Greater Victoria Drinking Water Quality
2018 Annual Report

Parks & Environmental Services Department | Environmental Protection

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EXECUTIVE SUMMARY

This report provides the annual overview of Capital Regional District (CRD) Water Quality Monitoring program and its results on water quality in 2018 within the Greater Victoria Drinking Water System (GVDWS) and its individual system components (Map 1). The results indicate that Greater Victoria's drinking water continues to be of good quality and is safe to drink.

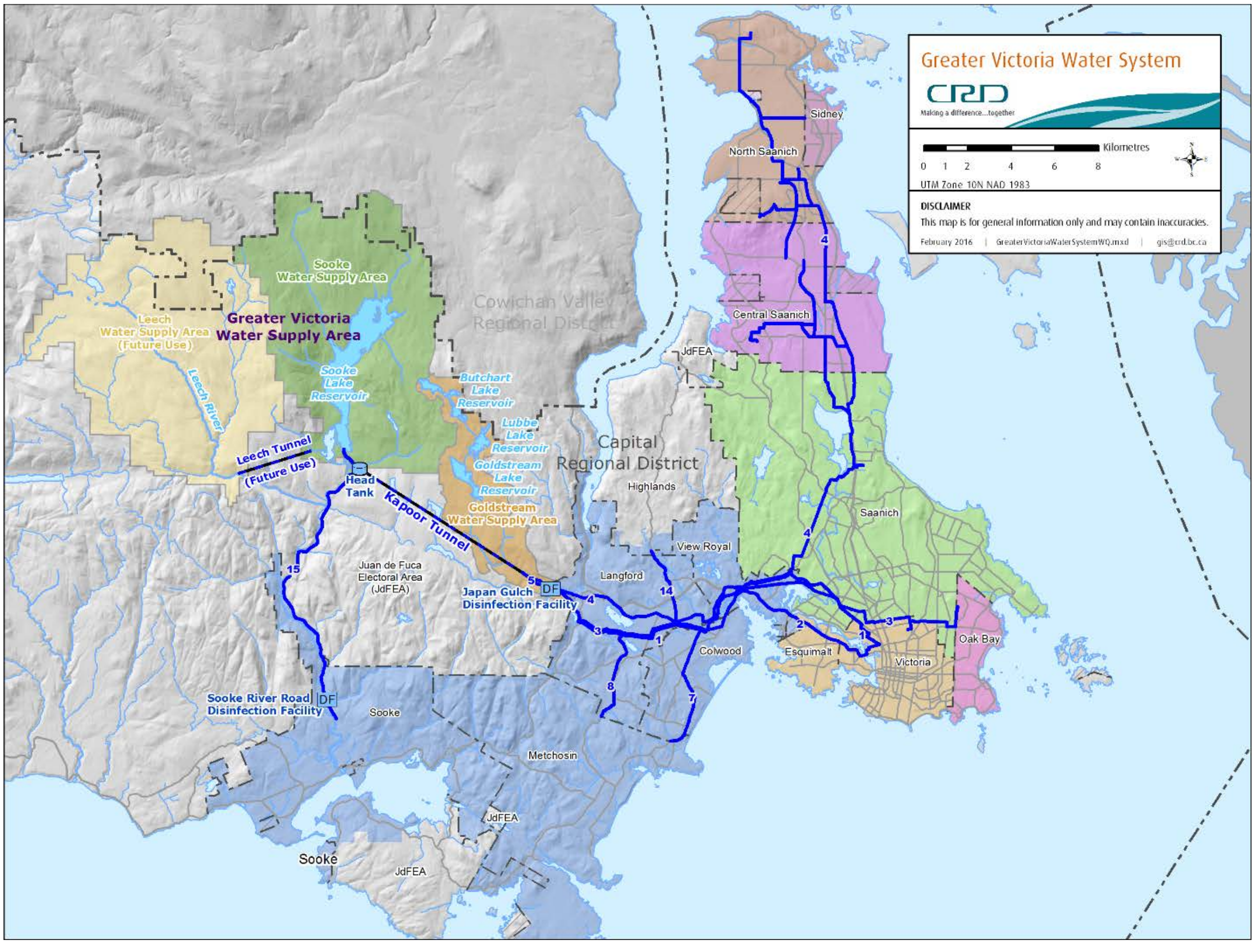
The monitoring program is designed to meet the requirements of the provincial regulatory framework, which is defined by the *BC Drinking Water Protection Act* and *Drinking Water Protection Regulation*, and follow the federal guidelines for drinking water quality.

The approximately 11,000 hectares of the Sooke and Goldstream watersheds comprise the source of our regional drinking water supply area. Water flows from the reservoirs to the Sooke and Japan Gulch disinfection facilities and then through large-diameter transmission mains and a number of storage reservoirs into eight different distribution systems, which in turn deliver the drinking water to the consumers. The monitoring program covers the entire system to anticipate any issues (i.e., source water monitoring), ensure treatment is effective (i.e., monitoring at the treatment facilities), and confirm a safe conveyance of the treated water to customers (i.e., transmission and distribution system monitoring). It also enables CRD staff to address any concerns or questions by the general public. The program adopts a multiple-lines-of-evidence approach (biological, chemical and physical) to ensure all aspects of water quality are considered. The program is comprehensive, collecting approximately 8,000 samples and conducting approximately 55,000 individual analyses annually. The results are discussed with the Island Health Authority, which oversees compliance with drinking water standards, and with our CRD operations and municipal staff, who rely on the information to properly operate and maintain the system components.

The five source water reservoirs, with established and intact ecosystems, provide raw water of excellent and stable water quality that can be utilized unfiltered for the preparation of potable water. Water quality monitoring in the watersheds serves several purposes: 1) to verify that we continue to comply with the criteria for an unfiltered surface water source; 2) to understand the quality of the water flowing into the reservoirs; 3) to ensure that we are aware of the presence and absence of water quality-relevant organisms, including specific pathogens in the lakes, prior to any treatment; 4) to confirm that the water quality parameters remain within the effectivity range of our disinfection treatment; and 5) to detect any taste and odour concerns that could then pass through the system.

This annual water quality report separates the water system components that are the CRD's responsibility from system components that are the responsibility of the municipalities. The CRD provides water quality sampling and testing services for compliance purposes to all municipal water systems. Each water distribution system was assessed for compliance with the regulatory requirements. This annual report contains the compliance summary for CRD and municipal water distribution systems in the GVDWS.

MAP 1. Greater Victoria Drinking Water System



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1.0 INTRODUCTION

This report is the annual overview of the results from water quality samples collected in 2018 from the Greater Victoria Drinking Water System (GVDWS) (Map 1). The report summarizes data from the Capital Regional District (CRD) owned and operated water infrastructure that includes the source reservoirs, the Regional Transmission System and the Juan De Fuca Water Distribution System, as well as data from the municipal distribution systems. Monthly and weekly summary reports on water quality data are posted on the CRD's website at: https://www.crd.bc.ca/about/data/drinking-water-quality-reports.

2.0 WATER SYSTEM DESCRIPTION

In 2018, the GVDWS supplied drinking water to approximately 380,000 people and is the third largest drinking water system operating in British Columbia. It comprises two separate service areas:

1. The **Japan Gulch Service Area** that supplies water to approximately 365,000 people in Victoria, Saanich, Oak Bay, Esquimalt, the Saanich Peninsula municipalities and the Westshore municipalities via the Japan Gulch disinfection facility.

2. The **Sooke Drinking Water Service Area** that supplies water to approximately 15,000 people in Sooke and East Sooke via the Sooke River Road disinfection facility.

2.1 Source Water Systems

Drinking water for the GVDWS comes from protected watersheds called the Greater Victoria Water Supply Area (see Map 1). This CRD owned and managed area, which is approximately 11,000 hectares in size, is located about 30 km northwest of Victoria and encompasses about 98% of the Sooke Lake, 98% of the Goldstream Lake and 92% of the Leech River catchment areas.

Japan Gulch Service Area

The five reservoirs in the supply area have been used as a source of drinking water since the early 1900s. The Sooke Lake Reservoir, the largest of the reservoirs, is the primary water source for this system, supplying approximately 98% of Greater Victoria's drinking water. The four reservoirs in the Goldstream system (Butchart, Lubbe, Goldstream and Japan Gulch) are typically offline and are used only as a backup water supply. Controlled releases from the Goldstream watershed provide water for salmon enhancement in the lower Goldstream River. The Leech River watershed does not yet contribute to the water supply for the GVDWS.

Water at the southern end of Sooke Lake Reservoir enters two of the variable depth gates in the intake tower and is screened through a stainless steel travelling screen (openings of 0.5 mm). From the intake tower, the water passes through two 1,200 mm-diameter pipelines to the head tank and then through the 8.8 km-long, 2.3 m-diameter Kapoor Tunnel and then into 1,525 mm- and 1,220 mm-diameter pipes connecting the Kapoor Tunnel to the Japan Gulch disinfection facility, where it is disinfected.

During the brief period of its use [typically used only when the Kapoor Tunnel is out of service for inspection by CRD Integrated Water Services (IWS) staff], water in the Goldstream River Watershed is released from Goldstream Reservoir and flows down the upper reaches of Goldstream River into Japan Gulch Reservoir. Water from Japan Gulch Reservoir enters the Japan Gulch intake tower through a low-level intake gate, passing through a 14-mesh, stainless steel screen and is then carried in a 1,320 mm-diameter pipe into the Japan Gulch disinfection facility.

Sooke Drinking Water Service Area

Drinking water for the Sooke Drinking Water Service Area is only supplied from Sooke Lake Reservoir, but travels a different route. This water is passed through a 14.5 km-long (9 miles), 600 mm-diameter PVC and ductile iron pipe from a point just above the head tank to the Sooke River Road disinfection plant. The Sooke Drinking Water Service Area has no backup water source.

2.2 Water Disinfection

The disinfection process in the GVDWS is both simple and effective and uses two disinfection facilities to provide disinfected drinking water to the two service areas:

- Japan Gulch disinfection facility supplies the Japan Gulch Service Area; a small portion of the District of Highlands is supplied with drinking water, mainly used for fire suppression.
- Sooke River Road disinfection facility supplies the Sooke Drinking Water Service Area.

Both disinfection facilities utilize the same disinfection concepts and process methods. The Japan Gulch facility uses delivered liquid sodium hypochlorite and liquid ammonia for the disinfection process and currently still has the old chlorine and ammonia gas injection plant as backup system. The Sooke River Road facility generates sodium hypochlorite on site and injects delivered liquid ammonia to achieve the disinfection effect.

At both disinfection facilities, the water passes through a three-part disinfection process in sequential order—two primary disinfection steps that provide disinfection of the water entering the system, followed by a secondary disinfection step that provides continuing disinfection throughout the transmission system and the distribution systems:

1. **UV Disinfection**. Ultraviolet (UV) disinfection provides the first step in the primary disinfection process (disinfection of the raw source water entering the plants) and inactivates parasites such as *Giardia* and *Cryptosporidium* [3-log (99.9%) inactivation], as well as reducing the level of bacteria in the water.
2. **Free Chlorine Disinfection**. Free chlorine disinfection provides the second step in the primary disinfection process, using a free chlorine dosage of approximately 1.5-2.5 mg/L and a minimum of 10-minute (depending upon flow) contact time between the free chlorine and the water. The free chlorine disinfection step inactivates bacteria and provides a 4-log (99.99%) reduction of viruses.
3. **Ammonia Addition**. The secondary disinfection process consists of the addition of ammonia to form chloramines at a point downstream where the water has been in contact with the free chlorine for approximately 10 minutes or more. The ammonia is added at a ratio of approximately one part ammonia to four-five parts chlorine. In the water, these chemicals combine to produce a chloramine residual (measured as total chlorine). Monochloramine is the desired residual product, which typically represents 90% of the total chlorine when leaving the plants. This residual remains in the water and continues to protect the water from bacterial contamination (secondary disinfection), as it travels throughout the pipelines of the distribution system.

In East Sooke, at the Iron Mine Reservoir, CRD IWS re-chloraminates the water to boost the chlorine residual provided to the extremities of that system. In Metchosin, at Rocky Point Reservoir, IWS maintains another re-chloramination station, which has not been in service for approximately two years. It has been deemed unnecessary for maintaining adequate residuals. Currently, there are no provisions to re-chloraminate the water at the far reaches of the distribution system on the Saanich Peninsula; however, re-chlorination stations are operational at the Upper Dawson Reservoir, Upper Dean Park Reservoir and Deep Cove pump station supplying Cloake Hill Reservoir. These re-chlorination stations are able to add free chlorine to the system if the total chlorine residuals have dropped to inadequate levels or during water quality emergencies.

2.3 CRD Transmission System

Using a series of large-diameter transmission mains, the CRD supplies treated water to its downstream customers. These large-diameter transmission mains are sorted into three sections:

1. Regional Transmission System, that supplies the core area and Westshore municipalities and up to the Saanich Peninsula boundary;

2. The Saanich Peninsula Trunk Water Distribution System that receives water at two points on the Saanich Peninsula from the Regional Transmission System and supplies it to the three municipalities and other customers on the Saanich Peninsula; and

3. The Sooke Supply Main.

2.3.1 Regional Transmission System

The CRD currently uses seven large-diameter transmission mains to supply drinking water to the municipal distribution systems in the Japan Gulch Service Area. These transmission mains range in diameter from 1,525 mm (60") down to 460 mm (18") and transfer water from the Japan Gulch disinfection facility to the distribution systems listed in Section 2.4.

- Main #1 is a 1,067 mm-diameter (42"), cement mortar-lined, welded steel pipe that starts at the Humpback pressure regulating valve (PRV) below the Humpback Reservoir Dam and ends at the David Street vault. This transmission main provides water primarily to the City of Victoria, but also services portions of Saanich and the Westshore communities.
- Main #2 is a 780 mm-diameter (31") steel and ductile iron pipe, which starts at the Colwood overpass and runs primarily through View Royal, Esquimalt and Vic West along the Old Island Highway and Craigflower Road. Main #2 joins Main #1 at the David Street vault after crossing the Bay Street Bridge. This supply main is 7.6 km in length and provides water to View Royal, Victoria and Esquimalt.
- Main #3 is primarily a 990 mm-diameter (39") steel pipe that supplies water from the Humpback PRV and terminates at the CRD's Mt. Tolmie Reservoir. There are several sections in this line that include 1,220 mm-diameter (48") and 810 mm-diameter (32") pipes. The 810 mm-diameter pipe terminates at the Oak Bay meter vault. This supply main is 21.3 km in length and provides water to the Westshore communities, Saanich, Victoria and Oak Bay.
- Main #4, a high pressure transmission main, is primarily a 1,220 mm-diameter (48"), welded steel pipe that supplies water from the Japan Gulch disinfection facility primarily to Saanich and the Saanich Peninsula. There are two small sections of 1,320 mm (52") and 1,372 mm (54") reinforced concrete pipe. This transmission main is 26.2 km in length and terminates near the Saanich-Central Saanich boundary where it transfers water to the 762 mm (30") trunk main, which extends to McTavish Reservoir. It supplies the municipalities on the Saanich Peninsula and to Bear Hill Reservoir and Hamsterly pump station, near Elk Lake.
- Main #5 is a 1,524 mm-diameter (60") pipe that connects the Kapoor Tunnel via the Japan Gulch disinfection facility to the Humpback PRV just below the old Humpback Reservoir dam. It is approximately 1.6 km in length and provides water to mains #1 and #3.
- Main #7 is a 610 mm-diameter (24") steel pipe that runs from Goldstream and Whitehead Road to Metchosin and Duke Road. It is 4 km in length and provides water to portions of Colwood, Langford and Metchosin.
- Main #8 is a 457 mm-diameter (18") steel and asbestos cement (AC) pipe that runs from Glen Lake School, primarily along Happy Valley Road to Happy Valley and Glenforest. It is 3.6 km in length and provides water to Langford, Colwood and Metchosin.

There are three active inter-connections between the high pressure Main #4 and the low pressure mains #1 and #3 where water can be transferred from Main #4 to the other two mains via PRV stations. These stations are located at Watkiss Way, Millstream at Atkins, at Goldstream/Veteran's Memorial Parkway, and Burnside at Wilkinson Road. There is also a series of inter-connections between mains #1 and #3 with the major inter-connections being at Price, Station, Tillicum and Dupplin roads.

2.3.2 Saanich Peninsula Trunk Water Distribution System

The Saanich Peninsula Trunk Water Distribution System receives water at two points on the Saanich Peninsula from the Regional Transmission System and supplies it to four customers on the Saanich Peninsula: the municipalities of Central Saanich, North Saanich, Sidney and the Agricultural Research Station.

The Saanich Peninsula Trunk Water Distribution System is comprised of 46 km of transmission mains, including the 750 mm (30") Bear Hill Main, the 400 mm (16") Keating Main, the 400 mm (16") Dean Park Main and the 250-500 mm (10-20") Saanich Peninsula mains.

At McTavish Reservoir (the terminus of the Regional Transmission System), the Saanich Peninsula Trunk Water Distribution System continues further along the peninsula via a 610 mm-diameter (24") concrete cylinder pipe. In the vicinity of the airport, this main reduces to a 406 mm-diameter (16") asbestos cement pipe that terminates at the Deep Cove pump house. A dedicated 250 mm-diameter (10") perm/PVC pipe connects Deep Cove pump station with Cloake Hill Reservoir. A 457 mm-diameter (18") pipe along Mills Road connects the trunk main to the northwest end of the Sidney Distribution System.

The CRD also operates six major pumping stations located at Hamsterly, Martindale, Lowe Road, Dean Park Lower, Dean Park Middle and Deep Cove, along with two minor pumping stations located at Mt. Newton and Dawson Upper Reservoir that are all considered part of the transmission system.

2.3.3 Sooke Supply Main

The Sooke Drinking Water Service Area is supplied by Main #15, a 600 mm pipe (upper section PVC, lower high pressure section – ductile iron) that conveys raw water from Sooke Lake Reservoir to the Sooke River Road disinfection facility. Main #15 feeds directly into the Sooke Distribution System downstream of the disinfection facility.

2.3.4 Storage Reservoirs

A number of storage reservoirs are considered part of the transmission system, even though most of them technically operate as a distribution reservoir with all its typical functions: balancing, fire and emergency storage.

The CRD owned and operated transmission system storage reservoirs in the Regional Transmission System are:

- Mt. Tolmie Reservoir, a two-cell concrete in-ground reservoir, 27,300 m^3 (6M gallon), located on Mt. Tolmie, at the terminus of Main #3 near the Oak Bay-Saanich boundary.
- Haliburton Reservoir, a one-cell concrete in-ground reservoir, 22,700 m^3 (5M gallon), located off Haliburton Road in Saanich; disconnected from the system (off Main #4) and empty; only to be used in emergencies.

The CRD owned and operated transmission system storage reservoirs in the Saanich Peninsula Trunk Water Distribution System are:

- Bear Hill Reservoir, a two-cell concrete above-ground reservoir, 4,546 m^3 (1M gallon), located on Bear Hill in Saanich.

- Cloake Hill Reservoir, a one-cell, 4,546 m^3 (1,000,000 gallon) reservoir located on Cloake Hill in North Saanich.
- Dawson Upper Reservoir, a one-cell, 455 m^3 (100,000 gallon) reservoir located off Benvenuto Avenue in Central Saanich.
- Dean Park Lower Reservoir, a two-cell concrete above-ground reservoir, 4,546 m^3 (1,000,000 gallon), located beside Dean Park Road in North Saanich.
- Dean Park Middle Reservoir, two cylindrical concrete above-ground tanks, 2,730 m^3 (600,000 gallon), located near the bottom of Dean Park in North Saanich.
- Dean Park Upper Reservoir, a two-cell concrete partly in-ground reservoir, 4,546 m^3 (1,000,000 gallon), located near the top end of Dean Park in North Saanich.
- McTavish Reservoir, a two-cell concrete in-ground reservoir, 6,820 m^3 (1,500,000 gallon), located on the south side of McTavish Road in North Saanich.

2.4 Distribution Systems

The GVDWS contains eight individual distribution systems. Six distribution systems are separately owned and operated by the municipalities of Central Saanich, North Saanich, Oak Bay, Saanich, Sidney and Victoria. Victoria owns and operates the distribution system in Esquimalt. Two distribution systems are owned by the CRD and operated by CRD IWS. These latter two systems include the combined distribution system in the Westshore communities of Langford, Colwood, Metchosin, View Royal and a small portion of Highlands, and a separate system supplying water to Sooke and parts of East Sooke. Each distribution system owner/operator is called a water supplier and is responsible for providing safe water to their individual customers and meeting all the requirements under the *BC Drinking Water Protection Act* and *Drinking Water Protection Regulation*.

2.4.1 Juan de Fuca Water Distribution System – CRD

In 2018, water was supplied to the Juan de Fuca Water Distribution System (in this report, not including Sooke – see Sooke/East Sooke Distribution System below) primarily from mains #1 and #3. Parts of Langford and View Royal were supplied from Main #4. The development at Bear Mountain in Langford was supplied by Main #4. The Westhills development, serviced by its own privately operated distribution system, was supplied via mains #1 and #3 in 2018. In the Juan de Fuca Water Distribution System, water flowed generally in a northerly and southerly direction away from the supply mains. The William Head Institution and the Beecher Bay meter vault are located at the southern extremities of this system.

The Juan de Fuca Water Distribution System includes the following distribution reservoirs:

- Bear Mountain Reservoir #1, a two-cell, 1,250 m^3 (275,000 gallon) reservoir located on the lower slopes of the Bear Mountain development in Langford.
- Deer Park Reservoir, a one-cell, 182 m^3 (40,000 gallon) reservoir located downstream of Rocky Point Reservoir re-chloramination station near the extremity of the water system off of Deer Park Trail in Metchosin.
- Fulton Reservoir, a two-cell, 4,580 m^3 (1,007,459 gallon) reservoir located at the end of Fulton Road in Colwood.
- Peacock Reservoir, a two-cell, 583.8 m^3 (128,420 gallon) reservoir located north of the Trans-Canada Highway off of Peacock Place in Langford.
- Rocky Point Reservoir, a three-cell, 546 m^3 (120,000 gallon) reservoir located near the end of Rocky Point Road in Metchosin.
- Skirt Mountain Reservoir, a three-cell, 6,525 m^3 (1,435,300 gallon) reservoir located near the top of Skirt Mountain in the Bear Mountain development in Langford.

- Stirrup Place Reservoir, a two-cell, 242 m^3 (53,300 gallon) reservoir located off of Stirrup Place Road in Metchosin.
- Walfred Reservoir, a three-cell, 560 m^3 (123,180 gallon) reservoir located on Triangle Mountain in Colwood.

2.4.2 Sooke/East Sooke Distribution System – CRD

The Sooke/East Sooke Distribution System begins downstream of the Sooke River Road disinfection facility at the end of Main #15 on Sooke River Road where the ammonia storage and metering building is located. The primary water supply main to the community follows Sooke River Road downstream and splits at Milne's Landing going east toward Sassenos and west toward the central area of Sooke. Two underwater pipelines across Sooke Basin supply East Sooke. Sunriver Estates came on-line in 2006 and is serviced by a 300 mm (12") pipeline on Phillips Road and the two-cell concrete Sunriver Reservoir.

The Sooke/East Sooke Distribution System includes the following distribution reservoirs:

- Coppermine Reservoir, a one-cell concrete partly in-ground reservoir, 455 m^3 (100,000 gallon), located off of Coppermine Road in East Sooke.
- Helgesen Reservoir, a four-cell concrete partly in-ground reservoir, 6,973 m^3 (153,385 gallon), located at the west end of Helgesen Road in Sooke.
- Henlyn Reservoir, a one-cell steel tank tower, 224 m^3 (49,270 gallon), located off of Henlyn Drive in Sooke.
- Silver Spray Reservoir, a two-cell cylindrical concrete tank, 841 m^3 (185,000 gallon), located off of Silver Spray Drive in East Sooke.
- Sunriver Reservoir, a two-cell concrete above-ground reservoir, 1,800 m^3 (395,944 gallon), located off of Sunriver Way in Sooke.

2.4.3 Central Saanich Distribution System – District of Central Saanich

In 2018, drinking water was supplied to the Central Saanich Distribution System via 10 pressure zones (seven off the Bear Hill main and three off the Martindale Valley main). The Bear Hill main supplied the Tanner Ridge area by direct feed, the central area in one pressure zone through three PRVs, the Saanichton area in two pressure zones through two PRVs, the Brentwood Bay area, and the Tsartlip First Nation through a PRV. Five smaller pressure zones served the rest of Central Saanich. Dawson Upper Reservoir (CRD owned and operated) supplied a small area of higher elevation residences in Brentwood Bay. Martindale pump station supplied an agricultural area in the southeast corner of the municipality. The Island View Road area was supplied by the Stelly's pump station. The Mount Newton pump station provided water to the northeast corner and to the Tsawout First Nation lands. A municipally-owned pump station on Oldfield Road serviced a small area in the southwest corner.

Bear Hill Reservoir (CRD owned and operated) has the largest service population in Central Saanich, providing approximately 80% of the Central Saanich's water. It is the primary supply to most of Central Saanich (south of Haldon Road), including Brentwood Bay.

The Central Saanich Distribution System has technically no balancing, fire or emergency storage, but relies on CRD infrastructure to provide this. Several CRD-owned reservoirs in Central Saanich, that are considered part of the transmission system, function as distribution reservoirs for the Central Saanich Distribution System.

2.4.4 North Saanich Distribution System – District of North Saanich

In 2018, drinking water was supplied to the North Saanich Distribution System from a number of points along the Saanich Peninsula Trunk Water Distribution System. This included Dean Park via the Lowe Road pump station, Dean Park pump stations and Dean Park Reservoirs (all CRD owned and operated), Deep Cove/Lands End area via connections upstream of the Deep Cove pump station, Cloake Hill Reservoir via Deep Cove pump station (all CRD owned and operated), and Swartz Bay. In the North Saanich Distribution System, Cloake Hill Reservoir (CRD owned and operated) was the largest pressure zone. Water flowed generally in an easterly direction through the Dean Park pressure zone, northwest into the Deep Cove/Lands End area and northeast to the Swartz Bay area. Dean Park Upper Reservoir (CRD owned and operated) supplied a small portion of the Dean Park Estates.

The North Saanich Distribution System has technically no balancing, fire or emergency storage but relies on CRD infrastructure to provide this. Several CRD-owned reservoirs in North Saanich that are considered part of the transmission system function as distribution reservoirs for the North Saanich Distribution System.

North Saanich provides water to the Greater Victoria Airport Authority via the water main on the south side and the east side of the airport. As water quality in the airport distribution system falls under federal jurisdiction, it was not monitored by the CRD in 2018 and is, therefore, not included in this report.

2.4.5 Oak Bay Distribution System – District of Oak Bay

In 2018, drinking water was supplied to the Oak Bay Distribution System at Lansdowne and Foul Bay roads from Main #3. The water flowed in a west to east direction across Lansdowne with north and south branches. Oak Bay conveys water via a 406 mm main, which crosses Oak Bay diagonally from northwest to southeast. Water was distributed from the north end to the south end via the 406 mm main. Oak Bay has an outer loop flow on Beach Drive to the Victoria boundary. The Oak Bay Distribution System has no balancing, fire or emergency storage, but rather relies on the CRD infrastructure to provide this.

Oak Bay used four local pressure zones supplied by booster pumps. Sylvan Lane pump station supplied the Barkley-Sylvan area; Plymouth supplied the north Henderson area; Foul Bay supplied the south Henderson area; and Uplands pump station (seasonal) supplied the Uplands area. There are two inter-connections with the Victoria/Esquimalt Distribution System, which are normally closed, but can be used in emergencies.

2.4.6 Saanich Distribution System – District of Saanich

In 2018, drinking water was supplied to the Saanich Distribution System at a number of points from the CRD's transmission mains. Water was supplied from Main #1 at Dupplin, Wilkinson and Marigold, Holland/Burnside, and Admirals/Burnside; from Main #3 at Douglas, Tillicum, Admirals, Shelbourne, Richmond, Foul Bay, Mt. Tolmie and Maplewood pump house; and from Main #4 at Burnside, Blue Ridge, Roy Road, Markham, Layritz, Cherry Tree Bend and Sayward. In the Saanich Distribution System, water flowed generally in a northerly direction from mains #1 and #3 and both east and west from Main #4.

There are four major pumping systems in the Saanich Distribution System. Maplewood pumps water north from Main #3, ending in the Gordon Head area. Cherry Tree Bend pumps from Main #4 to Wesley Reservoir and the west central high elevation area. The Mt. Tolmie/Plymouth pump station pumps water from Main #3 and the CRD Mt. Tolmie Reservoir to Saanich's Mt. Tolmie Reservoir and the Gordon Head area via a 610 mm-diameter (24") main.

Water from Sayward supplies the north end of the Saanich Distribution System via Main #4 with a southerly flow through Cordova Bay. Saanich also has a number of other small pressure zones controlled by pump stations.

The Saanich Distribution System includes some storage for balancing, fire and emergency purposes. The following distribution reservoirs are owned and operated by Saanich:

- Hartland Reservoir, a one-cell, 454.6 m^3 (100,000 gallon) reservoir located on Hartland Road in Saanich.
- Mt. Tolmie Reservoir (Saanich), a one-cell, 4,545 m^3 (1,000,000 gallon) reservoir located on the east side of the summit of Mt. Tolmie near Cromwell Reservoir in Saanich.

- Rithet Reservoir, a one-cell, 16,807 m^3 (3,700,000 gallon) reservoir located at the end of Perez Drive in Broadmead in Saanich.
- Wesley Reservoir, a two-cell, 3,182 m^3 (700,000 gallon) reservoir located at the end of Wesley Road on Haliburton Ridge in Saanich.

2.4.7 Sidney Distribution System – Township of Sidney

In 2018, drinking water was supplied to the northern portion of the Sidney Distribution System from the 300 mm-diameter water main on Mills Road via the 460 mm CRD transmission main on Mills Road from upstream of the Deep Cove pump station. The southern portion of the distribution system is supplied from a 300 mm main that is connected to the CRD transmission system and McTavish Reservoir. Within the Sidney Distribution System, water flowed generally from the west via Mills Road and from the south via McTavish Reservoir and met in the middle of the distribution system, with approximately 60% of the water coming from the Mills Road supply.

The Sidney Distribution System has no balancing, fire or emergency storage, but rather relies on the CRD infrastructure to provide this.

2.4.8 Victoria/Esquimalt Distribution System – City of Victoria/Township of Esquimalt

Note: The City of Victoria also owns and operates the Water Distribution System in the Township of Esquimalt.

In 2018, drinking water was supplied to the Victoria/Esquimalt Distribution System from mains #1 and #2 at David Street/Gorge Street and David Street/Rock Bay Avenue. From these supply points, the system divides into several smaller looped water mains within the distribution system. Water was also supplied to Victoria from Main #3 at Cook Street/Mallek Crescent, Sommerset Street/Tolmie Avenue, Douglas Street/Tolmie Avenue and Shelbourne/North Dairy. In general, water flows from a north to south direction.

