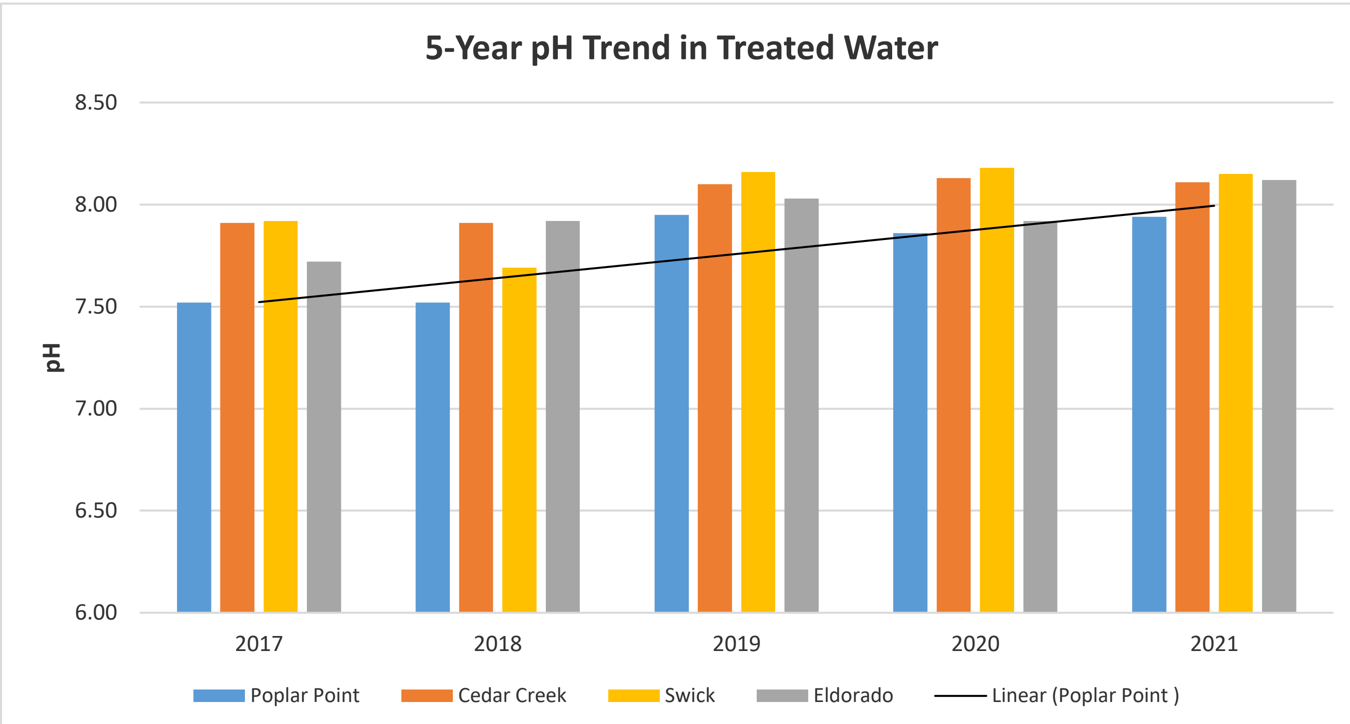


Figure 29. 5-Year pH trend in Treated Water

Color

Drinking water color below 15 Apparent Color Units (ACU) is typically undistinguishable to the average person. Elevated levels of color post treatment can have a direct connection to the concentration levels of chlorination byproducts such as THM's and HAA's. As with previous year data, chlorination and UVT treatment resulted in a 2-3 color unit drop in the treated water and only 1 exceedance above the Aesthetic objective of 15 ACU at all sites (Table 23). There was a marginal decrease in the overall Color intensity relative to the 5-year average (Figure 31).

Intake	Average (ACU)	Minimum (ACU)	Maximum (ACU)	Objective (ACU)	Number of Exceedances	Number of Tests in 2021
Poplar Point	6	4	11	AO:≤15	0	172
Eldorado	10	6	17	AO:≤15	1	23
Cedar Creek	7	4	12	AO:≤15	0	91
Swick	7	4	13	AO:≤15	0	91

Table 23. Treated Water Color annual summary

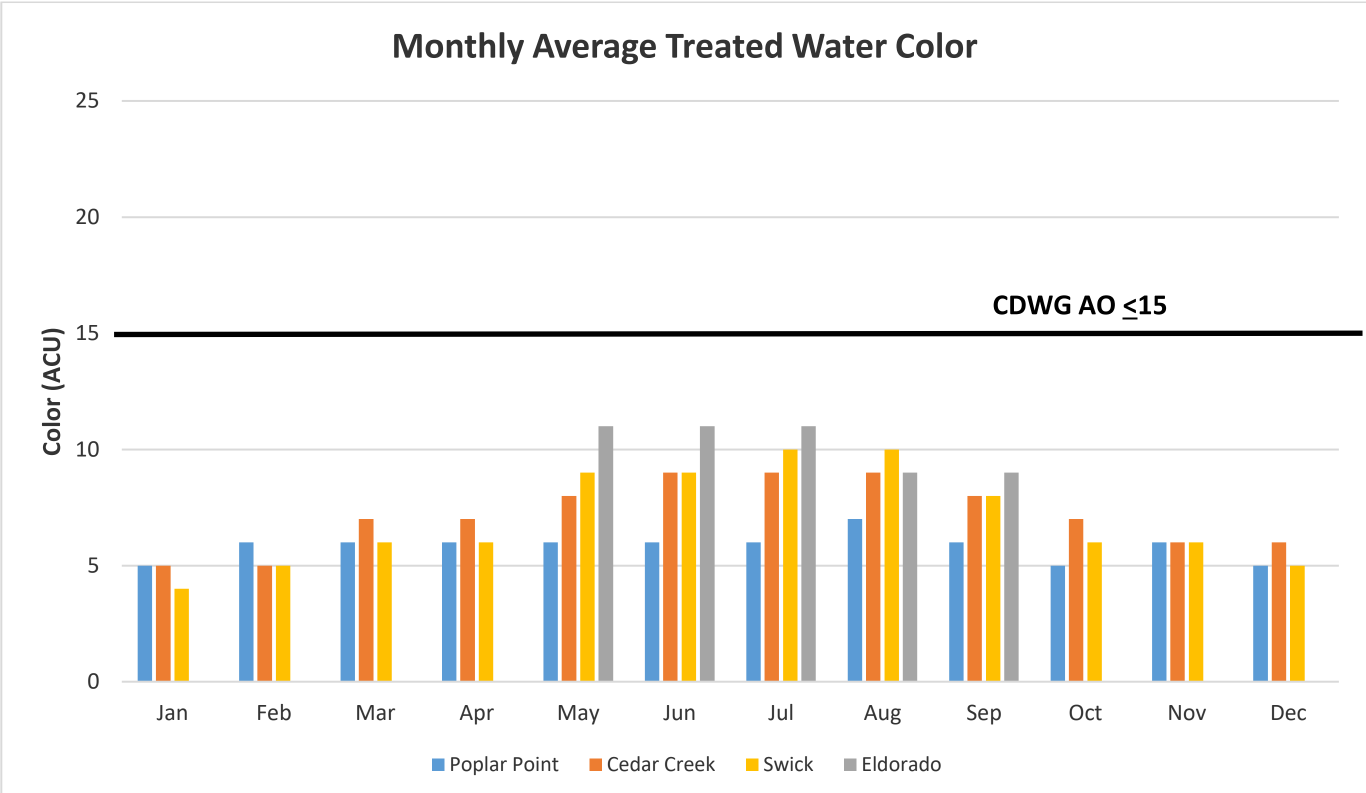


Figure 30. Monthly average Color for Treated Water

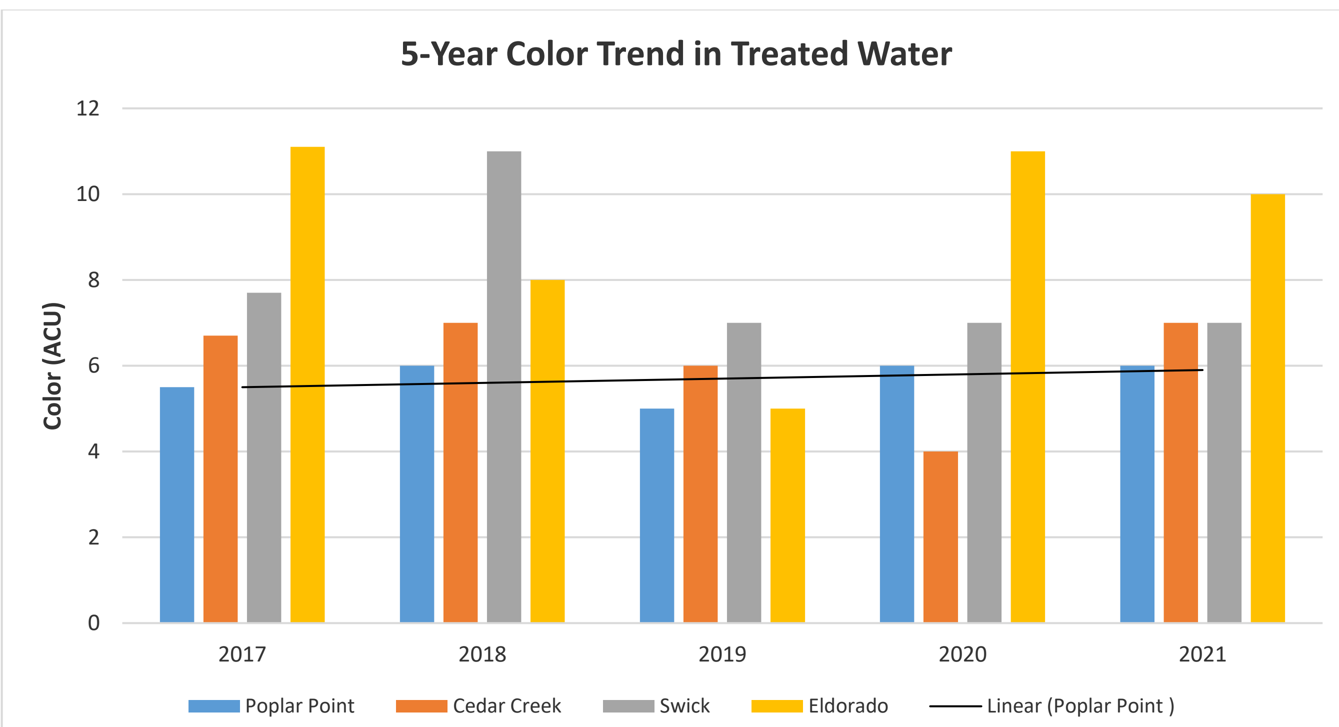


Figure 31. 5-Year Color trend in Treated Water

Temperature

The water temperature levels post treatment is not significantly different that the source water temperature as there is little heating or chilling applied during the treatment process. Elevated temperatures in treated water have been proven to enhance THM byproduct formation and therefore are preferred to be within objective limits. Minor objective exceedances were observed for both source and treated water during summer season, particularly at the shallower intakes at Eldorado and Swick (Table 24). There is a marginal upward trend in the 5-year average temperature (Figure 33).

Intake	Average (°C)	Minimum (°C)	Maximum (°C)	Objective (°C)	Number of Exceedances	Number of Tests in 2021
Poplar Point	6.8	4.5	11.0	AO:≤15	0	172
Eldorado	16.5	9.5	21.5	AO:≤15	13	23
Cedar Creek	8.7	4.5	13.0	AO:≤15	0	91
Swick	11.4	5.5	19.5	AO:≤15	18	91

Table 24. Treated Water Temperature annual summary

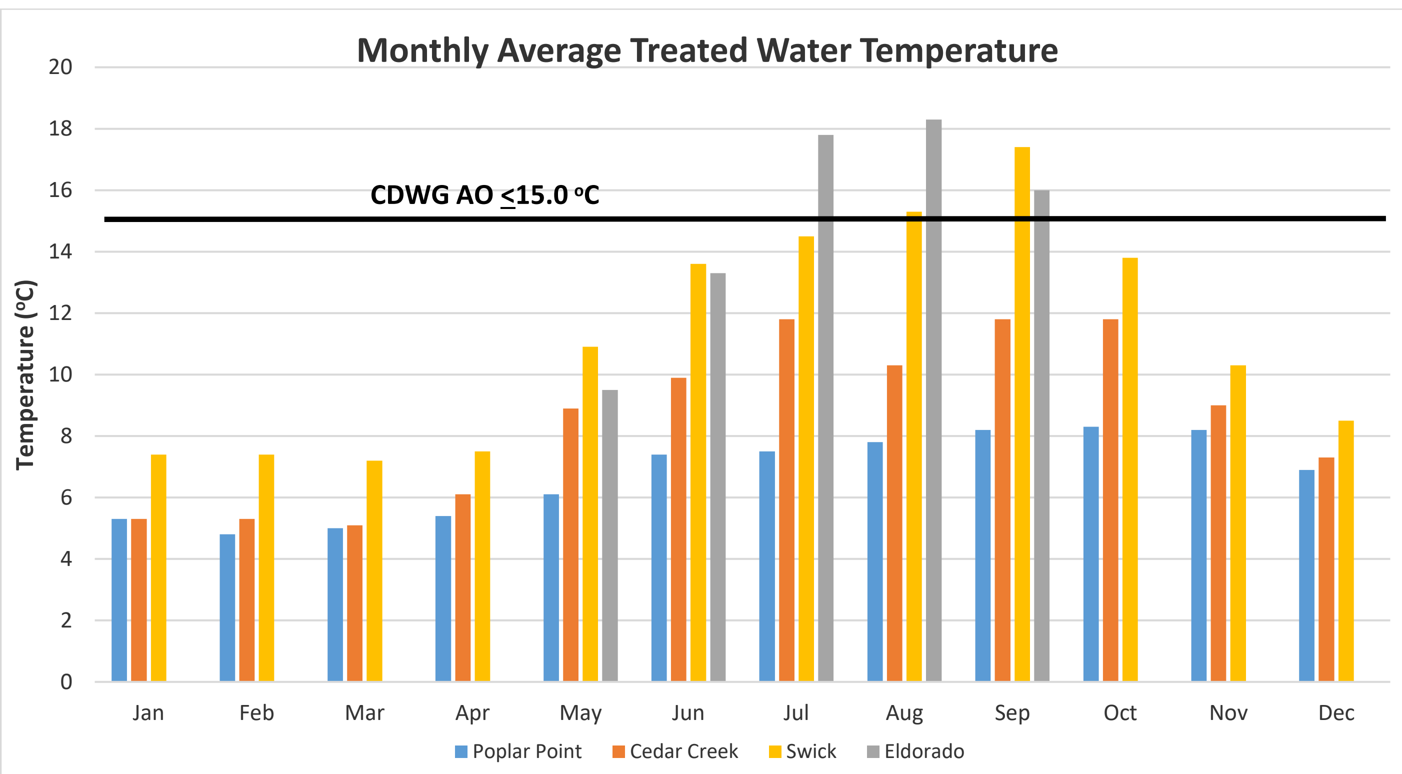


Figure 32. Monthly average Temperature of Treated Water

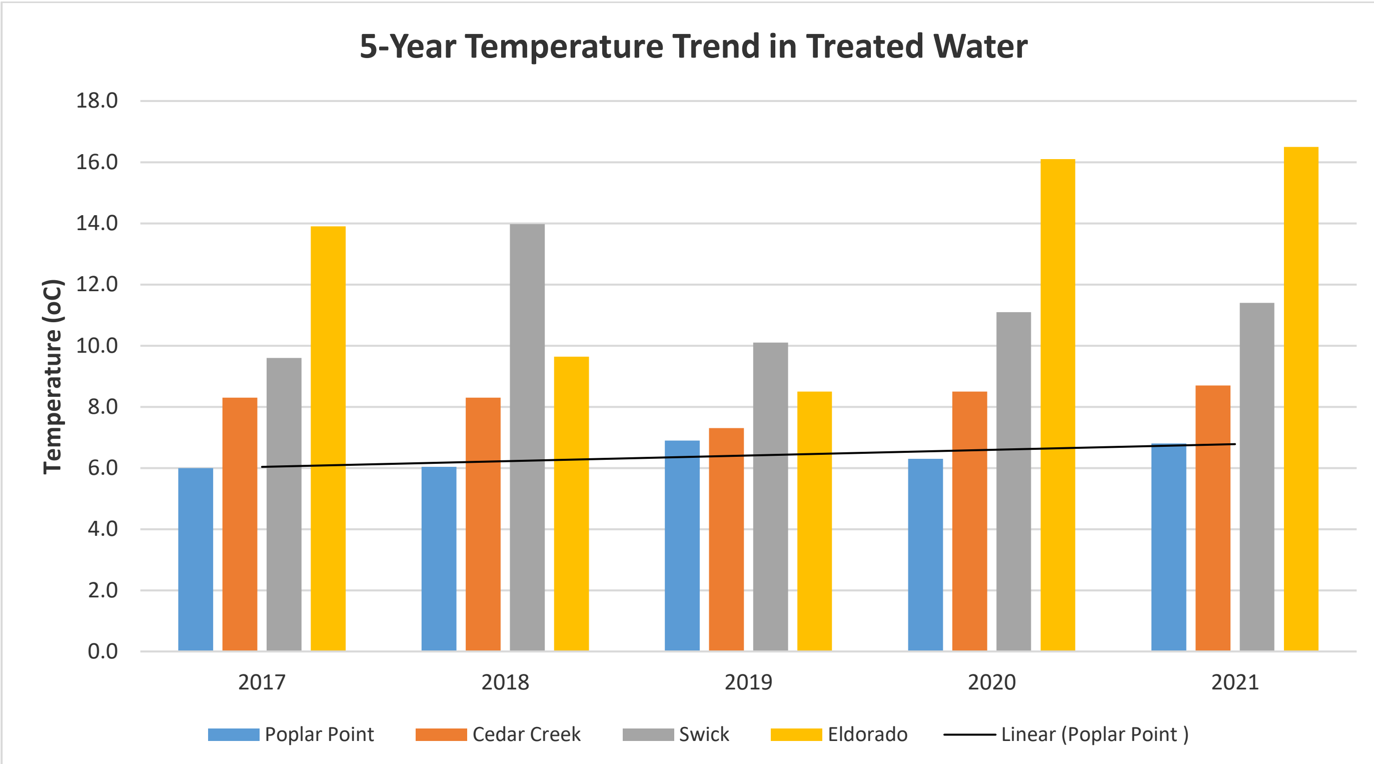


Figure 33. 5-Year Temperature trend in Treated Water

UV Transmittance

After dosing thought the UV reactor cells, the transmittance of the treated water is increased by an average of 2% over the UV transmittance of the source water for all sites. All test results met the objective of >80% transmittance throughout 2021 and similar to the raw water, there was a noticeable increase in water clarity all intakes after treatment (Table 25). There was a minor decreasing trend in UVT over the past 5 years (Figure 35).

Intake	Average (%T)	Minimum (%T)	Maximum (%T)	Objective (%T)	Number of Exceedances	Number of Tests in 2021
Poplar Point	88.1	85.4	89.2	>80	0	172
Eldorado	86.6	85.3	87.7	>80	0	23
Cedar Creek	88.0	85.7	89.1	>80	0	91