Water was supplied at multiple locations to Vic West and Esquimalt from Main #2. These locations include Tyee Road/Bay Street, Burleith Crescent/Craigflower Road, Garthland Road/Craigflower Road and Admirals Road/Maple Bank Road.

The Victoria/Esquimalt Distribution System has no balancing, fire or emergency storage, but rather relies on the CRD infrastructure to provide this.

3.0 MULTIPLE BARRIER APPROACH TO WATER QUALITY

The CRD and the municipalities that operate their distribution systems use a multiple barrier approach to prevent the drinking water in the GVDWS from becoming contaminated. Multiple barriers can include procedures, operations, processes and physical components. In a drinking water system, any individual contamination barrier used in isolation has an inherent risk of failure and may result in contamination of the drinking water. However, if a number of individual barriers are used together in combination with each other and, especially if they are arranged so that they complement each other, these multiple barriers are a very powerful means of preventing drinking water contamination. All CRD owned and operated, and most other large drinking water utilities, use the multiple barrier approach to prevent drinking water contamination. The exact types and applications of barriers are unique for each system, in order to address the system-specific risks.

The following barriers are used in the GVDWS to prevent the drinking water from becoming contaminated:

1. **Good Water System Design**. Good water system design is one of the preeminent barriers to drinking water contamination, as it allows all of the other components within the water system to operate in an optimal fashion and does not contribute to the deterioration of the quality of the drinking water contained within the system. Good water system design includes such aspects as: drinking water treatment plants that are easy to operate; piping appropriately sized to the number of users being supplied; and the use of appropriate pipe materials. All new designs are designed by qualified professionals registered in BC, reviewed and approved by qualified CRD or municipal staff, and approved and permitted by a Public Health Engineer from the Island Health Authority. This acts as a multiple check on good system design.
2. **Source Water Protection**. The CRD uses what is considered the ultimate source water protection: ownership of the catchment (watershed) lands surrounding the source reservoirs. This land area is called the Greater Victoria Drinking Water Supply Area. Within this area, no public access, commercial logging, farming, mining, or recreation is permitted and no use of herbicides, pesticides, or fertilizers is allowed. This source water protection barrier eliminates many of the organic and inorganic chemicals that can contaminate the source water and virtually eliminates the potential for human disease agents being present. Very few drinking water utilities in Canada and United States can claim this type of protection. In addition, the CRD Watershed Protection Division operates a complete and comprehensive watershed management program that provides additional protection to the quality of Greater Victoria’s source water.
3. **Water Disinfection**. The GVDWS is an unfiltered drinking water system that continues to meet the stringent United States Environmental Protection Agency (USEPA) criteria to remain an unfiltered surface water supply. The treatment process consists of primary disinfection (ultraviolet light and free chlorine) of the raw source water entering the treatment plant and secondary disinfection (chloramination) that provides a disinfectant residual throughout the transmission and distribution systems. Although the water treatment barrier used in Greater Victoria is not as rigorous as that provided by most drinking water utilities using a surface water supply, the microbiological quality of the source water is exceptionally good and the chief medical health officer for Island Health has approved this treatment process as providing safe drinking water for the public.
4. **Distribution System Maintenance**. All water suppliers in the GVDWS provide good distribution system maintenance, including activities such as: annual water main flushing, hydrant maintenance, valve exercising, leak detection, and reservoir cleaning and disinfection. This barrier helps to promote good water quality within the distribution systems.
5. **Infrastructure Replacement**. The timely replacement of aging water system infrastructure is an important mechanism to prevent the deterioration of water quality in the pipes and provides a continual renewal of the water system.
6. **Well Trained and Experienced Staff**. All water system operators must receive regular training and be certified to operate water system components. In addition, the laboratory staff cannot analyze drinking water samples in accordance with the *BC Drinking Water Protection Regulation* unless the laboratory has been inspected by representatives of the BC Ministry of Health and issued an operating certificate. CRD and municipal staff meet these requirements.

7. **Cross Connection Control**. Cross connection control provides a barrier to contamination by assisting in the detection of conditions that have the potential to introduce contaminants into the drinking water from another type of system. Therefore, in cooperation with the other water suppliers, in 2005, the CRD implemented a regional Cross Connection Control program throughout the GVDWS. 2008 saw the implementation of CRD Bylaw 3516, the Cross Connection Control Bylaw for the GVDWS.

8. **Water Quality Monitoring**. Rigorous water quality monitoring can be considered a barrier not only because it verifies the satisfactory operation of other barriers and detects contaminations quickly, but comprehensive monitoring data may also allow water suppliers to see trends and react proactively before a contamination occurs. The CRD has designed and executes a comprehensive water quality monitoring program for the GVDWS that collects daily bacteriological samples across the entire region for compliance purpose (on CRD water infrastructure and in the municipal water distribution systems). This CRD monitoring program tests for water quality parameters beyond the legislated requirements to verify good drinking water quality in the GVDWS.

4.0 WATER QUALITY REGULATIONS

The CRD and the municipal water suppliers in the GVDWS must comply with the BC *Drinking Water Protection Act* and *Drinking Water Protection Regulation*. The regulation stipulates the following water quality and sampling criteria for water supply systems:

- No detectable *Escherichia coli (E.coli)* per 100 mL
- At least 90% of samples have no detectable total coliform bacteria per 100 mL and no sample has more than 10 total coliform bacteria per 100 mL
- 5,000-90,000 population served: one sample per month per 1,000 population served
- >90,000 population served: 90 + 1 samples per month per 10,000 in excess of 90,000 population served

In addition to the aforementioned water quality monitoring criteria by the *Drinking Water Protection Regulation*, as due diligence to ensure public safety and maintain public trust, the CRD Water Quality Monitoring program also uses the much larger group of water quality parameters listed in the current version of the *Guidelines for Canadian Drinking Water Quality* (the Canadian guidelines) for compliance purposes. These limits are provided in Appendix A, tables 1, 2 and 3 under the column titled 'Canadian Guidelines'. The water quality limits in the Canadian guidelines[1] fall into one of the following five categories:

1. **Maximum Acceptable Concentration (MAC)**. This is a health-related limit and lists the maximum acceptable concentration of a substance that is known or suspected to cause adverse effects on health. Thus, an exceedance of an MAC can be quite serious and requires immediate action by the water supplier.
2. **Aesthetic Objectives (AO)**. These limits apply to certain substances or characteristics of drinking water that can affect its acceptance by consumers or interfere with treatment practices for supplying good quality drinking water. These limits are generally not health related unless the substance is well above the AO.
3. **Parameters without Guidelines**. Some chemical and physical substances have been identified as not requiring a numerical guideline because data currently available indicate that it poses no health risk or aesthetic problem at the levels currently found in drinking water in Canada. These substances are listed as 'No Guideline Required' in Appendix A, tables 1, 2 and 3.
4. **Archived Parameters**. Guidelines are archived for parameters that are no longer found in Canadian drinking water supplies at levels that could pose a risk to human health, including pesticides that are no longer registered for use in Canada, and for mixtures of contaminants that are addressed individually. Some of these parameters are still being included in the current water quality monitoring program because the analytical laboratory includes them in their scans. These parameters are listed as 'Guideline Archived' in Appendix A, tables 1, 2 and 3.
5. **Operational Guidance**. The limit was established based on operational considerations and listed as an operational guidance value. For example, the limit for aluminum is designed to apply only to drinking water treatment plants using aluminum-based coagulants.

It should be noted that not all of the water quality parameters analyzed by the CRD Water Quality Monitoring program have the Canadian guidelines' limits, since some of these parameters are used for operational purposes. Where the Canadian guidelines are silent for a particular parameter, the limit for that parameter is left blank in Appendix A, tables 1, 2 and 3.

In addition to the Canadian provincial regulations and federal guidelines, on a voluntary basis, the CRD also complies with most of the USEPA rules and regulations. Some of the limits in the USEPA rules are used as the basis for CRD's water treatment goals.

[1] (see: https://www.canada.ca/en/health-canada/services/environmental-workplace-health/reports-publications/water-quality/guidelines-canadian-drinking-water-quality-summary-table.html)

The GVDWS, as an unfiltered surface water system, must also meet the provincial Drinking Water Treatment Objectives for Surface Water Supplies in BC, which includes similar criteria as the conditions for filtration exemption in the Canadian guidelines, as well as the criteria for filtration exemption by the USEPA Surface Water Treatment Rules for Unfiltered Systems. In summary, the applicable criteria are:

- 4-log inactivation of viruses (met with chlorination)
- 3-log removal or inactivation of parasites (*Giardia* and *Cryptosporidium*) (met with UV disinfection)
- two forms of disinfection (UV and chlorination)
- Water entering disinfection facilities has average daily turbidity <1 NTU and not more than two days/year with an average daily turbidity of >5 NTU
- No *E. coli* or total coliform in treated water
- A watershed control program to minimize fecal, parasite and viral contamination of source water (in place)
- Detectable disinfectant residual in distribution system
- *E. coli* in source water ≤20 CFU/100 mL

5.0 OPERATIONAL CHANGES AND EVENTS – CRD SYSTEMS

5.1 Use of Goldstream Water

In 2018, the Goldstream Supply System was not used at all. Due to extensive dam upgrade works at Lubbe Reservoir, there was insufficient storage in the Goldstream System to allow for the typical Kapoor Tunnel shut-down and inspection. It is anticipated that the Kapoor Tunnel project will be delayed until the fall of 2020 and the Goldstream System will only be used for emergency purposes until then.

5.2 Sooke Lake Reservoir

Figure 1 shows the Sooke Lake Reservoir water levels in 2018 compared to previous years. As has been typical for a number of years, Sooke Lake Reservoir remained 100% full until the end of April. With the onset of dry and warm weather in May, the reservoir levels continuously receded throughout the summer and into the fall. The reservoir re-charge in the fall was delayed due to dry weather in October and early November. With the onset of heavy rainfall late in November, the reservoir levels rose very quickly and by the end of December, the lake had reached the full service level. 2018 saw one of the quickest reservoir filling times in recent history.

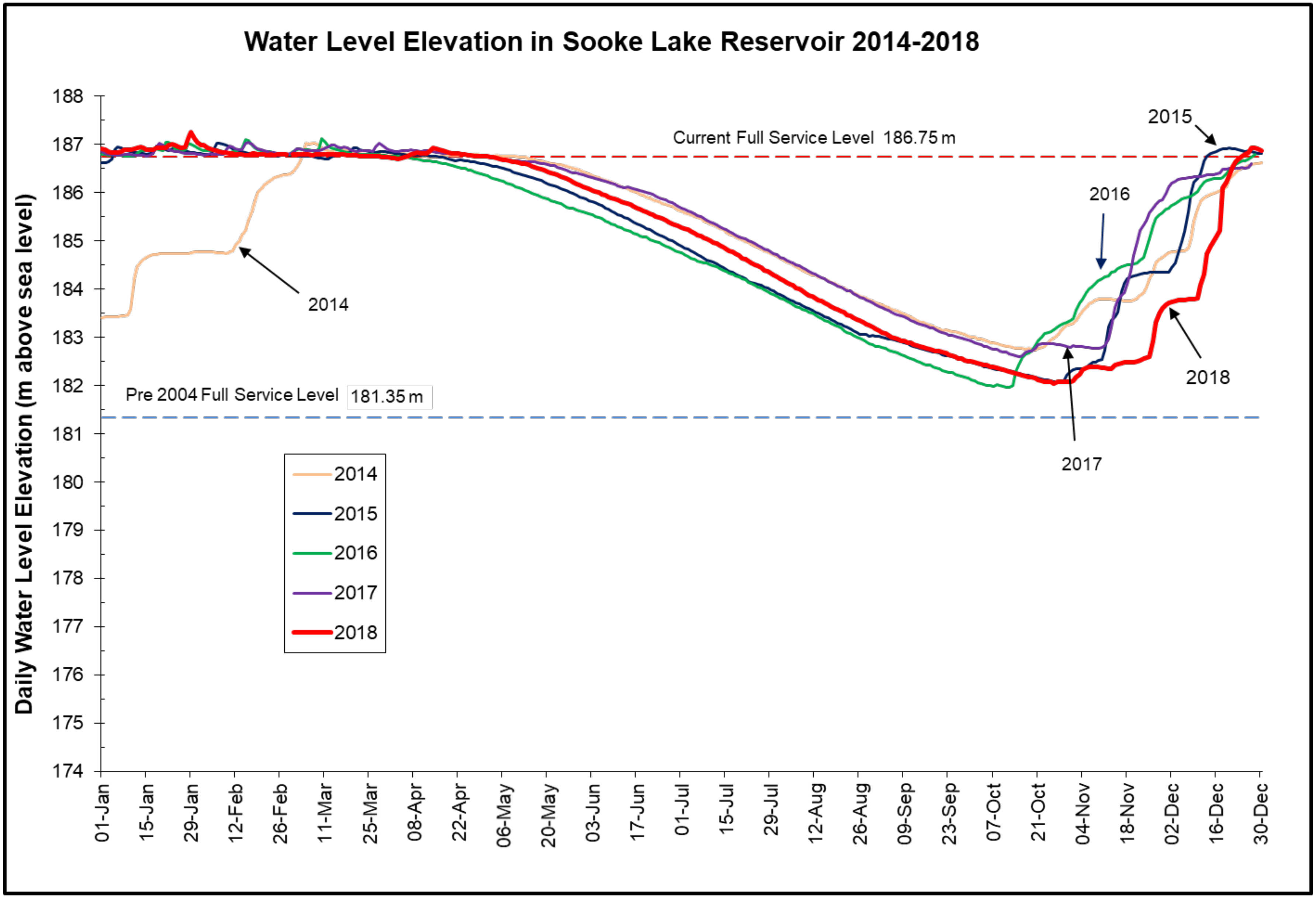

Figure 1 **Water Level Elevation in Sooke Lake Reservoir, 2014-2018**

5.3 Chlorine Dosage

In 2018, CRD IWS did make some adjustments to the chlorine dosage rate at both plants after coming off the high dosage period during the high total coliform event in Sooke Lake Reservoir in 2017. At the Sooke River Road disinfection facility, the chlorine dosage was decreased twice: from 2.5 mg/L to 2.3 mg/L in January, and from 2.3 mg/L to 2.1 mg/L in May, after system-wide residuals were found to be relatively high. At the Japan Gulch Disinfection Plant, the chlorine set point was decreased from 2.5 mg/L to 2.3 mg/L in January, which still allowed for a generous CT (Concentration x Contact Time) and a higher and longer lasting residual throughout the Japan Gulch Service Area.

5.4 CRD Reservoir Maintenance

CRD water system operators have followed the reservoir cleaning schedule developed through the reservoir review project led by the CRD Water Quality Operations Section. This schedule is based on a thorough water quality data review in each CRD owned and operated transmission or distribution reservoir, and is regularly updated based on new data and information. Following this cleaning schedule has resulted in improved water quality conditions and operational efficiencies in a number of reservoirs.

6.0 WATER QUALITY MONITORING

The Water Quality Program, as delivered by the Water Quality Operations Section and the Laboratory Services Section, both within the CRD Parks & Environmental Services Department, is responsible for the collection, analysis and reporting of water quality information in all CRD owned and operated portions of the GVDWS from the source reservoirs to the point of delivery (typically the water meter) to each consumer. While the municipal water suppliers are responsible for water quality and any potential corrective measures within their particular distribution system, CRD Water Quality staff provide water sampling and testing for regulatory compliance monitoring to these municipalities.

The CRD Water Quality Program has dedicated professional staff who are trained to collect water samples from source water and treated water sampling locations across the region, as well as technical staff trained to analyze and interpret water quality data in support of operational decisions. The CRD Water Quality Laboratory is certified for a number of water quality test methods and is staffed with highly-trained laboratory technicians. The CRD Aquatic Ecology Laboratory has professional staff specialized to analyze phyto- and zooplankton in lake water, test for cyanotoxins and understand the source water limnology.

6.1 CRD Water Quality Monitoring program

The CRD Water Quality Monitoring program consists of the following three components that provide direction for the collection and analysis of water quality samples from the water systems:

- **Compliance Monitoring:** The goal of the compliance monitoring is to ensure that water quality from source to consumer meets the relevant drinking water regulations and guidelines. The Island Health Authority, as the provincial regulator, has issued the CRD with two operating permits (for CRD water infrastructure in the Japan Gulch Service Area and in the Sooke Drinking Water Service Area). These operating permits require, in addition to the water quality and sampling criteria as per *Drinking Water Protection Regulation*, continuous monitoring of turbidity. The CRD Water Quality Operations Section, therefore, conducts bacteriological monitoring on the raw water entering the plants, treated water after leaving the plant and at the first customer sampling locations, sampling locations on the large transmission mains and sampling locations in the CRD-owned distribution systems, including distribution reservoirs. Bacteriological samples are collected at a frequency that meets the regulatory requirements and provides a consistent and day-to-day system-wide water quality oversight. Continuous turbidity monitoring, as per operating permits, is accomplished by online turbidity meters [monitored via Supervisory Control and Data Acquisition (SCADA)] at each disinfection facility. Part of the compliance monitoring program are the services provided by the CRD to the municipal water suppliers where CRD staff collect and analyze bacteriological samples from inside the municipal water distribution systems, report monthly results on the CRD website and include the results and findings in this annual report.

  The Island Health Authority has granted the GVDWS an exemption from filtration treatment, the conventional water treatment requirement for surface water source users in BC, based the evidence of year-round high source water quality. However, it expected that the CRD closely monitors a number of water quality parameters, in addition to the criteria listed in the regulations and in the operating permits. As a result, the CRD has included in its compliance monitoring program a number of water quality parameters that are regularly tested on the raw, as well as on the treated, water to verify compliance with the Canadian guidelines and USEPA rules and regulations. Such parameters in the raw water include parasites, organic and inorganic compounds, including metals and various water chemistry and physical parameters. On the treated water, these include disinfection byproducts, metals and water chemistry and physical parameters that are used to verify good drinking water quality.

- **Aquatic Ecology Monitoring:** The goal of the aquatic ecology monitoring is to understand and document the components that affect or may affect the natural cycles of the source streams and reservoirs. The source reservoirs and streams in the Greater Victoria Water Supply Area (Map 1) are monitored according to the recommendations by the CRD Aquatic Ecology Section, as there are no legislated requirements for either sampling frequency or parameter selection for these water bodies. It is, however, important for the CRD, as the supplier of unfiltered surface water, to have a comprehensive understanding of the natural processes taking place in the source waters and potential implications for the drinking water quality in the GVDWS. Depending on the season, the source lakes and their tributaries are sampled at a frequency ranging from monthly to weekly for parameters, such as algal species, distribution and concentrations, zooplankton species and concentrations, chlorophyll-a concentrations and nutrient concentrations. Additional samples may be collected based on risk management decisions, for instance, as a response to severe weather conditions or unusual observations.

- **Operational Water Quality Monitoring:** The CRD Water Quality Monitoring program provides an audit function on all water quality-related aspects of the GVDWS, including performance monitoring of the treatment plants and distribution system. Specific sampling and testing occurs to support operational decisions by the CRD and municipal system operators. Daily field tests of chloramine residual concentrations are conducted to verify the efficiency of the secondary disinfection region-wide. A number of qualitative (taste and odour) and quantitative tests (e.g., Heterotrophic Plate Count (HPC), turbidity) are regularly performed on samples across the region to verify the need for specific system maintenance. The customer inquiry program is also part of this monitoring program component, as a water quality complaint or observation by the public can give clues to ongoing system issues or identify water quality risks in the system. Water samples are collected from taps within individual houses or facilities in response to inquiries from customers about the quality of water being received at their address.

6.2 Sampling Plans

The efforts to collect the required number of samples for the CRD Water Quality Monitoring program are organized in three distinct sampling plans:

1. The **Watershed Sampling Plan** manages the sampling frequency, schedule and parameter list for the source water lakes and tributaries and is based on an up-to-date risk to water quality assessment. Sooke Lake Reservoir is sampled from a boat at three dedicated lake sampling stations from weekly in the summer to bi-weekly in the winter. Goldstream Reservoir is sampled monthly from a boat at two dedicated lake sampling stations. Tributary creeks to Sooke Lake Reservoir are sampled monthly near their mouths. Significant tributary lakes in the Sooke Lake watershed, as well as Butchart Lake and Japan Gulch Reservoir in the Goldstream System, are sampled quarterly by boat.
2. The **Treatment Plant Sampling Plan** includes the daily samples collected at the Japan Gulch disinfection facility and the two first customer locations (for mains #4 and #5) and the weekly samples collected at the Sooke River Road disinfection facility and the Sooke first customer location. This plan is designed to verify adequate treatment at both treatment plants and to detect unusual water quality conditions before they spread across the systems.
3. The **Transmission and Distribution System Sampling Plan** is a designed sampling plan that manages sampling at approximately 220 permanent sampling stations across the GVDWS, including all municipal systems. These permanent sampling stations are installed on transmission mains, storage reservoirs, distribution mains, booster pump stations and meter or valve stations. The plan is designed to achieve an evenly-distributed two-week rotation for most sampling stations, while providing a representative snapshot of the entire Japan Gulch Service Area each business day. The Sooke Drinking Water Service Area is sampled once per week. Samples collected on the daily runs as part of this plan are primarily used for compliance monitoring, but also for operational purposes.

When total coliform-positive bacteriological results are found in a CRD-owned system, CRD sampling staff resample those locations and, depending upon the situation, may direct CRD operators to flush the affected mains and/or drain and clean affected storage reservoirs. When total coliform-positive bacteriological results are found in a municipal system, the CRD sampling staff resample those locations and notify the municipal operators of the results. If a sample tests positive for *E.coli*, the Island Health Authority is notified immediately and emergency response procedures are followed.

6.3 Bacteriological Analyses

A description of the bacteriological parameters used in the CRD Water Quality Monitoring program, and the regulatory limits that were in place in 2018 for those parameters, are outlined below.

Total Coliform Bacteria

Total coliforms. Total coliforms are a group of bacteria found in high numbers in both human and animal intestinal (fecal) wastes and are found in water that has been contaminated with fecal material. Total coliform bacteria are also ubiquitous in the environment (water, soil, vegetation). Thus, in the absence of *E. coli*, the presence of total coliforms may indicate surface water infiltration or the presence of decaying organic matter. Although the total coliform bacteria group is a less reliable indicator of fecal contamination, it is preferred as an indicator of treatment adequacy in drinking water supply systems, because of its superior survival characteristics.

Test Method. In 2018, total coliform bacteria were analyzed at the CRD Water Quality Laboratory using the membrane filtration method and Chromocult Coliform Agar incubated at 36-38ºC for 21-24 hours. Test results were reported as colony-forming units (CFU) per 100 millilitres (mL) of water. Methods employing defined substrate technology rely on the fact that coliforms possess the enzyme β-galactosidase, which cleaves a chromogenic substrate, thus releasing a chromogen (coloured compound) that can be measured.

In compliance with regulations, the CRD Water Quality Monitoring program tests for total coliforms to ensure treatment efficacy and to monitor intrusion of organisms into the system post-treatment.

Regulatory Limits. Based on the requirements in the *Drinking Water Protection Regulation* and the Guidelines for Canadian Drinking Water Quality, the maximum acceptable concentration for the GVDWS is summarized as follows:

- *No sample should contain more than 10 total coliform organisms per 100 mL.*
- *No consecutive sample from the same site should show the presence of coliform organisms.*
- *Not more than 10% of the samples based on a minimum of 10 samples should show the presence of coliform organisms.*

Escherichia coli

***Escherichia coli* (*E. coli*)**. *E. coli* is the only member of the total coliform group found exclusively in the feces of human beings and warm-blooded animals. Although most members of this species are considered harmless, some strains of *E. coli* can be pathogenic. The presence of *E. coli* in water indicates recent fecal contamination and the possible presence of intestinal disease-causing bacteria, viruses and protozoa. The absence of *E. coli* in drinking water generally indicates that the water is free of intestinal disease-causing bacteria.

Test Method. In 2018, *E. coli* were analyzed by the CRD Water Quality Laboratory using the membrane filtration method and Chromocult Coliform Agar incubated at 36-38ºC for 21-24 hours. Test results were reported as colony-forming units (CFU) per 100 millilitres (mL) of water The *E. coli* test measures bacteria possessing the enzymes β-galactosidase and β-glucuronidase.

Regulatory Limits. In disinfected drinking water, the maximum acceptable concentration of *E. coli* (both federal and provincial limits) is zero *E. coli* per 100 mL.

Heterotrophic Plate Count Bacteria

Heterotrophic Plate Count Bacteria. Heterotrophic plate count bacteria (HPC7D) are used as a general measure of the bacterial population present in a drinking water system and in the raw source water. Under increasing nutrient conditions and/or a reduction in the concentration of chlorine residual, the heterotrophic bacteria are usually the first group to increase and provide an early warning of the potential growth of coliforms. In the CRD Water Quality Monitoring program, heterotrophic plate count bacteria are used to monitor the disinfection of the water at the disinfection plants and to track the decline in chlorine residuals in the distribution system and storage reservoirs.

Test Method. In 2018, heterotrophic plate count bacteria were analyzed by the CRD Water Quality Laboratory using membrane filtration (R2A media, 21-28ºC, seven-day incubation). As heterotrophic bacteria can be measured in several different ways, this method provides the quantity of heterotrophic bacteria capable of growing on R2A medium within seven days at room temperature. Raw water samples and water leaving the treatment plant were analyzed for HPC7D bacteria. In addition, samples with low chlorine residual levels (below 0.2 mg/L) were also analyzed for HPC7D.

Regulatory Limits. There is no federal or provincial regulatory limit on the quantity of heterotrophic bacteria allowed in drinking water. Therefore, in the absence of a regulatory limit, the CRD Water Quality Monitoring program uses an operational limit of 10,000 HPC7D bacteria per 1 mL of drinking water.

6.4 Certification and Audits

To ensure that the analytical testing is performed to the highest possible standard, the Water Quality Laboratory participates in several types of external quality assurance and quality control (QA/QC) programs, in addition to rigorous internal quality QA/QC procedures that are included as part of the methodology and are a normal component of good laboratory practice.

6.4.1 Certification

The Province of BC requires that all laboratories analyzing drinking water samples be approved in writing by the provincial health officer. Laboratory approval requires both an approval certificate and a proficiency testing certificate, as noted below:

- **Water Bacteriology Testing Laboratory Approval Certificate**. This certificate is issued by the BC provincial health officer for bacteriological testing of drinking water in the Province of BC. This certificate is renewed every three years via an on-site inspection (audit) of the analytical laboratory.
- **Clinical Microbiology Proficiency Testing Program Certificate of Participation**. This certificate is issued by the Advisory Committee for Water Bacteriology Laboratories, which is operated by the Department of Pathology and Laboratory Medicine at the University of British Columbia. Satisfactory performance is required to maintain laboratory certification.

6.4.2 Accreditation

In 2018, the CRD Water Quality Laboratory recertified accreditation to the International Standards Organization 17025 standard used by testing and calibration laboratories. The accreditation has management, quality and technical requirements. Accreditation is maintained by successful reassessment every two years by an accrediting body (The Canadian Association for Laboratory Accreditation) and satisfactory participation in an external proficiency testing program.

7.0 WATER QUALITY RESULTS

The overview results of the 2018 CRD Water Quality Monitoring program for the GVDWS are provided below. Water quality data are listed in Appendix A (tables 1, 2 and 3). Note that the median (middle value between the high and low) is used in these tables rather than the average value, as the median eliminates the effect of extreme values (very high or very low) on the average value and provides a more realistic representation of typical conditions.

7.1 Source Water Quality Results

Total Coliform Bacteria. Similar to previous years, the raw (untreated) source water entering both plants exhibited generally very low concentration of total coliform bacteria with some increased concentrations between August and October when the Sooke Lake south basin was destratified and, therefore, fully mixed with warm water. Total coliform spikes due to wind-induced internal seiches, as experienced in 2017, were not observed in 2018.

With 281 samples analyzed in 2018, the total coliform concentration ranged from 0-580 CFU/100 mL, with a median value of 8 CFU/100 mL. The types of total coliforms present were not indicative of any particular type of contamination.

***E. coli* Bacteria**. During more than two decades of monitoring bacteria within the GVDWS, it has been found that virtually 100% of the fecal coliform bacteria detected in the source water and the distribution system are *E. coli*. In 2018, as in previous years, the low detection of *E. coli* bacteria indicated that the raw water entering the Japan Gulch Disinfection Plant from Sooke Lake Reservoir was good quality source water and complied with the limit in the USEPA *Surface Water Treatment Rule* to remain an unfiltered drinking water supply (Figure 3).

In 2018, about 7% of the samples collected from the raw source water contained *E. coli* and those that were positive for *E. coli* have levels well below 20 CFU/100 mL. In 281 samples analyzed for *E. coli*, only some contained this bacteria and the concentration ranged from 0-10 CFU/100 mL with a median value of 0 CFU/100 mL. The slightly higher *E. coli* concentration during November and December were a typical result of the heavy rainfall and runoff into Sooke Lake, which transported organic matter accumulated over the course of the dry season in the watershed to the lake. In years with a Kapoor Tunnel Inspection Project, a slight *E. coli* concentration increase in mid-December can be attributed to the supply from the Goldstream System. In 2018, the Goldstream System was not used as a drinking water source.

***Giardia and Cryptosporidium* Parasites**. In 2018, parasite samples were collected eight times per year as part of the CRD's routine monitoring program. This sampling frequency was set after an evaluation of long-term data showed extremely low detection of these organisms. The eight parasite samples were collected from the raw water sampling location at the Japan Gulch Treatment Plant and shipped for analysis to an external laboratory. It should be noted that the efficiency of the analysis for detecting *Giardia*, and especially *Cryptosporidium*, is quite low (typically in the 15-25% range).

In 2018, no *Giardia* cysts were detected in all samples on the raw water entering the Japan Gulch Disinfection Plant. One sample from March 5, 2018 tested positive for *Cryptosporidium*, but with a very a low concentration of 1 oocyst/100 L. The 10-year median value for total *Giardia* cyst and total *Cryptosporidium* oocyst concentrations is 0. While these are extremely low values for a surface water supply, the addition of UV disinfection provides assurance that no infective parasites can enter the GVDWS.

The treatment target specified by the Canadian federal and provincial regulations, as well as the USEPA *Surface Water Treatment Rule*, require 3-log (99.9%) parasite inactivation to meet the filtration exemption criteria for surface water systems. Both CRD disinfection facilities provide UV treatment that, in conjunction with the CRD's drinking watershed management concept, is able to meet these targets and, therefore, adequately protects the public from waterborne parasitic illnesses.

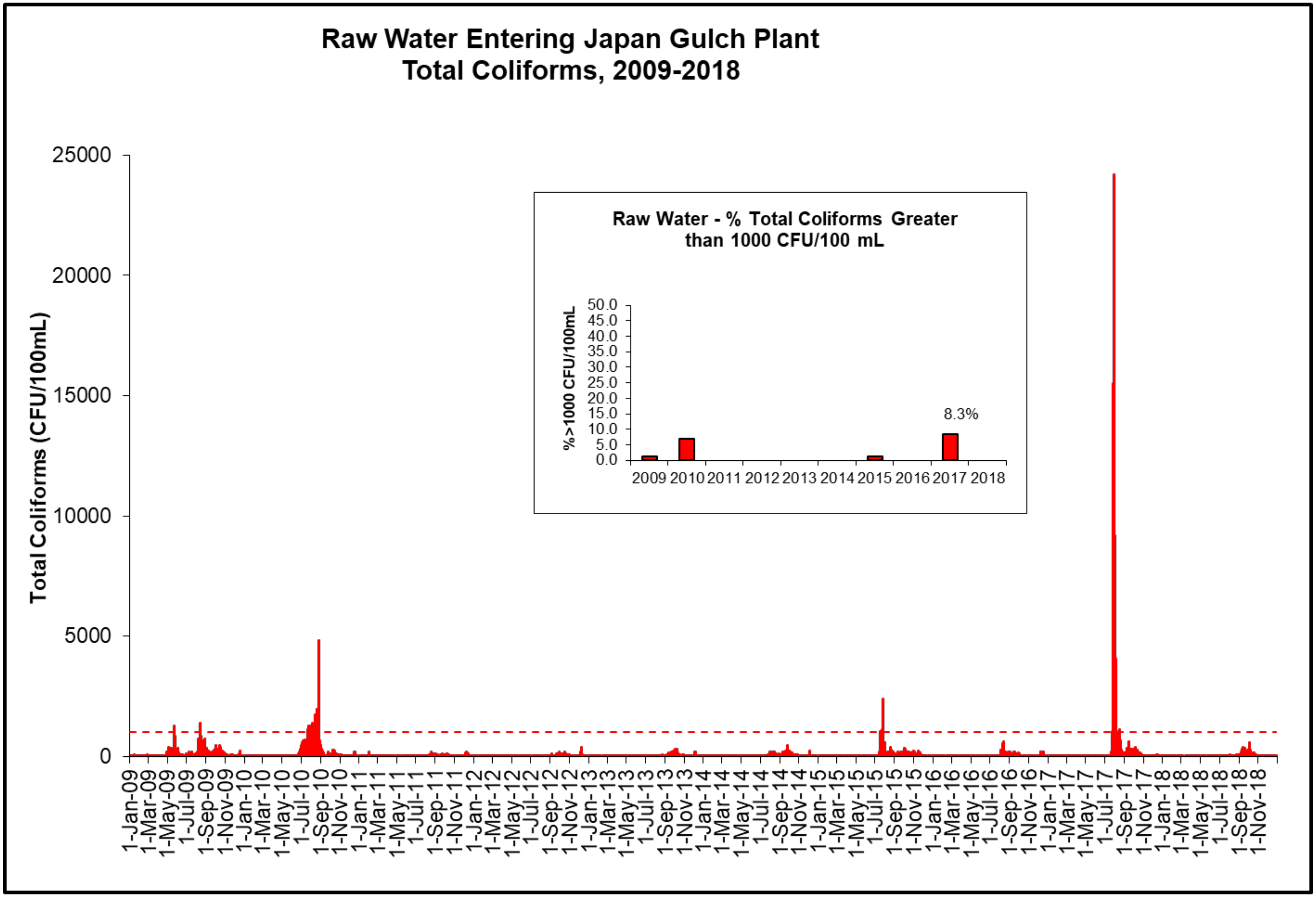

Figure 2 **Raw Water Entering Japan Gulch Plant Total Coliforms 2009-2018**

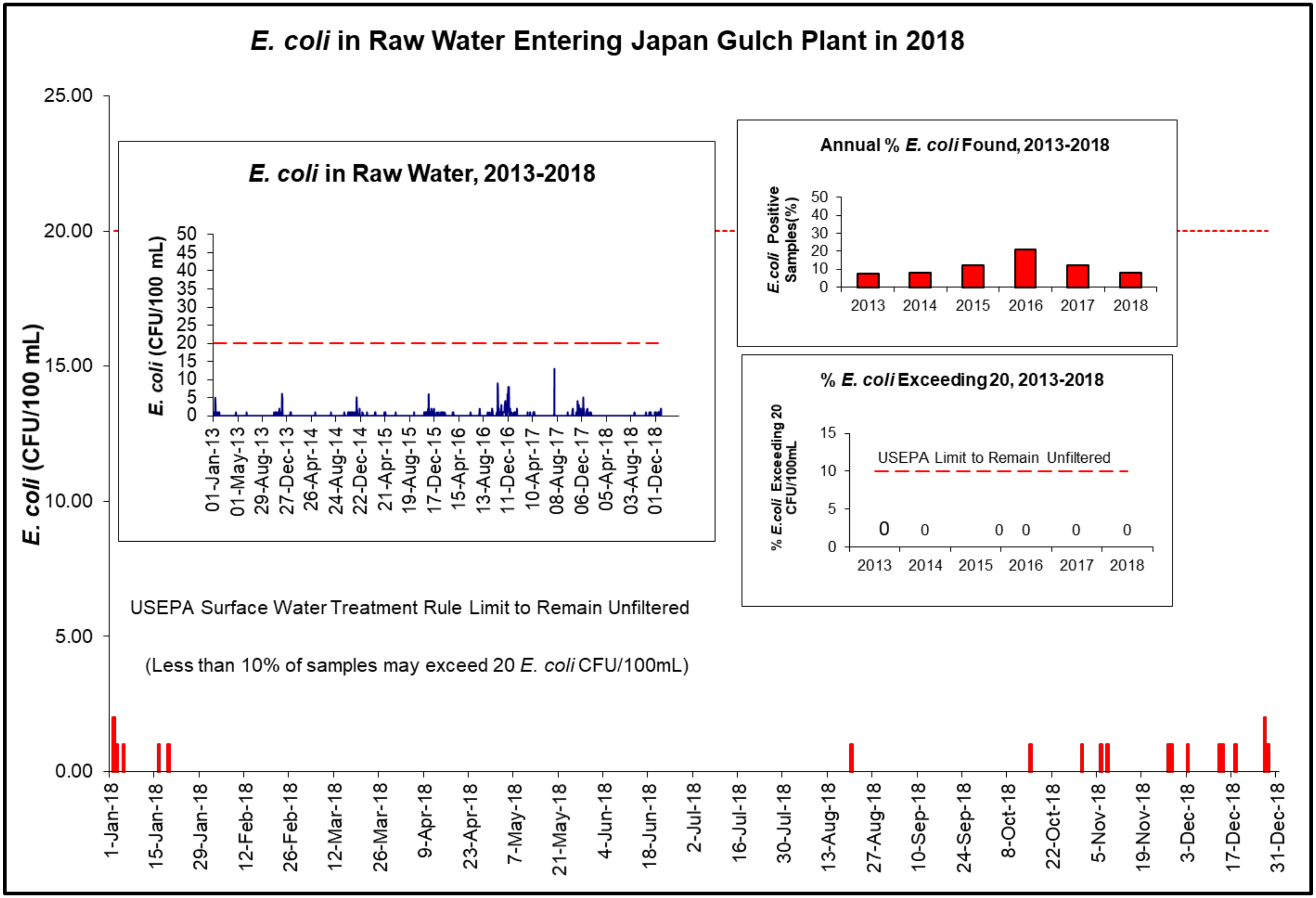

Figure 3 ***E.coli*** **in Raw Water Entering Japan Gulch Plant in 2018**

Algae. In 2018, algal activity for Sooke Lake was above average for the majority of the year (figures 4a-c; 5a-c). The dominant algae species continuously switched between *Astrionella formosa* (Image 1) and *Dinobryon divergens* (Image 2). These species are common in Sooke Lake and can be seasonally very abundant under favourable weather conditions, as occurred in 2018. Both of these species are capable of producing adverse taste and odour in the drinking water.

There was a low-level bloom in early spring of the stellate shaped, colonial diatom *Astrionella formosa*. In November, there was a low-level bloom of a colonial chrysophyte, *Dinobryon divergens*. Higher than normal algal concentrations were observed at this time; however, samples analyzed throughout both algal events did not detect any water quality impact on the treated water, and there were no customer inquiries regarding this potential impact.

A variety of cyanobacterial species were observed in Sooke Lake in 2018 (Figure 5a-c), increasingly abundant during the warmer months of the year. This has been a common occurrence since the beginning of water quality monitoring in Sooke Lake Reservoir. The identified cyanobacterial species are either capable or assumed capable of producing harmful cyanotoxins under bloom conditions. The species observed in the highest concentrations is a very small, colonial species, *Cyanodictyon.* Fortunately, a stable and naturally nutrient-poor ecosystem in the Sooke Lake watershed does not provide conditions needed for cyanobacteria blooms as seen in other lakes in BC and worldwide.

Similar to other lakes in the region, Sooke Lake Reservoir exhibits vertical stratification during the spring, summer and early fall months where warmer, less dense surface water (the epilimnion) sits atop a layer of colder, denser water located on the bottom of the lake, called the hypolimnion. The driver of the stratification process is, therefore, the typical warming trend during the progression of the spring season and into summer. In 2018, the Sooke Lake Reservoir did not begin to stratify until the end of April. The stratification in the Sooke Lake south basin began to break down in early August.

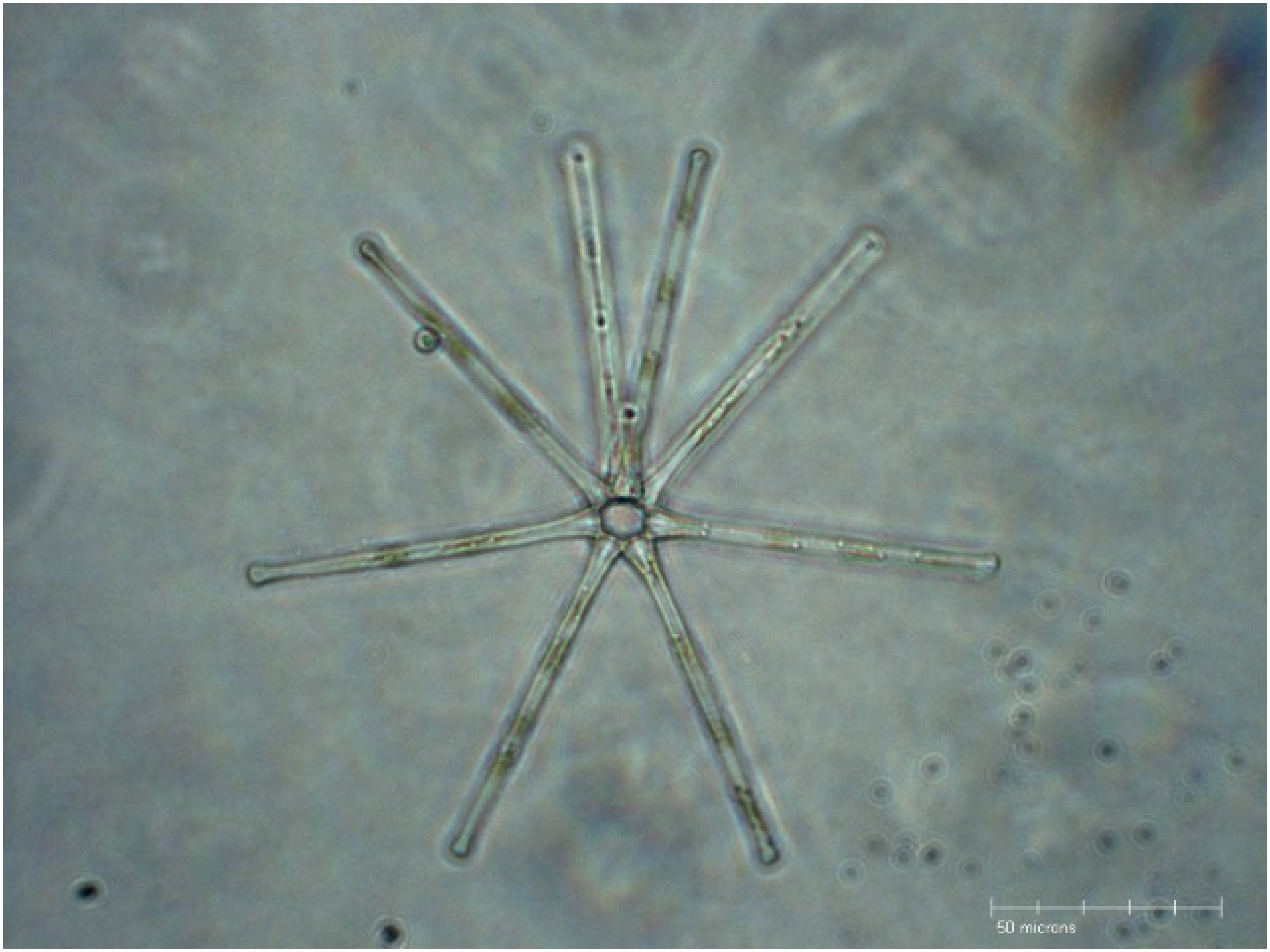

Image 1 Diatom species: *Astrionella formosa*

Image 2 **Chrysophyte species: *Dinobryon divergens***

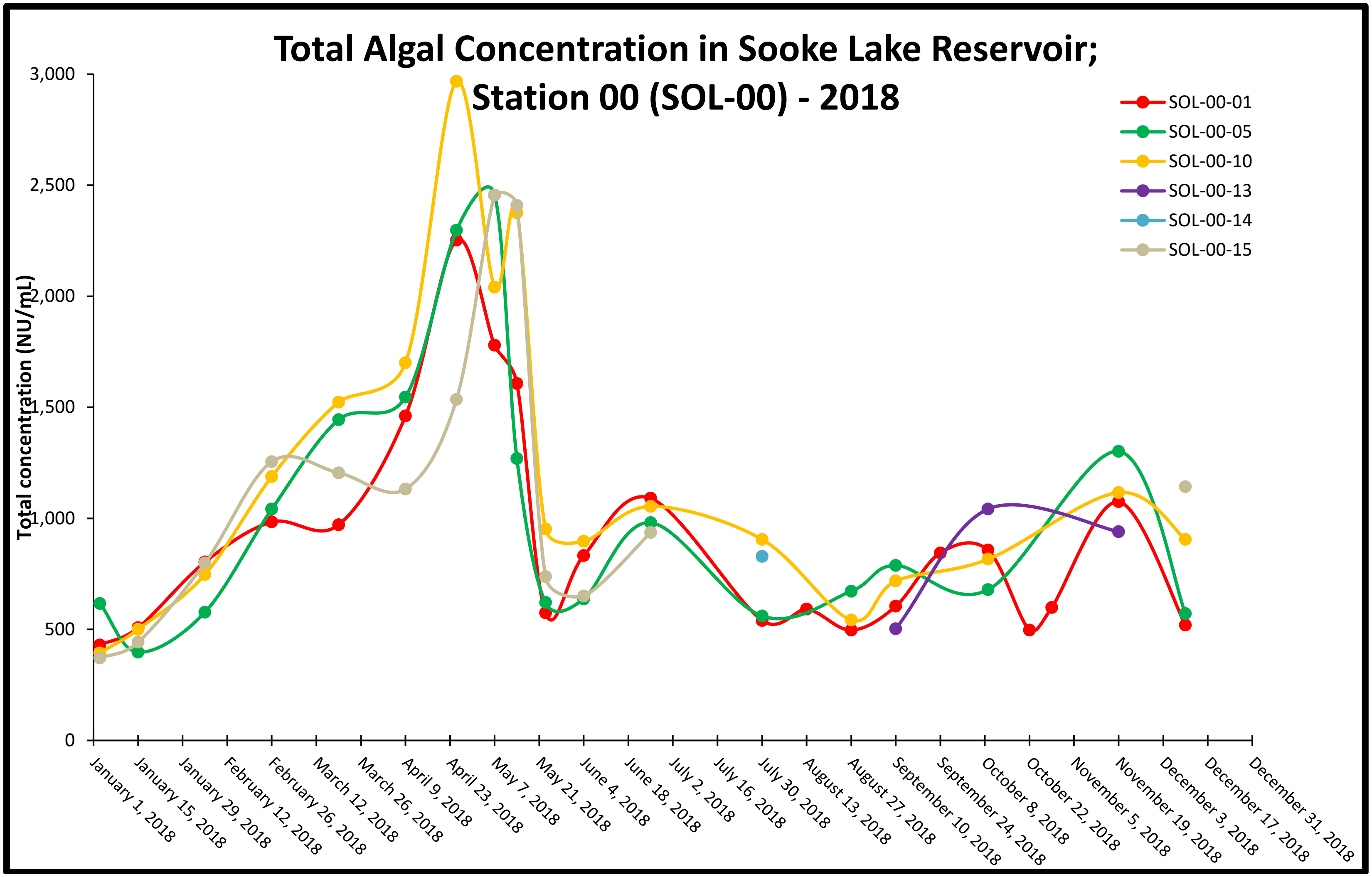

Figure 4A 2018 Total Algal Concentration (Natural Units/mL), Sooke Lake Reservoir, Intake Basin, 1 m Depth (SOL-00-01)

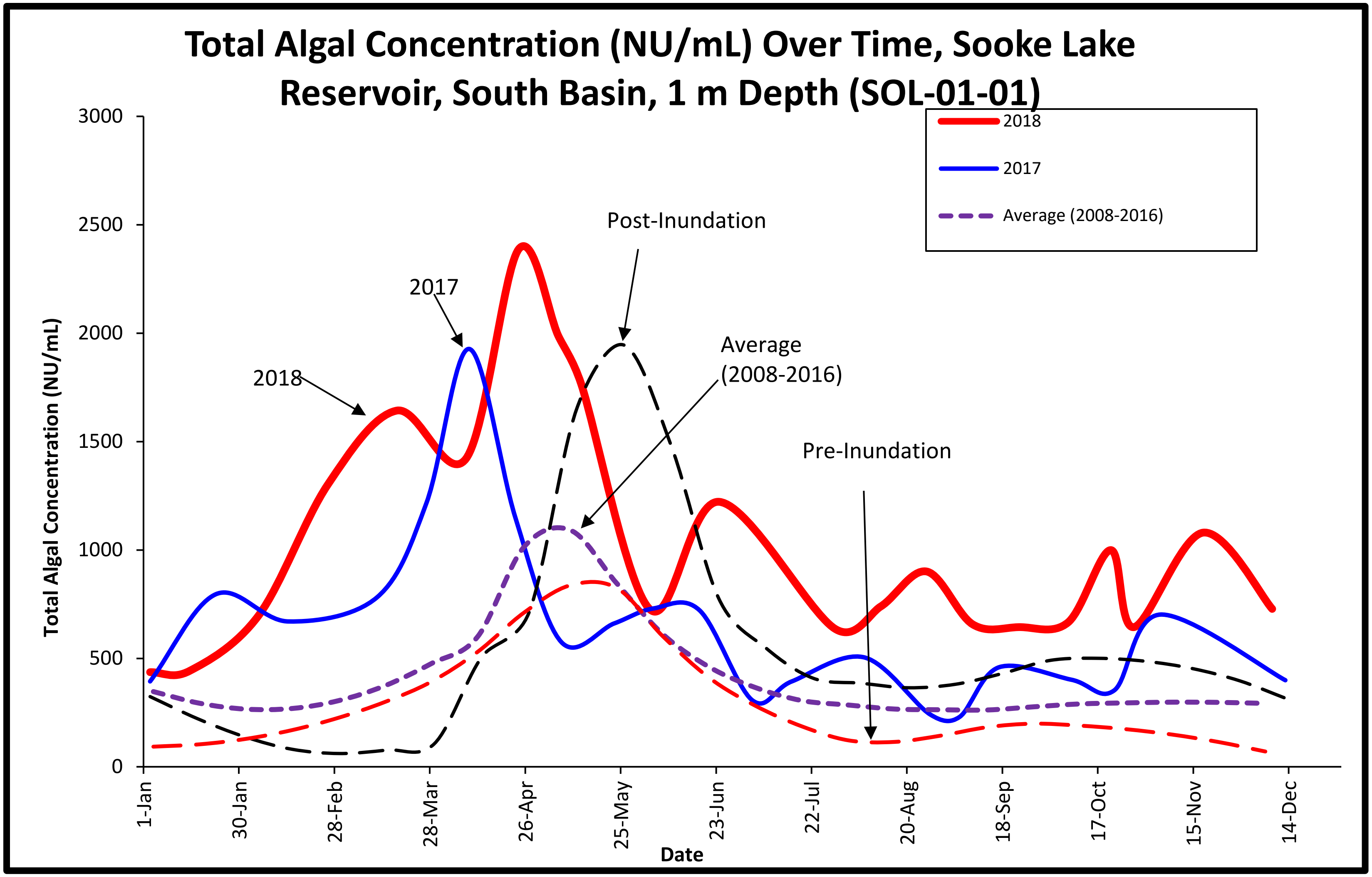

Figure 4B **Total Algal Concentration (Natural Units/mL) Over Time, Sooke Lake Reservoir, South Basin, 1 m depth (SOL-01-01)**

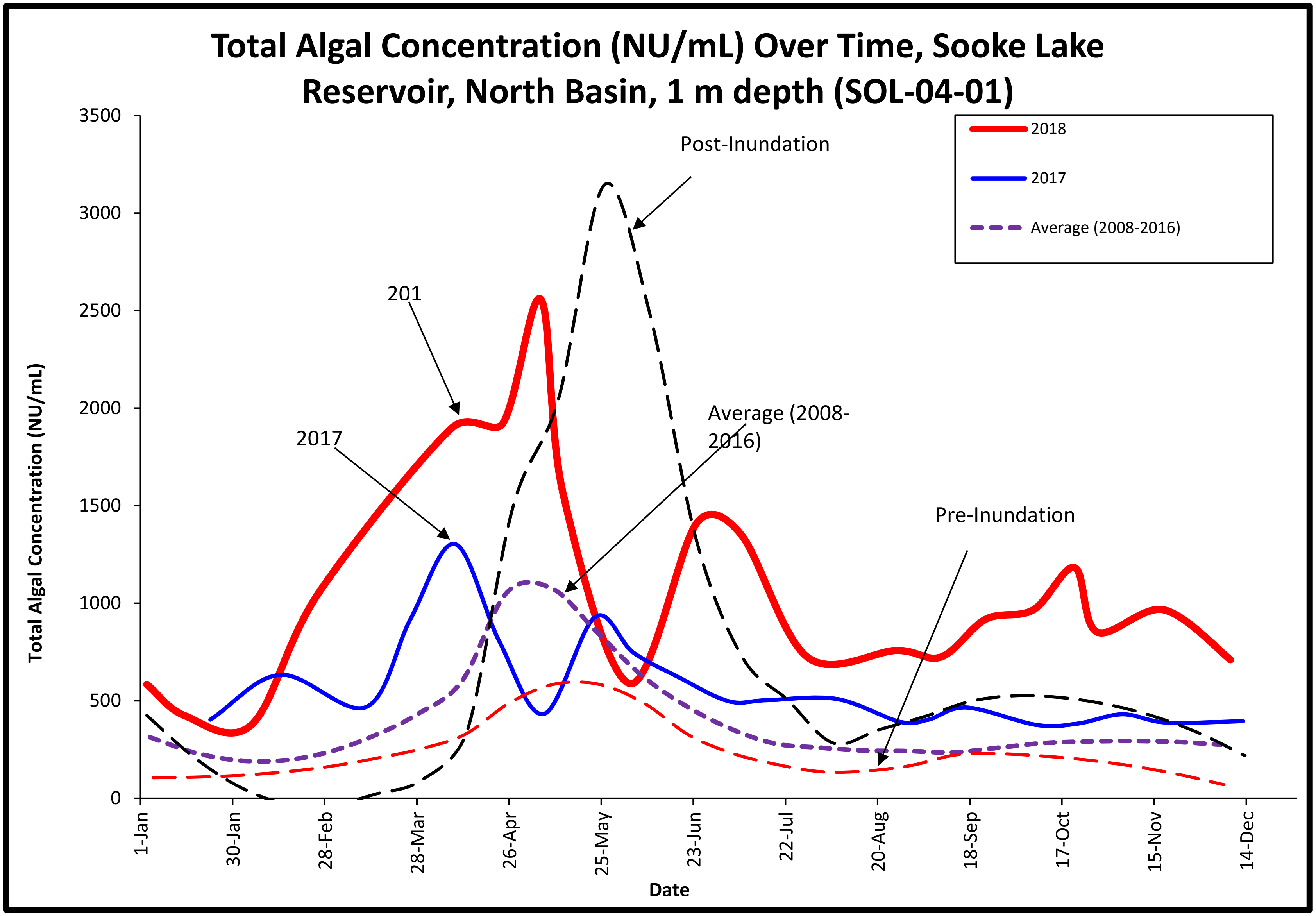

Figure 4C **Total Algal Concentration (Natural Units/mL) Over Time, Sooke Lake Reservoir, North Basin, 1 m depth (SOL-04-01)**

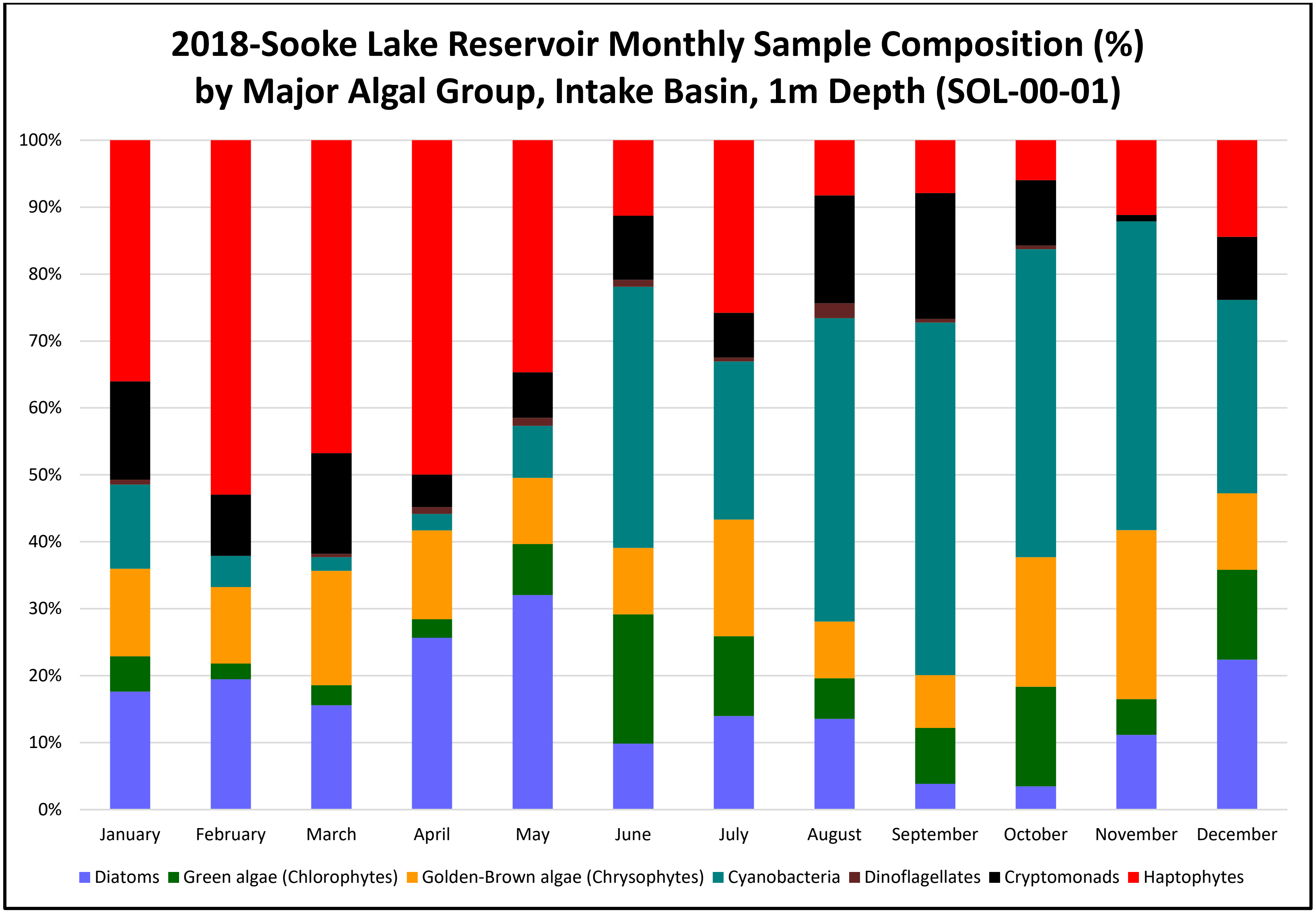

Figure 5A **2018 Sooke Lake Reservoir Monthly Sample Composition (%) by Major Algal Group, Intake Basin, 1 m Depth (SOL-00-01)**

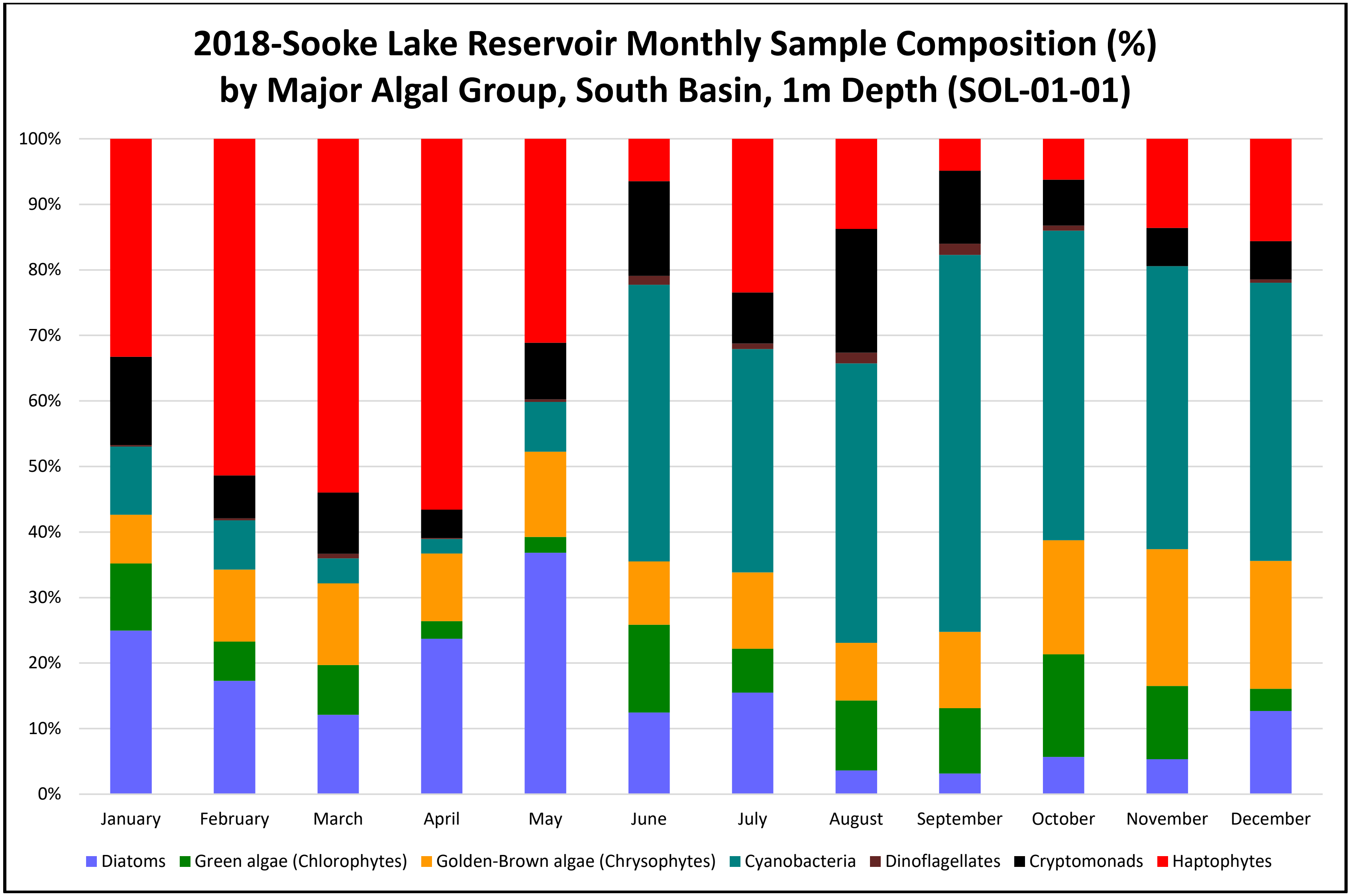

Figure 5B **2018 Sooke Lake Reservoir Monthly Sample Composition (%) by Major Algal Group, South Basin, 1 m Depth (SOL-01-01)**