Table 25. Treated Water UV Transmittance annual summary

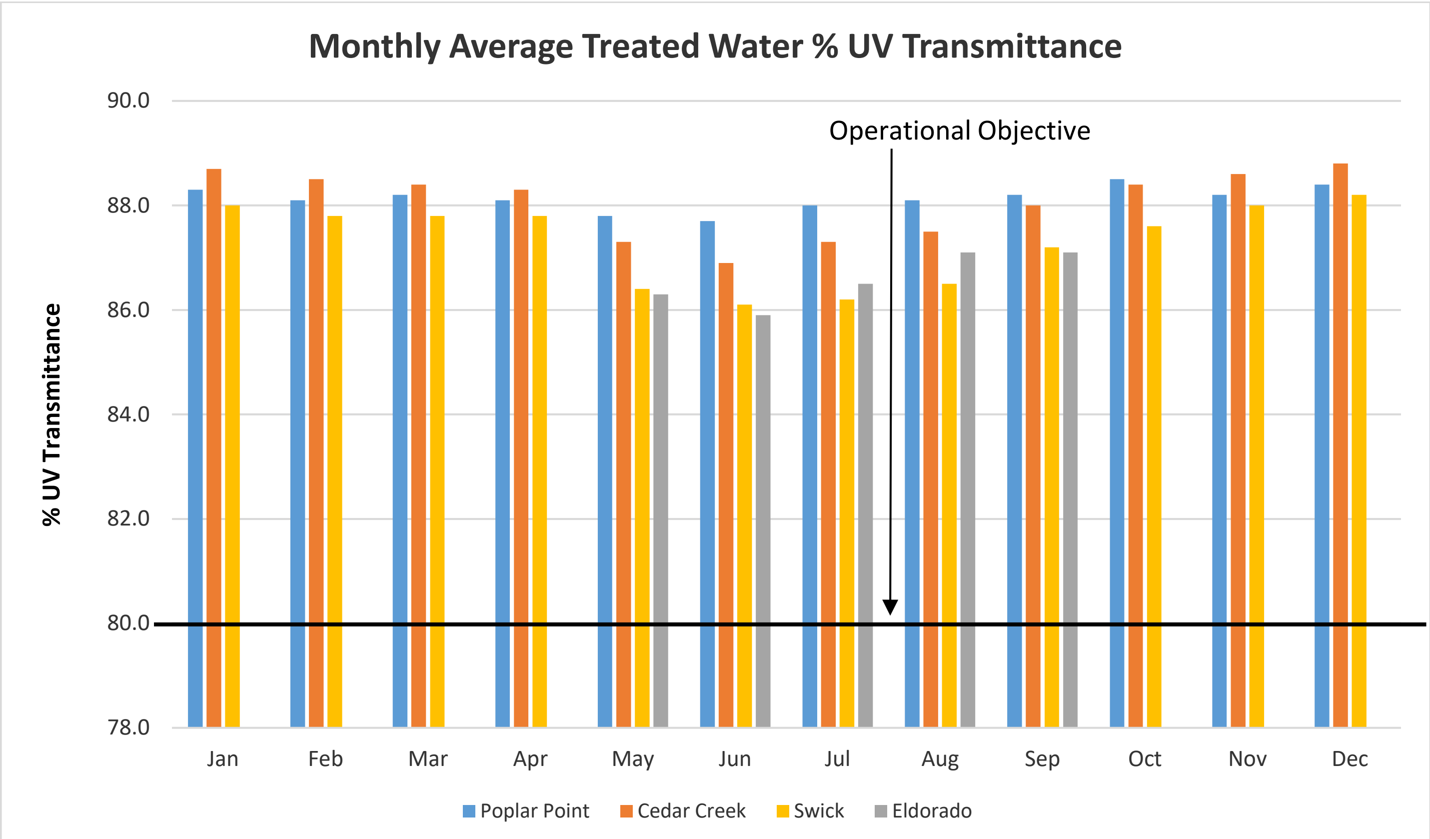


Figure 34. Monthly average % UVT for Treated Water

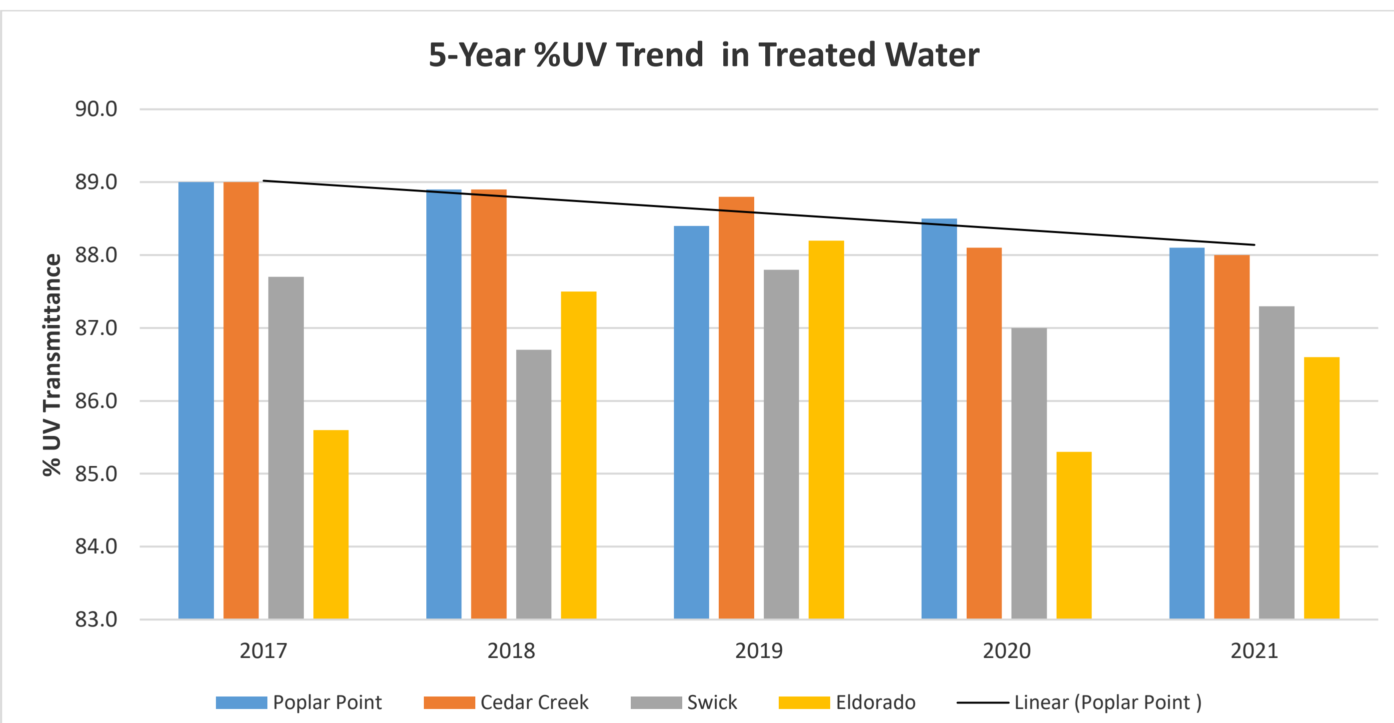


Figure 35. 5-Year %UVT trend in Treated Water

Annual Physical, Chemical and Biological Analysis

Comprehensive water analysis is conducted annually at each intake and compared to a variety of health and aesthetic objectives. There were no guideline exceedances for any of the parameters as per CDWQ guidelines (Table 26).

CARO Analytical Services			POPLAR POINT TREATED	ELDORADO TREATED	KVR TREATED	SWICK ROAD TREATED
Date Sampled			26-Jul-2021	26-Jul-2021	26-Jul-2021	26-Jul-2021
Physical Tests (Water)	Units	CDWQG	Water	Water	Water	Water
Color, True	CU	AO=15	<5.0	<5.0	<5.0	<5.0
Conductivity	uS/cm		282	266	278	276
Hardness (as CaCO3)	mg/L		126	125	125	125
pH	pH	7.5-10.5	8.23	8.19	8.20	8.22
Total Dissolved Solids	mg/L	AO≤500	160	157	167	164
Turbidity	NTU	OG ≤ 1	0.24	0.85	0.44	0.48
Anions and Nutrients (Water)						
Alkalinity, Total (as CaCO3)	mg/L		104	101	103	105
Ammonia, Total (as N)	mg/L		<0.050	<0.050	<0.050	<0.050
Chloride (Cl)	mg/L	AO≤250	7.05	7.20	11.90	9.46
Cyanide, total	mg/L	MAC=0.2	<0.0020	<0.0020	<0.0020	<0.0020
Fluoride (F)	mg/L	MAC=1.5	0.21	0.20	0.21	0.21
Nitrate (as N)	mg/L	MAC=10	0.081	<0.010	0.035	<0.010
Nitrite (as N)	mg/L	MAC=1	<0.010	<0.010	<0.010	<0.010
Sulfate (SO4)	mg/L	AO≤500	31.5	31.5	31.1	31.0

CARO Analytical Services			POPLAR POINT TREATED	ELDORADO TREATED	KVR TREATED	SWICK ROAD TREATED
Date Sampled			26-Jul-2021	26-Jul-2021	26-Jul-2021	26-Jul-2021
	Units	CDWQG	Water	Water	Water	Water
Total Metals (Water)						
Aluminum (Al)-Total	mg/L	OG <0.1	0.0066	0.015	0.0064	0.0071
Antimony (Sb)-Total	mg/L	MAC=0.006	<0.00020	<0.00020	<0.00020	<0.00020
Arsenic (As)-Total	mg/L	MAC=0.01	0.00050	0.00053	0.00056	<0.00050
Barium (Ba)-Total	mg/L	MAC=2	0.0217	0.0214	0.0221	0.0216
Boron (B)-Total	mg/L	MAC=5	<0.0500	<0.0500	<0.0500	<0.0500
Cadmium (Cd)-Total	mg/L	MAC=0.005	<0.000010	<0.000010	<0.000010	<0.000010
Calcium (Ca)-Total	mg/L		33.1	32.9	32.9	32.8
Chromium (Cr)-Total	mg/L	MAC=0.05	<0.00050	<0.00050	<0.00050	<0.00050
Copper (Cu)-Total	mg/L	MAC=2	0.00121	0.0147	0.00114	0.00503
Iron (Fe)-Total	mg/L	AO≤0.3	<0.010	0.025	<0.010	<0.010
Lead (Pb)-Total	mg/L	MAC=0.005	<0.00020	<0.00020	<0.00020	<0.00020
Magnesium (Mg)-Total	mg/L		10.40	10.30	10.40	10.40
Manganese (Mn)-Total	mg/L	MAC=0.12	0.00125	0.00193	0.00117	0.00115
Mercury (Hg)-Total	mg/L	MAC=0.001	<0.000010	<0.000010	<0.000010	<0.000010
Potassium (K)-Total	mg/L		2.67	2.63	2.65	2.66
Selenium (Se)-Total	mg/L	MAC=0.05	<0.00050	0.00063	<0.00050	<0.00050
Sodium (Na)-Total	mg/L	AO≤200	11.3	11.1	15.3	13.8
Uranium (U)-Total	mg/L	MAC=0.02	0.00242	0.00242	0.00239	0.00237
Zinc (Zn)-Total	mg/L	AO≤5	<0.0040	<0.0040	<0.0040	0.0059

MAC= Maximum Acceptable Concentration related to Health Concerns

AO = Aesthetic Objective related to Taste, Odor, Appearance

Table 26. Treated Water comprehensive analysis summary

Pesticides and Herbicides

The scan presented here includes historically applied compounds as well as newly formulated spray compounds. As of July 2021, none of the scanned Pesticides or Herbicides have been identified in the Kelowna water drinking water system at appreciable levels (Table 27).

CARO Analytical Services			POPLAR POINT TREATED	ELDORADO TREATED	KVR TREATED	SWICK ROAD TREATED
Date Sampled			26-Jul-2021	26-Jul-2021	26-Jul-2021	26-Jul-2021
Parameter	Units	CDWQG	Water	Water	Water	Water
Organochlorine Pesticides						
Aldrin	ug/L		<0.006	<0.006	<0.006	<0.006
alpha-BHC	ug/L		<0.010	<0.010	<0.010	<0.010
beta-BHC	ug/L		<0.050	<0.050	<0.050	<0.050
delta-BHC	ug/L		<0.050	<0.050	<0.050	<0.050
DDT, Total	ug/L		<0.010	<0.010	<0.010	<0.010
Dieldrin	ug/L		<0.010	<0.010	<0.010	<0.010
Endosulfan I + II	ug/L		<0.010	<0.010	<0.010	<0.010
Endosulfan sulfate	ug/L		<0.050	<0.050	<0.050	<0.050
Endrin aldehyde	ug/L		<0.020	<0.020	<0.020	<0.020
Endrin ketone	ug/L		<0.020	<0.020	<0.020	<0.020
Herbicides						
Bromacil	ug/L		<0.100	<0.100	<0.100	<0.100
Bromoxynil	ug/L	MAC=5	<0.20	<0.20	<0.20	<0.20
Butachlor	ug/L		<0.020	<0.020	<0.020	<0.020
Cyanazine	ug/L		<0.10	<0.10	<0.10	<0.10
2,4-D	ug/L	MAC=100	<0.10	<0.10	<0.10	<0.10
Dicamba	ug/L	MAC=120	<0.10	<0.10	<0.10	<0.10
Dinoseb	ug/L		<0.10	<0.10	<0.10	<0.10
Diuron	ug/L	MAC=150	<0.200	<0.200	<0.200	<0.200
MCPA	ug/L	MAC=100	<0.020	<0.020	<0.020	<0.020
2,4,5-T	ug/L		<0.10	<0.10	<0.10	<0.10
Picloram	ug/L	MAC=190	<0.10	<0.10	<0.10	<0.10

CARO Analytical Services			POPLAR POINT TREATED	ELDORADO TREATED	KVR TREATED	SWICK ROAD TREATED
Pesticides/Fungicides			26-Jul-2021	26-Jul-2021	26-Jul-2021	26-Jul-2021
Alachlor	ug/L		<0.10	<0.10	<0.10	<0.10
Atrazine & Metabolites	ug/L	MAC=5	<0.10	<0.10	<0.10	<0.10
Azinphos-methyl	ug/L	MAC=20	<0.20	<0.20	<0.20	<0.20
Captan	ug/L		<0.100	<0.100	<0.100	<0.100
Chlordane (cis + trans)	ug/L		<0.050	<0.050	<0.050	<0.050
Chlorothalonil	ug/L		<0.050	<0.050	<0.050	<0.050
Chlorpyrifos	ug/L	MAC=90	<0.010	<0.010	<0.010	<0.010
Deltamethrin	ug/L		<0.100	<0.100	<0.100	<0.100
Diazinon	ug/L	MAC=20	<0.020	<0.020	<0.020	<0.020
Dichlorvos	ug/L		<0.10	<0.10	<0.10	<0.10
Diclofop-methyl	ug/L	MAC=9	<0.10	<0.10	<0.10	<0.10
Dimethoate	ug/L	MAC=20	<0.200	<0.200	<0.200	<0.200
Disulfoton	ug/L		<0.100	<0.100	<0.100	<0.100
Endrin	ug/L		<0.020	<0.020	<0.020	<0.020
Fenchlorphos (Ronnel)	ug/L		<0.100	<0.100	<0.100	<0.100
Heptachlor	ug/L		<0.010	<0.010	<0.010	<0.010
Heptachlor epoxide	ug/L		<0.010	<0.010	<0.010	<0.010
Lindane	ug/L		<0.050	<0.050	<0.050	<0.050
Linuron	ug/L		<0.050	<0.050	<0.050	<0.050
Malathion	ug/L	MAC=190	<0.10	<0.10	<0.10	<0.10
Methoxyxhlor	ug/L		<0.050	<0.050	<0.050	<0.050
Methyl parathion	ug/L		<0.100	<0.100	<0.100	<0.100
Metolachlor	ug/L	MAC=50	<0.10	<0.10	<0.10	<0.10
Metribuzin	ug/L	MAC=80	<0.200	<0.200	<0.200	<0.200
Parathion	ug/L		<0.100	<0.100	<0.100	<0.100
Pentachloronitrobenzene	ug/L		<0.100	<0.100	<0.100	<0.100
Permethrin	ug/L		<0.010	<0.010	<0.010	<0.010
Phorate	ug/L	MAC=20	<0.10	<0.10	<0.10	<0.10
Prometon	ug/L		<0.300	<0.300	<0.300	<0.300
Prometryne	ug/L		<0.10	<0.10	<0.10	<0.10
Simazine	ug/L	MAC=10	<0.200	<0.200	<0.200	<0.200
Sulfotep	ug/L		<0.100	<0.100	<0.100	<0.100
Tebuthiuron	ug/L		<0.200	<0.200	<0.200	<0.200
Temephos (Abate)	ug/L		<0.500	<0.500	<0.500	<0.500
Terbufos	ug/L	MAC=1	<0.10	<0.10	<0.10	<0.10
Triallate	ug/L		<0.10	<0.10	<0.10	<0.10
Trifluralin	ug/L	MAC=45	<0.200	<0.200	<0.200	<0.200

Table 27. Pesticide and Herbicide scans of treated water

Radiological Parameters

There were minor detectable levels of Gross Alpha compounds (naturally occurring) and minor concentrations of Gross Beta compounds (artificially occurring), but well below the CDWQ guidelines (Table 28).

SRC Analytical Services			POPLAR POINT TREATED	ELDORADO TREATED	CEDAR CREEK TREATED	SWICK ROAD TREATED
Date Sampled			26-Jul-2018	26-Jul-2018	26-Jul-2018	26-Jul-2018
Parameter	CDWQG	Units	Water	Water	Water	Water
Radiological						
Gross Alpha	<1	Bq/L	<0.09	<0.09	0.08	<0.08
Gross Beta	<1	Bq/L	0.15	<0.07	0.19	0.15

Table 28. Radiological scans of treated water

Appendix D

Water Distribution Water Quality Monitoring Parameters

Distribution Water Quality Parameters

Chlorine – Free

In order to maintain free chlorine residual throughout the distribution system, booster stations are equipped to inject additional sodium hypochlorite at strategic intervals and are sampled from point of source through to end of pipe in order to maintain an operational target of 0.2 mg/mL free chlorine residual throughout. These sites are monitored weekly and reported to IHA on a monthly basis. All minimal operating Chlorine residual concentrations were maintained in the distribution system in 2020 (Figure 36). The 5-year trend indicates fairly consistent Chlorine residuals throughout the distribution (Figure 37).

	Average (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Number of Tests in 2021
City System	0.74	0.20	2.2	979
Swick	0.42	0.02	1.4	56
Airport	1.08	0.22	1.52	56

Table 29. Free Chlorine in distribution water system summary

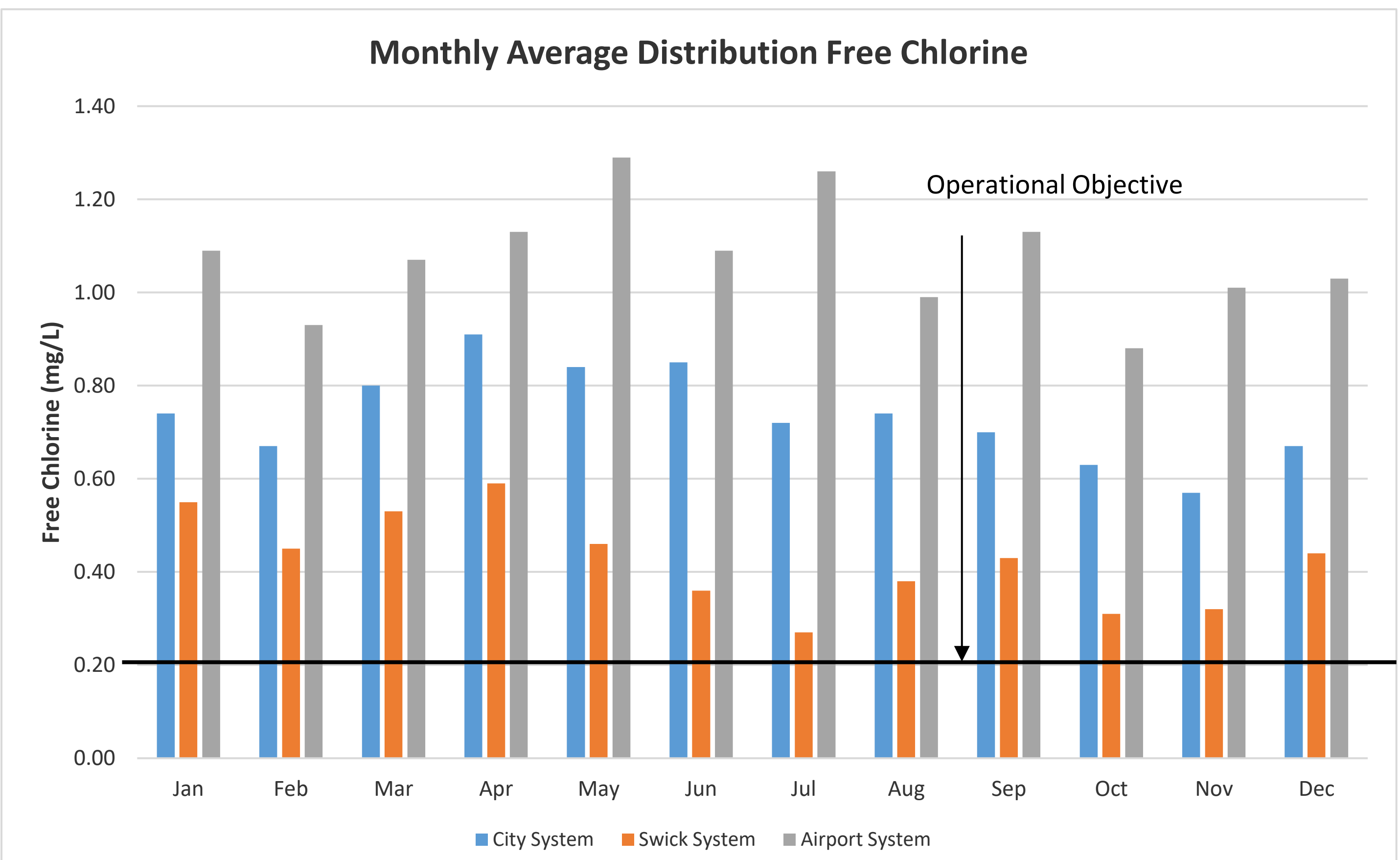


Figure 36. Monthly average Free Chlorine in Distribution System

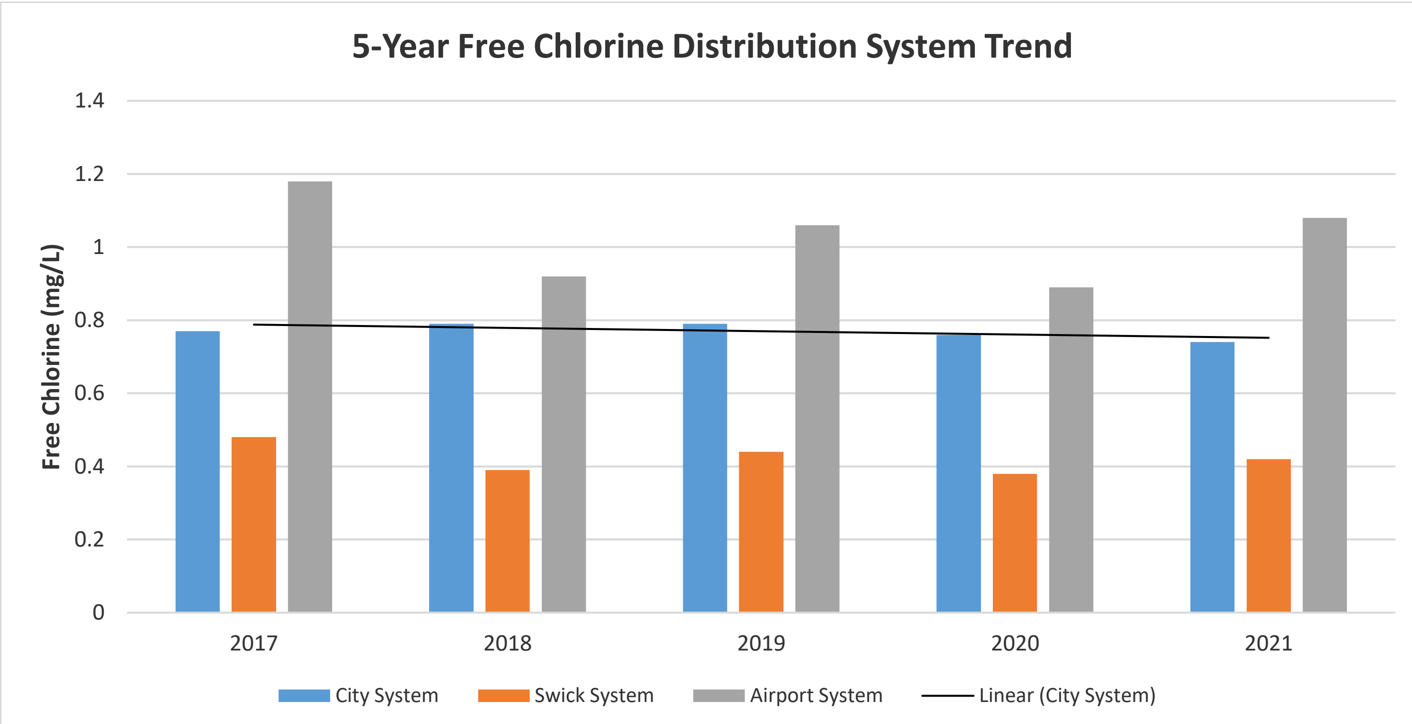


Figure 37. 5-Year Average Free Chlorine in Distribution System

Total Coliform

Total Coliform and E. Coli. bacteria are monitored routinely at various points along the distribution system to ensure that no bacterial re-growth has occurred and that new bacteria has not been introduced through leaks or line breaks. To date, there has been no indication that there were detectable levels of Total Coliform or E. Coli. at any of the distribution sampling sites (Table 30 and 31).