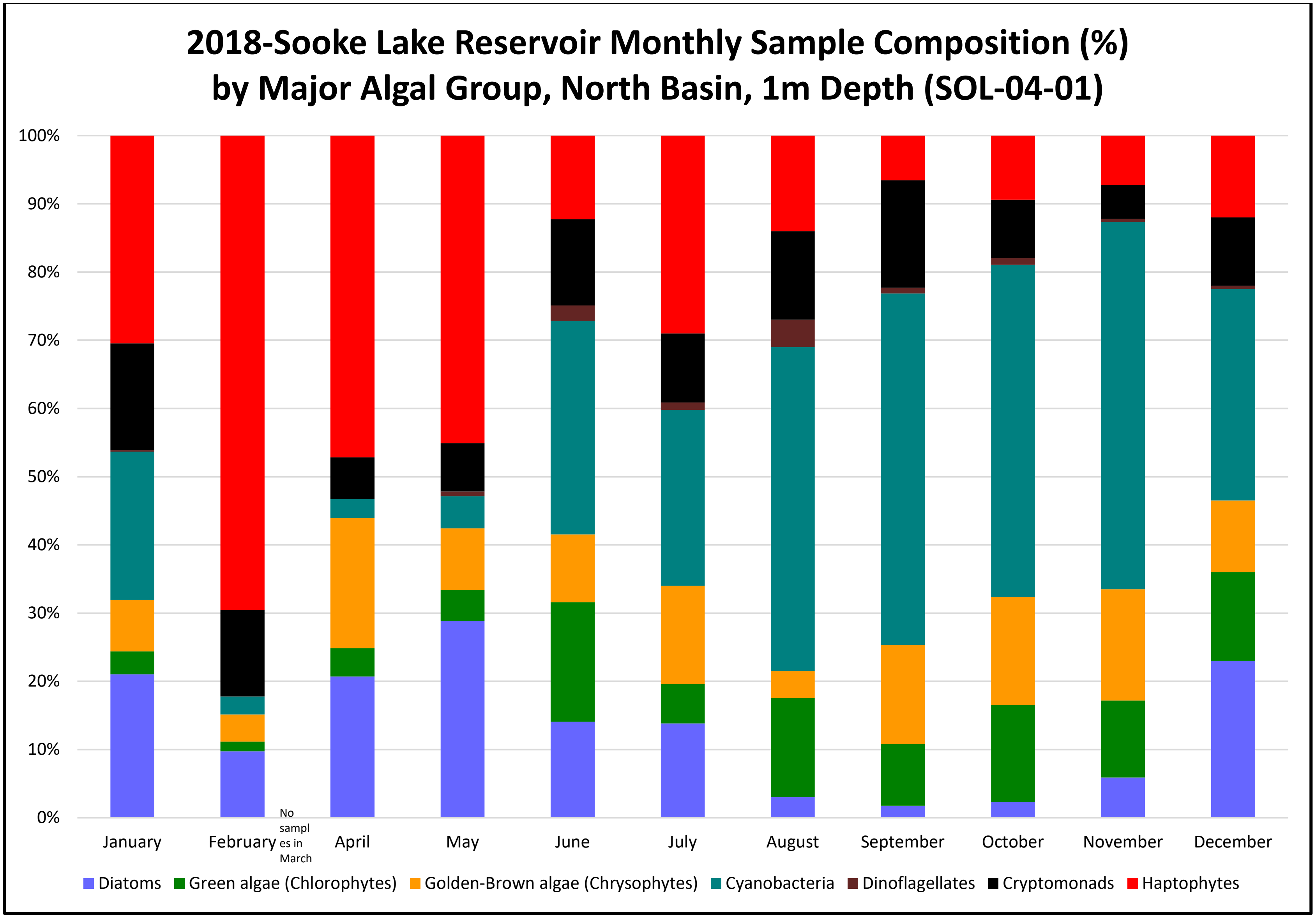

Figure 5C **2018 Sooke Lake Reservoir Monthly Sample Composition (%) by Major Algal Group, South Basin, 1 m Depth (SOL-01-01)**

Zooplankton. Zooplankton are small invertebrate organisms in the water column possessing limited swimming ability; they are sometimes referred to as the planktonic animals. The average zooplankton length ranges from 0.1-4.0 mm; as a result, some species can be seen with the unaided eye. Zooplankton are an important part of a lake trophic structure in that they feed upon the algae, but are also a food source for fish. Zooplankton and fish are both important contributors to within-lake recycling processes of nutrients, including nitrogen and phosphorus.

The rotifers are the smallest group that constitutes the zooplankton community in most lakes, including Sooke Lake Reservoir. They are characterized by having a band of hair-like structures on their head called cilia, which beat, thus aiding in both motion and feeding, with their preferred food sources being bacteria and small algal cells. Their method and speed of reproduction, as well as lack of defenses, allow their populations to fluctuate rapidly. They produce resting or overwintering eggs, which emerge in spring when conditions become optimal. Rotifers are not a preferred food for fish, but are vulnerable to predation by larger rotifer species, as well as species belonging to other groups of zooplankton.

A second main group of zooplankton, the copepods, are larger than the rotifers and characterized by a streamlined, segmented body and a pair of antenna used for chemical and motion sensing; they are also capable of swimming, which they do at a much faster rate than rotifers. The copepods possess an eye, allowing them to move quickly toward and away from a variety of stimuli, such as light, predation by fish and other copepods, as well as food sources, of which they prefer algae, rotifers and other juvenile or adult copepods. Their life cycle is longer than that of the rotifers (weeks to months in length instead of days to weeks) and, unlike the rotifers, they undergo more than 10 emergent stages in the progression from egg to adult. Also, unlike the rotifers, the copepods exhibit daily vertical migration in the water column where they tend to swim deeper during the daylight hours and rise toward the surface during the nighttime hours. Their strong swimming capability allows for this behaviour, which is thought to occur mainly to avoid predation. The amplitude of their migration is species-specific and can range from one to hundreds of metres each day; regardless, the amplitude of migration is greatest during the summer and fall months.

Zooplankton trends in Sooke Lake Reservoir are generally typical of ecological succession models. 2018 zooplankton activity was consistent with long term trends.

Turbidity. The turbidity is continuously measured at both disinfection facilities and at the Sooke Lake intake tower, but also sampled and lab tested daily from the Japan Gulch disinfection facility and weekly at the Sooke River Road disinfection facility. Figure 8 shows that the source water turbidity was well under 1 NTU throughout 2018; however, on three days during the summer season with peak demand and high flows due to outdoor water demand, sediments in the mains downstream of Kapoor Tunnel were dislodged and caused short-period turbidity excursions to slightly above 1 NTU. These events usually occurred on Wednesdays or Thursdays from 4 am to approximately 10 or 11 am during the peak summer demand times, only at Japan Gulch and not at the Sooke River Road disinfection facility. SCADA monitoring data shows that the average daily turbidity was still below 1 NTU on these turbidity event days. Also, the UV transmittance, a measure of how much ultraviolet light can pass through the water, was always around 90% during those events and the UV dose at least 60 mJ/cm^2, ensuring effective UV treatment. The CRD has taken measures to mitigate these turbidity events at the Japan Gulch disinfection facility (changed watering restrictions in the region, thoroughly cleaned tunnel and piping in December) and these measures were successful in greatly reducing the number of turbidity exceedances compared to the summer of 2016. The CRD will look at further measures to reduce or eliminate these nuisance events. Overall, Sooke Lake water was very clear in 2018 and turbidity of the raw water was at no time a factor of concern to the drinking water quality in the GVDWS.

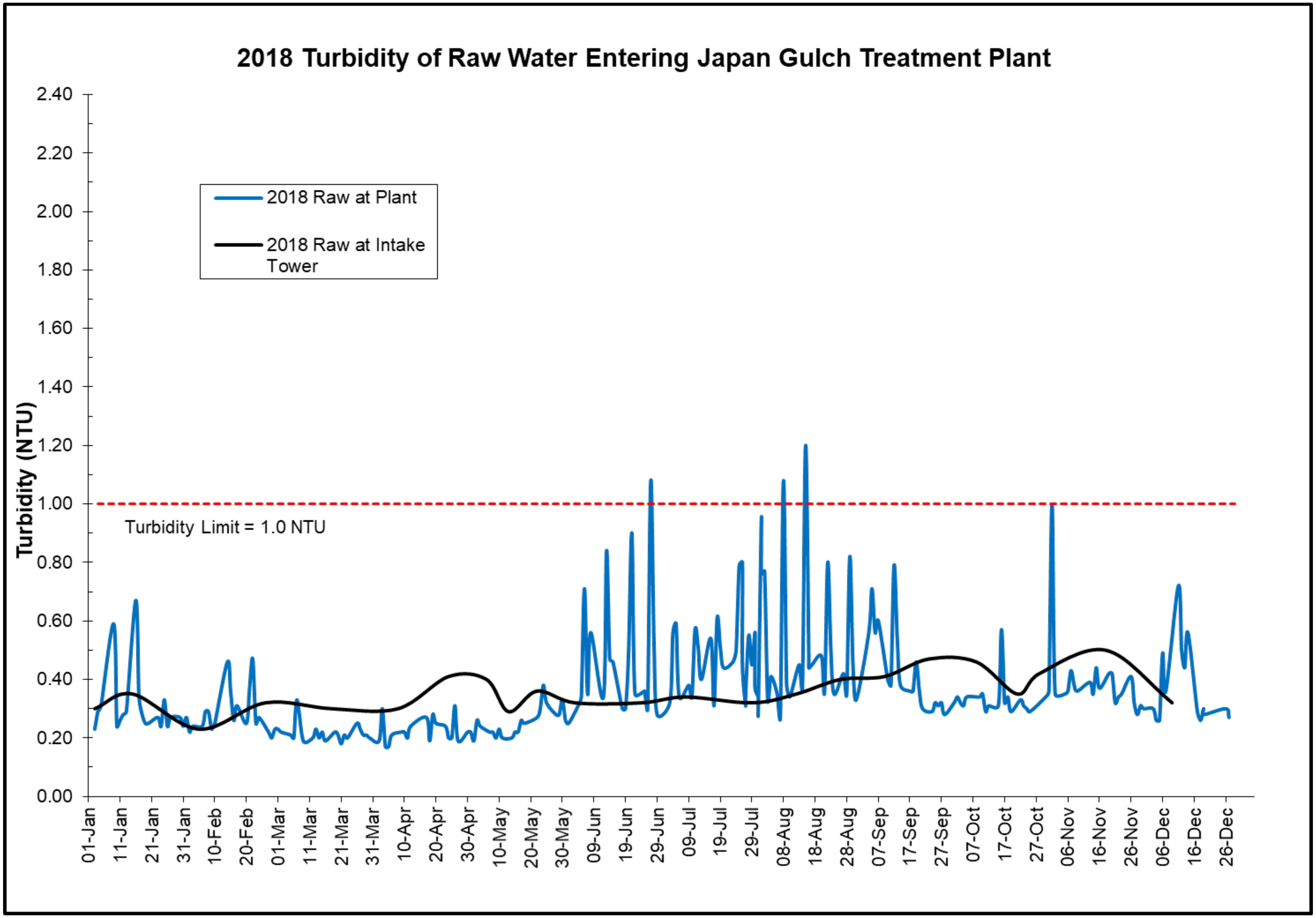

Figure 6 2018 Turbidity of Raw Water Entering Japan Gulch Treatment Plant

Raw Water Temperature. Cool water is beneficial in a distribution system because it reduces the potential for losses of chlorine residual and regrowth of bacteria. For that reason, the Canadian guidelines suggest a temperature limit of 15°C.

The temperature of the water entering the Japan Gulch disinfection facility in 2018 was nearly following the long-term average trend line until the beginning of July. After that, the temperature started to trend slightly below the long-term average for the rest of the year (Figure 9). The raw water entering both treatment plants exceeded the 15°C guideline limit between early August and late September. The typical usage of the lowest elevation intake tower gates during summers in previous years led to the depletion of the cool water stored in the hypolimnion water column of the reservoir's south basin. The cool water stored in the hypolimnion of the much deeper north basin is currently inaccessible for CRD with the existing infrastructure.

High raw water temperatures are not a new problem for the CRD. Before the expansion of Sooke Lake Reservoir, the water temperature entering the plant reached 15°C as early as mid-June.

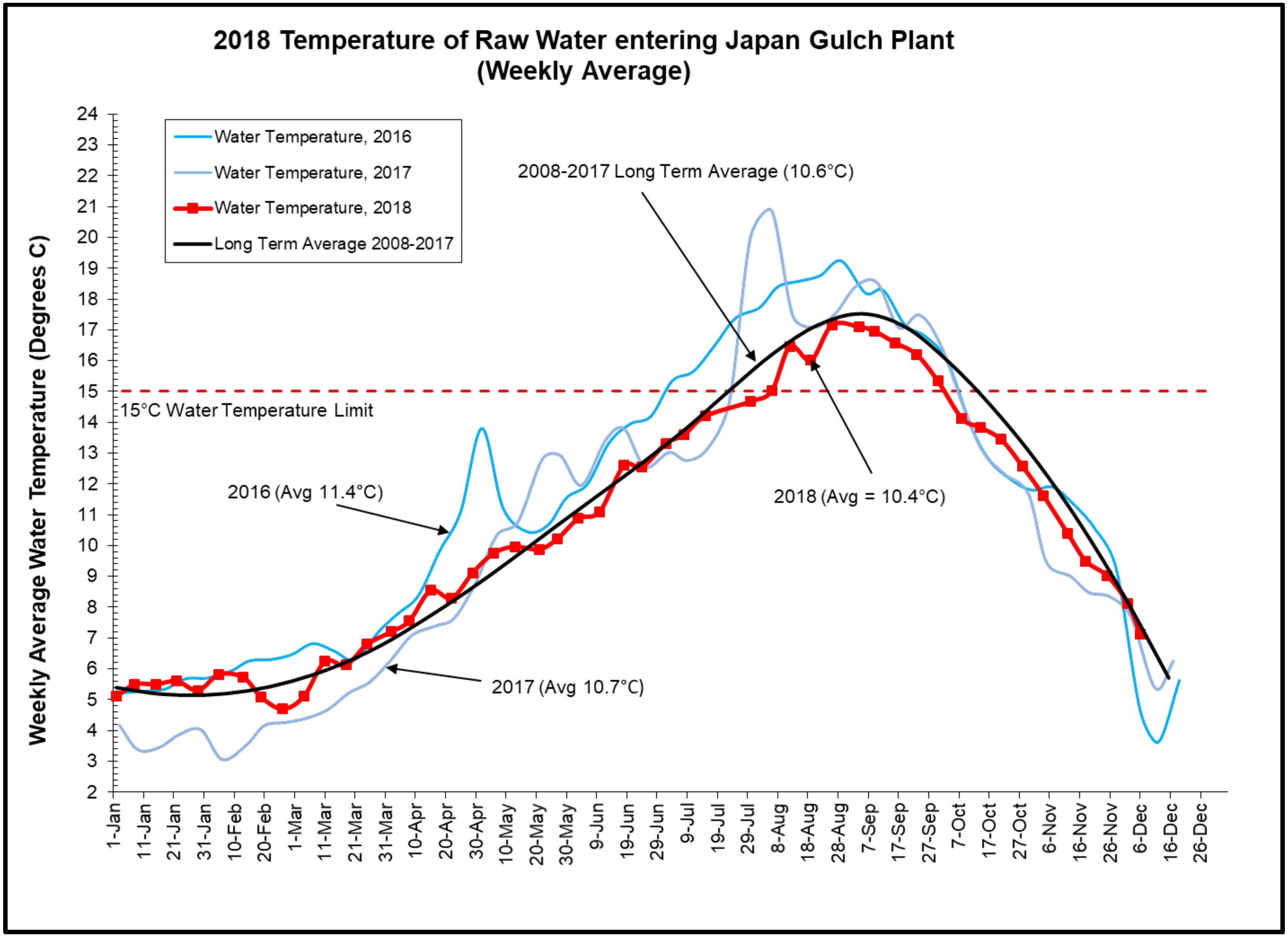

Figure 7 **2018 Temperature of Raw Water Entering Japan Gulch Plant (Weekly Average)**

Physical/Chemical Parameters. The raw water entering the Japan Gulch disinfection facility had the following physical and chemical characteristics:

- Median pH: 7.33
- Median $CaCO_3$ Hardness: 16.50 mg/L
- Median Alkalinity: 14.95 mg/L
- Median Colour: 7.0 TCU
- Median Total Organic Carbon: 2.01 mg/L
- Median Conductivity (25ºC): 40.80 µS/cm

Inorganics/Metals. Table 1 in Appendix A lists all the inorganic and metal parameters tested in the source water in 2018. No unusual or concerning levels or trends have been detected.

Organics/Radionuclides. Table 1 in Appendix A lists all the organic radiological parameters tested in the source water in 2018. Most of them were not detected or in insignificant concentrations. These results confirm the high level of protection from any anthropogenic impacts on the supply watershed.

Nutrients. Figures 10-13 show the total nitrogen and the total phosphorus concentrations in both the South and North Basins at 1 m depths in Sooke Lake Reservoir. Total phosphorus concentrations at both stations trended without much variation, mostly below the long-term average in 2018. The total phosphorus concentrations were extremely low in general and close to the detection limit of the laboratory analysis. The total nitrogen fluctuated slightly above the long-term average trend line; however, it fluctuated at a low level. Short-term nitrogen spikes in the north basin are usually attributable to significant rainfall and runoff event during that time. In general, the nutrient concentrations confirm the ultra-oligotrophic status (extremely unproductive, phosphorus limited) of Sooke Lake Reservoir, which is positive for a drinking water supply source.

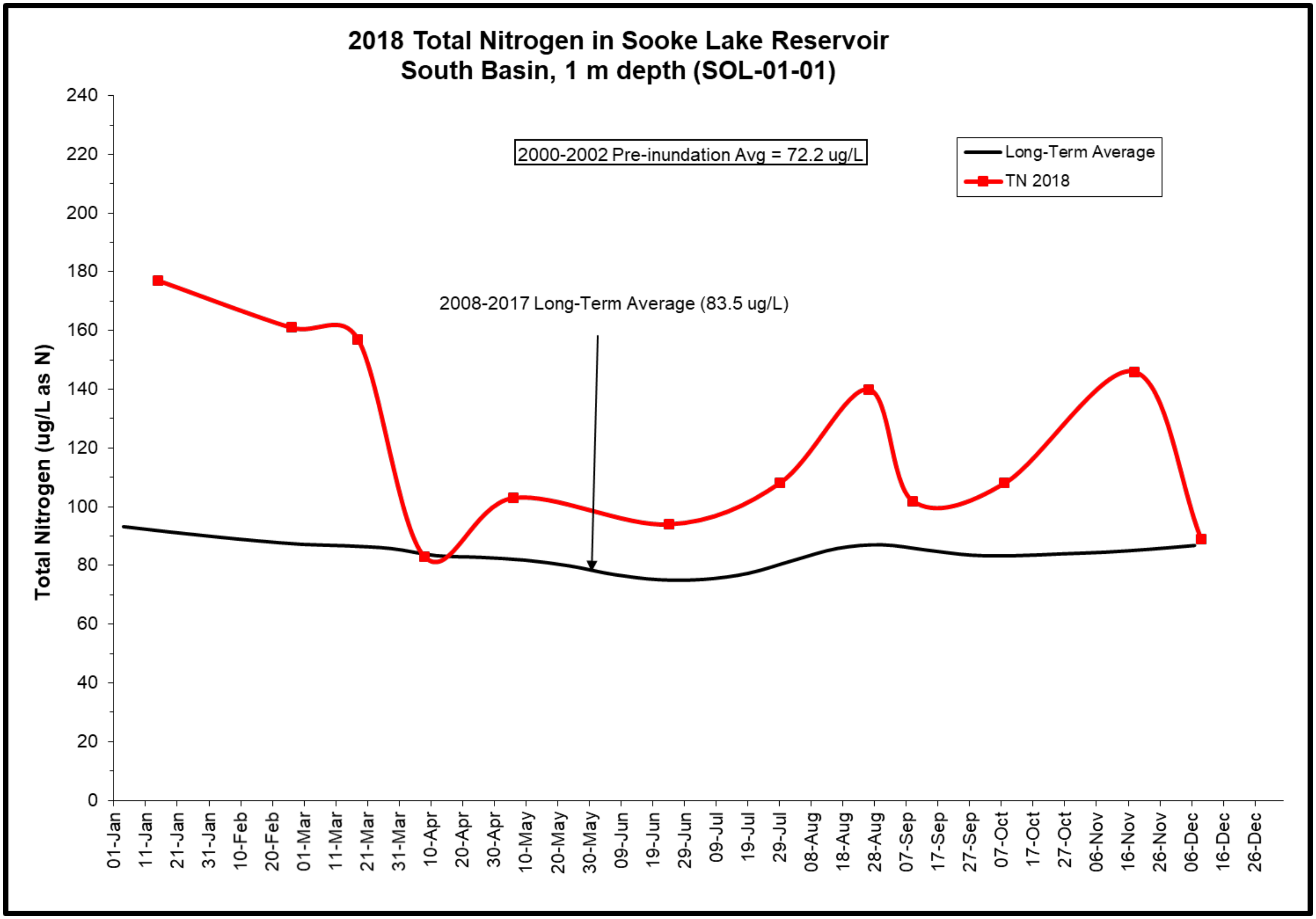

Figure 8 **Total Nitrogen in Sooke Lake Reservoir, South Basin, 1 m depth (SOL-01-01)**

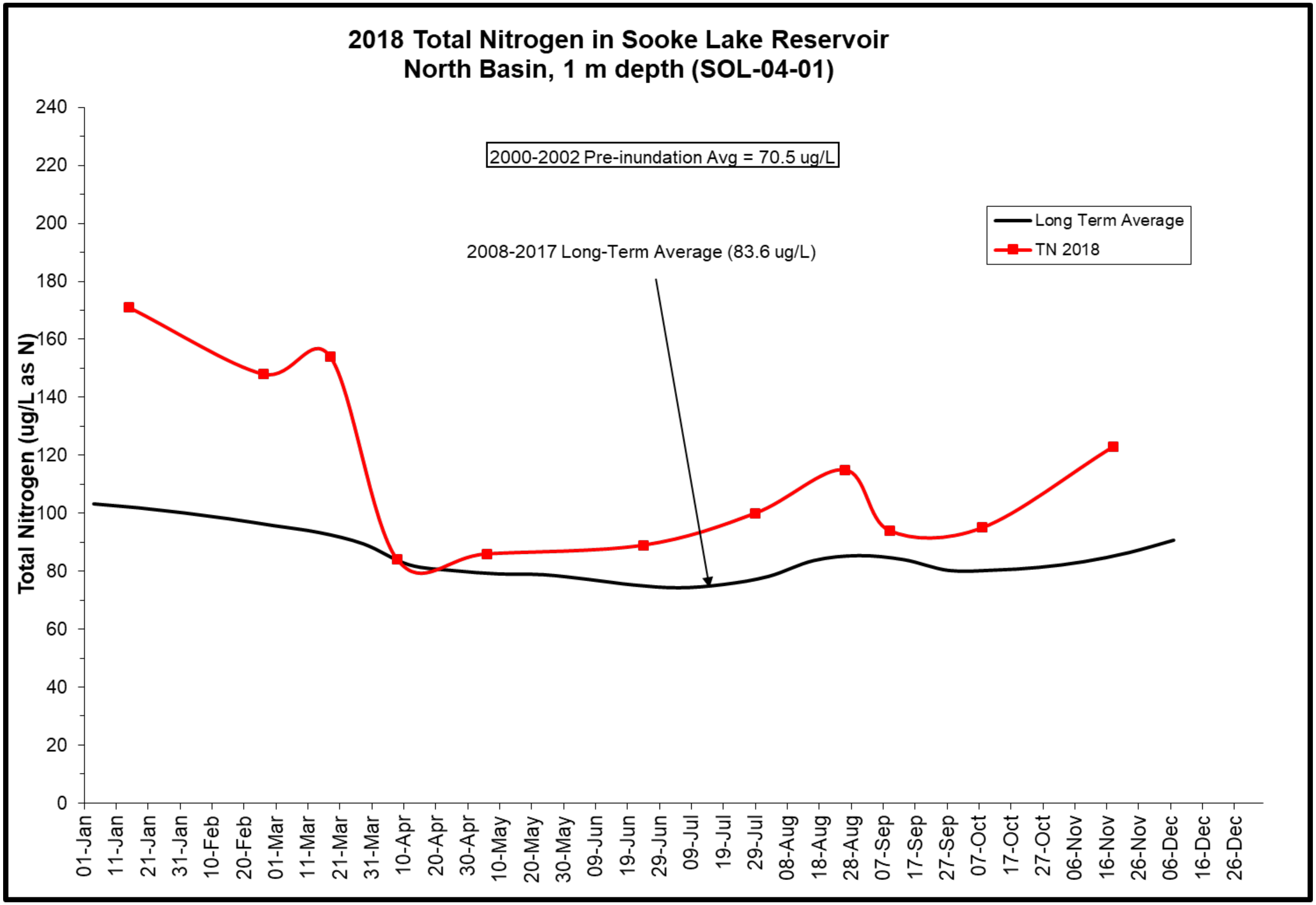

Figure 9 **Total Nitrogen in Sooke Lake Reservoir, North Basin, 1 m depth (SOL-04-01)**

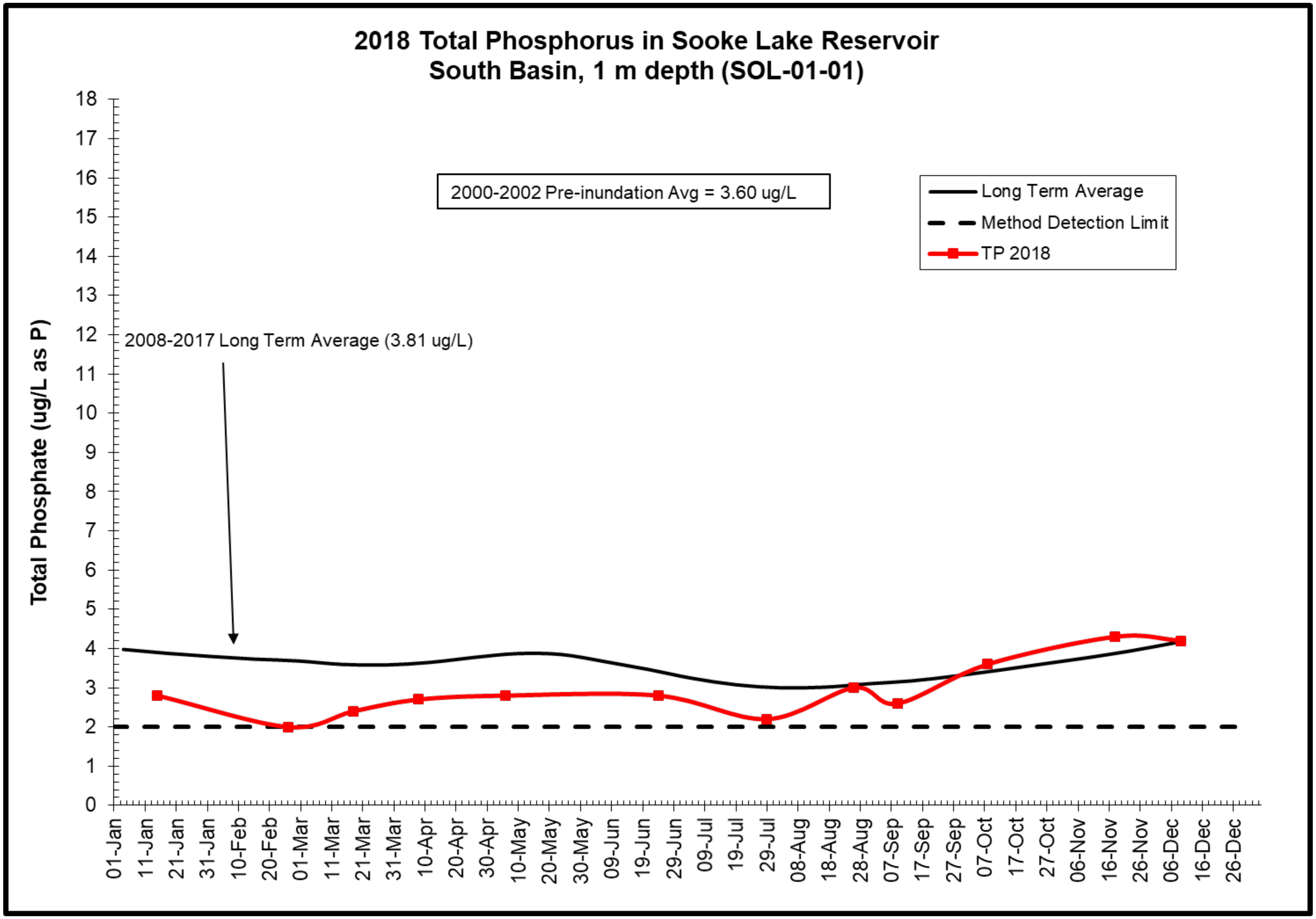

Figure 10 Total Phosphorus in Sooke Lake Reservoir, South Basin, 1 m depth (SOL-01-01)

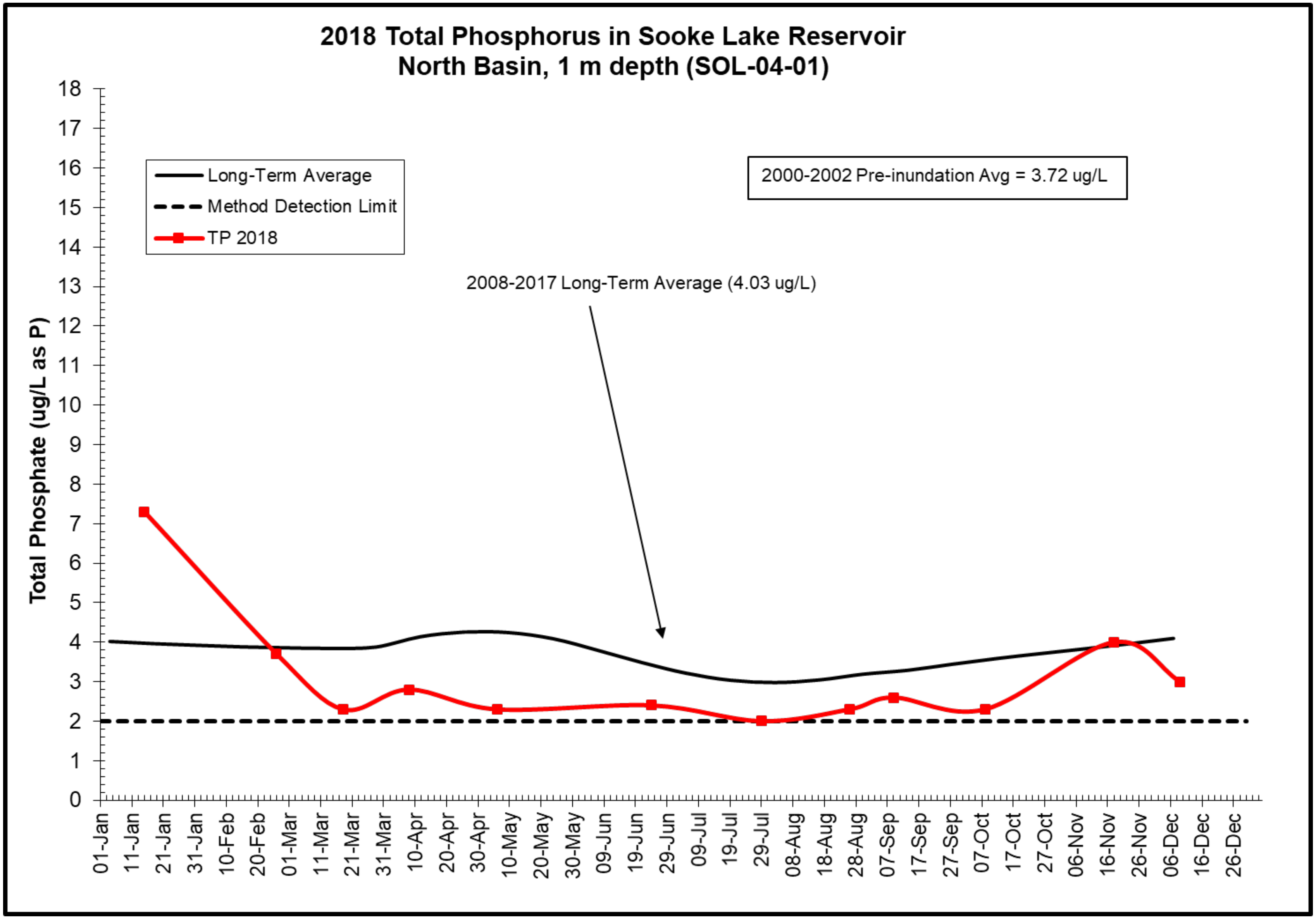

Figure 11 Total Phosphorus in Sooke Lake Reservoir, North Basin, 1 m depth (SOL-04-01)

7.2 Treatment Monitoring Results

The following sections summarize the water quality data collected and analyzed to monitor and verify the effectiveness of the disinfection process at both CRD disinfection facilities in the GVDWS.

7.2.1 Japan Gulch Disinfection Facility

Bacteriological Results after UV Treatment. Figure 14 shows the results from 231 samples collected and analyzed just downstream of the UV reactors. The results indicate that the UV treatment is capable of greatly reducing the *E. coli* and total coliform concentrations. On September 10, 2018, total coliform bacteria were found downstream of the UV treatment coinciding with higher total coliform concentrations in the raw water. In response, CRD IWS increased the UV dosage for several weeks to achieve a higher bacteria inactivation rate by the UV treatment. Subsequent to this adjustment, no post-UV samples tested positive for total coliform. Throughout this event, no total coliform were detected downstream of the chlorination plant, assuring that no bacteria breakthrough occurred.

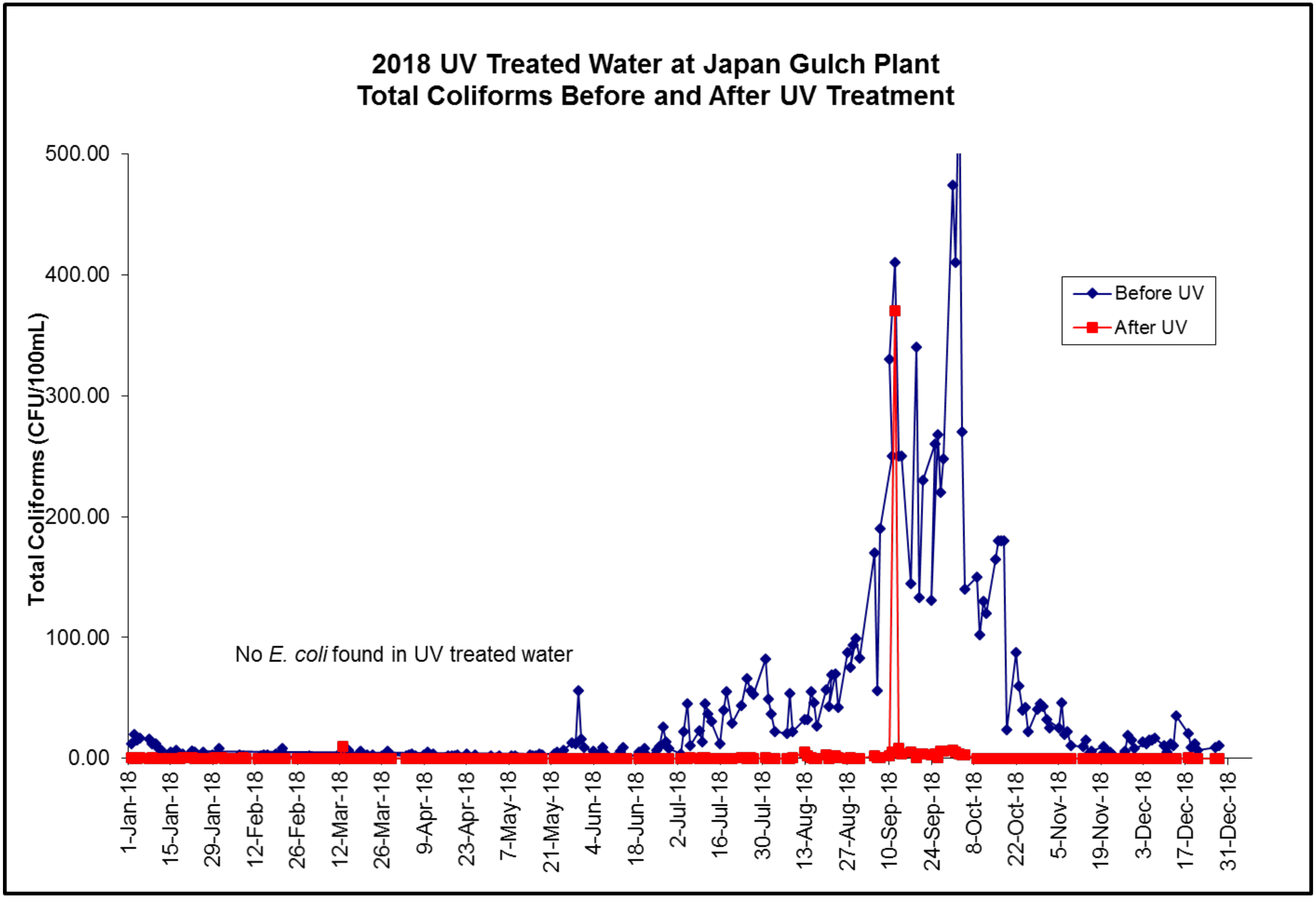

Figure 12 2018 UV Treated Water at Japan Gulch Plant Total Coliforms Before and After UV Treatment

Treated Water at Both First Customer Sampling Locations. The data collected from the two treated water sampling locations near the first customers below the Japan Gulch disinfection facility (one at Main #4 and one at Main #5) indicated that the bacteriological quality of the disinfected water was good in all months of 2018 (Figure 15 and Appendix A, Table 2). In total, 231 samples were collected from the Main #4 first customer location and 173 samples from the Main #5 first customer location.

In January, one sample at the Main #5 first customer location and in February and March, one sample each at the Main #4 first customer location tested positive for total coliform bacteria. This represents under 10% of the monthly totals at both first customer locations. The positive sample from March 13, 2018, had a total coliform concentration of 14 CFU/100 mL and was, therefore, in exceedance of the 10 CFU/100 mL total coliform limit as per *Drinking Water Protection Regulation*. Resamples from the next day, following each hit, could not confirm a true water contamination. The treatment plant operation was also verified and a bacteria breakthrough could be ruled out based on the information. While the regulations require 90% of all monthly samples in the entire system to be free of total coliform bacteria, the CRD monitors the first customer locations based on even more stringent criteria where water quality is gauged on the bacteriological results of these two first customer locations only.

The total chlorine residual ranged from 1.1 to 2.6 mg/L with a median value of 1.65 mg/L (Figure 15).

The median pH was 7.10 and the median total organic carbon concentration 1.90 mg/L at these two sampling stations in 2018.

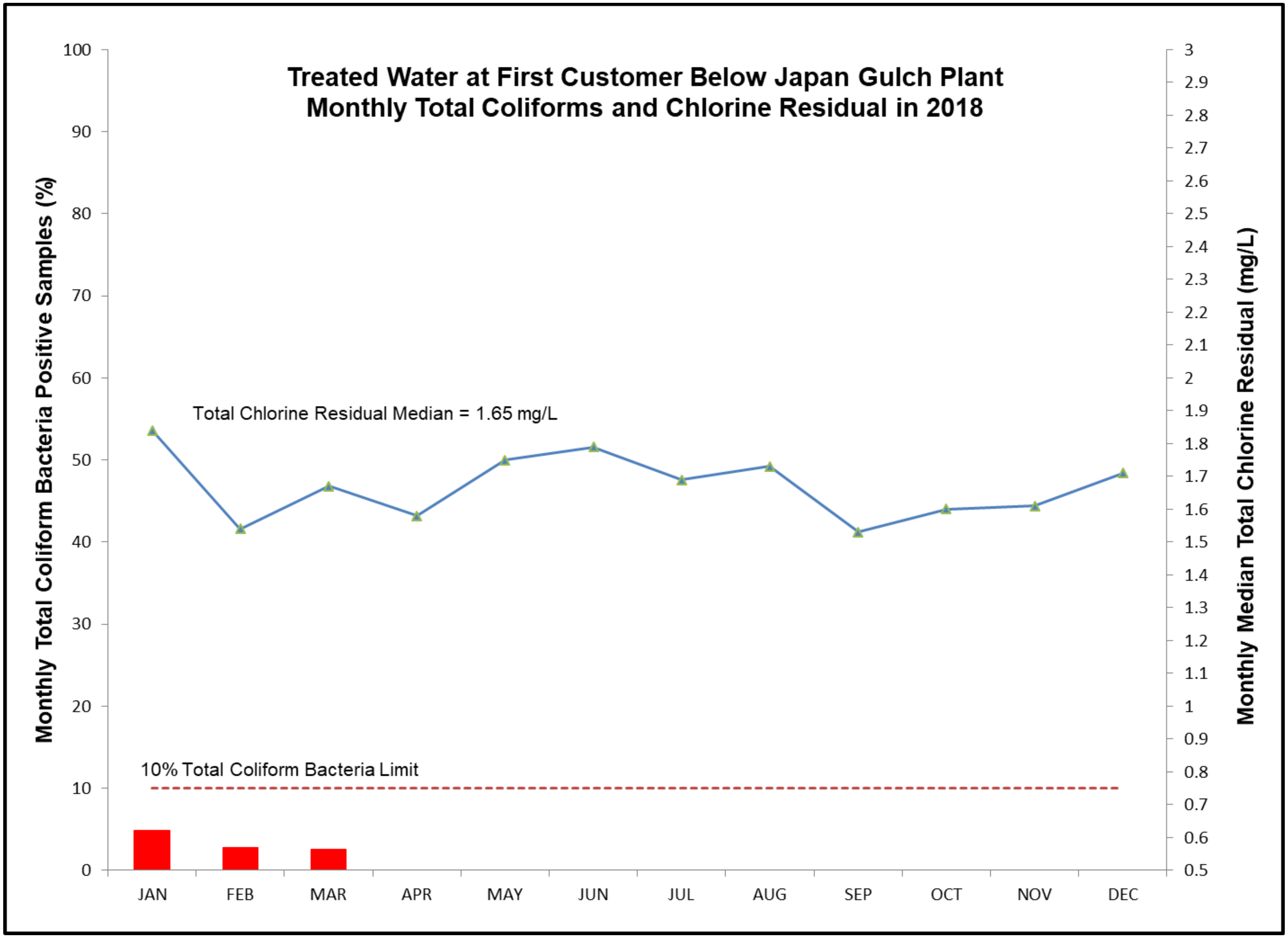

Figure 13 **Treated Water at two First Customer Locations below Japan Gulch Plant; Monthly Total Coliforms and Chlorine Residual in 2018**

7.2.2 Sooke River Road Disinfection Facility

Bacteriological Results after UV Treatment. Figure 16 shows the results from 44 samples collected and analyzed just downstream of the UV reactors. The results indicate that the UV treatment is capable of greatly reducing the *E. coli* and total coliform concentrations. No total coliform bacteria were detected downstream of the UV treatment. This is evidence of a very effective UV disinfection stage at this plant.

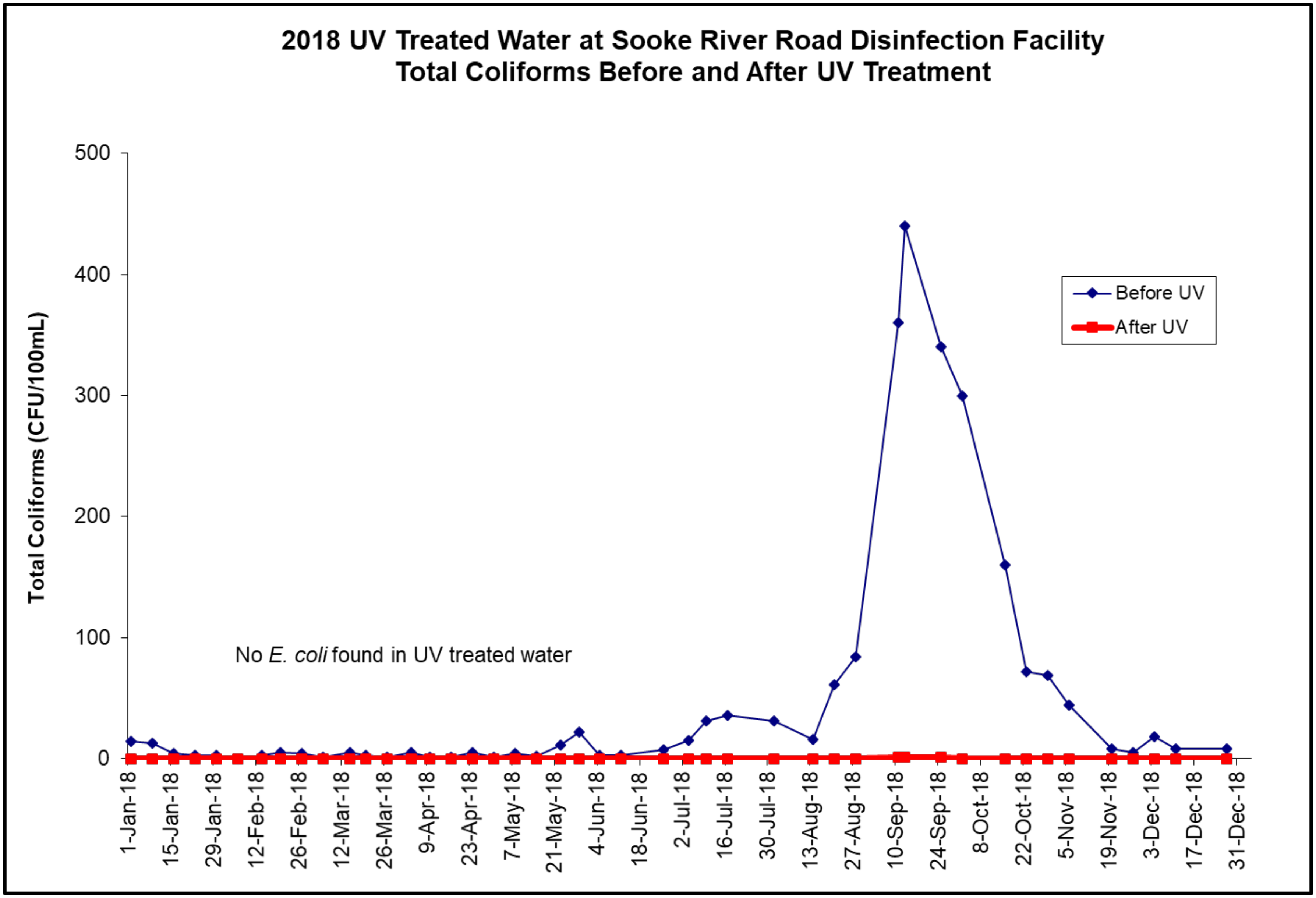

Figure 14 **2018 UV Treated Water at Sooke River Road Disinfection Facility Total Coliforms Before and After UV Treatment**

Treated Water at First Customer. The data collected from the treated water sampling location near the first customer below the Sooke River Road disinfection facility indicated that the bacteriological quality of the disinfected water was good in all months of 2018 (Figure 17). No total coliform bacteria were detected in all 44 samples from this sampling station in 2018.

The total chlorine residual ranged from 1.57 to 2.50 mg/L with a median value of 1.99 mg/L.

The median pH was 7.53 at this sampling station in 2018. The disinfection byproduct concentrations were only analyzed on samples from the Sooke/East Sooke Distribution System downstream of the first customer sampling station.

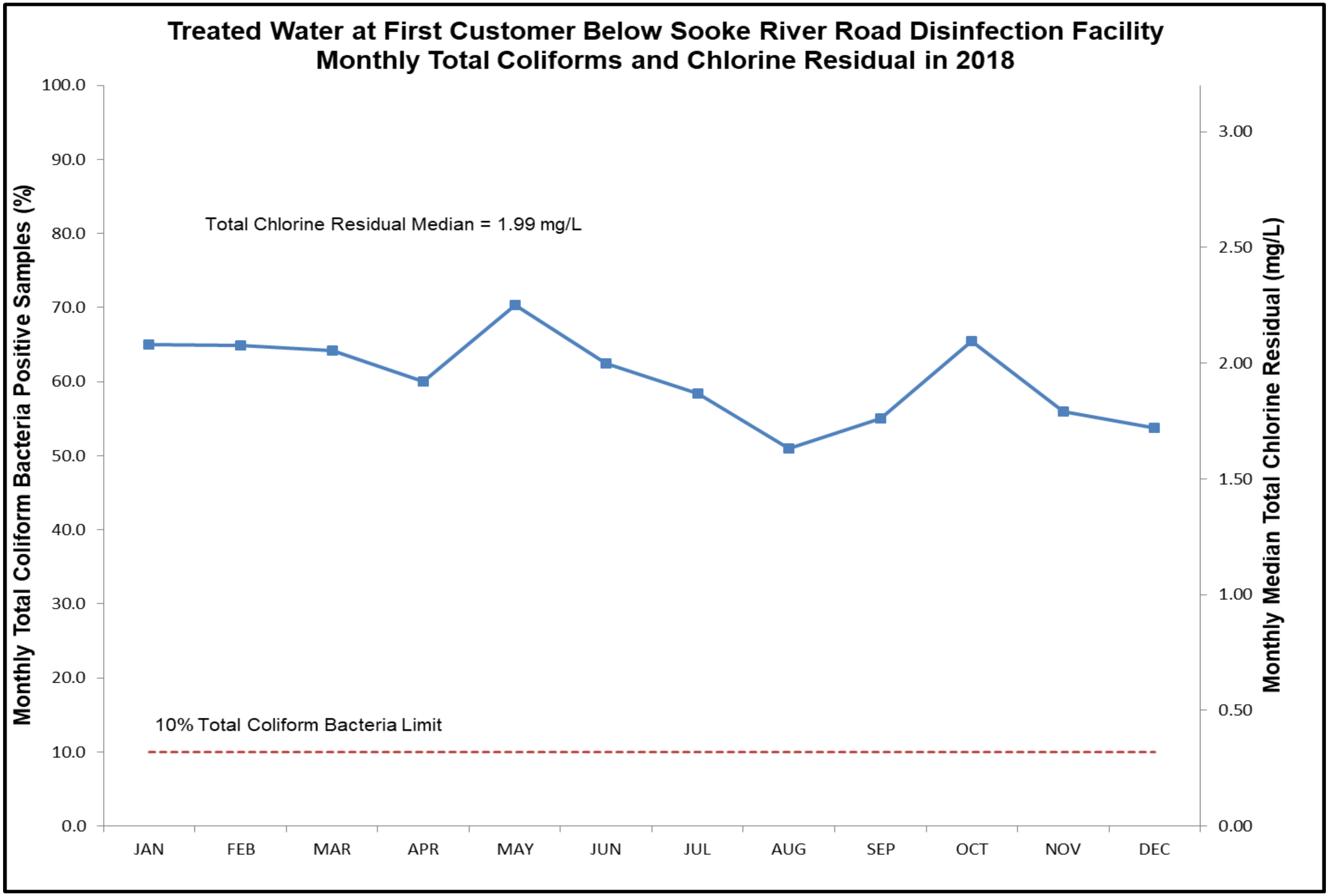

Figure 15 **Treated Water at First Customer below Sooke Rover Road Disinfection Facility, Monthly Total Coliforms and Chlorine Residual in 2018**

7.3 CRD Transmission System Results

The following sections summarize the water quality data collected and analyzed for monitoring and verifying the safety of the drinking water conveyed through the transmission system before it reaches the municipal distribution systems. Bacteriological results of the samples collected in the transmission system are considered for compliance purposes. There is no applicable requirement for monthly sample numbers for a transmission system. The number of samples collected monthly from the CRD Transmission System infrastructure was based on a water quality risk assessment and based on professional judgement.

7.3.1 Transmission Mains

Bacteriological Results. Figure 18 and Table 1 show the results from 685 CRD transmission main samples collected and analyzed in 2018. The results (no *E. coli* and very few total coliform bacteria detected) indicate that the water delivered through the transmission mains was bacteriologically safe. This system complied with the 10% total coliform-positive limit for all months. There were two consecutive positive samples in 2018, both in January.

Chlorine Residual. Figure 18 demonstrates that the annual median total chlorine concentration in the transmission mains was 1.67 mg/L and, therefore, provides for adequate secondary disinfection within the transmission system and within most areas of the downstream municipal distribution systems.

Water Temperature. The annual median water temperature in the transmission mains was 10.0°C, with monthly medians ranging between 5.9°C (March) and 17.0°C (September) (Table 1).

Table 1 2018 Bacteriological Quality of the CRD Transmission Mains

Month	Samples Collected	Total Coliforms (CFU/100mL)				*E.coli* CFU/100mL)	Turbidity		Chlorine Residual	Water Temp.
		Samples TC > 0	Percent TC>0	Resamples TC > 0	Samples TC > 10	Samples >0	Samples Collected	Samples >1 NTU	Median mg/L as CL2	Median ° C
JAN	69	5	7.2	2	0	0	25	0	1.83	6.0
FEB	59	0	0.0	0	0	0	26	0	1.65	6.1
MAR	61	0	0.0	0	0	0	25	0	1.69	5.9
APR	57	0	0.0	0	0	0	28	0	1.54	7.7
MAY	66	0	0.0	0	0	0	27	1	1.71	9.5
JUN	51	0	0.0	0	0	0	27	0	1.77	10.7
JUL	58	2	3.4	0	0	0	29	3	1.71	14.0
AUG	64	0	0.0	0	0	0	27	2	1.69	16.5
SEP	46	1	2.2	0	0	0	24	1	1.51	17.0
OCT	63	0	0.0	0	0	0	26	0	1.51	14.0
NOV	48	0	0.0	0	0	0	22	0	1.53	10.4
DEC	43	0	0.0	0	0	0	15	0	1.66	7.7
Total:	685	8	1.2	2	0	0	301	7	1.66	10.0

Notes:
TC = Total Coliforms, *E. coli* = *Escherichia coli,* Cl_2 = chlorine, NTU = Nephelometric turbidity unit.
> = Greater than, mg/L = milligrams per litre, °C = degrees Celsius

Disinfection Byproducts. The CRD collected one set of samples for a disinfection byproduct analysis from a transmission main at Willingdon and West Saanich Road. The total trihalomethane (TTHM) and total haloacetic acid (HAA) concentrations from this sample set was 21 and 16 µg/L, respectively, well below the MAC (TTHM = 100 and HAA = 80 µg/L) stipulated in the Canadian guidelines. This location was also sampled and tested for the disinfection byproduct Nitrosodimethylamine (NDMA), a newly-listed parameter that is classified as "probably carcinogenic" by Health Canada and associated with disinfection using chloramines. The Canadian guidelines MAC for NDMA is 40 ng/L. The test result from one sample at this location was "not detected".

This was the only transmission main where disinfection byproduct samples were collected. The CRD disinfection byproduct monitoring focuses on locations with higher potential for disinfection byproduct formation, such as system extremities with high water age or areas downstream of re-chlorination stations (free chlorine).

Metals. The CRD Water Quality Monitoring program for the CRD Transmission System included regular metal tests in five strategic locations where the water transitions from the CRD Transmission System to a downstream distribution system. In particular, the CRD pays attention to metals commonly found in drinking water, such as iron, manganese, copper and lead. In one location (Lansdowne and Foul Bay roads) where water flows from Main #3 into the Oak Bay Distribution System, elevated lead concentrations have been found in each of the six samples analyzed in 2018. In all samples the concentrations were below the MAC as per Canadian guidelines (5 µg/L as of March 2019), but an order of magnitude higher than in other samples across the GVDWS (1.58-4.37 µg/L). Similar results have been found previously at Cook and Mallek streets where Main #3 connections to the City of Victoria Distribution System. It is unlikely that the lead sources lie within the CRD Transmission System, but rather within the municipal systems, and backflow patterns allow these lead concentrations to reach back into the transmission system. The municipalities of Oak Bay and Victoria have been notified and are working with the Island Health Authority to address the lead sources in their systems.

Physical/Chemical Parameters. The drinking water in the regional transmission mains had the following physical and chemical characteristics:

- Median pH: 7.30
- Median $CaCO_3$ Hardness: 17.2 mg/L
- Median Alkalinity: 14.9 mg/L
- Median Colour: 4.00 TCU
- Median Turbidity: 0.36 NTU
- Median Conductivity (25ºC): 47.5 µS/cm

Compliance Status. The transmission mains of the CRD Transmission System were in full compliance with the *BC Drinking Water Protection Act* and *Drinking Water Protection Regulation*.

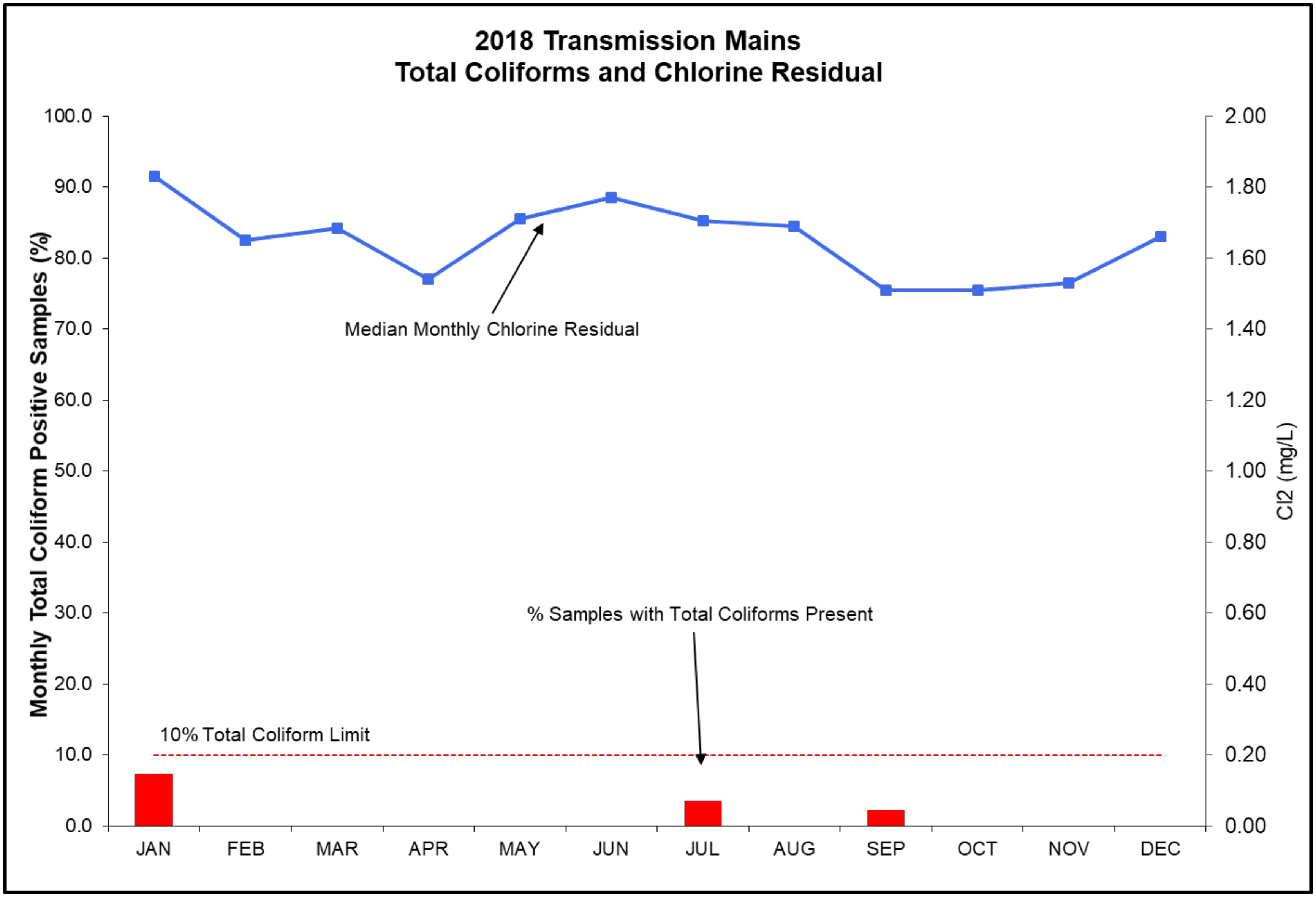

Figure 16 **Transmission Mains Total Coliforms and Chlorine Residual in 2018**

7.3.2 Storage Reservoirs

Bacteriological Results. Figure 19 shows the 2018 results from 110 samples on CRD storage reservoirs that are considered part of the CRD Transmission System. The results indicate that the water in these storage reservoirs was bacteriologically safe. There were total coliform positive samples in 2018 (Table 2). Typically, storage reservoirs are vulnerable to bacteria regrowth and potential contamination due to the long retention times and generally lower chlorine residual concentrations. Because of the higher risks to water quality in reservoirs compared to pipes, the CRD typically monitors the water quality closely in all of its storage reservoirs and follows a rigorous maintenance schedule at these facilities.