	Average (MPN/100ml)	Minimum (MPN/100ml)	Maximum (MPN/100ml)	Guideline (MPN/100ml)	Number of Exceedances	Number of Tests in 2021
City System	<1.0	<1.0	<1.0	<1.0	<1.0	979
Swick	<1.0	<1.0	<1.0	<1.0	<1.0	76
Airport	<1.0	<1.0	<1.0	<1.0	<1.0	56

Table 30. Total Coliform in distribution water system summary

E. Coli.

	Average (MPN/100ml)	Minimum (MPN/100ml)	Maximum (MPN/100ml)	Guideline (MPN/100ml)	Number of Exceedances	Number of Tests in 2021
City System	<1.0	<1.0	<1.0	<1.0	<1.0	979
Swick	<1.0	<1.0	<1.0	<1.0	<1.0	76
Airport	<1.0	<1.0	<1.0	<1.0	<1.0	56

Table 31. E. Coli. in distribution water system summary

Trihalomethanes

Trihalomethanes (THM) and Haloacetic acids (HAA) are produced during the relatively slow organic reaction that occur between free chlorine and naturally occurring organic precursors such as humic and fulvic acids. Samples are tested quarterly (Figure 38) and also reported as an annual average to demonstrate compliance with the 0.10 mg/L Canadian Drinking Water guideline requirements. TTHM concentrations in 2021 were on average higher than 2020, but shown a as marginal decrease over the past 5 years. The airport THM's remain the highest of the 3 water systems (Figure 39).

	Average (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Guideline (mg/L)	Number of Exceedances	Number of Tests in 2021
City System	0.0658	0.0229	0.0937	<0.1	0	30
Swick	0.0685	0.0370	0.109	<0.1	1	8
Airport	0.070	0.0473	0.106	<0.1	1	4

Table 32. Summary of THM concentrations in the distribution water system

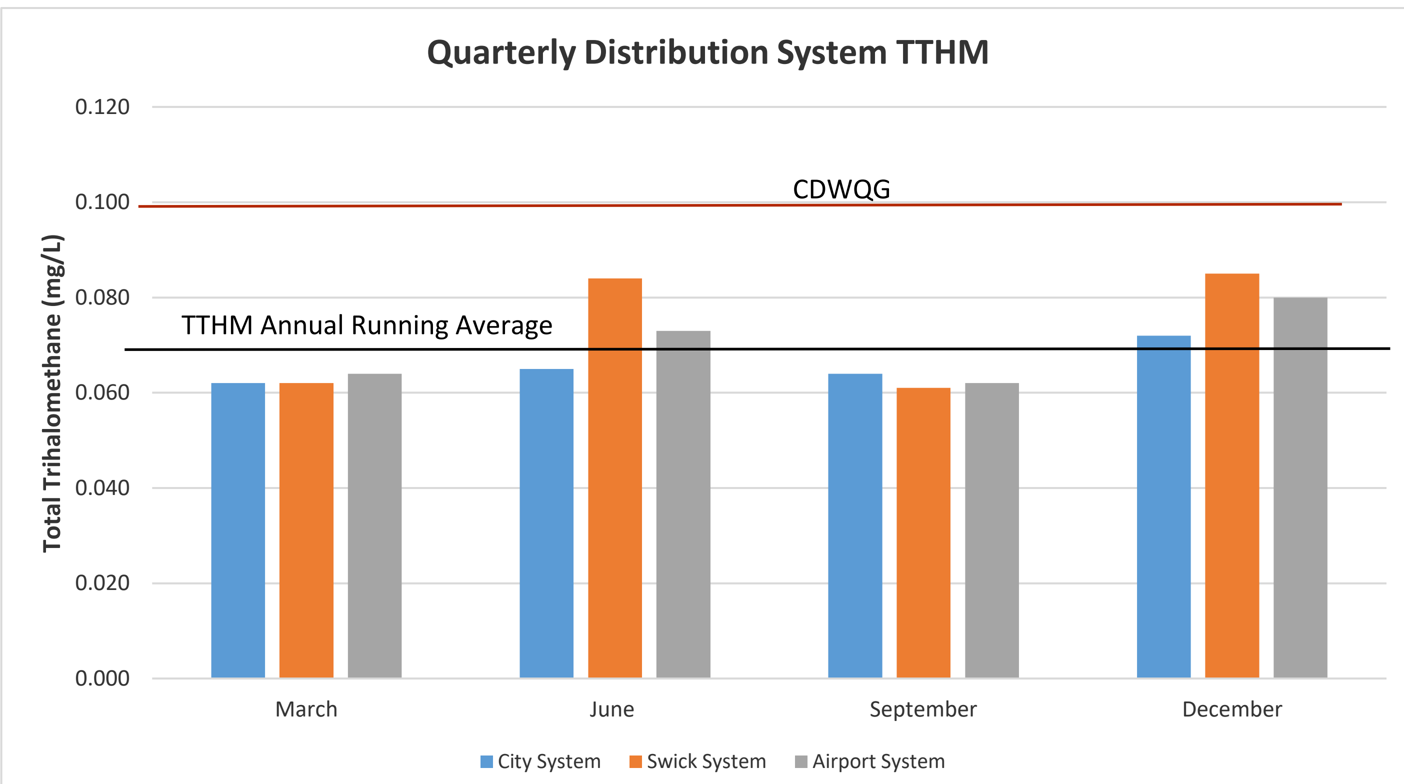


Figure 38. Quarterly TTHM in Distribution system

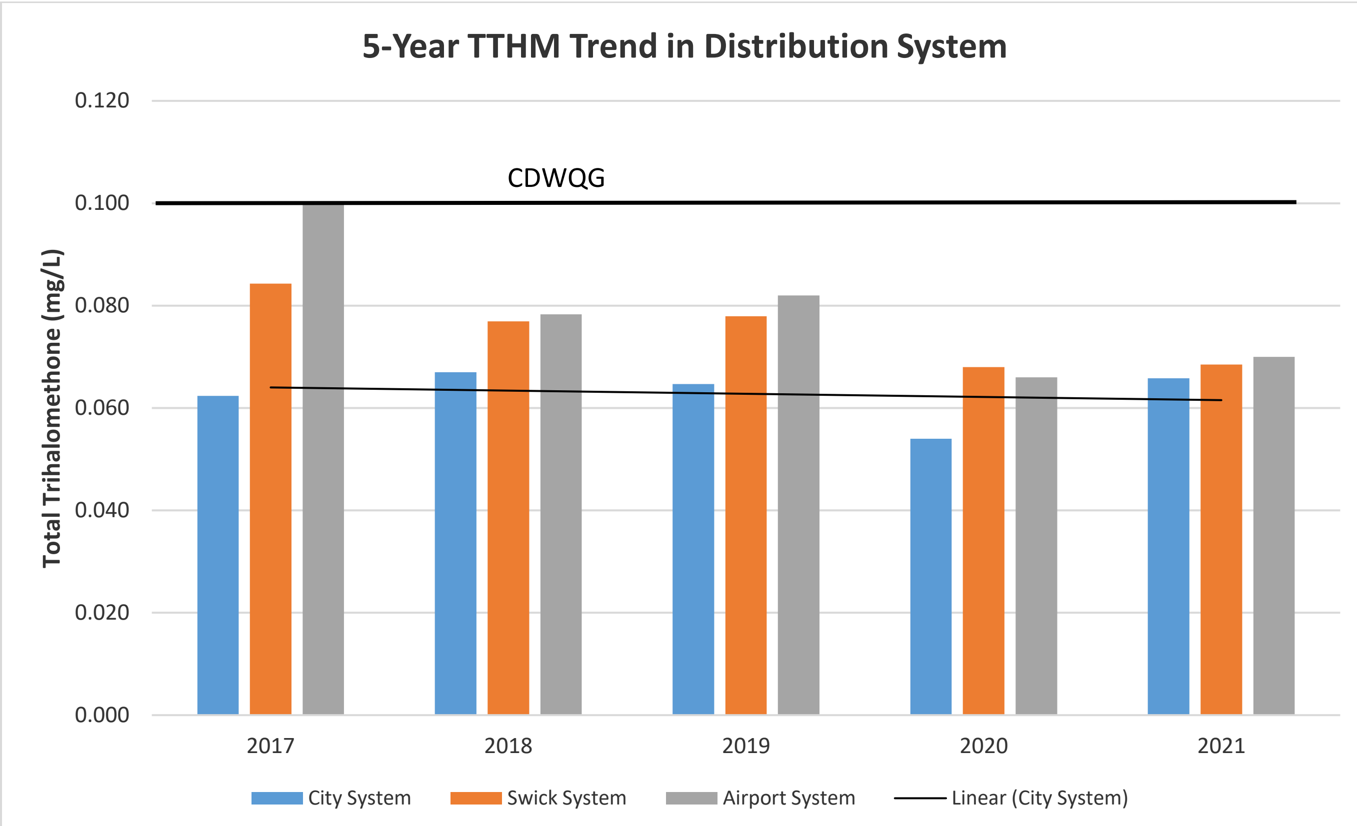


Figure 39. 5-year THM trend in Distribution Systems

Haloacetic Acids

Similar to the THM concentrations, HAA's have been found to be highest at the Airport water system relative to the organic precursor concentrations. There were no guideline exceedances of any of the concentrations throughout 2021 (Table 33).The 5-year trend indicates a marginally decreasing concentration of HAA's in the City system, but lower in non-flooding years (Figure 41).

	Average (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Guideline (mg/L)	Number of Exceedances	Number of Tests in 2021
City System	0.0390	0.0161	0.0685	<0.08	0	30
Swick	0.0250	0.0020	0.0377	<0.08	0	8
Airport	0.0463	0.0396	0.068	<0.08	0	4

Table 33. Summary of HAA concentrations in the distribution water system

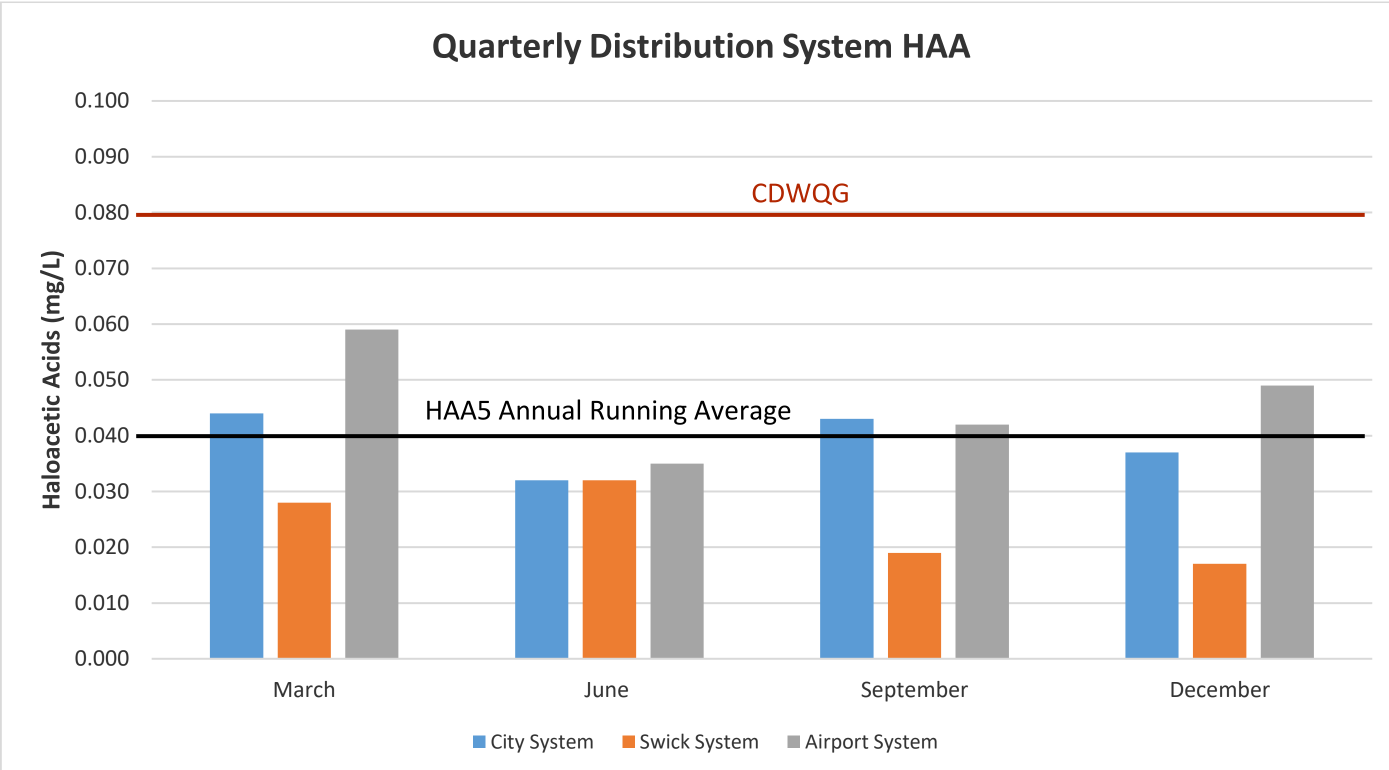


Figure 40. Quarterly Haloacetic Acids in Distribution Systems

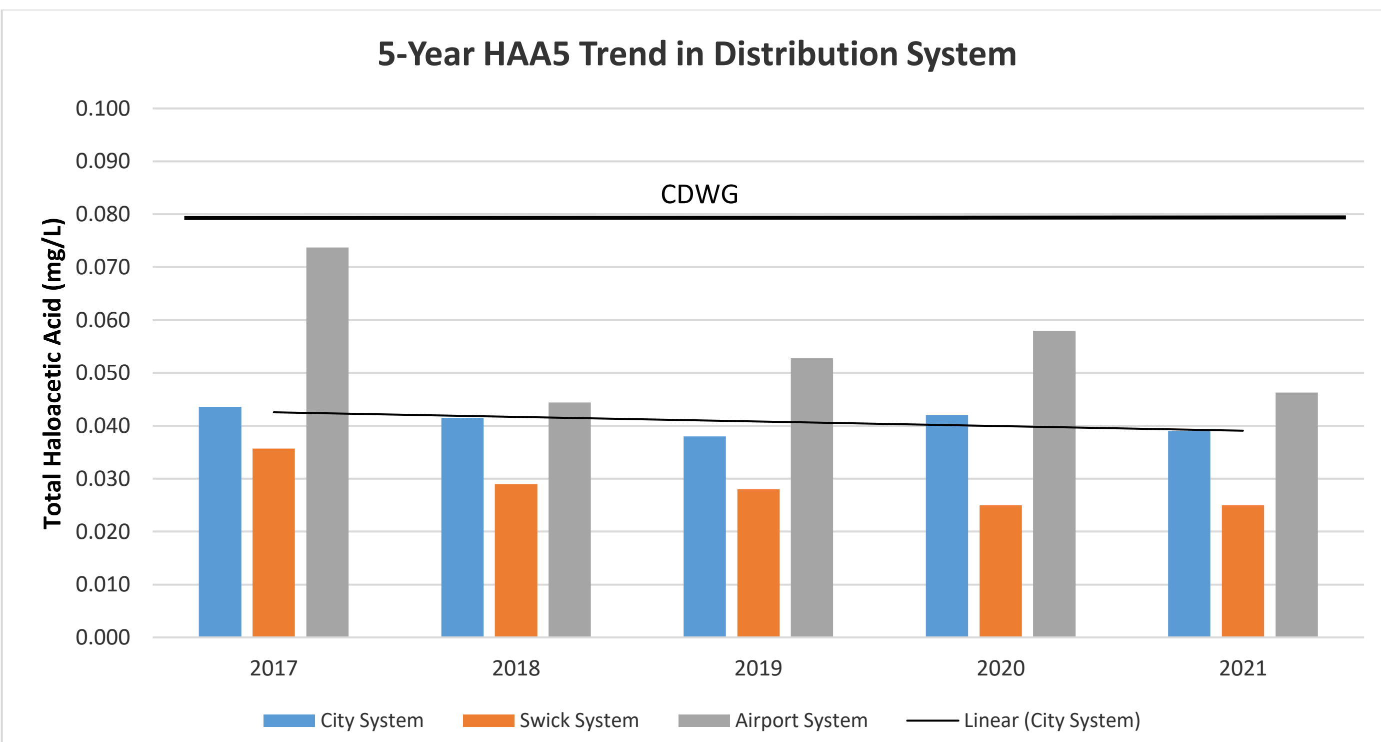


Figure 41. 5-year Haloacetic Acid trends in Distribution Systems

Appendix E

Drainage and Beaches

Drainage and Beaches

Introduction

One of the largest water quality impacts to Okanagan Lake stems from upland water sources and storm water outfall discharges. The principal stormwater scenario is that the stormwater flows develop in response to local precipitation and carry a wide variety of pollutants such as sand, silt, dissolved metals, pesticides, nutrients, and fecal material. Additionally, exceptional events can occur in which a fuel or chemical spill enters the stormwater system.

In order to understand the relationship that these water sources have to the water quality at the City intakes, the COK has been comparing and overlaying water quality parameters from impactful creeks identified in the Source Water Assessment with the intake water quality. These insights help shape environmental planning and action in the event that trends, or threats are identified. The monitoring consists of routine creek sampling, supplemental creek monitoring in the event of elevated Turbidity at intakes to determine if a connection in events exist. Monitoring is also increased during substantial rain events, first flush storm system events in spring, and beach sampling for E. Coli. during the summer months.

Creek Monthly Monitoring

The mouths of Brandt's, Mill, and Mission Creek are sampled a minimum of 5 times in one month (5/30) throughout the year, weather and conditions permitting. Turbidity and Bacterial trends are noted and communicated to the respective Utility groups to allow for operational adjustments or investigate possible storm-sanitary interconnect contamination.

Creek testing parameters include ammonia, chloride, true color, conductivity, dissolved oxygen, *E. coli*, pH, total suspended solids, temperature, and Turbidity and are graphically presented relative to a number of applicable water quality guidelines including:

- British Columbia Aquatic Water Quality Guidelines (BCAWQG)
- Canadian Drinking Water Quality guidelines (CDWQG) Aesthetic Objectives (AO)
- Canadian Council of the Ministry of Environment (CCME)
- Guidelines for Canadian Recreational Water Quality (GCRWQ)

Specific sampling sites listed in the figures can be found in the Sampling Site section of this Appendix.

Ammonia

Presence of high concentrations of Ammonia can indicate that sewage contamination may be present and coming from septic or sanitary leakage. For all major tributaries, the concentrations were below calculated CCME guidelines for freshwater and did not indicate any significant sewage influence. Similarly, the annual average ammonia concentrations demonstrated minimal amount of variation from year to year (Figure 43).

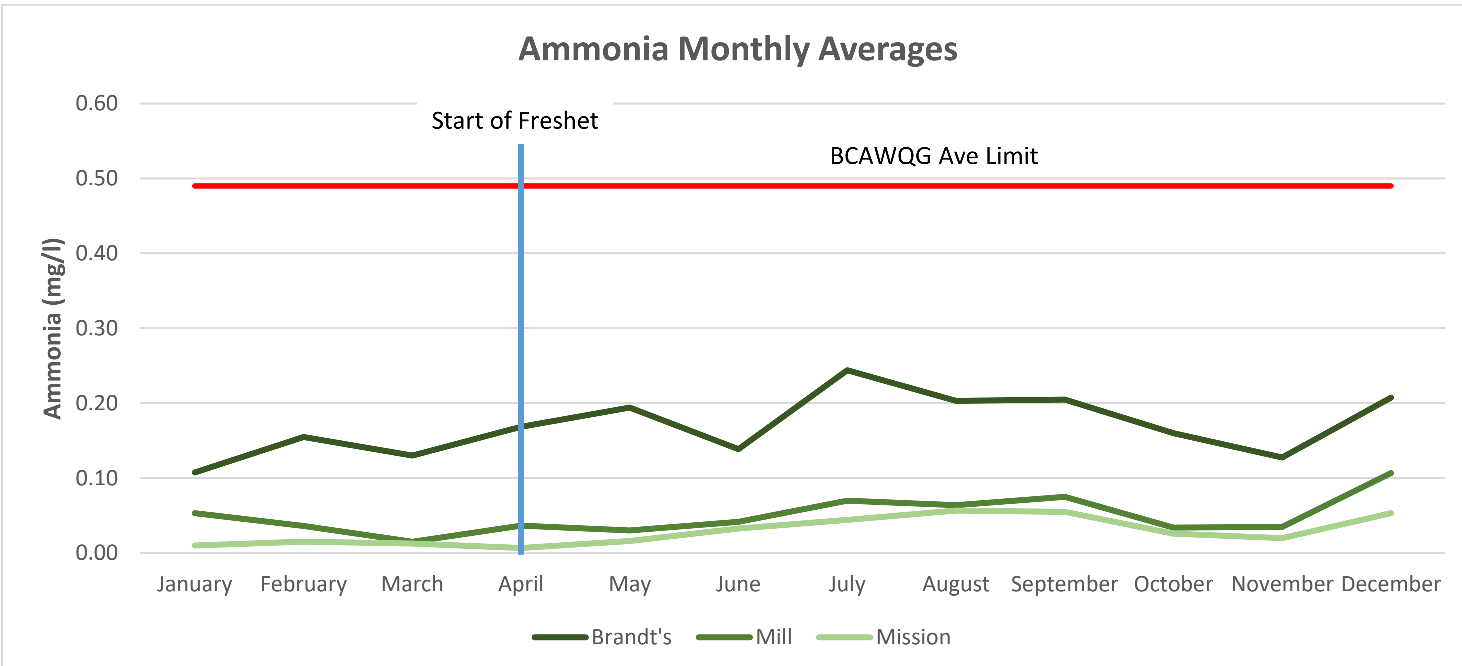


Figure 42. Monthly Ammonia average for creek samples

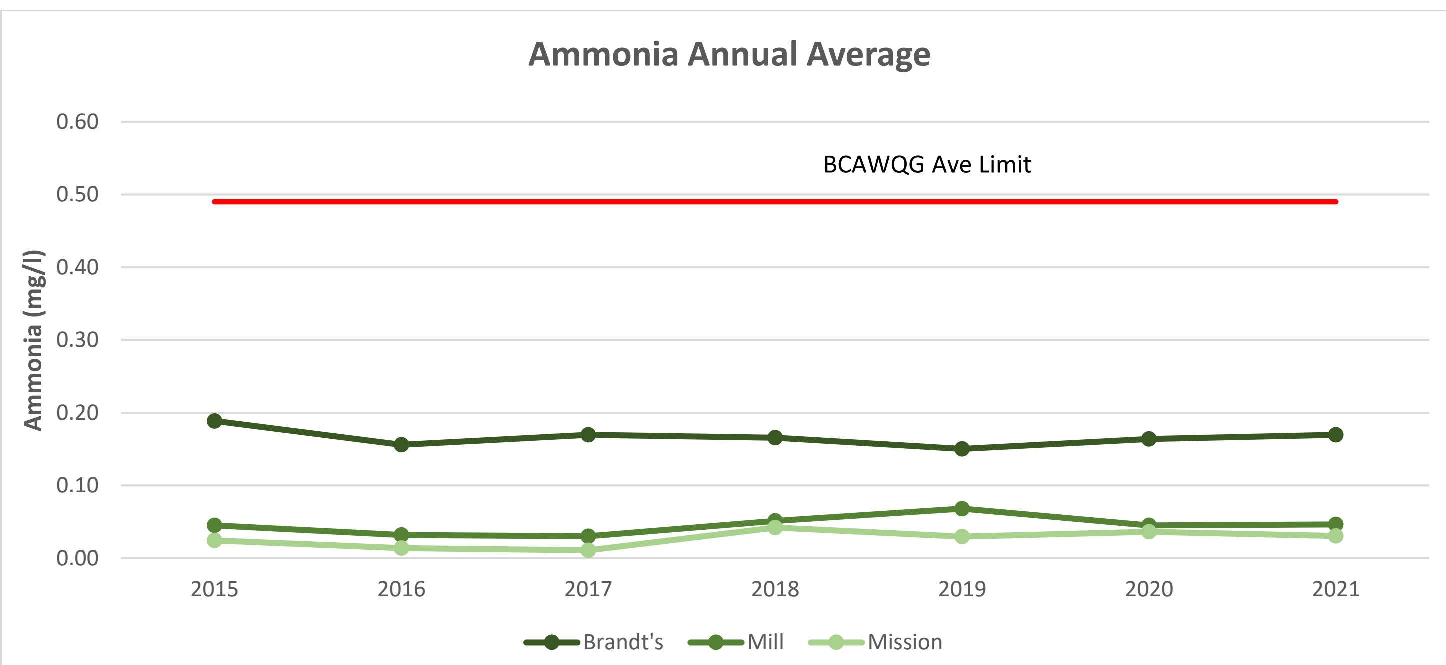


Figure 43. 7-Year Ammonia average for creek samples

Chloride

Presence of elevated Chloride concentrations is a potential indicator that dissolved road salt is contributing to discharge into creeks. Monthly data indicated a downward trend through freshet in all tributaries and all within Aesthetic objectives. The 7-year trend indicated that the flooding events of 2017 and 2018 had a very marginal effect on chloride concentrations relative to non-flooding years (Figure 45).

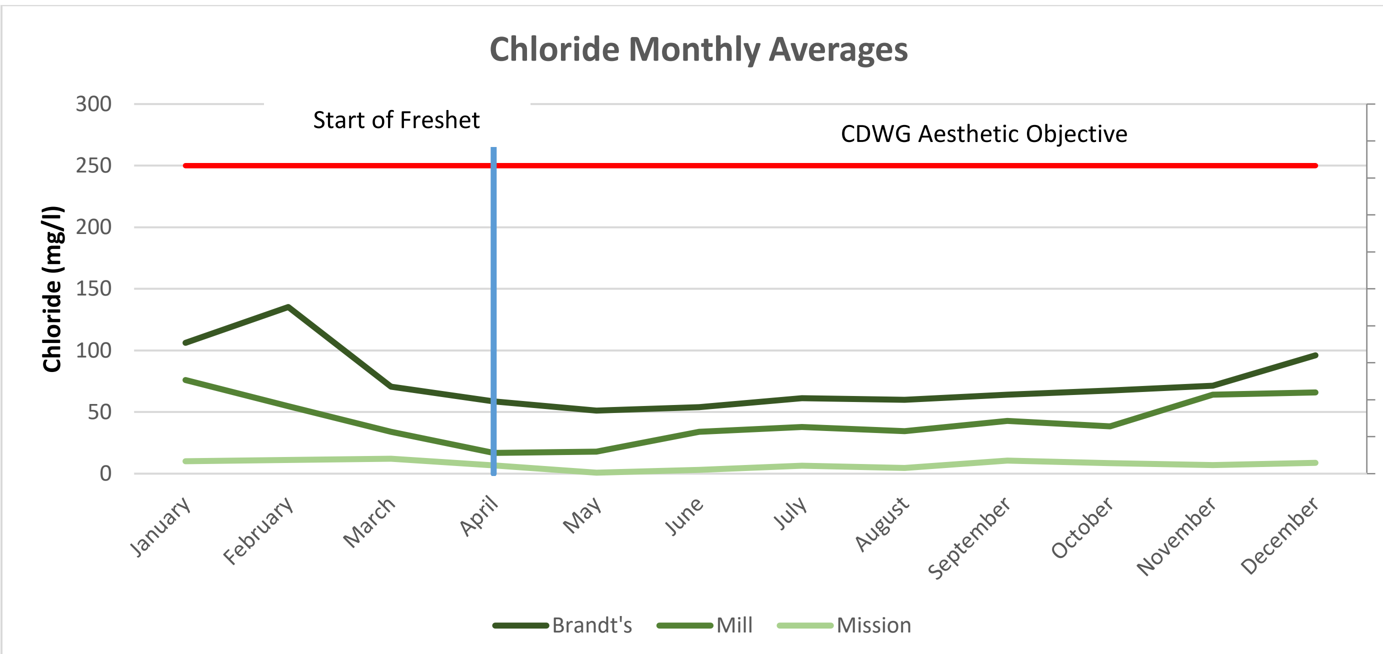


Figure 44. Monthly Chloride average for creek samples

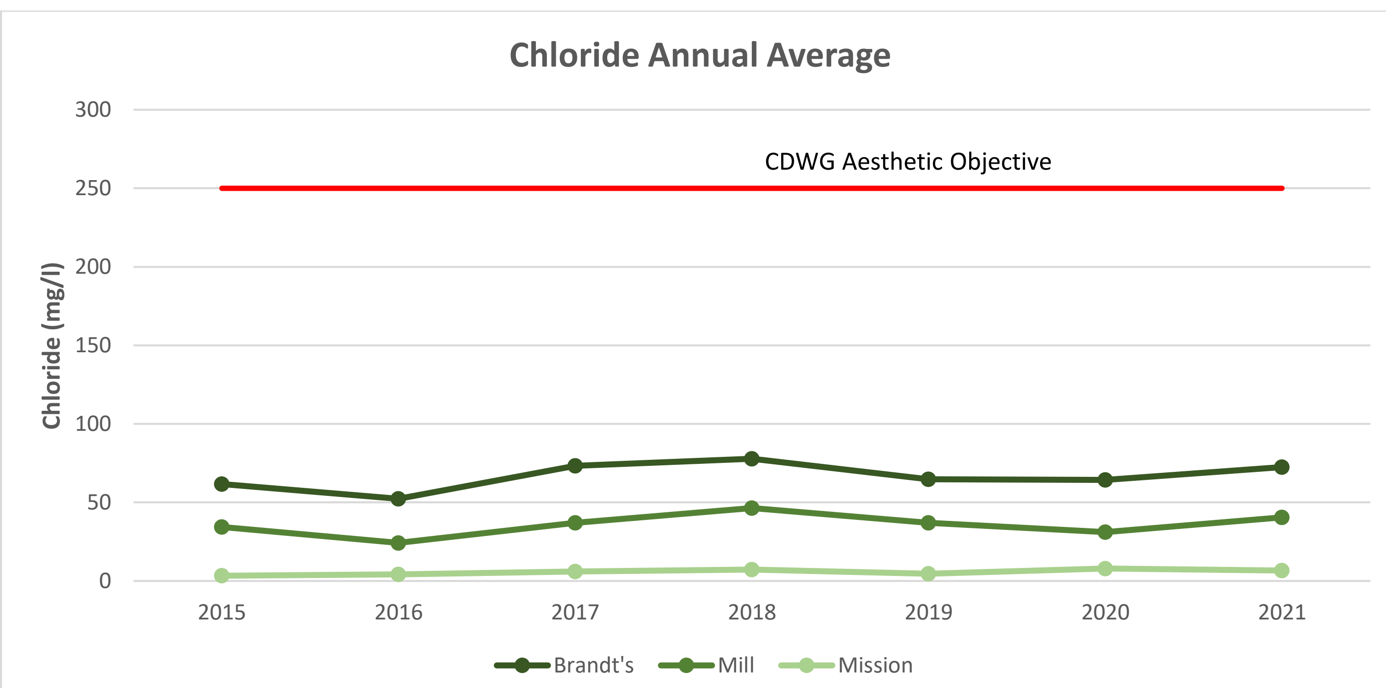


Figure 44. 7-year Chloride average for creek samples

Color

Color in creeks is typically related to the volume of the water flow and the extent of upstream or in-stream bank / bed erosion occurring. The decomposition of naturally occurring organic materials in the bank and floating materials give the creek water its distinctive dark brown appearance and reduces the overall water clarity. The color concentrations tend to spike in in Mission and Mill creeks during times of freshet and subside during low flow seasons (Figure 46). Color was measured at the lowest concentration at any point over the past 7 years (Figure 47).

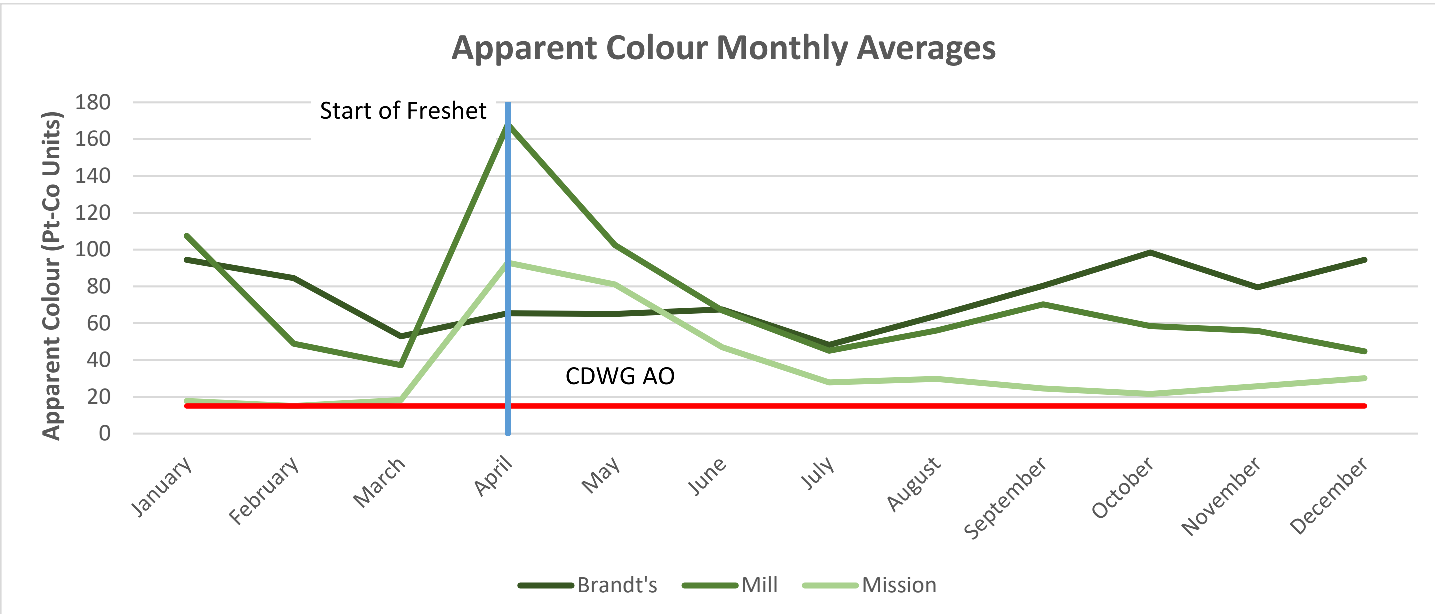


Figure 46. Monthly Color averages for creek samples

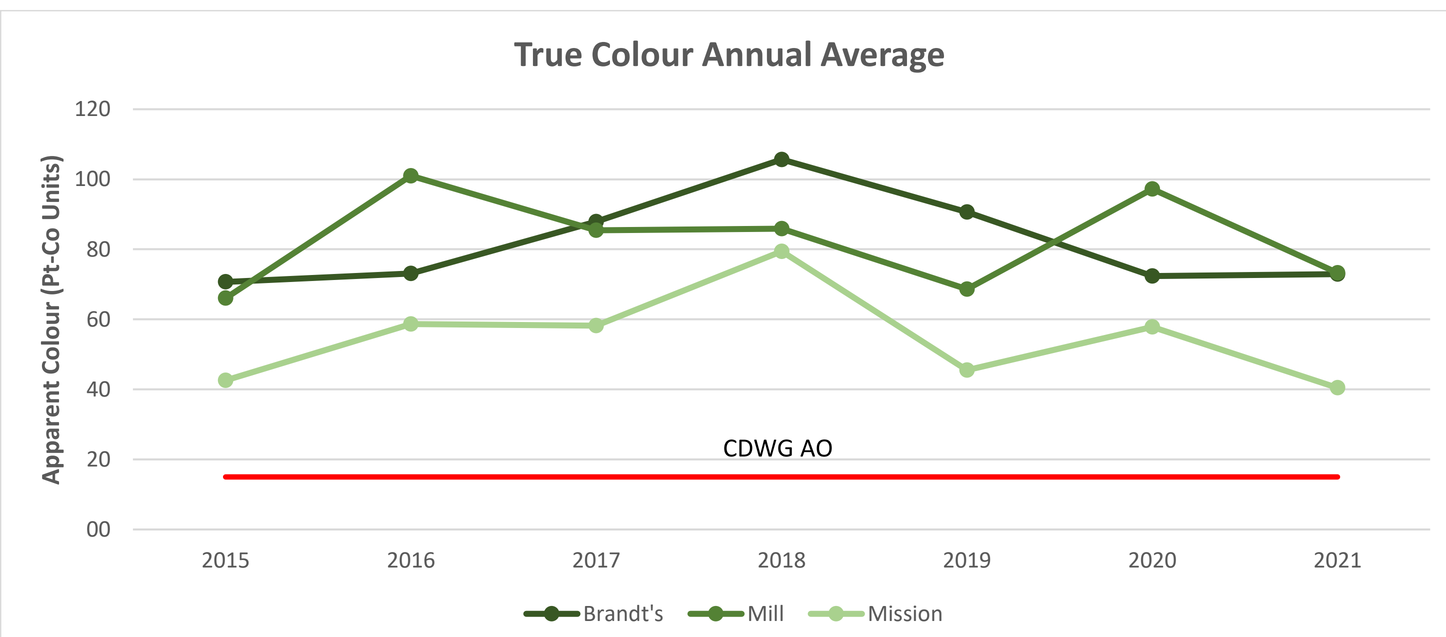


Figure 47. 7-Year Color average for creek samples

Conductivity

Conductivity concentrations, an indication of the amount of minerals in the water, trended lower through freshet with little evidence of impact of road salt application (Figure 48). The overall 7-year trend indicates that conductivity is increasing in the major tributaries and potentially influencing the overall conductivity in Okanagan Lake (Figure 49).

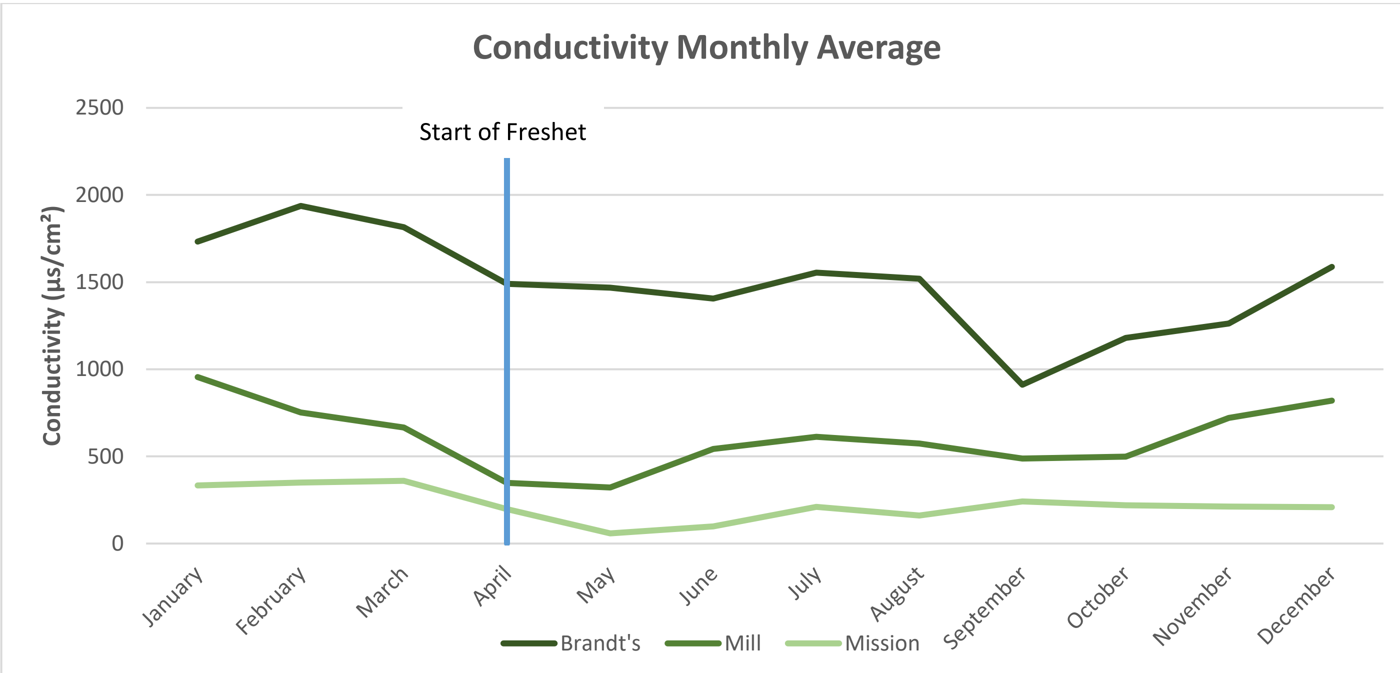


Figure 48. Monthly Conductivity averages for creek samples

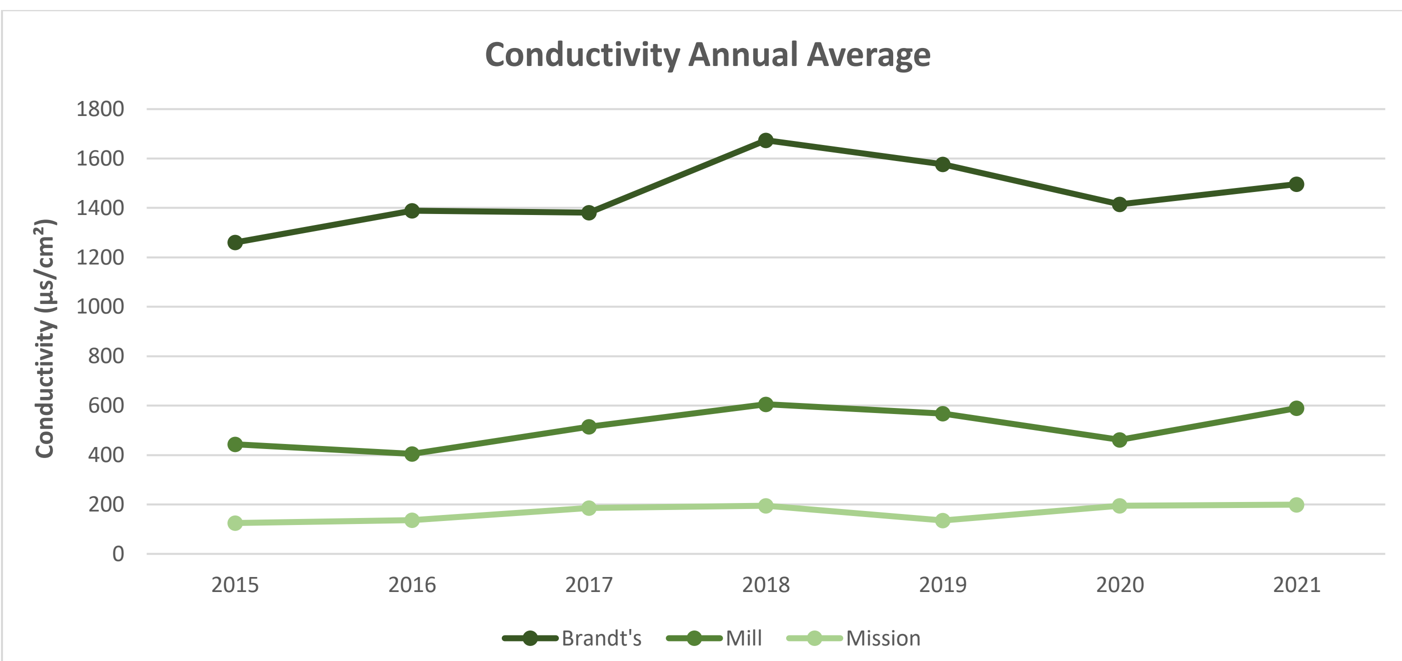


Figure 49. 7-Year Conductivity average for creek samples

Dissolved Oxygen

Dissolved Oxygen concentration levels above 14 mg/L or below 2 mg/L have a detrimental effect on aquatic life and becomes more saturated in colder water as is demonstrated in the seasonal measurement (Figure 50). Tributaries tested indicate that the monthly average for dissolved oxygen never went below the CCME lower range limit while the 7-year averages show a marginal increasing trend (Figure 51).