Chlorine Residual. Figure 19 indicates that the median total chlorine concentration in the storage reservoirs ranged from 0.73 mg/L to 1.48 mg/L.

Water Temperature. The annual median water temperature in the storage reservoirs was 11.4°C, with monthly medians ranging between 6.7°C (January) and 17.0°C (August) (Table 2).

Table 2 2018 Bacteriological Quality of Storage Reservoirs

Month	Samples Collected	Total Coliforms (CFU/100mL)				*E.coli* CFU/100mL)	Turbidity		Chlorine Residual	Water Temp.
		Samples TC > 0	Percent TC>0	Resamples TC > 0	Samples TC > 10	Samples >0	Samples Collected	Samples >1 NTU	Median mg/L as CL2	Median ° C
JAN	10	0	0.0	0	0	0	1	0	1.40	7.0
FEB	6	0	0.0	0	0	0	2	0	1.09	7.1
MAR	8	0	0.0	0	0	0	2	0	1.12	6.7
APR	8	0	0.0	0	0	0	2	0	1.07	8.5
MAY	13	0	0.0	0	0	0	2	0	1.48	9.9
JUN	11	0	0.0	0	0	0	2	0	1.43	11.8
JUL	10	0	0.0	0	0	0	2	0	1.40	14.0
AUG	8	0	0.0	0	0	0	2	0	1.41	16.7
SEP	6	0	0.0	0	0	0	1	0	0.79	17.0
OCT	11	0	0.0	0	0	0	3	0	0.73	14.9
NOV	14	0	0.0	0	0	0	2	0	0.80	11.8
DEC	5	0	0.0	0	0	0	1	0	0.85	8.7
Total:	110	0	0.0	0	0	0	22	0	1.14	11.4

Notes:
TC = Total Coliforms, *E. coli* = *Escherichia coli;* Cl_2 = chlorine, NTU = Nephelometric turbidity unit.
> = Greater than, mg/L = milligrams per litre, °C = degrees Celsius

Disinfection Byproducts. The CRD collected a total of 30 samples for a disinfection byproduct analysis. The samples were collected at two storage reservoirs in the CRD Transmission System (Cloake Hill and Upper Dean Park reservoirs). At both locations, the CRD maintains a re-chlorination station that can boost free chlorine concentrations if the residuals fall below 0.2 mg/L. While this procedure is rarely exercised, any free chlorine concentration can lead to an increase in disinfection byproduct formation. The annual average TTHM and HAA concentrations from 11 samples were 19.4 and 20.5 µg/L at Cloake Hill and 17.4 and 13.8 µg/L at Upper Dean, respectively, well below the MAC (TTHM = 100 and HAA = 80 µg/L) stipulated in the Canadian guidelines. In nine samples, the NDMA concentrations at both locations were below the detection limit (2 ng/L) and were, therefore, well below the Canadian guideline MAC of 40 ng/L.

Physical/Chemical Parameters. The drinking water in the regional transmission storage reservoirs had the following physical and chemical characteristics in 2018:

- Median pH: 7.20
- Median Alkalinity: 14.2 mg/L
- Median Colour: 3.0 TCU
- Median Turbidity: 0.36 NTU
- Median Conductivity (25ºC): 48.6 µS/cm

Nitrification. Nitrification occurs in many chloraminated water systems. It is a complex bacteriological process in which ammonia is oxidized initially to nitrite and then to nitrate and is caused by two groups of bacteria that have low growth rates relative to other bacteria. Water temperature seems to be a critical factor for nitrification in distribution systems, as it has been almost exclusively associated with warm water temperatures. Nitrification is also associated with high water age (reservoirs, dead ends, low-flow pipes) and with sediment biofilms.

Monitoring for nitrifying bacteria directly is inefficient; however, the extent of nitrification in the distribution system can be monitored by measuring chlorine residuals and nitrite (also nitrate, free ammonia). When the chlorine residuals drop (in the absence of any pipe break or plant disinfection failure) accompanied by increases of nitrite then nitrification is occurring. Since Greater Victoria's source water has no background nitrite, the presence of nitrite in the distribution system is the best indicator of nitrification.

The control of nitrification in a chloraminated distribution system involves limiting the excess free ammonia leaving the disinfection plant, maintaining an adequate chlorine residual throughout the distribution system, minimizing water age in storage facilities and in the low-flow areas of the distribution system, and maintaining annual flushing routines to limit the accumulation of sediment and biofilm in the distribution system piping. CRD Water Quality Operations staff, in conjunction with CRD Operations and Engineering staff, are undertaking projects to optimize the reservoir and pipe-cleaning schedules to address nitrification and other water quality affecting processes throughout the distribution systems. An upgrade project for the Japan Gulch disinfection facility, partially completed in 2018, will improve the chemical dosing system and further reduce the potential for free ammonia in the treated water.

Compliance Status. The CRD owned and operated storage reservoirs in the CRD Transmission System were in full compliance with the *BC Drinking Water Protection Act* and *Drinking Water Protection Regulation*.

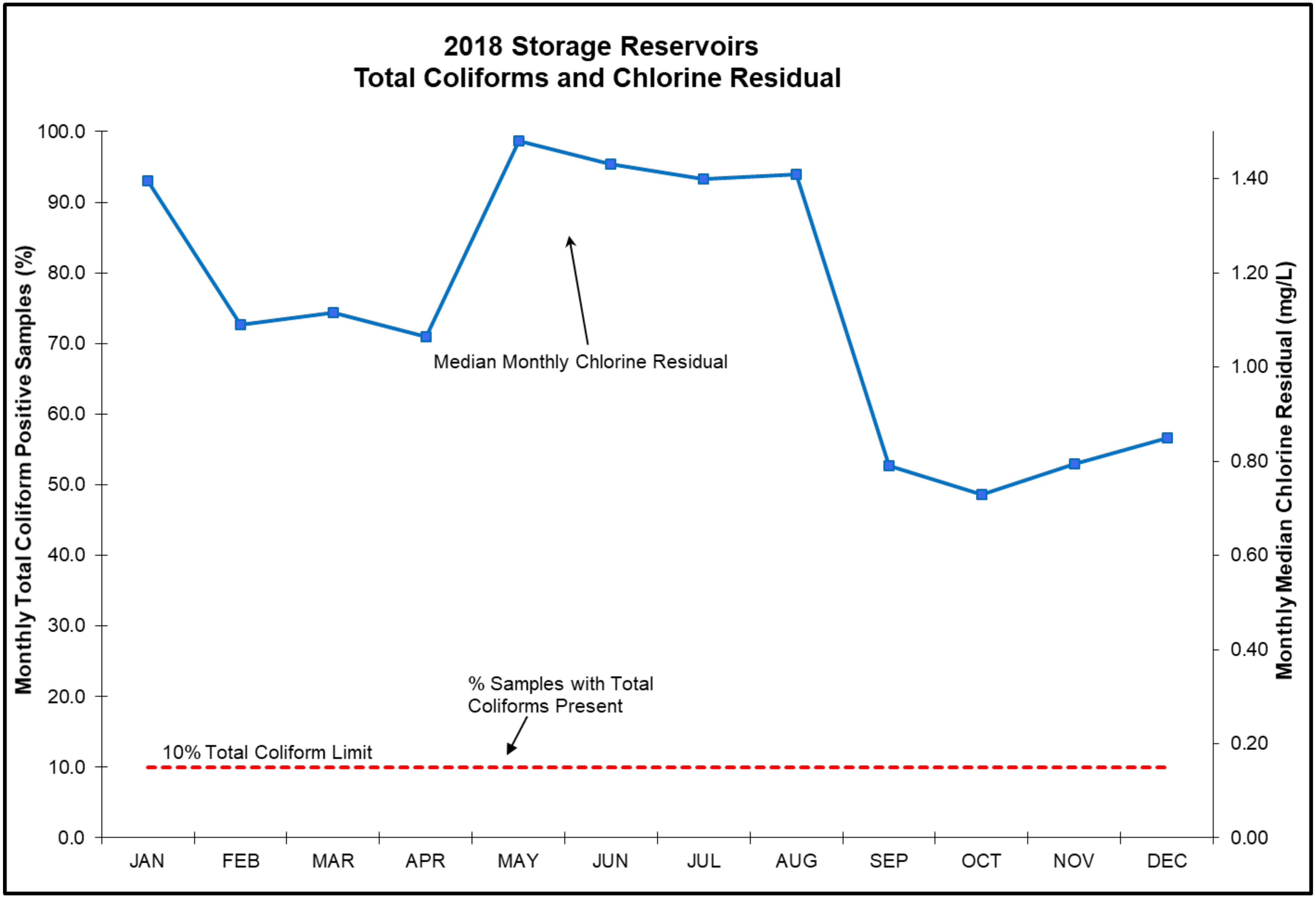

Figure 17 Storage Reservoirs Total Coliforms and Chlorine Residual in 2018

7.4 Distribution System Results

The following sections summarize the water quality monitoring results within the various distribution systems and indicate the compliance status of each system.

7.4.1 Juan de Fuca Water Distribution System – Westshore Municipalities (CRD owned and operated)

In 2018, 33 distribution system sampling locations were used by the CRD Water Quality Monitoring program to monitor the bacteriological quality of the water in the Westshore system.

Sample Collection. In 2018, 773 bacteriological and 133 water chemistry samples were collected from the Juan de Fuca Water Distribution System (Table 3). Based on current population data for the Westshore municipalities, 66 samples are required for bacteria testing each month. Table 3 shows the number of monthly samples collected and analyzed for compliance.

Bacteriological Results. Total coliforms were found in five samples, two of them in March, one in May and two in September. One sample in March and one sample in September exceeded the 10 CFU/100 mL total coliform concentration threshold. There were no consecutive positive samples in 2018. This system complied with the 10% total coliform-positive limit for all months of the year during 2018. The annual total coliform percentage positive was well below the 10% limit at only 0.6% (Table 3).

There were no *E coli* positive samples in 2018.

Chlorine Residual. The annual median chlorine residual in the Westshore municipalities of the Juan de Fuca Water Distribution System was 1.11 mg/L (Table 3). The lowest monthly median was in September (0.78 mg/L) and the maximum monthly median was in January (1.53 mg/L) (Figure 20; Table 3).

Water Temperature. The annual median water temperature in the Juan de Fuca Water Distribution System was 12.0ºC, with monthly medians ranging between 6.7°C (January) and 18.0ºC (August) (Table 3).

Table 3 2018 Bacteriological Quality of the Juan de Fuca Distribution System – Westshore Municipalities (CRD)

Month	Samples Collected	Total Coliforms (CFU/100mL)				*E.coli* CFU/100mL)	Turbidity		Chlorine Residual	Water Temp.
		Samples TC > 0	Percent TC>0	Resamples TC > 0	Samples TC > 10	Samples >0	Samples Collected	Samples >1 NTU	Median mg/L as CL2	Median ° C
JAN	70	0	0.0	0	0	0	6	0	1.53	6.7
FEB	54	0	0.0	0	0	0	5	0	1.22	6.8
MAR	57	2	3.5	0	1	0	7	0	0.90	7.4
APR	54	0	0.0	0	0	0	5	0	0.97	9.2
MAY	67	1	1.5	0	0	0	5	0	1.13	12.0
JUN	58	0	0.0	0	0	0	4	0	1.34	13.5
JUL	56	0	0.0	0	0	0	4	0	1.20	15.6
AUG	77	0	0.0	0	0	0	7	0	1.14	18.0
SEP	61	2	3.3	0	1	0	5	0	0.78	17.1
OCT	82	0	0.0	0	0	0	6	0	0.97	14.1
NOV	70	0	0.0	0	0	0	4	0	0.99	11.1
DEC	67	0	0.0	0	0	0	6	0	1.21	8.4
Total:	773	5	0.6	0	2	0	64	0	1.11	12.0

Notes:
TC = Total Coliforms, E. coli = Escherichia coli, Cl2 = chlorine, NTU = Nephelometric turbidity unit.
> = Greater than, mg/L = milligrams per litre, °C = degrees Celsius

Disinfection Byproducts. One location in the Juan de Fuca Water Distribution System had 16 samples collected for disinfection byproducts. The annual average TTHM and haloacetic acid (HAA5) concentrations in six samples each were 18 and 7 µg/L, respectively, far below the Canadian guideline MAC (TTHM = 100; HAA5 = 80). In four samples the NDMA concentrations ranged from 'not detected' to 4.4 ng/L, well below the Canadian guideline MAC of 40 ng/L.

Physical/Chemical Parameters. The drinking water in the Westshore municipalities of the Juan de Fuca Water Distribution System had the following physical and chemical characteristics in 2018:

- Median pH: 7.47
- Median CaCO3 Hardness: 17.15 mg/L
- Median Alkalinity: 16.1 mg/L
- Median Colour: 3.2 TCU
- Median Conductivity (25ºC): 54.4 µS/cm
- Median Turbidity: 0.32 NTU

Metals. In 2018, CRD undertook a Juan de Fuca lead investigation project to identify any potential lead sources within this system. Fifty water samples were collected and analyzed from across the entire Juan de Fuca system and then follow-up investigations were conducted when certain thresholds were exceeded. Overall, lead concentrations were very low (median 0.31 µg/L) with only some hydrant locations exhibiting slightly higher concentrations (still below MAC of 5 µg/L). Follow up investigations confirmed that standard fire hydrants are a common source of lead; however, this lead source is so small that it does not affect the safety of the drinking water in the overall system. The lead concentrations short distances away from the investigated fire hydrants were comparable to normal background level.

Compliance Status. The Westshore municipalities of the Juan de Fuca Water Distribution System were in compliance with the *BC Drinking Water Protection Act* and *Drinking Water Protection Regulation*, except for March and September with total coliform-positive results in exceedance of 10 CFU/100 mL. Immediate resamples following these test results were negative for total coliform bacteria and could, therefore, not confirm a real drinking water contamination. This system was also under-sampled in eight of 12 months in 2018, as per *Drinking Water Protection Regulation.* The CRD has since taken steps to ensure the water quality monitoring program in the Juan de Fuca system meets the regulatory requirements.

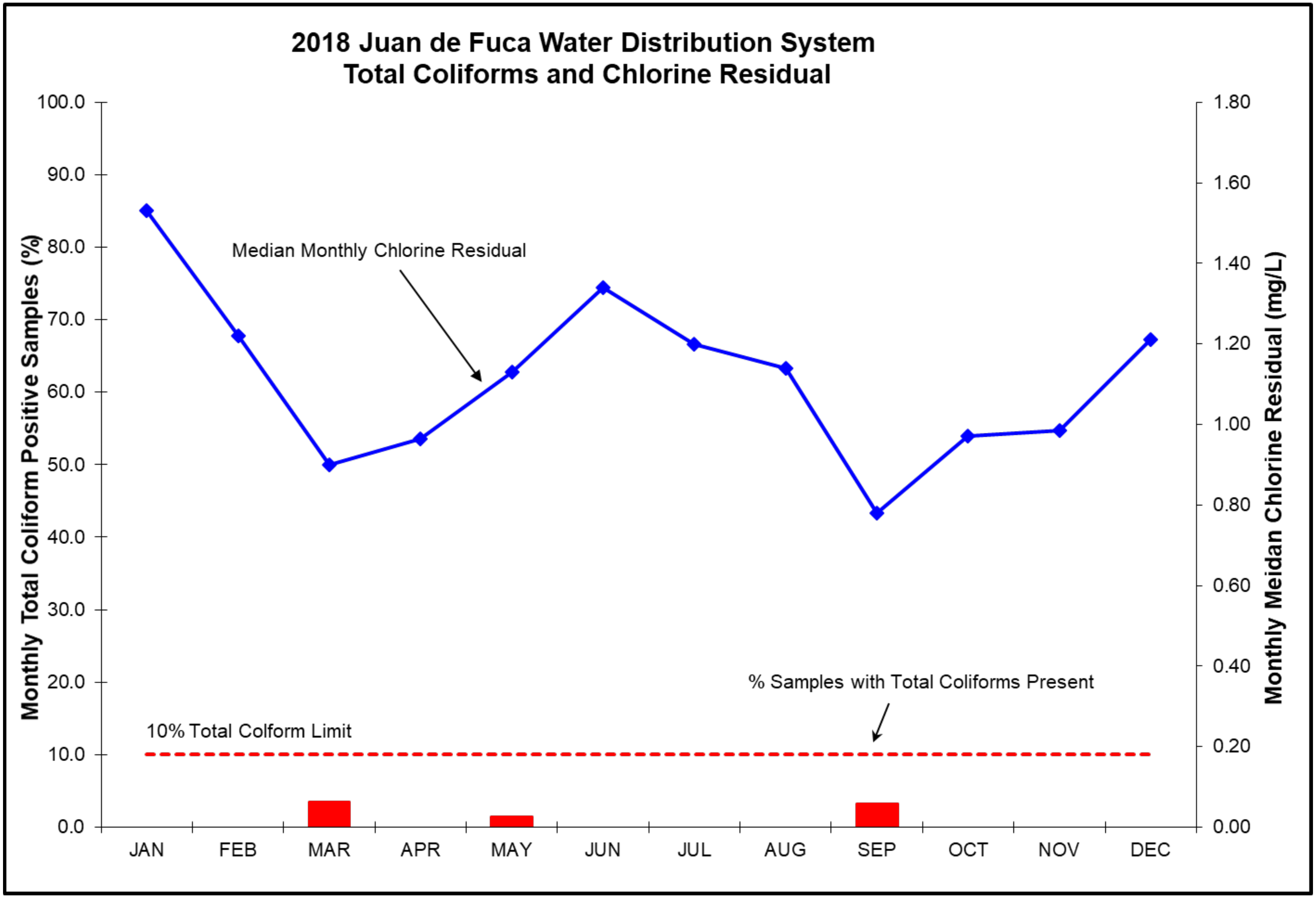

Figure 18 Juan de Fuca – Westshore Distribution System Total Coliforms and Chlorine Residual in 2018

7.4.2 Sooke/East Sooke Distribution System (CRD Owned and Operated)

In 2018, 17 sampling locations were used by the CRD Water Quality Monitoring program to monitor the bacteriological quality of the water in Sooke/East Sooke system. All Sooke/East Sooke sampling stations were sampled once per week.

Sample Collection. In 2018, 432 bacteriological and 205 water chemistry samples were collected from the Sooke/East Sooke Distribution System (Table 4). Based on current population data for the District of Sooke, 13 samples are required for bacteria testing each month. Table 4 shows the number of monthly samples collected and analyzed for compliance.

Bacteriological Results. No total coliform nor *E. coli* bacteria were found in any sample collected in 2018 (Table 4).

Chlorine Residual. The annual median chlorine residual in the Sooke/East Sooke Distribution System was 1.08 mg/L (Table 4). The lowest monthly median was in September (0.58 mg/L) and the maximum monthly median was in May (1.39 mg/L).

Water Temperature. The annual median water temperature in the Sooke/East Sooke Distribution System was 11.8°C, with monthly medians ranging between 7.0ºC (January) and 17.3°C (August) (Table 4).

Table 4 2018 Bacteriological Quality of the Sooke/East Sooke Distribution System (CRD)

Month	Samples Collected	Total Coliforms (CFU/100mL)				*E.coli* CFU/100mL)	Turbidity		Chlorine Residual	Water Temp.
		Samples TC > 0	Percent TC>0	Resamples TC > 0	Samples TC > 10	Samples >0	Samples Collected	Samples >1 NTU	Median mg/L as CL2	Median ° C
JAN	44	0	0.0	0	0	0	4	0	1.28	7.0
FEB	36	0	0.0	0	0	0	5	1	1.23	7.0
MAR	31	0	0.0	0	0	0	4	1	1.29	7.1
APR	37	0	0.0	0	0	0	5	0	1.26	9.0
MAY	49	0	0.0	0	0	0	5	0	1.39	12.5
JUN	30	0	0.0	0	0	0	5	0	1.38	14.0
JUL	34	0	0.0	0	0	0	5	0	0.93	16.0
AUG	42	0	0.0	0	0	0	5	0	0.76	17.3
SEP	32	0	0.0	0	0	0	5	0	0.58	16.7
OCT	39	0	0.0	0	0	0	7	0	0.78	13.7
NOV	30	0	0.0	0	0	0	3	0	0.92	10.7
DEC	28	0	0.0	0	0	0	4	0	1.02	8.5
Total:	432	0	0.0	0	0	0	57	2	1.08	11.8

Notes:
TC = Total Coliforms, *E. coli* = *Escherichia coli,* Cl_2 = chlorine, NTU = Nephelometric turbidity unit.
> = Greater than, mg/L = milligrams per litre, °C = degrees Celsius

Disinfection Byproducts. One location in the Sooke distribution system had 12 samples collected for disinfection byproducts. The annual average TTHM and HAA5 concentrations from six samples each were 39 and 28 µg/L, respectively, far below the Canadian guideline MAC (TTHM = 100; HAA5 = 80). In four samples the NDMA concentrations ranged from 'not detected' to 1.6 ng/L, well below the Canadian guideline MAC of 40 ng/L.

Physical/Chemical Parameters. The drinking water in the Sooke/East Sooke Distribution System had the following physical and chemical characteristics:

- Median pH: 7.5
- Median $CaCO_3$ Hardness: 17.7 mg/L
- Median Alkalinity: 16.2 mg/L
- Median Turbidity: 0.30 NTU
- Median Conductivity (25ºC): 57.0 µS/cm

Metals. The CRD Water Quality Monitoring program for the Sooke/East Sooke system included bi-monthly metal tests in two strategic locations in 2018; the first customer sampling location just downstream of the plant and Whiffen Spit Road. All metallic parameters including lead were well below the MAC or AO limits as per Canadian guidelines.

The 2018 Juan de Fuca lead investigation project (see Section 7.4.1) included the Sooke/East Sooke System (38 samples collected). The results were very similar in both systems, however, the Henlyn pump station, servicing the Henlyn Reservoir in Sooke, exhibited lead concentrations in exceedance of the Canadian guidelines MAC of 5 µg/L. The lead concentrations from this pump station ranged from 15.9 to 22.5 µg/L. CRD has since changed the pumping cycle to reduce the contact time of the water with pump station equipment and also has initiated a pump station equipment replacement project.

Compliance Status. The Sooke/East Sooke Distribution System was in full compliance with the *BC Drinking Water Protection Act* and *Drinking Water Protection Regulation.*

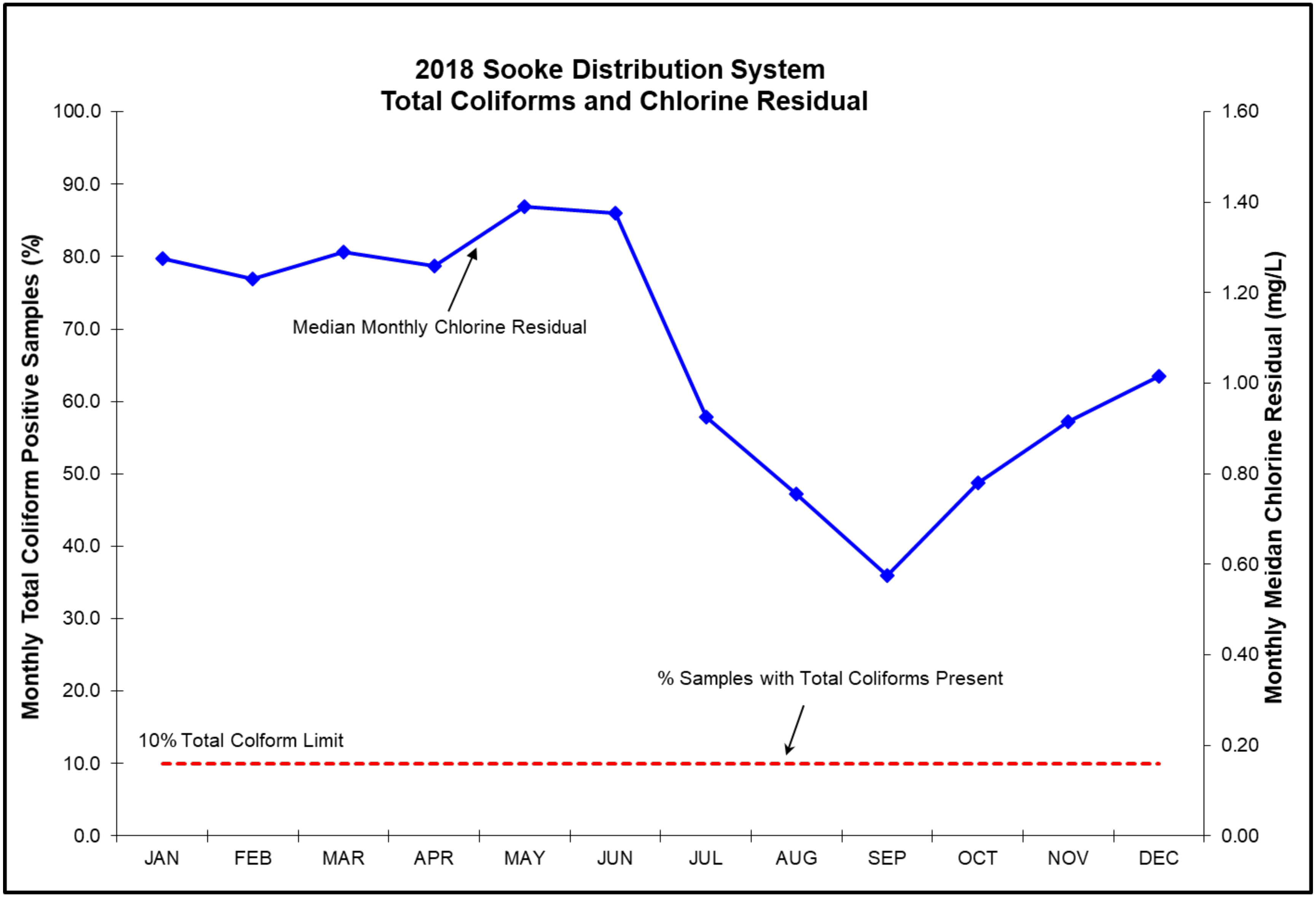

Figure 19 Sooke/East Sooke Distribution System Total Coliforms and Chlorine Residual in 2018

7.4.3 Central Saanich Distribution System – (District of Central Saanich Owned and Operated)

In 2018, 11 sampling locations were used by the CRD Water Quality Monitoring program to monitor the bacteriological quality of the water in the Central Saanich Distribution System. Central Saanich sampling stations are part of the daily distribution sampling runs by CRD staff.

Sample Collection. In 2018, 258 bacteriological and 129 water chemistry samples were collected from the Central Saanich Distribution System (Table 5). Based on current population data for the District of Central Saanich, 17 samples are required for bacteria testing each month. Table 5 shows the number of monthly samples collected and analyzed for compliance.

Bacteriological Results. Total coliforms were found in one sample collected in 2018, in January. This system complied with the 10% total coliform positive limit for all of 2018. No samples exceeded the 10 CFU/100 mL total coliform concentration. There were also no consecutive positive samples in 2018 (Table 5).

None of the samples contained *E. coli* in 2018 (Table 5).

Chlorine Residual. The annual median chlorine residual in the Central Saanich Distribution System was 1.28 mg/L (Table 5). The lowest monthly median was in October (0.89 mg/L) and the maximum monthly median was in June (1.59 mg/L) (Figure 22).

Water Temperature. The annual median water temperature in the Central Saanich Distribution System was 12.4°C, with monthly medians ranging between 7.5°C (January) and 18.0°C (August) (Table 5).

Table 5 2018 Bacteriological Quality of the Central Saanich Distribution System

Month	Samples Collected	Total Coliforms (CFU/100mL)				*E.coli* CFU/100mL)	Turbidity		Chlorine Residual	Water Temp.
		Samples TC > 0	Percent TC>0	Resamples TC > 0	Samples TC > 10	Samples >0	Samples Collected	Samples >1 NTU	Median mg/L as CL2	Median ° C
JAN	21	1	4.8	0	0	0	8	2	1.45	7.5
FEB	16	0	0.0	0	0	0	4	0	1.28	7.5
MAR	22	0	0.0	0	0	0	6	2	1.34	7.5
APR	22	0	0.0	0	0	0	6	0	1.32	9.2
MAY	23	0	0.0	0	0	0	6	1	1.57	12.3
JUN	22	0	0.0	0	0	0	6	0	1.59	13.1
JUL	21	0	0.0	0	0	0	6	0	1.51	15.4
AUG	22	0	0.0	0	0	0	8	0	1.32	18.0
SEP	21	0	0.0	0	0	0	4	0	0.93	17.6
OCT	25	0	0.0	0	0	0	4	0	0.89	14.4
NOV	24	0	0.0	0	0	0	6	0	1.03	12.2
DEC	19	0	0.0	0	0	0	4	0	1.09	9.4
Total:	258	1	0.4	0	0	0	68	5	1.28	12.4

Notes:
TC = Total Coliforms, *E. coli* = *Escherichia coli,* Cl_2 = chlorine, NTU = Nephelometric turbidity unit.
> = Greater than, mg/L = milligrams per litre, °C = degrees Celsius

Disinfection Byproducts. No data for 2018.

Physical/Chemical Parameters. The drinking water in the Central Saanich Distribution System had the following physical and chemical characteristics in 2018:

- Median pH: 7.1
- Median Turbidity: 0.35 NTU
- Median Colour: 4.0 TCU
- Median Conductivity (25ºC): 47.5 µS/cm

Metals. No data for 2018.