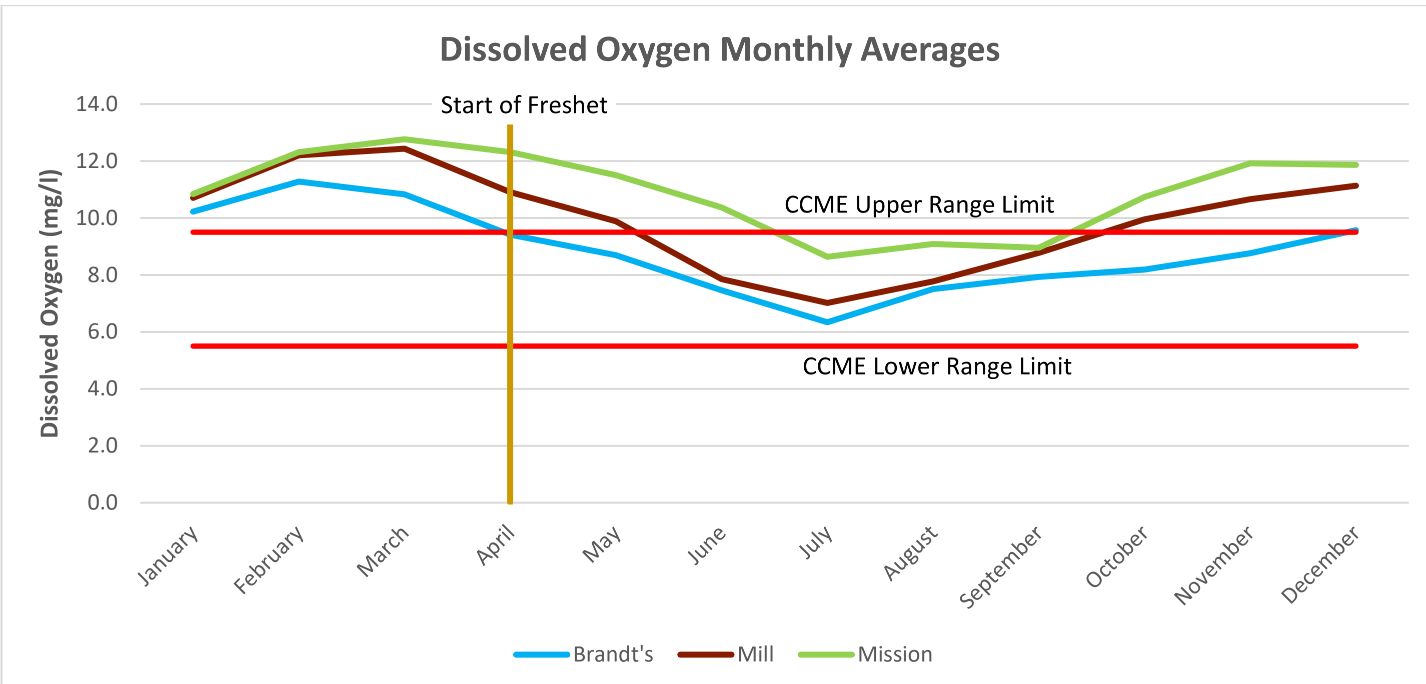


Figure 50. Monthly Dissolved Oxygen average for creek samples

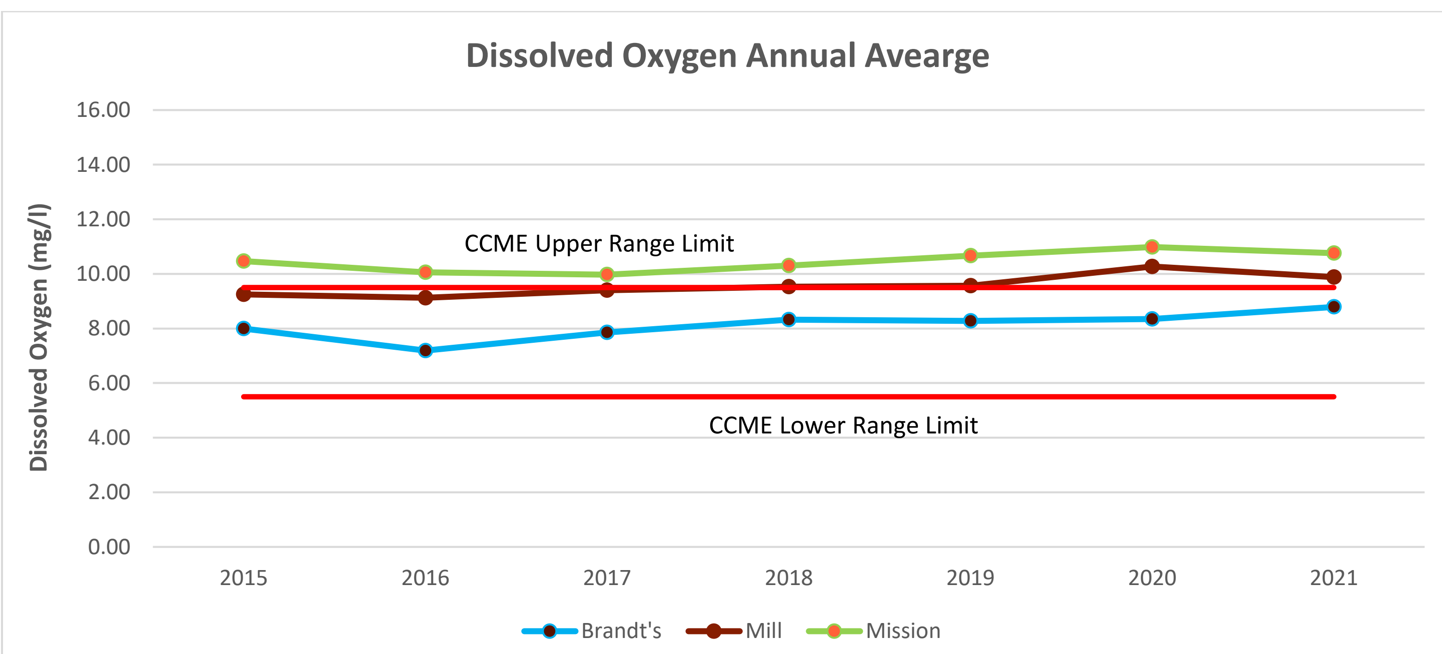


Figure 51. 7-year Dissolved Oxygen average for creek samples

E.coli.

The highest E. coli counts have typically been observed in Brandt's creek with elevated counts in the fall and winter most likely due to lower flow, lack of water freezing in the winter, and an increase in waterfowl present (Figure 52). The dredging of Mill creek in 2018/2019 most likely related to the overall increasing trend in E.coli. counts over the past 7 years (Figure 53). The only creek regularly observed within the Recreational guidelines is Mission creek.

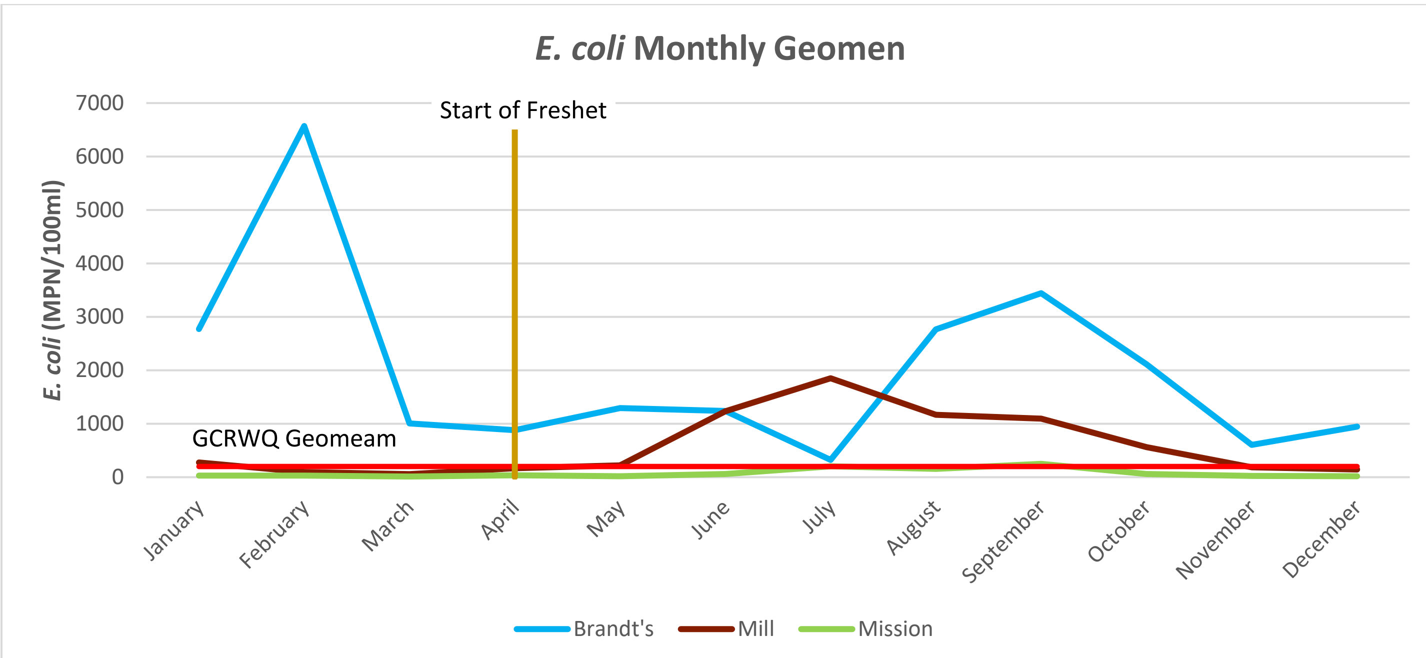


Figure 52. Monthly E. coli averages in creek samples

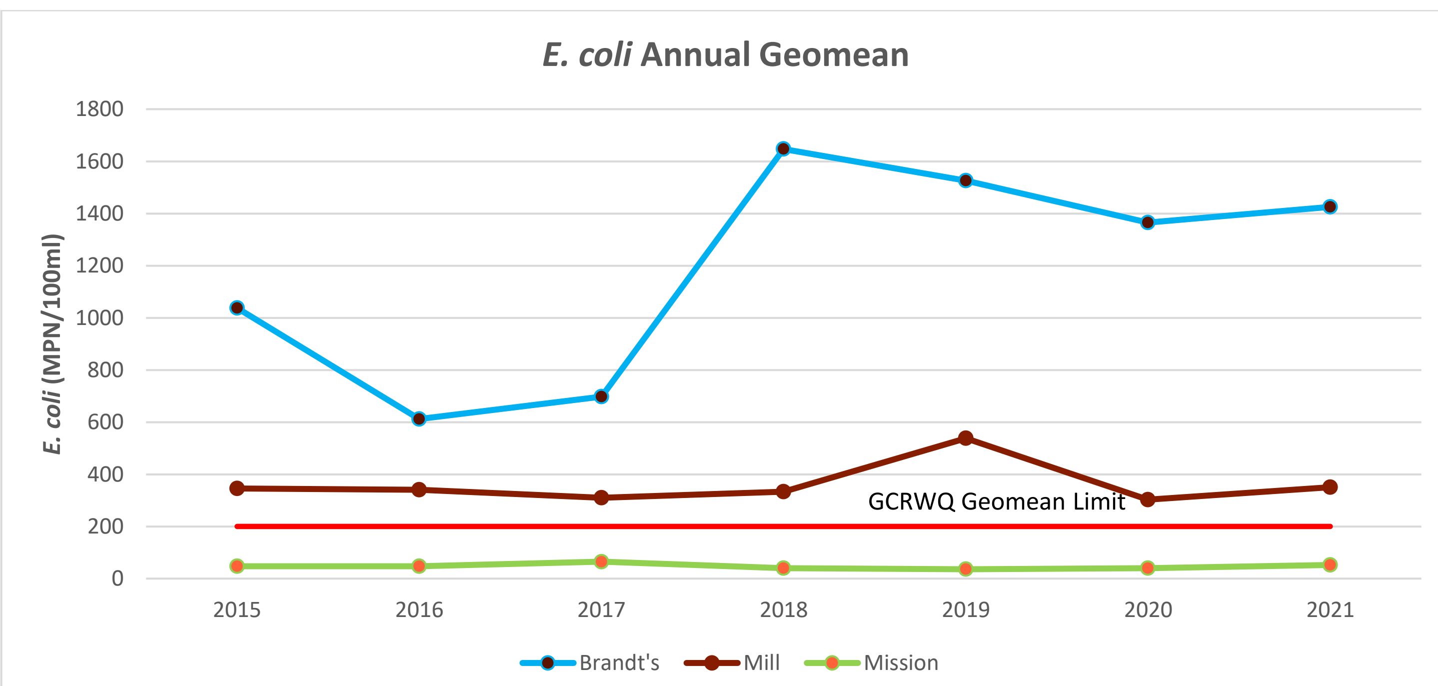


Figure 53. 7-year E.coli. average for creek samples

pH

Freshet periods tends to historically have an acidify effect on water quality while the most alkaline periods are observed during colder seasons (Figure 54).The 6-year trend indicates a modest decrease in all three creeks in 2020 relative to the previous 3 years, but all still within the drinking water guidelines ((Figure 55).

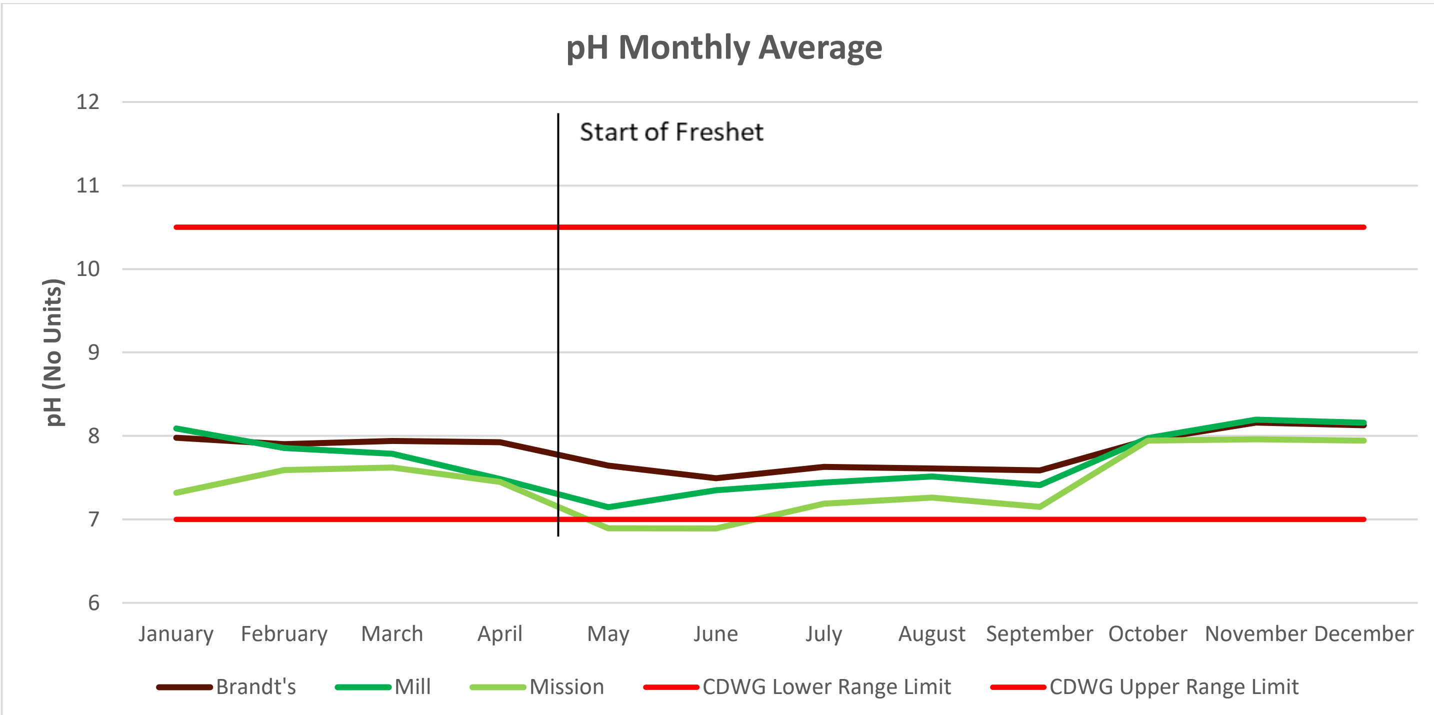


Figure 54. Monthly pH averages for creek samples

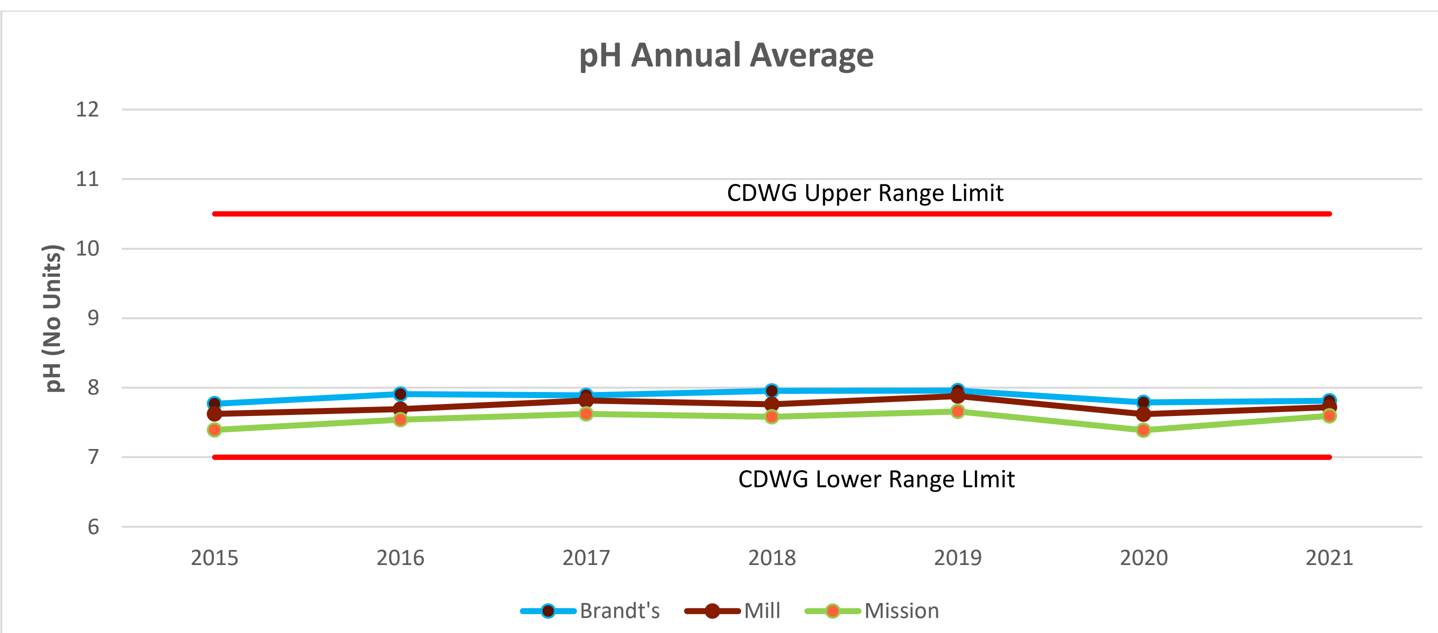


Figure 55. 7-year pH average for creek samples

Total Suspended Solids (TSS)

As with Color and Turbidity, Total Suspended Material increased during the intense freshet and rain events that flushed sediment through the tributaries (Figure 56). The overall trend saw a general rebound in TSS concentrations over the flooding years of 2017 and 2018 (Figure 57).

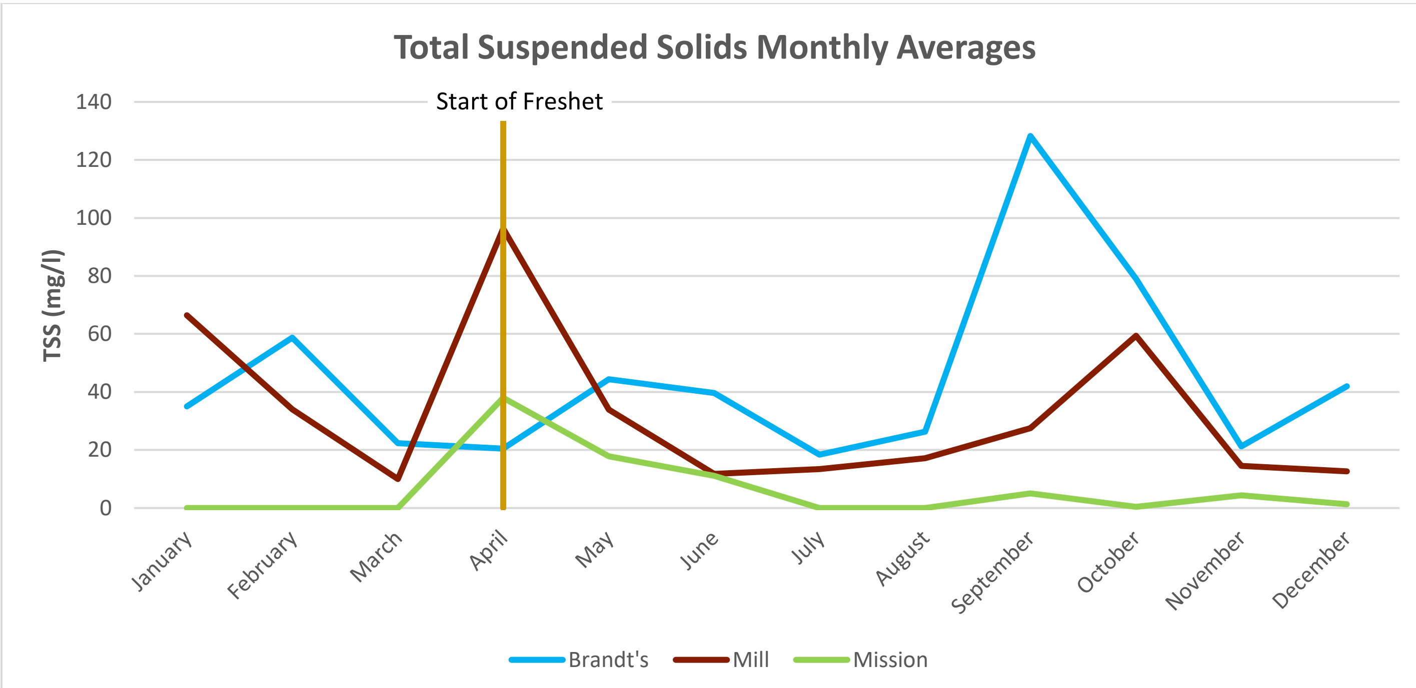


Figure 56. Monthly TSS averages for creek samples

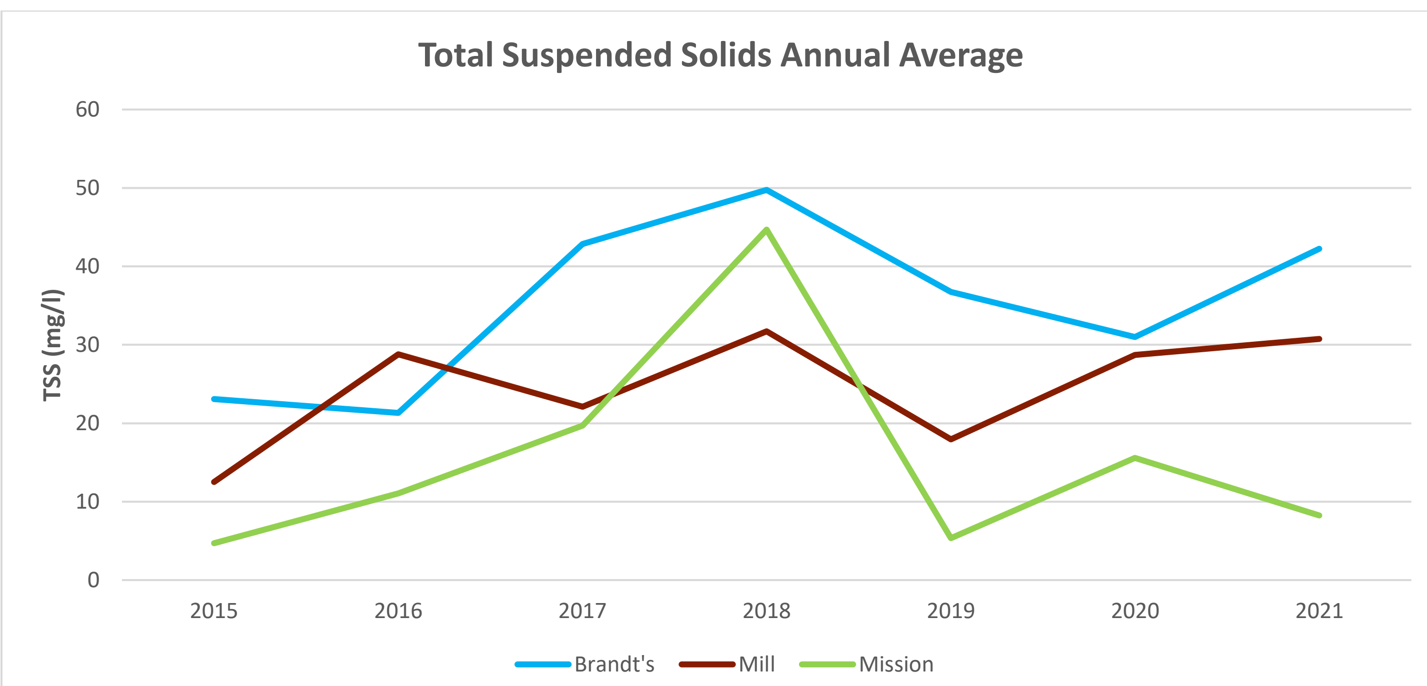


Figure 57. 7-year TSS average for creek samples

Turbidity

The monthly and year over year concentration patterns of Turbidity were closely linked to the concentration of Total Suspended Solids (Figures 56-59).

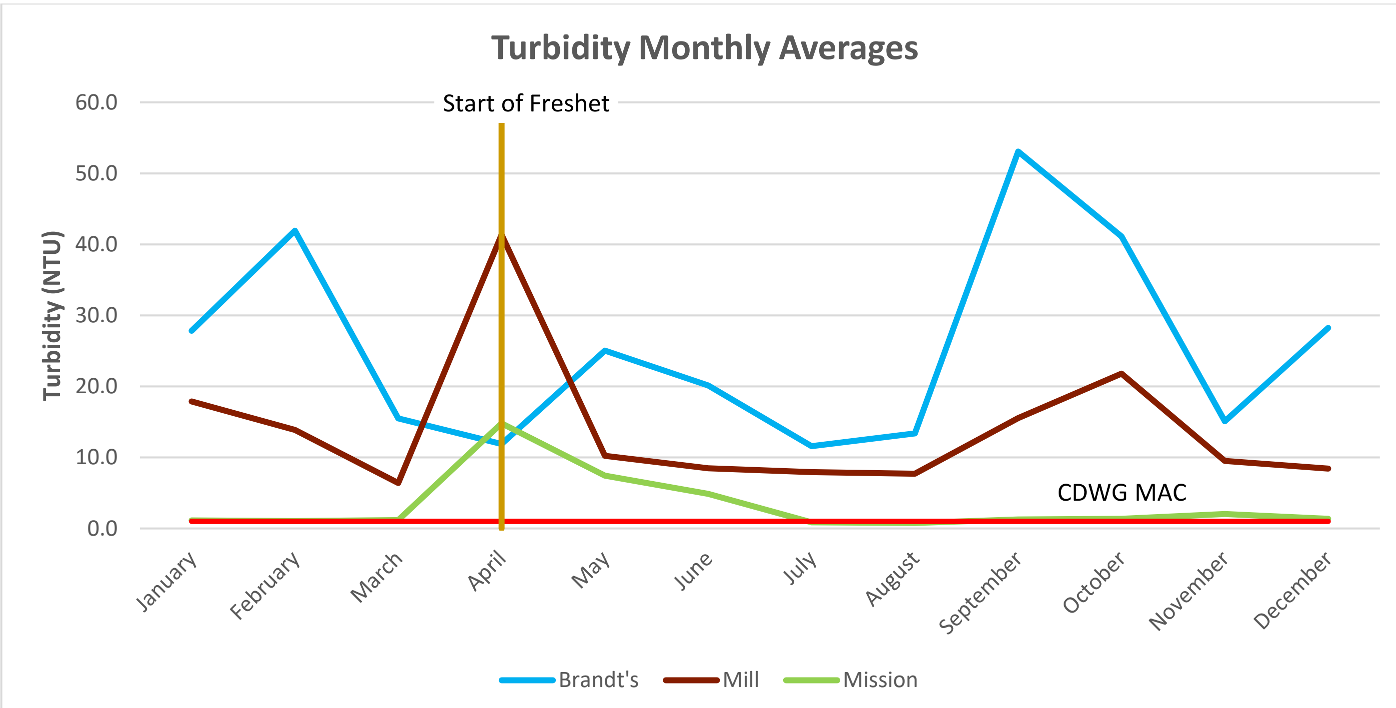


Figure 58. Monthly Turbidity averages for creek samples

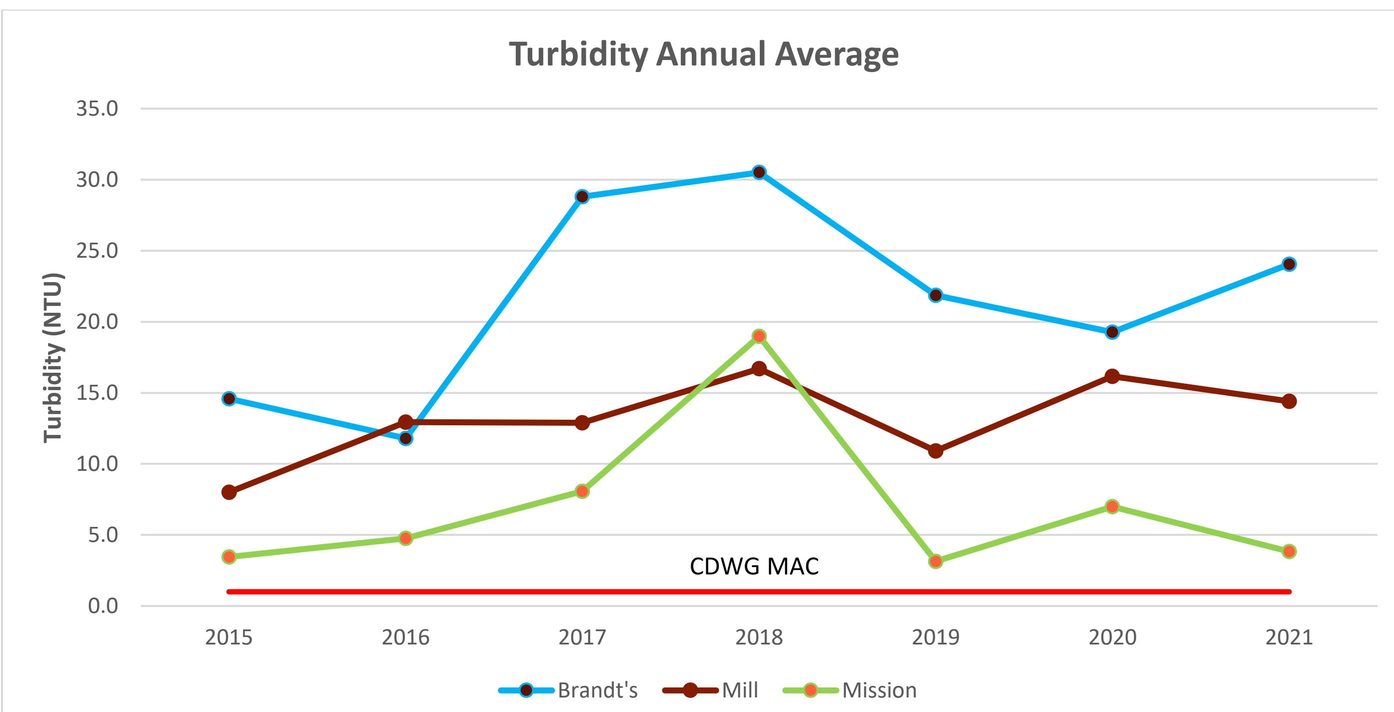


Figure 59. 7-yearTurbidity averages for creek samples

Temperature

The monthly temperature profile of each of the main tributaries was consistent with previous years, but overall average temperatures were 1-2 degrees cooler over the past 7 years (Figures 60-61).

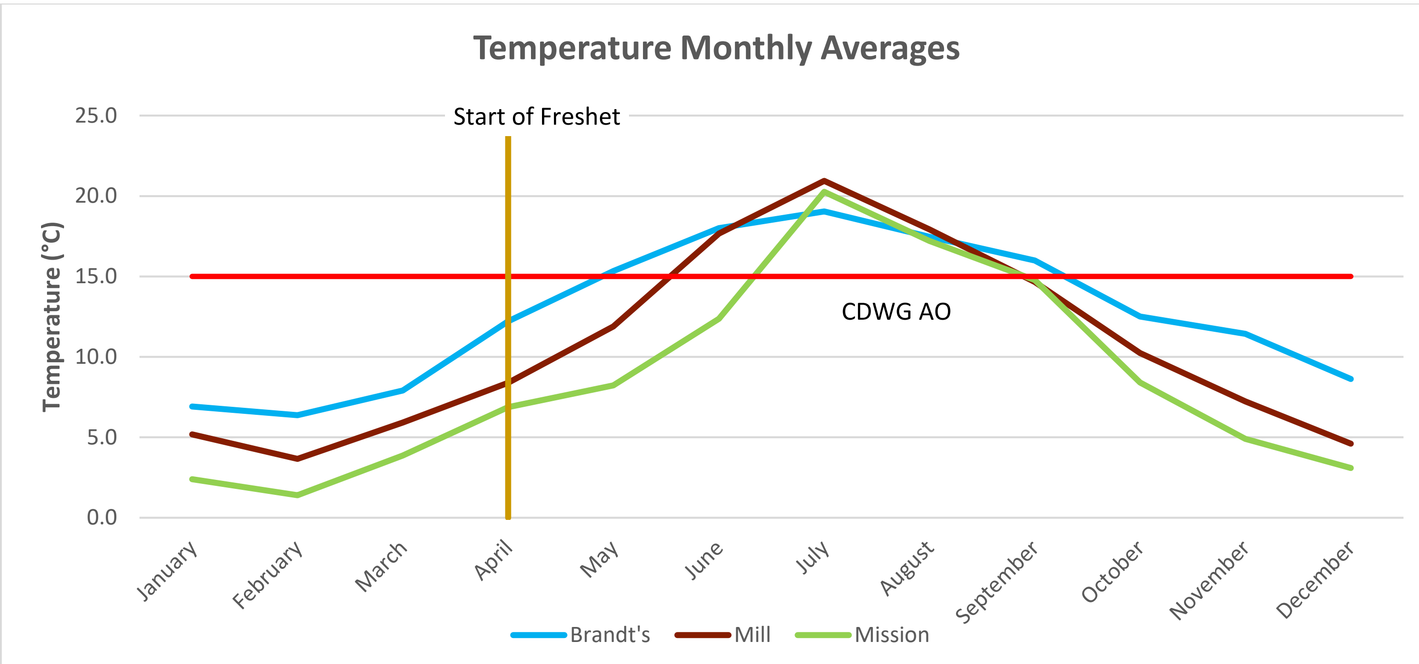


Figure 60. Monthly Temperature average for creek samples

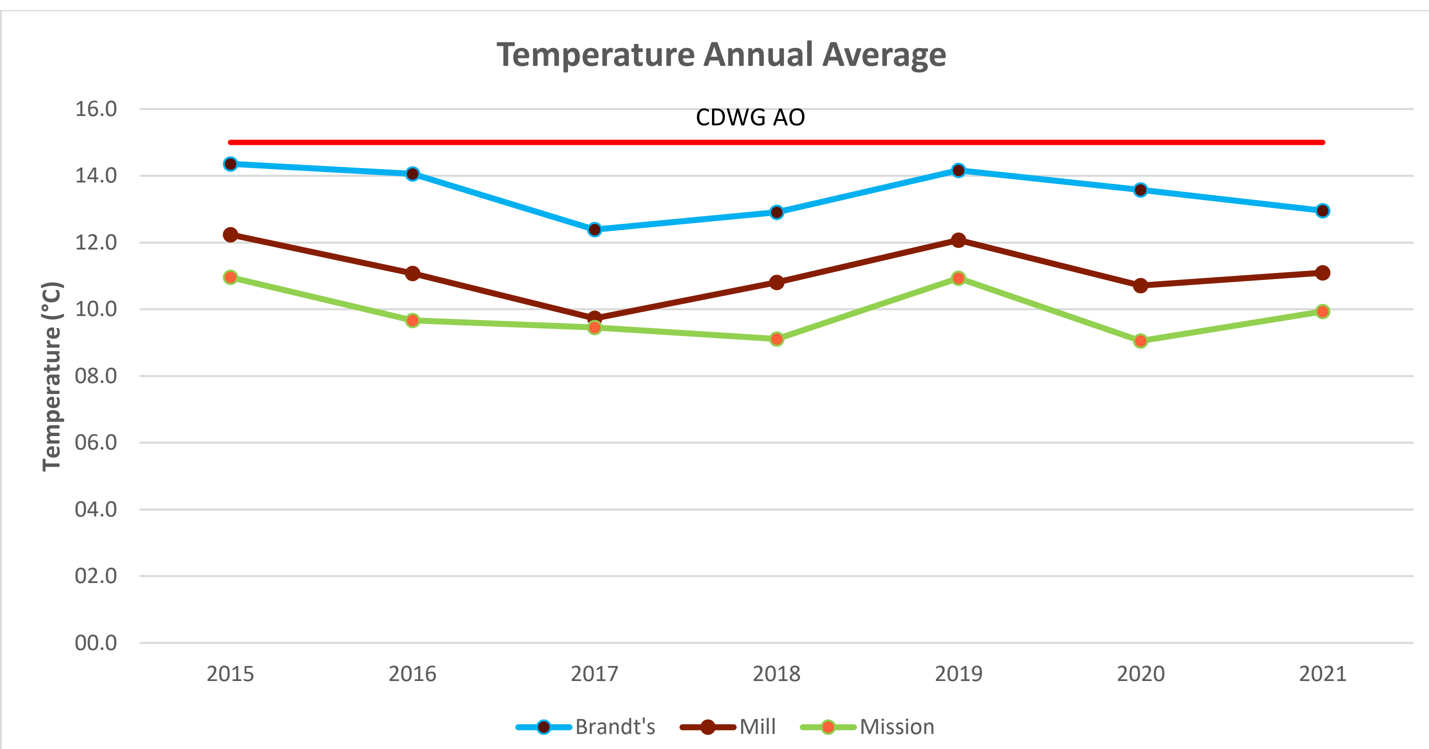


Figure 61. 7-year Temperature average for creek samples

<u>Nitrates and Phosphates</u>

Soluble nutrients and minerals carried through tributaries are one of the largest, consistent contributors of Nitrates and Phosphorus concentrations in OK lake. Monthly measurements do not indicate any elevated levels of nitrogen coinciding with freshet (Figure 62), but has been observed in a phosphorus spike in Mill and Brandt's (Figure 63). As this is only the second year of monitoring, longer term trends will be tracked moving forward.

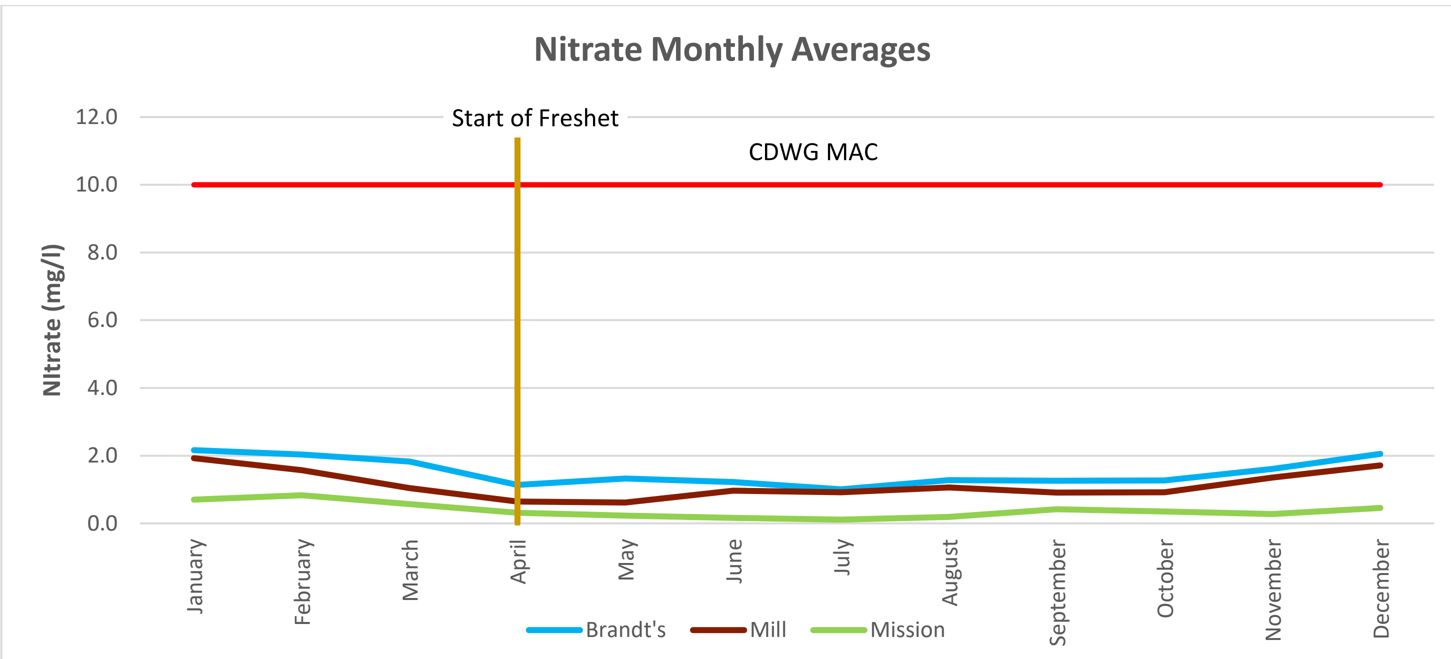


Figure 62. Monthly Nitrate concentrations for creek samples

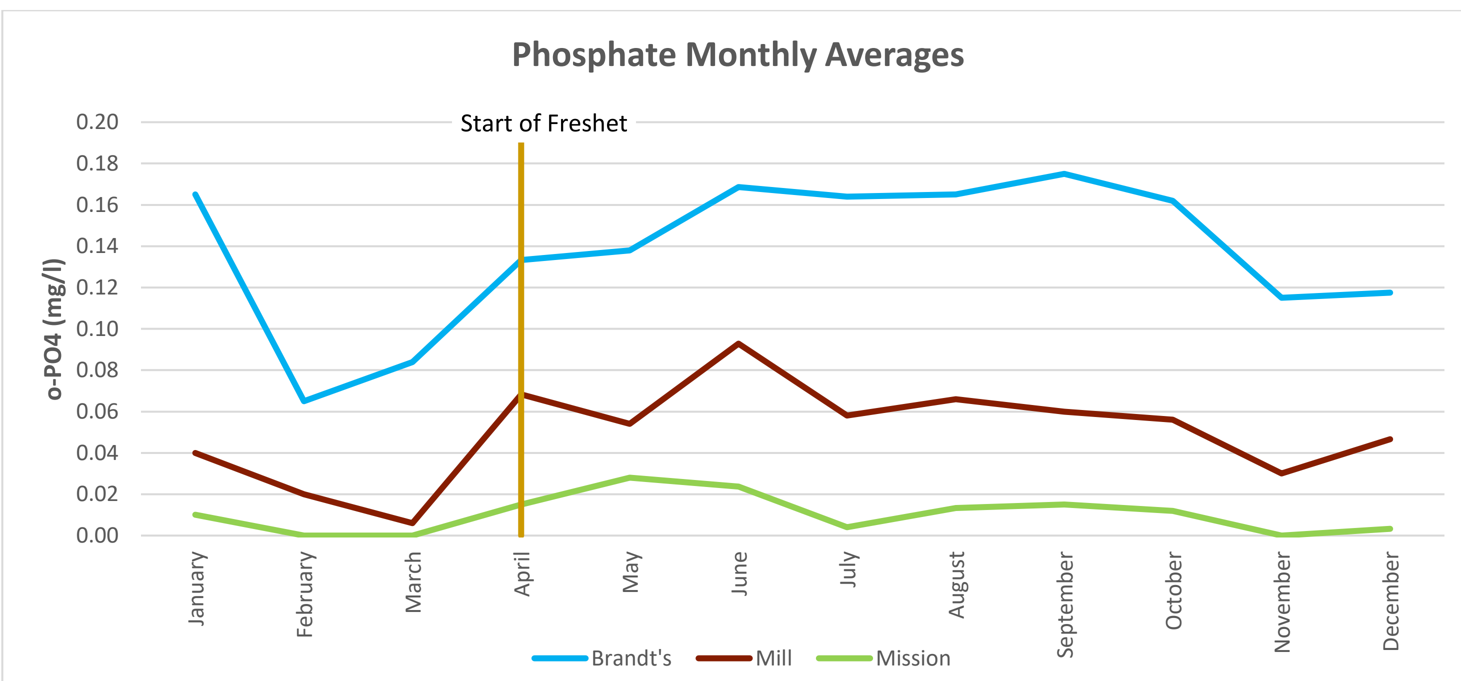
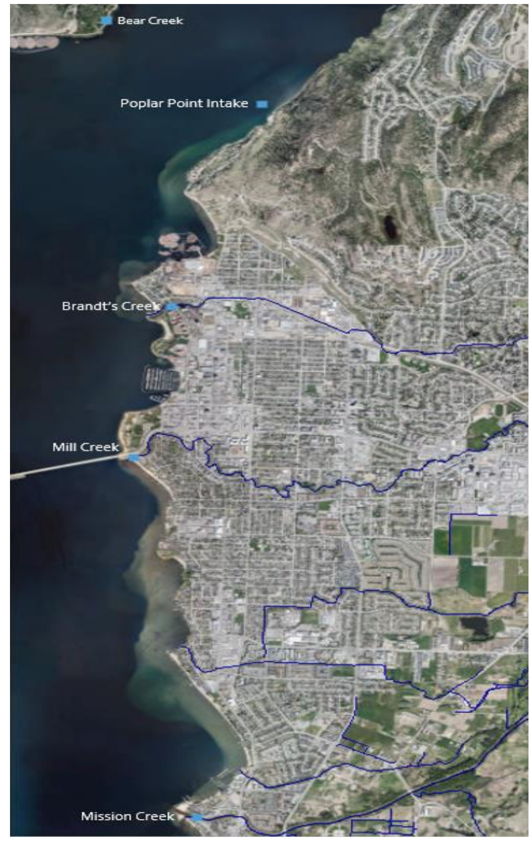


Figure 63. Monthly Phosphate concentrations for creek samples

Creek Testing during elevated Turbidity at Intakes

The mouths of Brandt's Creek, Mill Creek, and Mission Creek are sampled when there is increased Turbidity in raw water quality. Turbidity concentrations at the drinking water intakes are typically 0.5 NTU or below, but increases in the spring when freshet occurs, and the lake is mixing. The intent of this tracking is to potentially correlate the contribution of creek Turbidity and *E. coli* concentrations to Turbidity at the Intakes and subsequent natural asset planning and restoration that could take place in the future to minimize these impacts. It also provides a predictive model to assess elevated risk and allow for operational treatment adjustments in preparation for such impacts.