Compliance Status. The Central Saanich Distribution System was in compliance with the *BC Drinking Water Protection Act* and *Drinking Water Protection Regulation* in 2018. In February, the system was slightly under-sampled; however, due to additional sampling in other months, the annual average sample number per months was within the sampling requirements as per *Drinking Water Protection Regulation.*

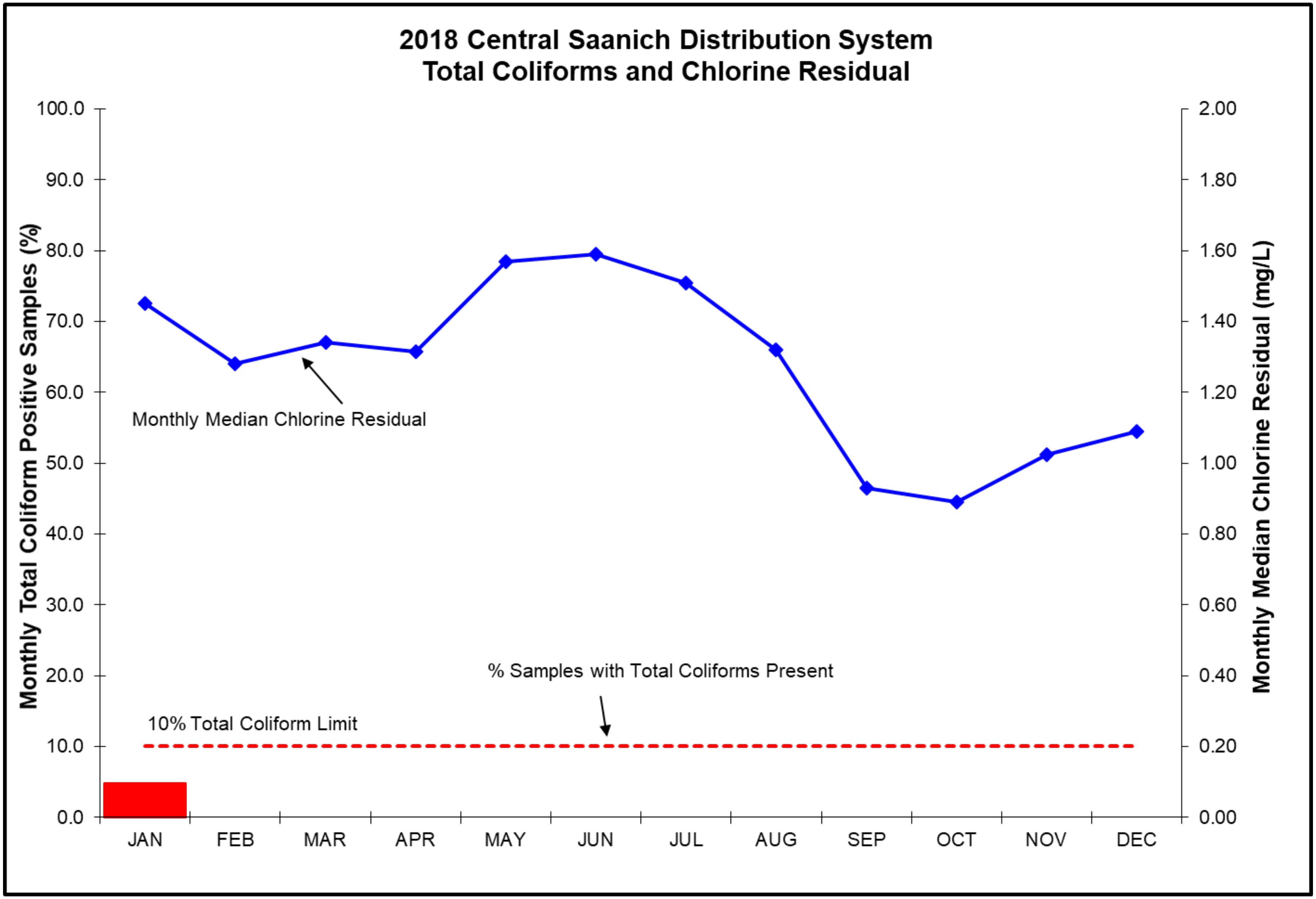

Figure 20 **Central Saanich Distribution System Total Coliforms and Chlorine Residual in 2018**

7.4.4 North Saanich Distribution System – (District of North Saanich Owned and Operated)

In 2018, eight sampling locations were used by the CRD Water Quality Monitoring program to monitor the bacteriological quality of the water in the North Saanich Distribution System. North Saanich sampling stations are part of the daily distribution sampling runs by CRD staff.

Sample Collection. In 2018, 206 bacteriological and 69 water chemistry samples were collected from the North Saanich Distribution System (Table 6). Based on current population data for the District of North Saanich, 12 samples are required for bacteria testing each month. Table 6 shows the number of monthly samples collected and analyzed for compliance.

Bacteriological Results. No sample tested positive for total coliforms in 2018 (Table 6).

None of the samples contained *E. coli* in 2018 (Table 6).

Chlorine Residual. The annual median chlorine residual in the North Saanich Distribution System was 0.93 mg/L (Table 6). The lowest monthly median was in September (0.47 mg/L) and the maximum monthly median was in June (1.34 mg/L) (Figure 23).

Water Temperature. The annual median water temperature in the North Saanich Distribution System was 12.0°C, with monthly medians ranging between 7.3°C (January) and 17.5°C (August) (Table 6).

Table 6 2018 Bacteriological Quality of North Saanich Distribution System

Month	Samples Collected	Total Coliforms (CFU/100mL)				*E.coli* CFU/100mL)	Turbidity		Chlorine Residual	Water Temp.
		Samples TC > 0	Percent TC>0	Resamples TC > 0	Samples TC > 10	Samples >0	Samples Collected	Samples >1 NTU	Median mg/L as CL2	Median ° C
JAN	18	0	0.0	0	0	0	2	0	1.08	7.3
FEB	14	0	0.0	0	0	0	0	0	0.89	7.6
MAR	19	0	0.0	0	0	0	2	0	0.77	7.6
APR	17	0	0.0	0	0	0	1	0	0.77	9.0
MAY	18	0	0.0	0	0	0	2	0	1.29	12.0
JUN	16	0	0.0	0	0	0	2	0	1.34	13.5
JUL	15	0	0.0	0	0	0	1	0	1.25	15.5
AUG	18	0	0.0	0	0	0	3	0	1.14	17.5
SEP	16	0	0.0	0	0	0	2	0	0.47	17.1
OCT	20	0	0.0	0	0	0	2	0	0.48	14.6
NOV	19	0	0.0	0	0	0	2	0	0.45	12.0
DEC	16	0	0.0	0	0	0	1	0	0.59	9.5
Total:	206	0	0.0	0	0	0	20	0	0.93	12.0

Notes:
TC = Total Coliforms, *E. coli* = *Escherichia coli,* Cl_2 = chlorine, NTU = Nephelometric turbidity unit.
> = Greater than, mg/L = milligrams per litre, °C = degrees Celsius

Disinfection Byproducts. No data in 2018.

Physical/Chemical Parameters. The drinking water in the North Saanich Distribution System had the following physical and chemical characteristics in 2018:

- Median pH: 7.27
- Median Colour: 3.5 TCU
- Median Turbidity: 0.36 NTU
- Median Conductivity (25ºC): 50.15 µS/cm

Metals. No data in 2018.

Compliance Status. The North Saanich Distribution System was in full compliance with the *BC Drinking Water Protection Act* and *Drinking Water Protection Regulation* in 2018.

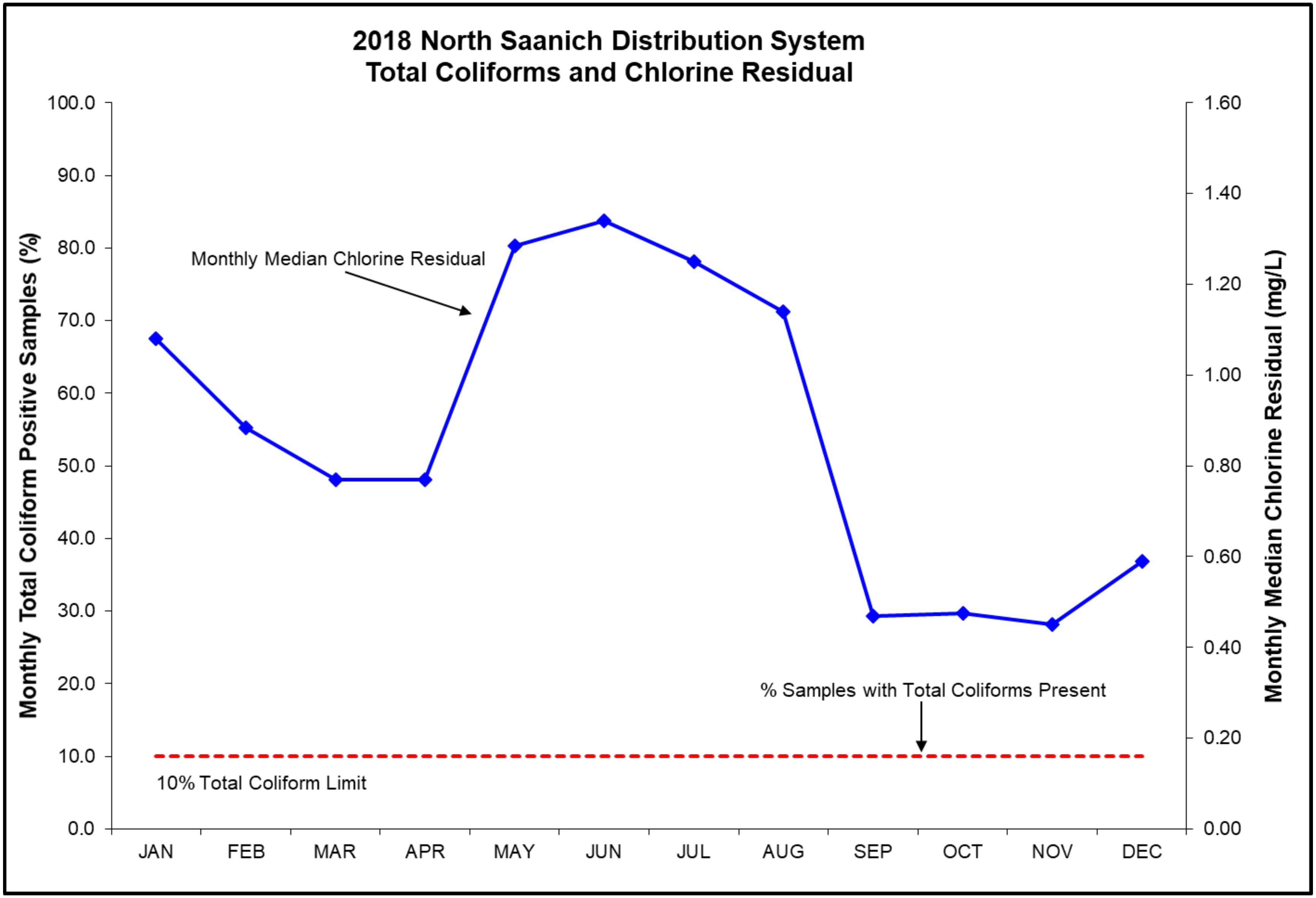

Figure 21 North Saanich Distribution System Total Coliforms and Chlorine Residual in 2018

7.4.5 Oak Bay Distribution System – (District of Oak Bay Owned and Operated)

In 2018, 11 sampling locations were used by the CRD Water Quality Monitoring program to monitor the bacteriological quality of the water in the Oak Bay Distribution System. Oak Bay sampling stations are part of the daily distribution sampling runs by CRD staff.

Sample Collection. In 2018, 256 bacteriological and 167 water chemistry samples were collected from the Oak Bay Distribution System (Table 7). Based on current population data for the District of Oak Bay, 19 samples are required for bacteria testing each month. Table 7 shows the number of monthly samples collected and analyzed for compliance.

Bacteriological Results. One sample in December tested positive for total coliforms. This system complied with the 10% total coliform positive limit for all of 2018. No samples exceeded the 10 CFU/100 mL total coliform concentration. There were also no consecutive positive samples in 2018 (Table 7).

None of the samples contained *E. coli* in 2018 (Table 7).

Chlorine Residual. The annual median chlorine residual in the Oak Bay Distribution System was 1.43 mg/L (Table 7). The lowest monthly median was in October (1.19 mg/L) and the maximum monthly median was in June (1.70 mg/L) (Figure 24).

Water Temperature. The annual median water temperature in the Oak Bay Distribution System was 12.4°C, with monthly medians ranging between 7.3°C (January) and 18.3°C (August) (Table 7).

Table 7 2018 Bacteriological Quality of Oak Bay Distribution System

Month	Samples Collected	Total Coliforms (CFU/100mL)				*E.coli* CFU/100mL)	Turbidity		Chlorine Residual	Water Temp.
		Samples TC > 0	Percent TC>0	Resamples TC > 0	Samples TC > 10	Samples >0	Samples Collected	Samples >1 NTU	Median mg/L as CL2	Median ° C
JAN	20	0	0.0	0	0	0	4	0	1.67	7.3
FEB	18	0	0.0	0	0	0	3	0	1.51	7.6
MAR	23	0	0.0	0	0	0	4	0	1.55	8.1
APR	21	0	0.0	0	0	0	4	0	1.40	9.8
MAY	22	0	0.0	0	0	0	1	0	1.61	12.4
JUN	20	0	0.0	0	0	0	3	0	1.70	13.5
JUL	23	0	0.0	0	0	0	4	0	1.57	16.1
AUG	25	0	0.0	0	0	0	5	0	1.43	18.3
SEP	21	0	0.0	0	0	0	2	0	1.31	18.1
OCT	22	0	0.0	0	0	0	4	0	1.19	15.2
NOV	22	0	0.0	0	0	0	3	0	1.20	11.9
DEC	19	1	5.3	0	0	0	1	0	1.31	9.0
Total:	256	1	0.4	0	0	0	38	0	1.43	12.4

Notes:
TC = Total Coliforms, *E. coli* = *Escherichia coli,* Cl_2 = chlorine, NTU = Nephelometric turbidity unit.
> = Greater than, mg/L = milligrams per litre, °C = degrees Celsius

Disinfection Byproducts. No data for 2018.

Physical/Chemical Parameters. The drinking water in the Oak Bay Distribution System had the following physical and chemical characteristics:

- Median pH: 7.4
- Median Alkalinity: 15.9 mg/L
- Median Turbidity: 0.34 NTU
- Median Conductivity (25ºC): 49.55 µS/cm
- Median Colour: 4.0 TCU

Metals. No data in 2018

Compliance Status. The Oak Bay Distribution System was in compliance with the *BC Drinking Water Protection Act* and *Drinking Water Protection Regulation*, but slightly under-sampled in February.

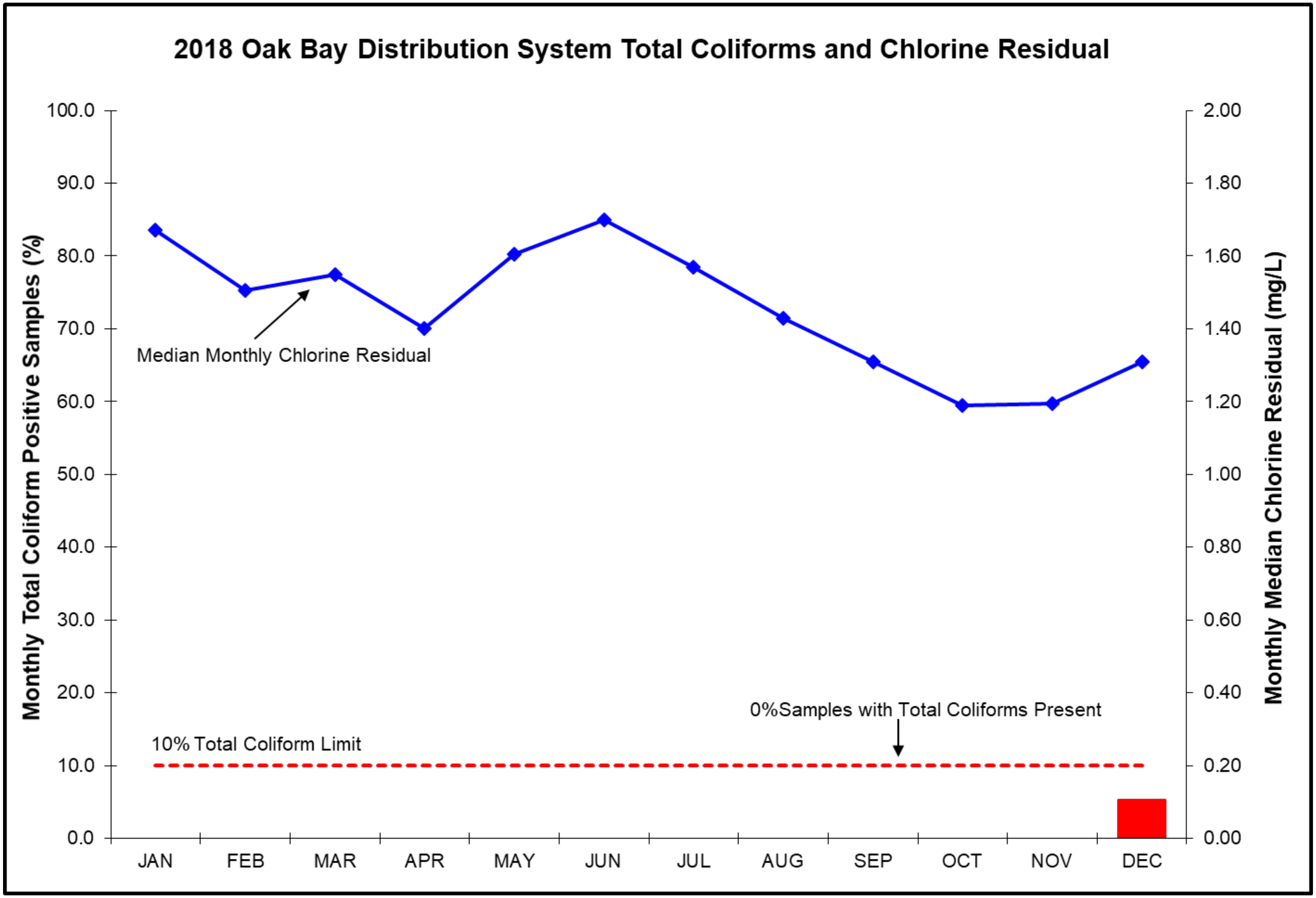

Figure 22 Oak Bay Distribution System Total Coliforms and Chlorine Residual in 2018

7.4.6 Saanich Distribution System – (District of Saanich Owned and Operated)

In 2018, 73 sampling locations were used by the CRD Water Quality Monitoring program to monitor the bacteriological quality of the water in the Saanich Distribution System. Saanich sampling stations were part of the daily distribution sampling runs by CRD staff and a weekly run by Saanich staff.

Sample Collection. In 2018, 1,220 bacteriological and 596 water chemistry samples were collected from the Saanich Distribution System (Table 8). Based on current population data for the District of Saanich, 93 samples are required for bacteria testing each month. Table 8 shows the number of monthly samples collected and analyzed for compliance.

Bacteriological Results. Total coliforms were found in seven samples collected in 2018. Total coliform-positive results occurred in January, March, June and July. There were no consecutive positive samples in 2018. One sample in December, two in June and one in July exceeded the 10 CFU/100 mL total coliform concentration limit. This system complied with the 10% total coliform positive limit for all months. The annual total coliform percentage positive was below the 10% limit at only 0.6% (Table 8).

No sample tested positive for *E. coli* in 2018 (Table 8).

Chlorine Residual. The annual median chlorine residual in the Saanich Distribution System was 1.26 mg/L (Table 8). The lowest monthly median was in October (0.92 mg/L) and the maximum monthly median was in June (1.53 mg/L) (Figure 25).

Water Temperature. The annual median water temperature in the Saanich Distribution System was 12.3°C, with monthly medians ranging between 7.4°C (January) and 18.1°C (August) (Table 8).

Table 8 2018 Bacteriological Quality of Saanich Distribution System

Month	Samples Collected	Total Coliforms (CFU/100mL)				*E.coli* CFU/100mL)	Turbidity		Chlorine Residual	Water Temp.
		Samples TC > 0	Percent TC>0	Resamples TC > 0	Samples TC > 10	Samples >0	Samples Collected	Samples >1 NTU	Median mg/L as CL2	Median ° C
JAN	94	2	2.1	0	1	0	46	0	1.30	7.4
FEB	77	0	0.0	0	0	0	36	1	1.29	7.5
MAR	91	1	1.1	0	0	0	31	3	1.27	7.5
APR	124	0	0.0	0	0	0	32	0	1.26	9.6
MAY	109	0	0.0	0	0	0	47	1	1.40	12.9
JUN	100	3	3.0	0	2	0	38	0	1.53	13.9
JUL	110	1	0.9	0	1	0	47	0	1.43	16.5
AUG	112	0	0.0	0	0	0	39	0	1.37	18.1
SEP	97	0	0.0	0	0	0	38	0	0.94	17.3
OCT	111	0	0.0	0	0	0	46	1	0.92	14.4
NOV	100	0	0.0	0	0	0	37	1	0.94	11.7
DEC	95	0	0.0	0	0	0	36	0	1.08	9.6
Total:	1220	7	0.6	0	4	0	473	7	1.26	12.3

Notes:
TC = Total Coliforms, *E. coli* = *Escherichia coli,* Cl_2 = chlorine, NTU = Nephelometric turbidity unit.
> = Greater than, mg/L = milligrams per litre, °C = degrees Celsius

Disinfection Byproducts. No data for 2018.

Physical/Chemical Parameters. The drinking water in the Saanich Distribution System had the following physical and chemical characteristics in 2018:

- Median pH: 7.42
- Median Alkalinity: 14.9 mg/L
- Median Turbidity: 0.35 NTU
- Median Conductivity (25ºC): 50.05 µS/cm
- Median Colour: 4.0 TCU

Metals. No data in 2018.

Compliance Status. The Saanich Distribution System was in compliance with the *BC Drinking Water Protection Act* and *Drinking Water Protection Regulation*, except for June, July and December with four samples that exceeded the limit of 10 CFU/100 mL total coliform concentration. The system was under-sampled in February.

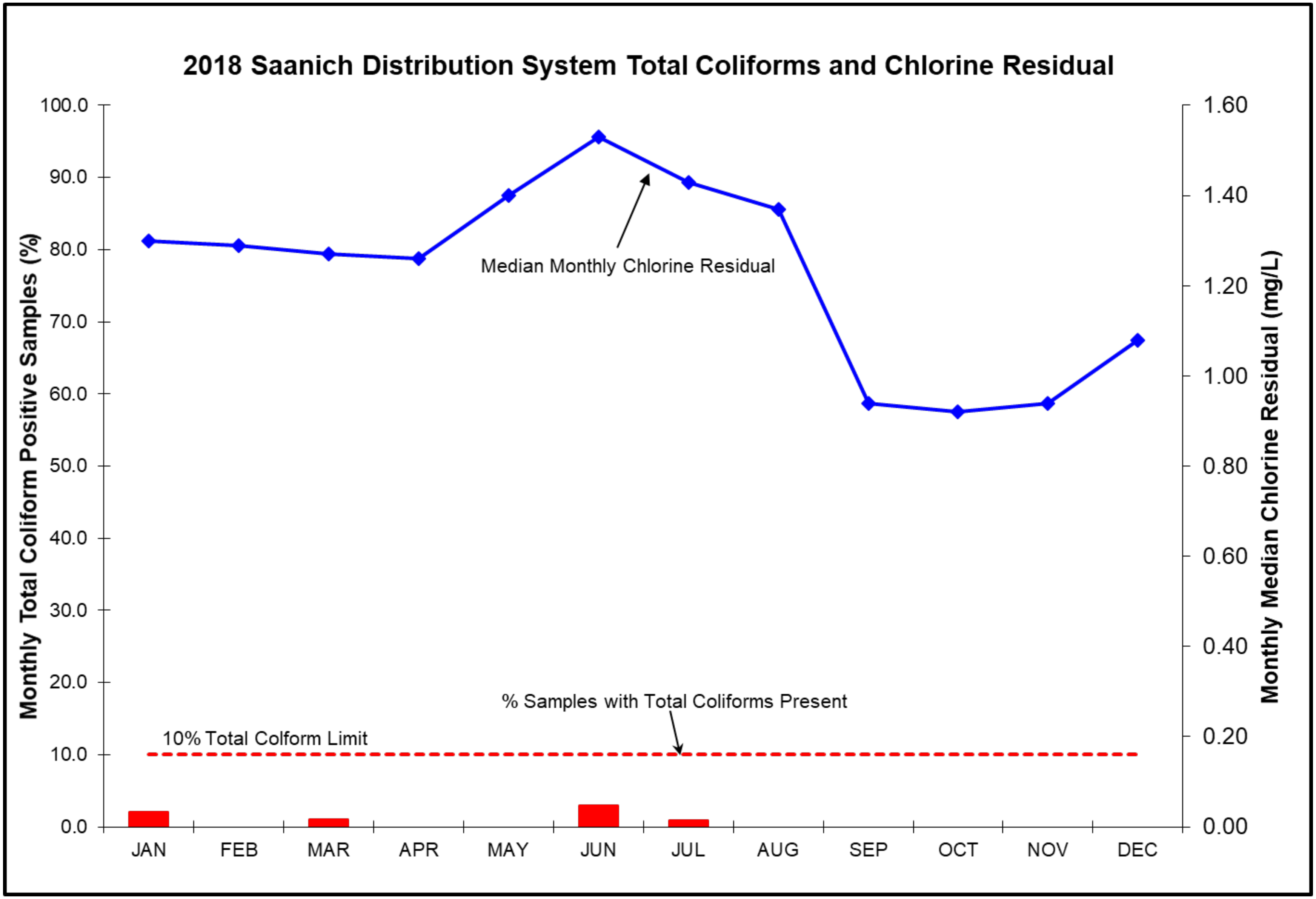

Figure 23 Saanich Distribution System Total Coliforms and Chlorine Residuals in 2018

7.4.7 Sidney Distribution System – (Town of Sidney Owned and Operated)

In 2018, seven sampling locations were used by the CRD Water Quality Monitoring program to monitor the bacteriological quality of the water in the Sidney Distribution System. Sidney sampling stations are part of the daily distribution sampling runs by CRD staff.

Sample Collection. In 2018, 177 bacteriological and 63 water chemistry samples were collected from the Sidney Distribution System (Table 9). Based on current population data for the Town of Sidney, 12 samples are required for bacteria testing each month. Table 9 shows the number of monthly samples collected and analyzed for compliance.

Bacteriological Results. No sample tested positive for total coliforms in 2018 (Table 9).

Also, no sample tested positive for *E. coli* in 2018 (Table 9).

Chlorine Residual. The annual median chlorine residual in the Sidney Distribution System was 1.29 mg/L (Table 9). The lowest monthly median was in September and October (0.73 mg/L) and the maximum monthly median was in January (1.57 mg/L) (Figure 26).

Water Temperature. The annual median water temperature in the Sidney Distribution System was 12.4°C, with monthly medians ranging between 7.3°C (January) and 18.3°C (August) (Table 9).

Table 9 2018 Bacteriological Quality of Sidney Distribution System

Month	Samples Collected	Total Coliforms (CFU/100mL)				*E.coli* CFU/100mL)	Turbidity		Chlorine Residual	Water Temp.
		Samples TC > 0	Percent TC>0	Resamples TC > 0	Samples TC > 10	Samples >0	Samples Collected	Samples >1 NTU	Median mg/L as CL2	Median ° C
JAN	14	0	0.0	0	0	0	1	0	1.57	7.3
FEB	11	0	0.0	0	0	0	1	0	1.31	8.0
MAR	17	0	0.0	0	0	0	1	0	1.21	7.6
APR	16	0	0.0	0	0	0	1	0	1.36	9.4
MAY	16	0	0.0	0	0	0	1	0	1.46	11.7
JUN	16	0	0.0	0	0	0	1	0	1.45	13.6
JUL	16	0	0.0	0	0	0	1	0	1.42	14.9
AUG	16	0	0.0	0	0	0	1	0	1.27	18.3
SEP	15	0	0.0	0	0	0	1	0	0.73	17.8
OCT	14	0	0.0	0	0	0	1	0	0.73	15.0
NOV	14	0	0.0	0	0	0	2	0	0.89	12.3
DEC	12	0	0.0	0	0	0	1	0	1.14	9.4
Total:	177	0	0.0	0	0	0	13	0	1.29	12.4

Notes:
TC = Total Coliforms, *E. coli* = *Escherichia coli,* Cl_2 = chlorine, NTU = Nephelometric turbidity unit.
> = Greater than, mg/L = milligrams per litre, °C = degrees Celsius

Disinfection Byproducts. No data for 2018.

Physical/Chemical Parameters. The drinking water in the Sidney Distribution System had the following physical and chemical characteristics in 2018:

- Median pH: 7.10
- Median Alkalinity: 14.1 mg/L
- Median Turbidity: 0.36 NTU
- Median Conductivity (25ºC): 48.3 µS/cm
- Median Colour: 4.3 TCU

Metals. No data in 2018.

Compliance Status. The Sidney Distribution System was in compliance with the *BC Drinking Water Protection Act* and *Drinking Water Protection Regulation*, but was slightly under-sampled in February.