<u>Poplar Point Intake</u>

Although Brandt's Creek has the closest proximity to the Poplar Point intake, it's relatively low flow and drainage into a designated wetland before entering the lake prevents it from having a significant impact. In past years, Mill and Mission Creeks have proven to be water quality influencers when wind and current direction move northward, but Turbidity and E. coli measurements do not indicate that to be an issue in 2021 (Figure 64, 65). Bear also did not appear to have a significant contribution to elevated counts during freshet.

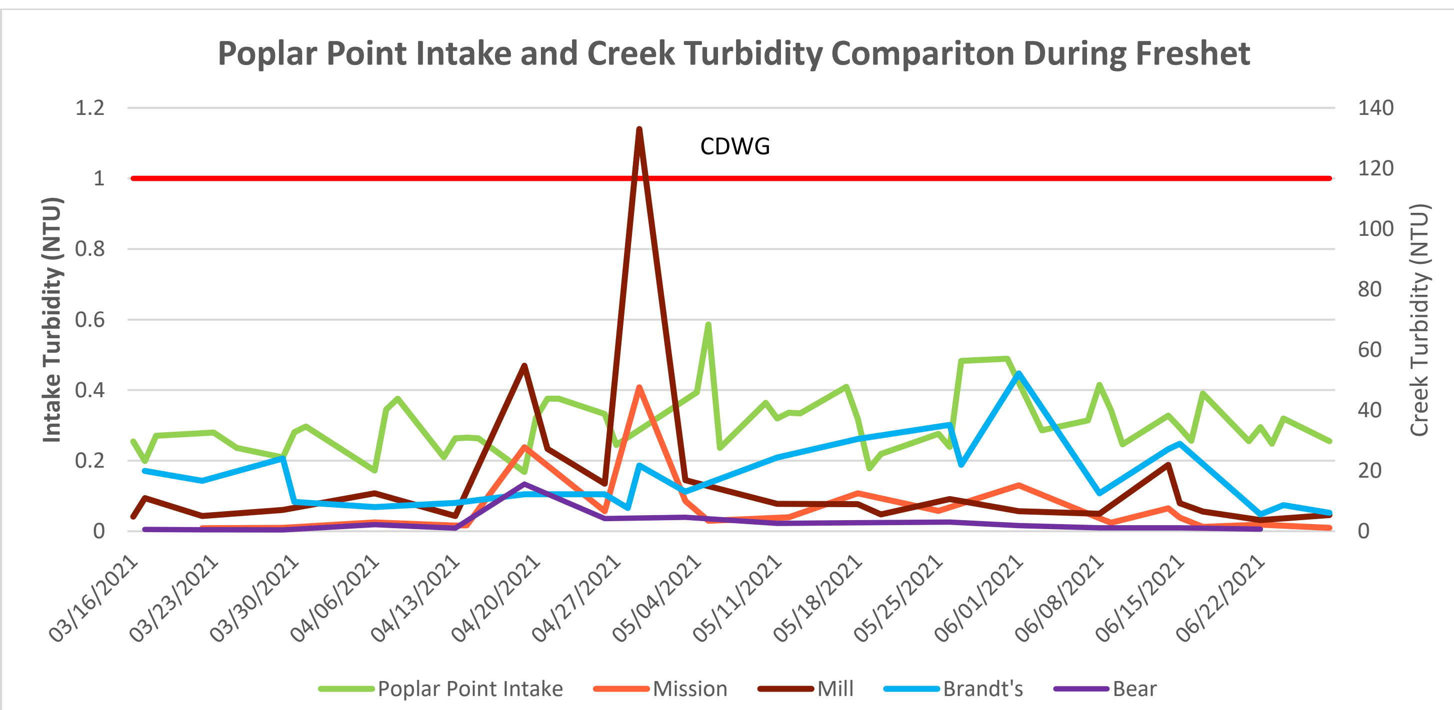


Figure 64. Poplar Point Intake Turbidity relative to surrounding Tributary Turbidities during freshet

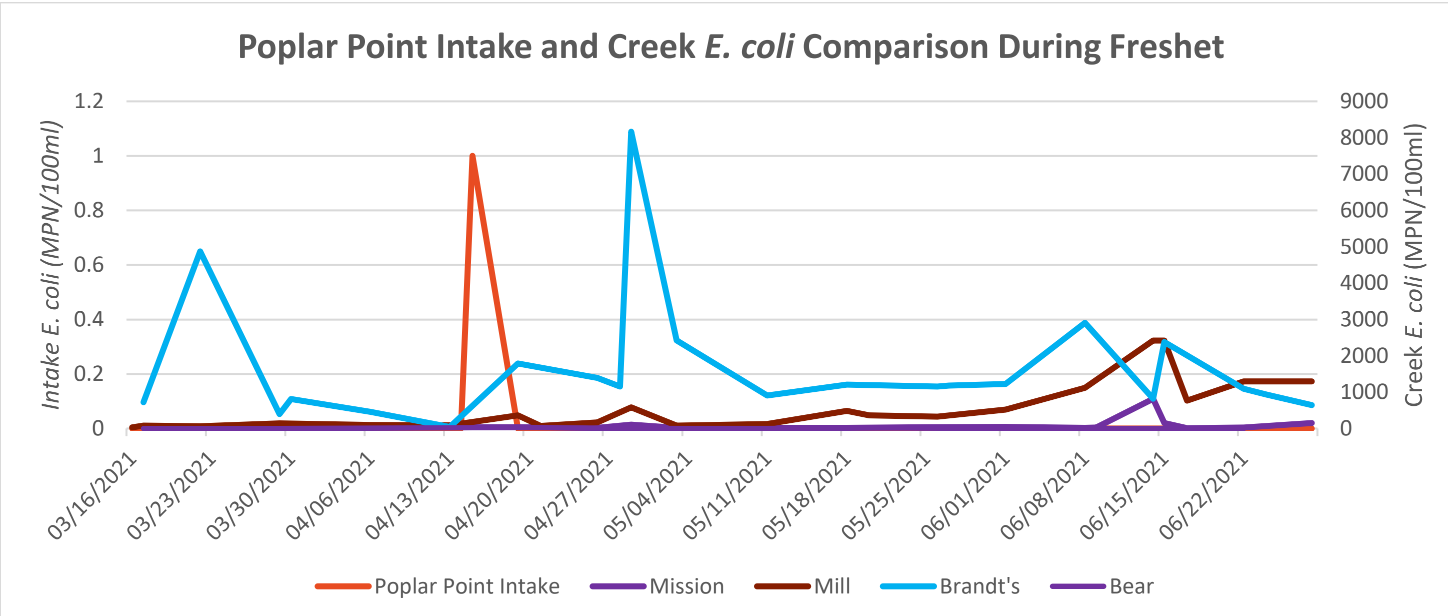


Figure 65. Poplar Point Intake E. coli relative to surrounding Tributary E. coli during freshet

<u>Cedar Creek Intake</u>

Historically, Mission Creek has proven to have the highest impact to water quality at the Cedar Creek intake due to the high volume of water and proximity, but is very much dependent on wind and current direction. There appeared to be only a minimal connection between Mission and Cedar Turbidity as well as between Bellevue Creek E. coli and Cedar E. coil (Figure 66, 67).

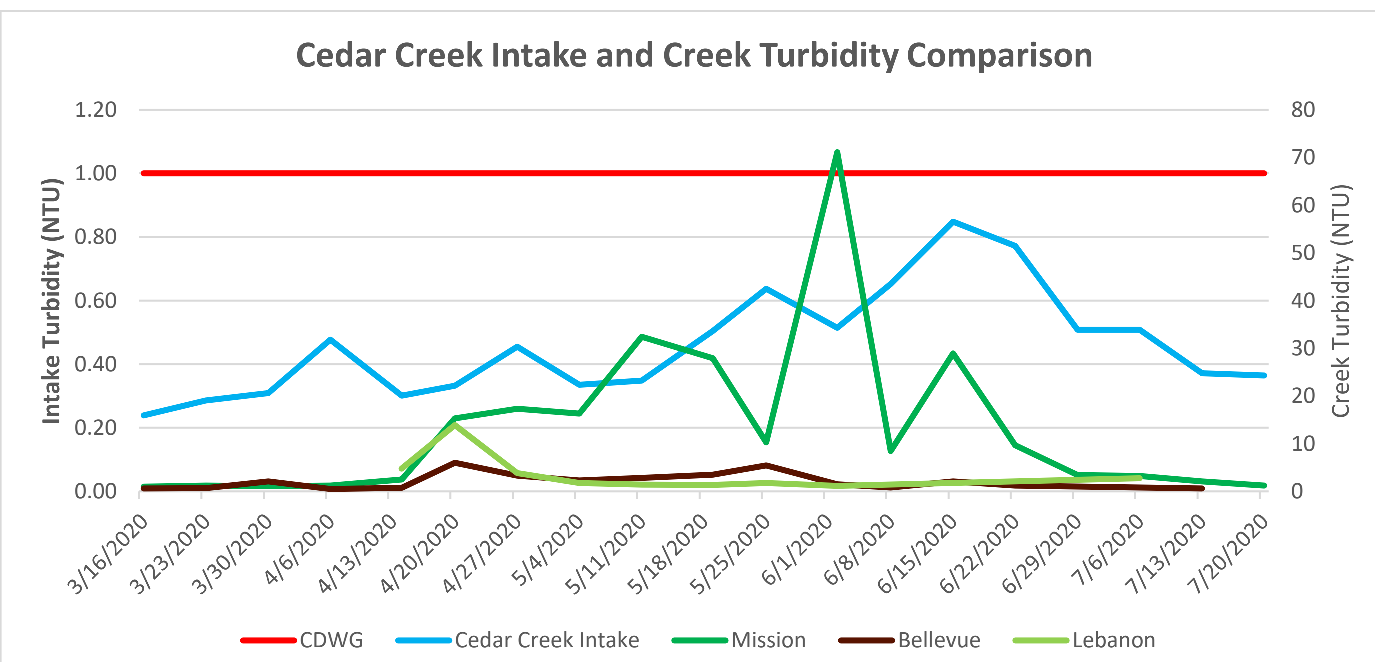


Figure 66. Cedar Creek Intake Turbidity relative to surrounding Tributary Turbidities during freshet

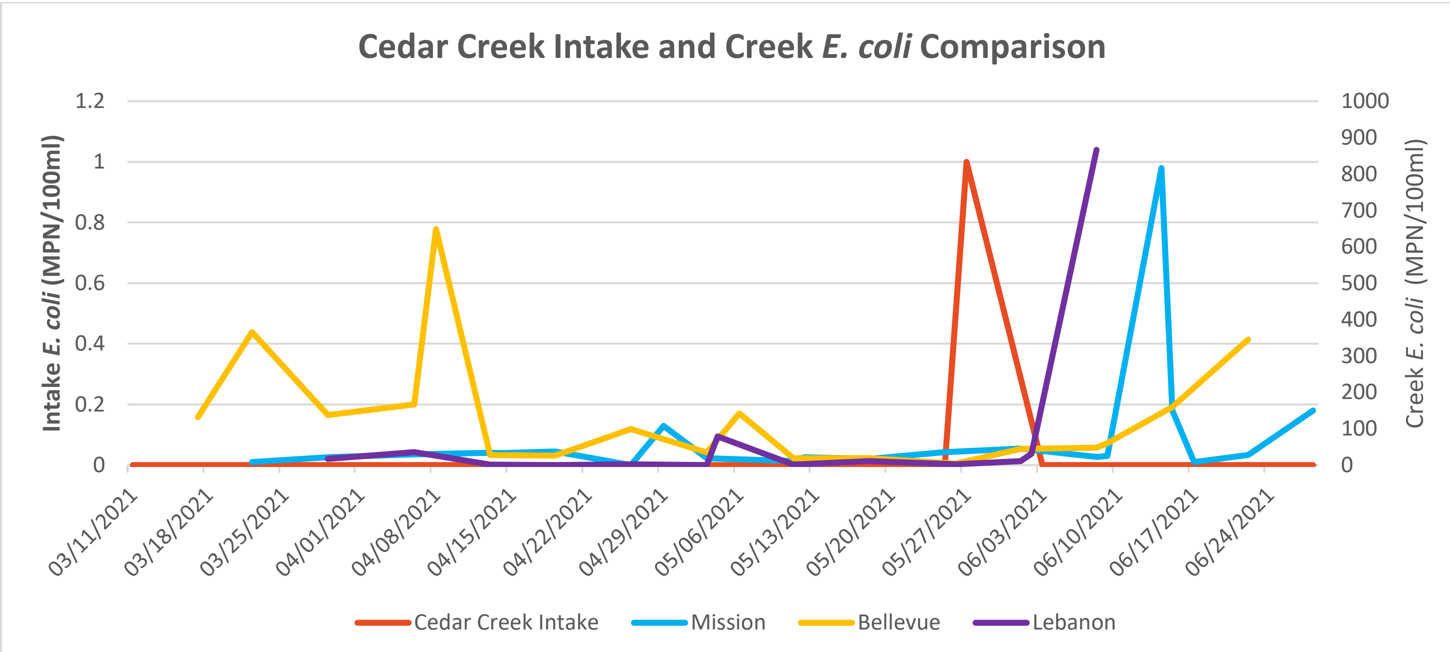


Figure 67. Cedar Creek Intake E. coli relative to surrounding Tributary E. coli during freshet

<u>Eldorado Intake</u>

Due to the relatively shallower depth, Eldorado has typically seen the highest impact from tributary water quality. Both Mission and Mill creeks have historically had the greatest influence, but 2020 measurements only indicated a marginal impact and did not appear to have a significant impact (Figure 68). E.coli counts remained low through the seasonal use of the intake, similar to the creeks (Figure 69).

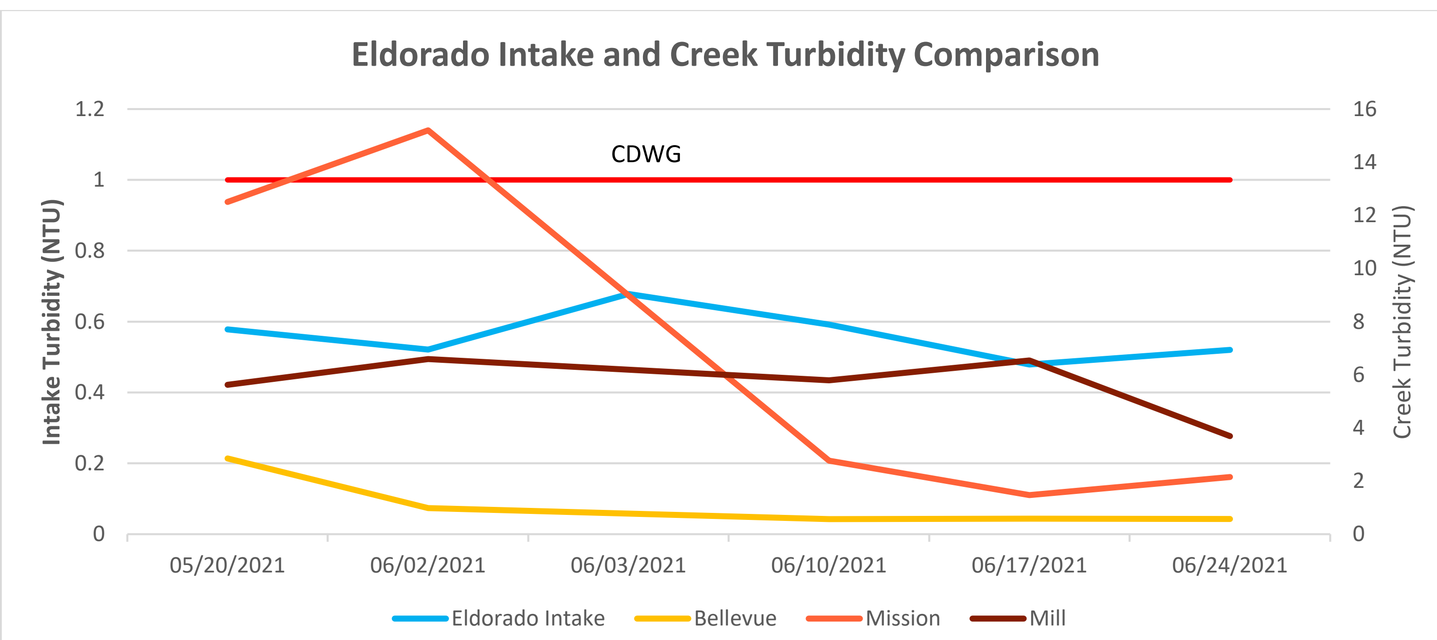


Figure 68. Eldorado Intake Turbidity relative to surrounding Tributary Turbidities during freshet

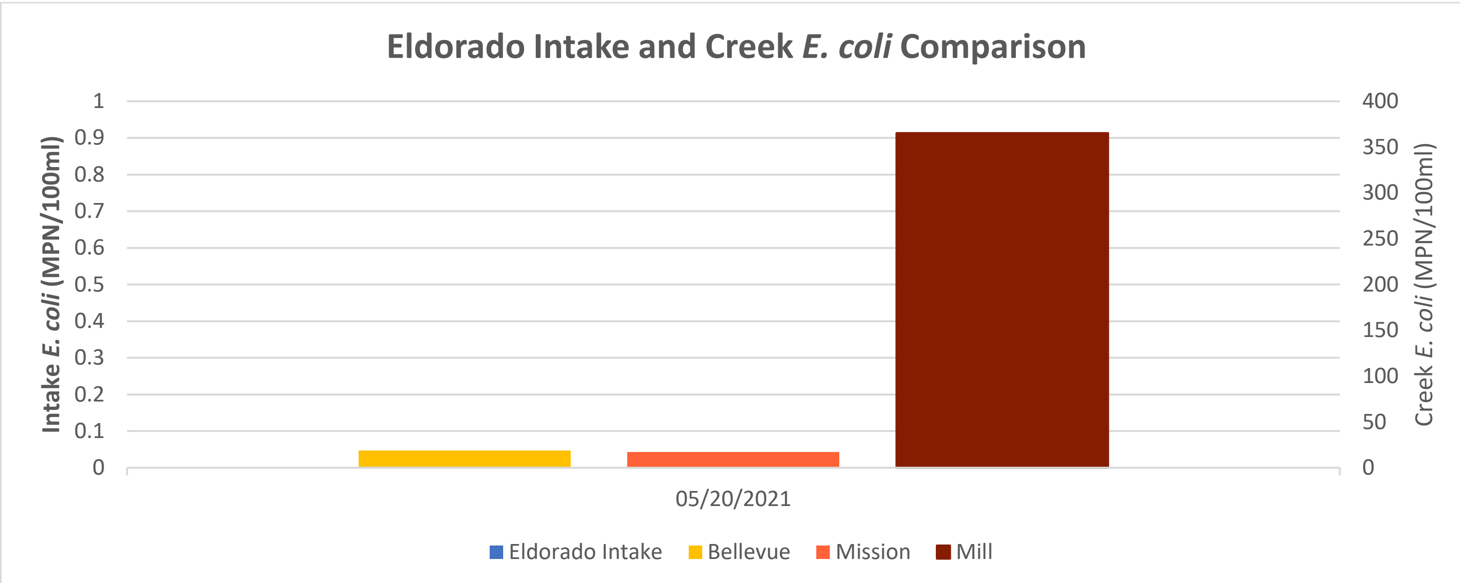


Figure 69. Eldorado Intake E. coli relative to surrounding Tributary E. coli during freshet

Swick Intake

Varty creek has the closest proximity in relation to Swick, but the impact varies dramatically based on the overall volume and time span of the snowmelt in the lower snow shed. Other creeks in the area are considered seasonal as well and did not appear to have any significant impact to the observed Turbidity or E.coli counts at the Swick intake (Figure 70, 71).

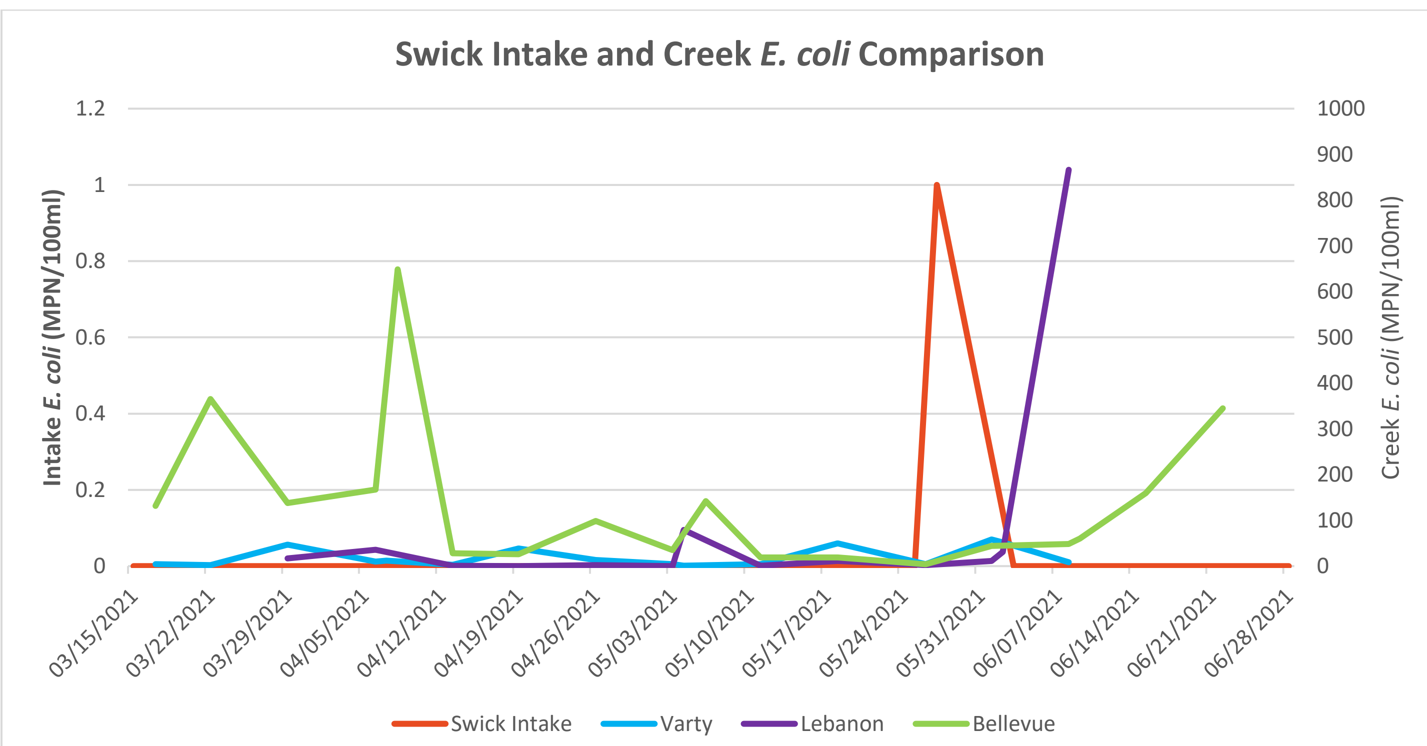


Figure 70. Swick Intake Turbidity relative to surrounding Tributary Turbidities during freshet

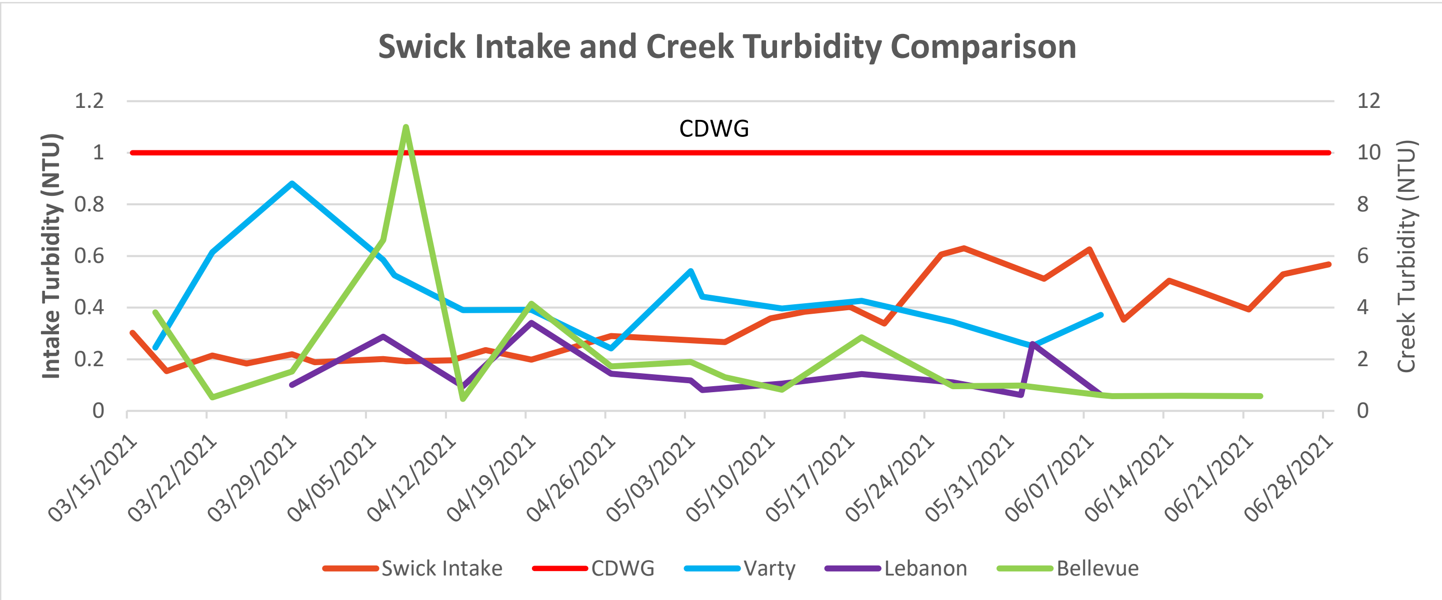


Figure 71. Swick Intake E. coli relative to surrounding Tributary E. coli during freshet

First Flush and Rain Event Monitoring at Outfalls

First flush is defined as the first major rain or snow melt that would push significant material through the storm water system and eventually into Okanagan lake. Brandt's Creek and Mill Creek outfalls were monitored during the first flush and rain events of more than 5mm during March-October (Table 34-35). As expected, there was consistent trend of First Flush depositing the highest amount of Suspended Solids, Color, E. coli and Turbidity into the creeks relative to subsequent rain events. Conductivity, Chloride, and pH all tended to drop as a result of a dilution and buffering and acidity effect of the snow / rain water – which is consistent with previous years' trend.

Brandt's Creek Outfall						
Parameter	Brandt's Creek at Brant Ave, Apr 28, 2021, Pre-Rainfall	Rain Event ~7.7mm, April 29, 2021	Brandt's Creek at Brant Ave, Aug 31, 2021, Pre-Rainfall	Rain Event ~10mm, Aug 31, 2021	Brandt's Creek at Brant Ave, Sept 22, 2021, Pre-Rainfall	Rain Event ~13mm, Sept 27, 2021
Ammonia (mg/l)	0.05	0.5	0.05	0.36	0.07	0.42
Chloride (mg/l)	82	30	85	13	85	21
True Color (Pt-Co Units)	44	446	58	542	9	353
Conductivity (µs/cm²)	1991	233	1820	127137	1776	93
Dissolved Oxygen (mg/l)	9.28	8.81	7.83	8.69	8.47	8.77
E. coli (MPN/100ml)	30	538	644	1860	389	1553
Nitrate as NO3 (mg/l)	1.6	0.8	1.97	0.31	2.46	0.4
Total Phosphate as PO4 (mg/l)	0.14	0.55	0.1	0.24	0.19	0.32
pH	8.15	7.74	8.14	8.24	8.01	7.59
Total Suspended Solids (mg/l)	11	97	50	238	26	46
Temperature (°C)	12.5	14.4	15.9	16	14.9	16.1
Turbidity (NTU)	7.01	54.6	30.2	160	15.4	46.1

Table 34. Water Quality at Brandt's creek during rainfall events

Mill Creek Outfall						
Parameter	Mill Creek at Hardy St, June 14, 2021, Pre-Rainfall	Rain Event ~ 8mm, June 17, 2021,	Mill Creek at Hardy St, Sept 21, 2021, Pre-Rainfall	Rain Event ~7mm, Sept 27, 2021	Mill Creek at Hardy St, Oct 18, 2021, Pre-Rainfall	Rain Event ~10mm, Oct 28, 2021
Ammonia (mg/l)	0.04	0.01	0.04	0.58	0.02	0.14
Chloride (mg/l)	28	73	32	21	27	11
True Color (Pt-Co Units)	54	115	47	459	36	218
Conductivity (µs/cm²)	511	494	512	167	491	88
Dissolved Oxygen (mg/l)	9.19	8.2	9.73	8.38	10.7	10.5
E. coli (MPN/100ml)	816	>2420	140	882	344	364
Nitrate as NO3 (mg/l)	1.1	1.34	0.93	0.54	1.0	0.34
Total Phosphate as PO4 (mg/l)	0.08	0.13	0.05	0.18	0.02	0.1
pH	8.1	7.2	8.04	7.54	7.87	7.78
Total Suspended Solids (mg/l)	12	22	9	38	8	60
Temperature (°C)	16.1	16.5	12.1	17.4	9.8	9.1
Turbidity (NTU)	6.59	14.9	4.79	54.3	3.8	44.8

Table 35. Water quality at Mill creek during rainfall events

Fascieux Creek Rain Event Sampling

Fascieux Creek is a typical storm collection creek within the Utility boundary that is monitored at multiple locations during rain events to potentially identify contamination connected with raw sewage. Along with various chemical parameters, E. coli. is the primary indicator for storm / sanitary interconnection as it is not naturally occurring and carries a significant health risk. Further investigation is required in the event that E. Coli. counts are in excess of 25,000 MPN/100mL. Chemical and Biological profiles and trends recorded were similar to that noted at the Brandt's and Mill Creek outfalls (Tables 34-35). The tested samples did not indicate any significant increase in E. coli. concentrations, which indicates that there are no current interconnection issues with sanitary for this outfall system.

Fascieux Creek at Gosnell Drive					
Parameter	Rain Event ~7mm, April 29, 2021	Rain Event ~8mm, June 14, 2021	Rain Event ~9.5mm, Sept 27, 2021	Rain Event ~10,mm, Oct 28, 2021	2021 Average
Ammonia (mg/l)	0.10	0.06	0.09	0.10	0.09
Chloride (mg/l)	17	13	5	13	13
True Color (Pt-Co Units)	98	63	94	82	84
Conductivity (µs/cm²)	334	247	287	254	280
Dissolved Oxygen (mg/l)	6.86	6.54	6.5	7.72	6.91
E. coli (MPN/100ml)	1450	135	1162	1112	965
Nitrate as NO3 (mg/l)	0.39	0.36	0.35	0.34	0.36
Total Phosphate as PO4 (mg/l)	0.16	0.17	0.12	0.18	0.16
pH	7.46	7.20	7.54	7.71	7.48
Total Suspended Solids (mg/l)	9	7	6	10	8
Temperature (°C)	11.8	15.0	15.3	11.1	13.3
Turbidity (NTU)	6.7	4.6	8.1	11.3	7.7

Table 36. Water quality test results of Fascieux Creek at Gosnell during rain events

Fascieux Creek at Gordon Drive					
Parameter	**Rain Event ~7mm, April 29, 2021**	**Rain Event ~8mm, June 14, 2021**	**Rain Event ~9.5mm, Sept 27, 2021**	**Rain Event ~10,mm, Oct 28, 2021**	**2021 Average**
Ammonia (mg/l)	0.12	0.01	0.18	0.14	0.11
Chloride (mg/l)	17	9	16	21	16
True Color (Pt-Co Units)	113	93	113	211	133
Conductivity (µs/cm²)	230	165	339	193	232
Dissolved Oxygen (mg/l)	8.20	6.64	5.60	8.86	7.33
E. coli (MPN/100ml)	256	155	1198	546	539
Nitrate as NO3 (mg/l)	0.70	0.44	0.35	0.31	0.45
Total Phosphate as PO4 (mg/l)	0.11	0.23	0.07	0.22	0.16
pH	7.57	7.20	7.41	7.58	7.44
Total Suspended Solids (mg/l)	12	4	10	29	14
Temperature (°C)	12.1	14.9	15.6	9.8	13.1
Turbidity (NTU)	8.3	7.2	12.3	30.8	14.7

Table 37. Water quality test results of Fascieux Creek at Gordon during rain events

Fascieux Creek at Watt Road					
Parameter	**Rain Event ~7mm, April 29, 2021**	**Rain Event ~8mm, June 14, 2021**	**Rain Event ~9.5mm, Sept 27, 2021**	**Rain Event ~10,mm, Oct 28, 2021**	**2021 Average**
Ammonia (mg/l)	0.25	0.01	0.36	0.13	0.19
Chloride (mg/l)	30	17	16	21	21
True Color (Pt-Co Units)	101	100	110	183	124
Conductivity (µs/cm²)	420	313	322	223	319
Dissolved Oxygen (mg/l)	7.10	4.42	6.79	9.09	6.85
E. coli (MPN/100ml)	697	816	1725	487	931
Nitrate as NO3 (mg/l)	0.42	0.61	0.35	0.40	0.45
Total Phosphate as PO4 (mg/l)	0.20	0.11	0.13	0.18	0.16
pH	7.45	7.10	7.40	7.59	7.39
Total Suspended Solids (mg/l)	6	11	18	159	49
Temperature (°C)	13.3	16.1	16.1	10.6	14.0
Turbidity (NTU)	8.4	9.0	14.8	77.4	27.4

Table 38. Water quality test results of Fascieux Creek at Watt during rain events

Beach Sampling for *E. coli*

City of Kelowna beaches were sampled at eleven sites once a week from June to September of 2021. The beaches sampled were City Park (2 sites), Gyro Beach Park (2 sites), Rotary Beach Park (2 sites), Sarson's Beach Park (2 sites), Strathcona Park (1 site), and Waterfront Park (2 sites). The graphs indicate the geometric mean for each site relative to the geometric mean guideline, which is the primary determining factor when beaches need further testing or required water quality notification for swimmers. Rotary consistently had the highest E.coli. counts of any beach and resulted in swimming notifications for short periods of time in September (Figure 72, 73).

Exceedances were attributed to a number of factors including larger numbers of water fowl in the area, high densities of milfoil, wind events, warm weather, and current flow. Testing from a number of stormwater outfalls in the area did not indicate the presence of fecal matter that would have contributed to these events.

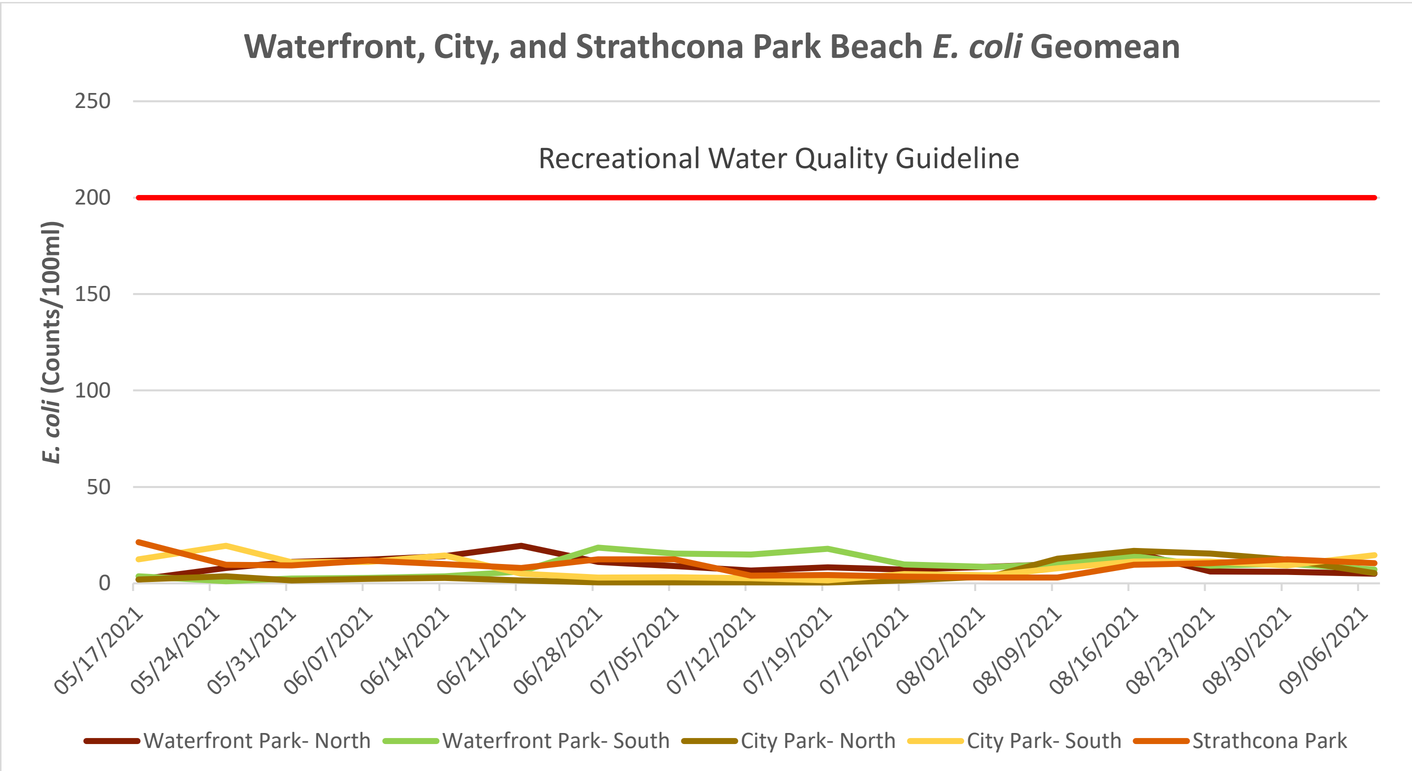


Figure 72. E. Coli. test results at north Kelowna beaches

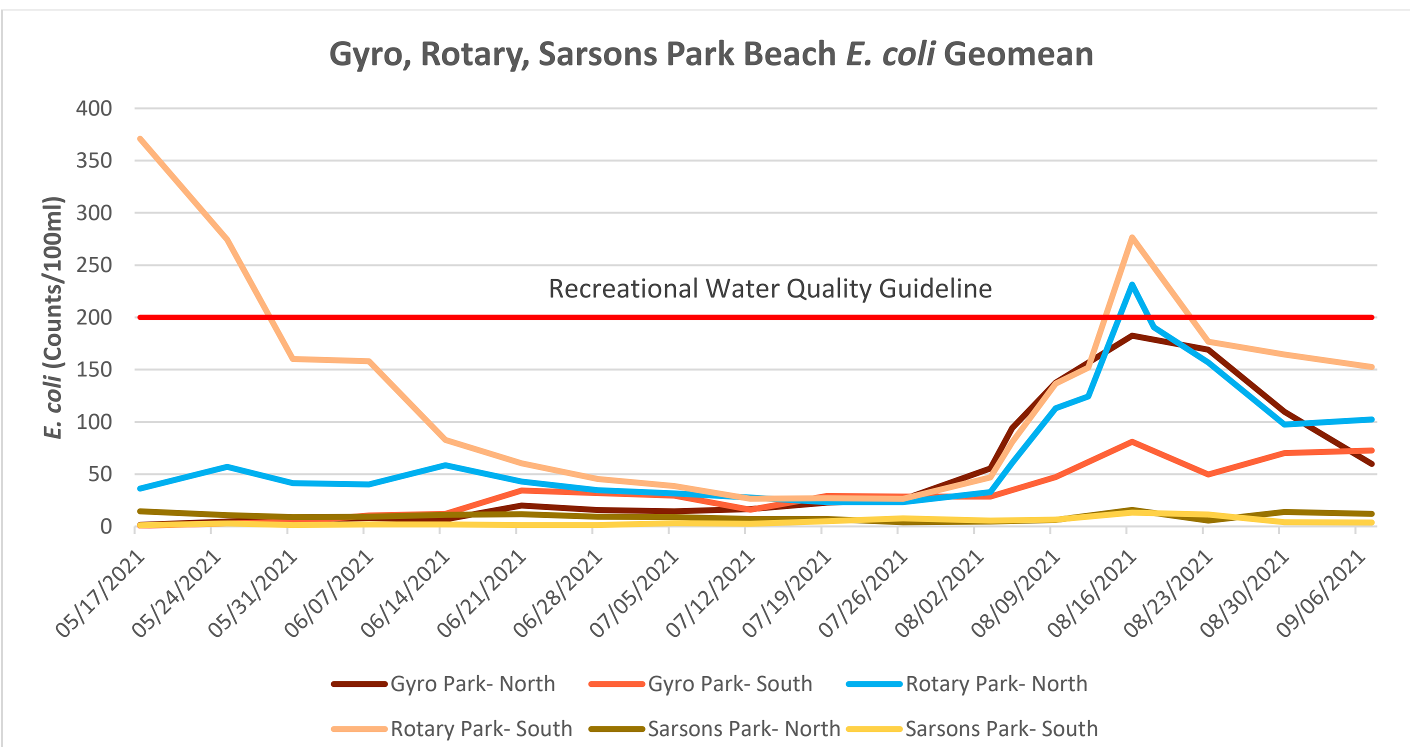


Figure 73. E. Coli. test results at south Kelowna beaches

Tributary and Beach Sampling Sites

The creeks sampled are Brandt's Creek, Mill Creek, Mission Creek, and Fascieux Creek. The main sample site on Brandt's Creek is near the mouth of Brandt's Creek located in Rotary Marsh Wetland on Sunset Drive (Figure 62). The other sample site on Brandt's Creek is a 750mm outfall pipe located on Gordon Drive and Weddell Place which is sampled for first flush as well as during rain events of 7mm or more. The main sample site on Mill Creek is located near the mouth at the end of Lake Avenue (Figure 62). The other sample site on Mill Creek is a 1075mm outfall pipe located on Enterprise Way and Hardy Street which is sampled for first flush as well as during rain events of 5mm or more. The main sample site located on Mission Creek is near the mouth and is accessed by Bluebird Road (Figure 62). Fascieux Creek has three sampling site locations: Gordon Drive between KLO Road and Bothe Road, Gosnell Road and Quesnel Road, and at the end of Watt Road. Beach sites are located between lower Mission and Knox Mountain foreshore.

Figure 74. Kelowna Beach and Creek sample sites