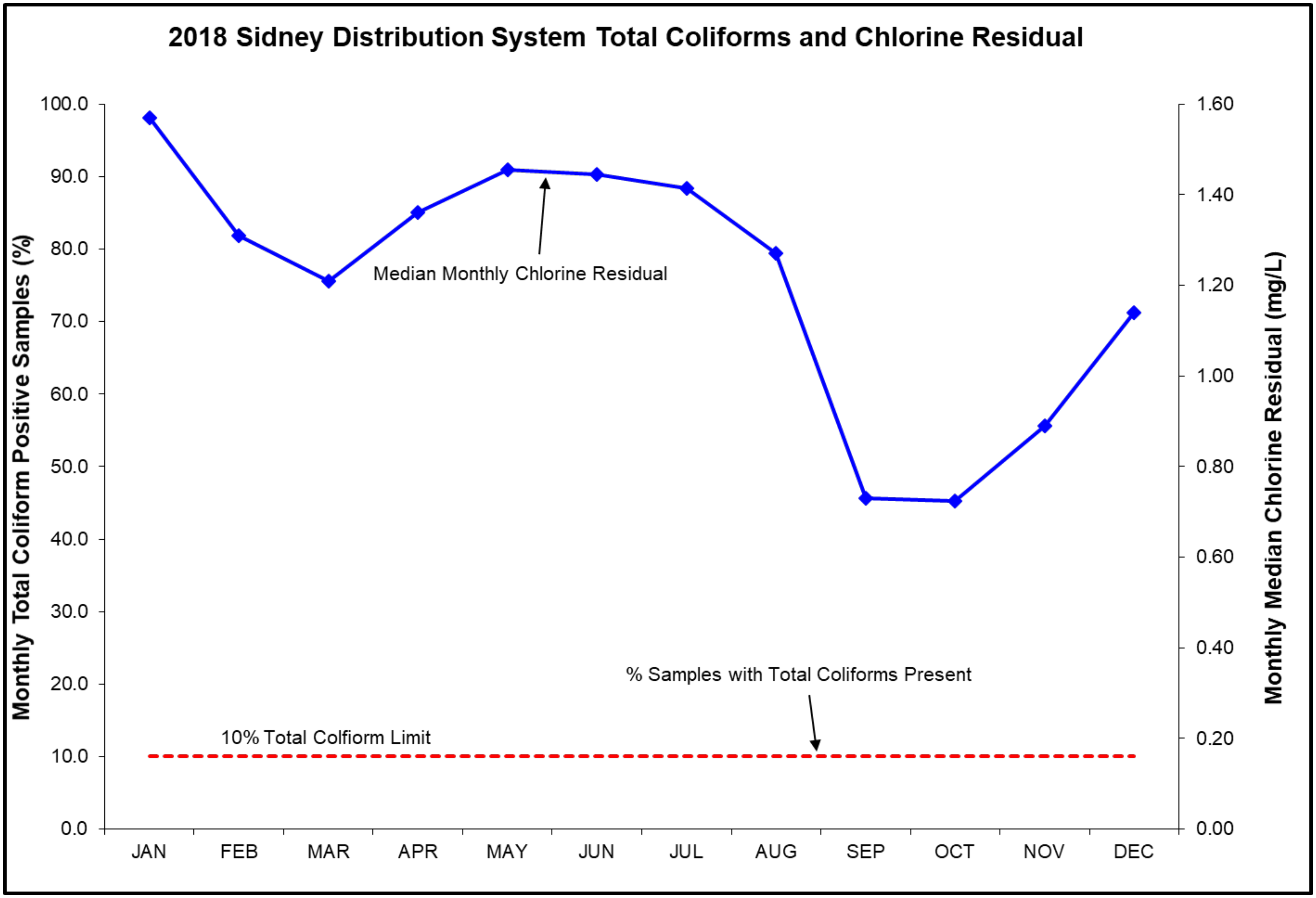

Figure 24 Sidney Distribution System Total Coliforms and Chlorine Residuals in 2018

7.4.8 Victoria/Esquimalt Distribution System – (City of Victoria Owned and Operated)

In 2018, 16 sampling locations were used by the CRD Water Quality Monitoring program to monitor the bacteriological quality of the water in the Victoria/Esquimalt Distribution System. Victoria/Esquimalt sampling stations are part of the daily distribution sampling runs by CRD staff.

Sample Collection. In 2018, 1,031 bacteriological and 194 water chemistry samples were collected from the Victoria/Esquimalt Distribution System (Table 10). Based on current population data for Victoria and Esquimalt, 92 samples are required for bacteria testing each month. Table 10 shows the number of monthly samples collected and analyzed for compliance.

Bacteriological Results. Total coliforms were found in four samples collected in March, August and November of 2018 (Table 10). There were no consecutive positive samples in 2018. No sample exceeded the 10 CFU/100 mL total coliform concentration limit. This system complied with the 10% total coliform positive limit for all months. No *E. coli* was detected in any sample in 2018 (Table 10).

Chlorine Residual. The annual median chlorine residual in the Victoria/Esquimalt Distribution System was 1.43 mg/L (Table 10). The lowest monthly median was in November (1.28 mg/L) and the maximum monthly median was in January (1.61 mg/L) (Figure 27).

Water Temperature. The annual median water temperature in the Victoria/Esquimalt Distribution System was 13.8°C, with monthly medians ranging between 7.5°C (January) and 19.1°C (August) (Table 10).

Table 10 2018 Bacteriological Quality of Victoria Distribution System

Month	Samples Collected	Total Coliforms (CFU/100mL)				*E.coli* CFU/100mL)	Turbidity		Chlorine Residual	Water Temp.
		Samples TC > 0	Percent TC>0	Resamples TC > 0	Samples TC > 10	Samples >0	Samples Collected	Samples >1 NTU	Median mg/L as CL2	Median ° C
JAN	32	0	0.0	0	0	0	5	0	1.61	7.5
FEB	27	0	0.0	0	0	0	2	0	1.48	7.7
MAR	69	1	1.4	0	0	0	6	0	1.54	8.1
APR	96	0	0.0	0	0	0	6	0	1.46	10.0
MAY	113	0	0.0	0	0	0	6	1	1.54	13.0
JUN	95	0	0.0	0	0	0	5	0	1.61	15.0
JUL	102	0	0.0	0	0	0	6	0	1.56	17.2
AUG	107	1	0.9	0	0	0	7	0	1.44	19.1
SEP	91	0	0.0	0	0	0	5	0	1.33	17.9
OCT	109	0	0.0	0	0	0	6	0	1.34	14.8
NOV	96	2	2.1	0	0	0	4	0	1.28	11.9
DEC	94	0	0.0	0	0	0	4	0	1.36	9.0
Total:	1031	4	0.4	0	0	0	62	1	1.43	13.8

Notes:
TC = Total Coliforms, *E. coli* = *Escherichia coli,* Cl_2 = chlorine, NTU = Nephelometric turbidity unit.
> = Greater than, mg/L = milligrams per litre, °C = degrees Celsius

Disinfection Byproducts. No data for 2018.

Physical/Chemical Parameters. The drinking water in the Victoria/Esquimalt Distribution System had the following physical and chemical characteristics in 2018:

- Median pH: 7.38
- Median Alkalinity: 16.7 mg/L
- Median Turbidity: 0.34 NTU
- Median Conductivity (25ºC): 49.95 µS/cm
- Median Colour: 4.00 TCU

The system experienced occasional elevated turbidity in certain dead-end pipe sections, which should be addressed with regular flushing at those locations.

Metals. No data in 2018 from within this system. However, data from some CRD-Victoria transition points indicate there may be lead sources in certain City of Victoria distribution system sections.

Compliance Status. The Victoria/Esquimalt Distribution System was in compliance with the *BC Drinking Water Protection Act* and *Drinking Water Protection Regulation*, except for the months of January, February, March and September, due to insufficient monthly compliance samples.

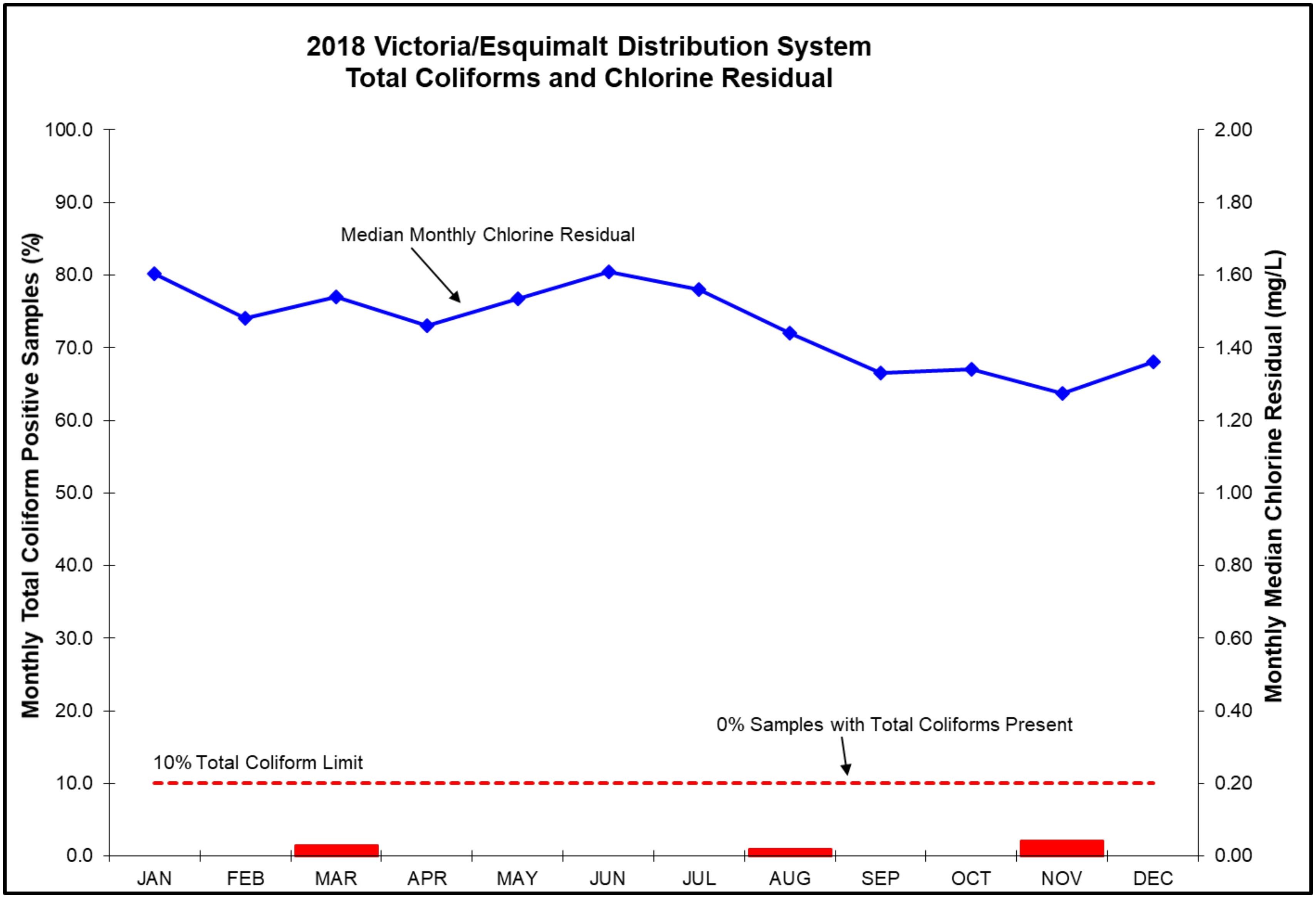

Figure 25 **Victoria/Esquimalt Distribution System Total Coliforms and Chlorine Residuals in 2018**

7.5 Water Quality Inquiry Program

Records of customer inquiries, including complaints about drinking water quality, have been maintained since 1992. In 2018, as was the case in recent years, there was no single category of water quality inquiry or complaint that stood out among the rest. During periods of water main flushing activities (January-April, October-December) in the distribution systems, complaints or concerns about water discolouration were more prevalent. A number of inquiries or complaints about chlorine taste and odour were received in 2018, but most of these were of a general nature where people object to the addition of any chemical to the drinking water. The number of these chlorine complaints or inquiries in 2018 was consistent with that of previous years. CRD staff have noticed an increase in public inquiries regarding lead in the drinking water and the potential impact on human health. This was not unexpected, as Health Canada guidelines for lead concentrations in drinking water were recently lowered from 10 ug/L to 5 ug/L and health risks associated with lead in drinking water has been a subject of increased media attention.

In addition to complaints, CRD staff received a number of queries from people concerned about the general safety of their drinking water. These concerns were addressed individually and, in general, most customers are content to know that CRD staff were actively sampling both the source water and the treated drinking water being delivered to their homes. For those people wanting to know more about the composition of their drinking water, they were either provided with the annual tables or directed to the CRD website.

8.0 CONCLUSIONS

1. The water quality data collected in 2018 indicate that the drinking water in Greater Victoria is of good quality and safe to drink. The drinking water temperature exceeded the aesthetic objective of 15°C between August and October. This is the only parameter that system-wide did not meet water quality criteria listed in the G*uidelines for Canadian Drinking Water Quality*.

2. Greater Victoria continues to enjoy a water supply in which *Giardia* and *Cryptosporidium* parasites are well below the levels commonly considered by the health authorities to be responsible for disease outbreaks.

3. The bacteriological quality of the raw source water was excellent in 2018. Total coliform concentrations were very low for most of the year with medium concentrations in late summer/early fall. This bacteriological pattern is typical for Sooke Lake Reservoir and does not cause any issues with the existing water treatment systems. *E. coli* bacterial levels in the raw source water were low for the entire year.

4. Consumers in the GVDWS receive drinking water that has very low disinfection byproducts. Overall levels of trihalomethanes and haloacetic acids remain well below the Canadian guidelines' limits and the USEPA limits. The newly-monitored disinfection byproduct, Nitrosodimethylamine, was, if detected at all, only in concentrations well below the current MAC in the Canadian guidelines.

5. The algal activity in 2018 was above average in Sooke Lake Reservoir, due to conducive weather conditions that facilitated the activity of certain low risk algal species. Cyanobacteria with the potential to produce harmful cyanotoxins under bloom conditions were present, as usual, throughout the year. However, a stable and nutrient-poor ecosystem, such as the Sooke Lake Watershed, does not provide conditions needed for cyanobacteria or extensive adverse algal blooms with serious implications for the drinking water quality. These natural nutrient-poor conditions limit the biological productivity in Sooke Lake Reservoir, which is very favourable for a drinking water source.

6. The number of water quality inquiries and complaints received by CRD staff in 2018 was low and similar to that in previous years. The subject of the majority of inquiries and concerns were, as usual, related to chlorine taste and odour or temporary water discolouration, due to operational activities. Lead is emerging as a priority topic for public concerns.

7. The CRD Juan de Fuca and Saanich distribution systems were not in full compliance with the *BC Drinking Water Protection Regulation*, due to several samples containing total coliform concentrations higher than the limit of 10 CFU/100 mL. Resamples did not confirm a drinking water contamination, therefore, there was no risk to the public, due to these results.

8. The CRD Juan de Fuca, Victoria/Esquimalt, Sidney, Saanich, Oak Bay and Central Saanich distribution systems did not meet the monthly sampling requirements as per *BC Drinking Water Protection Regulation.* This issue has been addressed since May 2018, with additional sampling/testing efforts by the CRD for the CRD and municipal water systems.

9. The analytical results in all CRD and municipal water systems show that the drinking water was of good quality and was safe for consumption at all times throughout 2018.

10. Elevated lead concentrations continued to be detected at a few CRD sampling stations where water is supplied to the City of Victoria and Oak Bay distribution systems. It was concluded that the lead originates most likely from within the municipal systems. Most results are below the current MAC in the Canadian guidelines; however, it is unknown to what extent and magnitude lead concentrations exist in particular parts of the municipal water systems. It is the responsibility of the affected municipalities to look further into this issue. The CRD has initiated actions at vulnerable sites that will prevent municipal water to backflow into the CRD Transmission System. Lead investigations in the Juan de Fuca and Sooke/East Sooke distribution systems found very low lead concentrations in the drinking water.

APPENDIX A

TABLE 1. 2018 UNTREATED (RAW) WATER QUALITY ENTERING JAPAN GULCH PLANT

(Guideline values provide reference only for untreated water)

PARAMETER		2018 ANALYTICAL RESULTS				CANADIAN GUIDELINES	TEN YEAR RESULTS (2008-2017)			Target Sampling Frequency
Parameter Name	Units of Measure	Median Value	Samples Analyzed	Range Minimum	Range Maximum	≤ = Less than or equal to	10 Year Median	Samples Analyzed	Range Minimum - Maximum	
Physical Parameters (ND means less than instrument can detect)										
Alkalinity, Total	mg/L	14.95	14	14.3	16.6		8.84	124	15.00 - 19.10	12/yr
Carbon, Dissolved Organic	mg/L as C	1.54	12	1.16	2		ND	115	1.96 - 4.65	12/yr
Carbon, Total Organic	mg/L as C	2.01	12	0.82	2.88	Guideline Archived	1.00	116	2.07 - 5.19	12/yr
Colour, True	TCU	7.00	51	ND	9	≤15 AO	2.80	554	6.44 - 15.20	52/yr
Conductivity @ 25 C	uS/cm	40.80	51	38.2	62.9		27.50	529	42.20 - 56.40	52/yr
Hardness as $CaCO_3$	mg/L	16.30	7	ND	18.1		6.95	191	17.16 - 20.90	12/yr
pH	pH units	7.33	52	7.1	7.5	6.5 - 8.5 AO	6.73	531	7.23 - 7.66	52/yr
Tannins and Lignins	mg/L	0.21	2	0.13	0.28	Guideline Archived	ND	21	0.23 - 0.38	2/yr
Total Dissolved Solids	mg/L	27.00	12	19	40	≤500 AO	ND	115	26.77 - 48.00	12/yr
Total Suspended Solids	mg/L	ND	12	ND	2		ND	115	0.91 - 4.67	12/yr
Total Solids	mg/L	33.00	12	ND	43		ND	111	27.65 - 45.00	12/yr
Turbidity, Grab Samples	NTU	0.34	236	0.2	1.4	1.0 Operational Guideline	0.17	2460	0.37 - 1.95	250/yr
Ultraviolet Absorption, 5 cm	Abs.@254 nm	0.27	50	0.19	0.31		0.16	510	0.26 - 0.57	52/yr
Ultraviolet Transmittance	%	88.25	50	87.2	91.5		0.20	1107	88.23 - 94.40	52/yr
Water Temp., Grab Samples	degrees C	9.70	241	4.6	18.5	≤15 AO	2.70	2515	10.61 - 21.00	250/yr
Non-Metallic Inorganic Chemicals (ND means less than instrument can detect)										
Bromide	ug/L as Br	ND	4	ND	ND		ND	85	3.22 - 22.79	12/yr
Chloride	mg/L as Cl	2.2	4	2.1	2.3	≤ 250 AO	ND	21	2.74 - 4.58	2/yr
Cyanide	mg/L as Cn	ND	2	ND	ND	0.2 MAC	ND	19	0.00 - 0.00	2/yr
Fluoride	mg/L as F	0.02	4	ND	0.02	1.5 MAC	ND	20	0.02 - 0.13	2/yr
Nitrate, Dissolved	ug/L as N	ND	12	ND	32	10000 MAC	ND	106	17.76 - 69.20	12/yr
Nitrite, Dissolved	ug/L as N	ND	13	ND	ND	1000 MAC	ND	104	ND - ND	12/yr
Nitrate + Nitrite	ug/L as N	ND	12	ND	32		ND	106	18.01 - 69.20	12/yr
Nitrogen, Ammonia	ug/L as N	ND	12	ND	130		ND	108	9.92 - 110.00	12/yr
Nitrogen, Total Kjeldahl	ug/L as N	104.5	12	69	208		0.00	106	85.98 - 307.00	12/yr
Nitrogen, Total	ug/L as N	118.5	12	75	208		0.00	111	99.70 - 307.00	12/yr
Phosphate, Ortho, Dissolved	ug/L as P	ND	12	ND	10		ND	105	1.91 - 24.30	12/yr
Phosphate, Total, Dissolved	ug/L as P	2.95	12	ND	13.5		ND	109	2.46 - 5.90	12/yr
Phosphate, Total	ug/L as P	3.3	12	ND	8.2		ND	110	4.11 - 12.60	12/yr
Silica	mg/L as SiO_2	3.9	12	3.44	4.26		0.09	94	3.66 - 5.57	12/yr
Silicon	ug/L as Si	1860	7	1690	2090		681.00	98	1,825.42 - 2,860.00	12/yr
Sulphate	mg/L as SO_4	1.55	10	ND	2.4	≤ 500 AO	ND	110	1.89 - 8.16	12/yr
Sulphide	mg/L as H_2S	ND	8	ND	0.09	≤ 0.05 AO	ND	19	0.02 - 0.13	2/yr
Sulphur	mg/L as S	ND	7	ND	ND		ND	97	1.52 - 3.00	12/yr

Appendix A, Table 1, continued

PARAMETER		2018 ANALYTICAL RESULTS				CANADIAN GUIDELINES	TEN YEAR RESULTS (2008-2017)			Target Sampling Frequency
Parameter Name	Units of Measure	Median Value	Samples Analyzed	Range Minimum	Range Maximum	≤ = Less than or equal to	10 Year Median	Samples Analyzed	Range Minimum - Maximum	
Metallic Inorganic Chemicals (ND means less than instrument can detect)										
Aluminum	ug/L as Al	**19.2**	7	9.1	46.5	200 Operational Guideline	3.90	98	17.25 - 81.00	6/yr
Antimony	ug/L as Sb	**ND**	7	ND	ND	6 MAC	ND	98	0.28 - 0.50	6/yr
Arsenic	ug/L as As	**ND**	7	ND	ND	10 MAC	ND	98	0.07 - 0.30	6/yr
Barium	ug/L as Ba	**3.9**	7	3.7	4.3	1000 MAC	ND	98	3.89 - 5.30	6/yr
Beryllium	ug/L as Be	**ND**	7	ND	ND		ND	98	ND - ND	6/yr
Bismuth	ug/L as Bi	**ND**	7	ND	ND		ND	97	ND - ND	6/yr
Boron	ug/L as B	**ND**	7	ND	ND	5000 MAC	ND	98	25.07 - 50.00	6/yr
Cadmium	ug/L as Cd	**ND**	7	ND	ND	5 MAC	ND	98	0.01 - 0.20	6/yr
Calcium	mg/L as Ca	**4.86**	7	4.58	5.34		2.06	98	4.99 - 6.13	6/yr
Chromium	ug/L as Cr	**ND**	7	ND	ND	50 MAC	ND	98	0.54 - 4.00	6/yr
Cobalt	ug/L as Co	**ND**	7	ND	ND		ND	98	ND - ND	6/yr
Copper	ug/L as Cu	**1.51**	7	0.93	3.02	≤ 1000 AO	ND	98	2.26 - 30.50	6/yr
Iron	ug/L as Fe	**43.4**	7	14.8	113	≤ 300 AO	12.00	98	37.86 - 205.00	6/yr
Lead	ug/L as Pb	**ND**	7	ND	ND	10 MAC	ND	98	0.12 - 0.60	6/yr
Lithium	ug/L as Li	**ND**	1	ND	ND		ND	95	2.57 - 10.40	6/yr
Magnesium	mg/L as Mg	**1.11**	7	1.06	1.18		0.44	98	1.17 - 1.60	6/yr
Manganese	ug/L as Mn	**12.7**	7	2.6	36.9	≤ 50 AO	ND	98	7.57 - 81.80	6/yr
Mercury, Total	ug/L as Hg	**ND**	7	ND	ND	1.0 MAC	ND	98	0.11 - 0.16	6/yr
Molybdenum	ug/L as Mo	**ND**	7	ND	ND		ND	98	ND - ND	6/yr
Nickel	ug/L as Ni	**ND**	7	ND	ND		ND	98	0.57 - 3.00	6/yr
Potassium	mg/L as K	**0.14**	7	0.12	0.14		0.08	98	0.15 - 0.23	6/yr
Selenium	ug/L as Se	**ND**	7	ND	ND	50 MAC	ND	98	ND - ND	6/yr
Silver	ug/L as Ag	**ND**	7	ND	ND		ND	98	0.01 - 0.02	6/yr
Sodium	mg/L as Na	**1.57**	7	1.41	1.67	≤ 200 AO	0.65	98	1.73 - 2.91	6/yr
Strontium	ug/L as Sr	**15.1**	7	13.3	16.5		ND	98	15.46 - 21.80	6/yr
Thallium	ug/L as Tl	**ND**	7	ND	ND		ND	98	ND - ND	6/yr
Tin	ug/L as Sn	**ND**	7	ND	ND		ND	98	ND - ND	6/yr
Titanium	mg/L as Ti	**ND**	7	ND	ND		ND	98	ND - ND	6/yr
Vanadium	ug/L as V	**ND**	7	ND	ND		ND	98	ND - ND	6/yr
Zinc	ug/L as Zn	**ND**	7	ND	ND	≤ 5000 AO	ND	98	4.21 - 82.90	6/yr
Zirconium	ug/L as Zr	**ND**	7	ND	ND	_	ND	98	ND - ND	6/yr
Microbial Parameters										
Coliform Bacteria										
Coliforms, Total	Coliforms/100 mL	9	236	**ND**	580		ND	2463	137.55 - 24,200.00	250/yr
E. coli	*E. coli*/100 mL	ND	236	**ND**	2		ND	2463	0.71 - 23.00	250/yr
Heterotrophic / Other Bacteria										

Appendix A, Table 1, continued

PARAMETER		2018 ANALYTICAL RESULTS				CANADIAN GUIDELINES	TEN YEAR RESULTS (2008-2017)			Target Sampling Frequency
Parameter Name	Units of Measure	Median Value	Samples Analyzed	Range		≤ = Less than or equal to	10 Year Median	Samples Analyzed	Range	
				Minimum	Maximum				Minimum - Maximum	
Hetero. Plate Count, 28ºC (7 day)	CFU/1 mL	340	226	**ND**	1800		ND	2413	456.82 - 7,200.00	250/yr
Cyanobacterial Toxins										
Anatoxin a	ug/L	Analyzed as required - last analyzed in 2005					ND	2	ND - ND	Special
Microcystin-LR	ug/L	Analyzed as required - last analyzed in 2011				1.5 MAC (Total Microcystins)	ND	11	ND - 0.34	Special
Parasites						No MAC Established				
Cryptosporidium, Total oocysts	oocysts/100 L	ND	8	**ND**	1	Zero detection desirable	0	125	0 - 2	4/yr
Giardia, Total cysts	cysts/100 L	ND	6	**ND**	ND	Zero detection desirable	0	132	0-2	4/yr
Radiological Parameters (ND means less than instrument can detect)										
Gross alpha radiation	Bq/L	**ND**	1	ND	ND	0.5 (Screening)	ND	23	0.01 - 0.04	2/yr
Gross beta radiation	Bq/L	**ND**	1	ND	ND	1.0 (Screening)	ND	23	0.03 - 0.11	2/yr
Iodine-131	Bq/L	**ND**	1	ND	ND	6 Bq/L	ND	15	ND - ND	Special
Cesium-134	Bq/L	**Not tested in 2018**					ND	14	0.08 - 0.20	Special
Cesium-137	Bq/L	**ND**	1	ND	ND	10 Bq/L	ND	15	ND - ND	Special
Ruthenium-103	Bq/L	**Not tested in 2018**					ND	12	0	
Uranium	ug/L as U	**ND**	7	ND	ND	20 MAC	ND	98	0	6/yr
Organic Parameters (ND means less than instrument can detect)										
Pesticides/Herbicides										
1,4-DDD	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	18	ND - ND	2/yr
1,4'-DDE	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	18	ND - ND	2/yr
1,4'-DDT	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	18	ND - ND	2/yr
2,4,5-T	ug/L	**ND**	2	ND	ND		ND	19	ND - ND	2/yr
2,4,5-TP (Silvex)	ug/L	**ND**	2	ND	ND		ND	19	ND - ND	2/yr
2,4-D	ug/L	**ND**	1	ND	ND	100 MAC	ND	19	ND - ND	2/yr
2,4-D (BEE)	ug/L	**ND**	2	ND	ND		ND	14	ND - ND	2/yr
2,4-DB	ug/L	**ND**	**1**	**ND**	**ND**		ND	16	ND - ND	2/yr
2,4-DP (Dichlorprop)	ug/L	**ND**	2	ND	ND		ND	14	ND - ND	2/yr
4,4'-DDD	ug/L	**Not tested in 2018**				Guideline Archived	ND	18	ND - ND	2/yr
4,4'-DDE	ug/L	**Not tested in 2018**				Guideline Archived	ND	18	ND - ND	2/yr
4,4'-DDT	ug/L	**Not tested in 2018**				Guideline Archived	ND	18	ND - ND	2/yr
Alachlor	ug/L	**ND**	1	ND	ND	Guideline Archived	ND	11	ND - ND	2/yr
Aldicarb	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	20	ND - ND	2/yr
Aldrin	ug/L	**ND**	2	ND	ND	5.0 MAC	ND	18	ND - ND	2/yr
Atrazine	ug/L	**ND**	2	ND	ND	20 MAC	ND	19	ND - ND	2/yr

Appendix A, Table 1, continued

PARAMETER		2018 ANALYTICAL RESULTS				CANADIAN GUIDELINES	TEN YEAR RESULTS (2008-2017)			Target Sampling Frequency
Parameter Name	Units of Measure	Median Value	Samples Analyzed	Range Minimum	Range Maximum	≤ = Less than or equal to	10 Year Median	Samples Analyzed	Range Minimum - Maximum	
Azinphos-methyl	ug/L	**ND**	2	ND	ND		ND	19	ND - ND	2/yr
BHC (alpha)	ug/L	**ND**	2	ND	ND		ND	19	ND - ND	2/yr
BHC (beta)	ug/L	**ND**	3	ND	ND		ND	18	ND - ND	2/yr
BHC (delta)	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	19	ND - ND	2/yr
Bendiocarb	ug/L	**ND**	2	ND	ND		ND	20	ND - ND	Irregular
Bromacil	ug/L	**ND**	2	ND	ND	5.0 MAC	ND	11	ND - ND	2/yr
Bromoxynil	ug/L	**ND**	2	ND	ND	90 MAC	ND	16	ND - ND	2/yr
Carbaryl	ug/L	**ND**	2	ND	ND	90 MAC	ND	20	ND - ND	2/yr
Carbofuran	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	20	ND - ND	2/yr
Chlordane (alpha)	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	12	ND - ND	2/yr
Chlordane (gamma)	ug/L	**ND**	2	ND	ND	90 MAC	ND	18	ND - ND	2/yr
Chlorpyrifos (Dursban)	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	19	ND - ND	2/yr
Cyanazine (Bladex)	ug/L	**ND**	**2**	**ND**	**ND**		ND	17	ND - ND	2/yr
Demanton	ug/L	**ND**	3	ND	ND	20 MAC	ND	4	ND - ND	2/yr
Diazinon	ug/L	**ND**	2	ND	ND	120 MAC	ND	20	ND - ND	2/yr
Dicamba	ug/L	**ND**	2	ND	ND	9.0 MAC	ND	21	ND - ND	2/yr
Diclofop-methyl	ug/L	**ND**	2	ND	ND		ND	17	ND - ND	2/yr
Dichlorvos	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	14	ND - ND	2/yr
Dieldrin	ug/L	**ND**	2	ND	ND	20 MAC	ND	18	ND - ND	2/yr
Dimethoate	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	20	ND - ND	2/yr
Dinoseb	ug/L	**ND**	2	ND	ND	70 MAC	ND	15	ND - ND	2/yr
Diquat	ug/L	**ND**	2	ND	ND		ND	19	ND - ND	2/yr
Endosulfan l	ug/L	**ND**	2	ND	ND		ND	18	ND - ND	2/yr
Endosulfan ll	ug/L	**ND**	2	ND	ND		ND	18	ND - ND	2/yr
Endosulfan Sulphate	ug/L	**ND**	**2**	**ND**	**ND**		ND	19	ND - ND	2/yr
Endosulfan (Total)	ug/L	**Not tested in 2018**				Guideline Archived	ND	14	ND - ND	2/yr
Endrin	ug/L	**ND**	2	ND	ND		ND	18	ND - ND	2/yr
Endrin Aldehyde	ug/L	**ND**	2	ND	ND		ND	19	ND - ND	2/yr
Endrin Ketone	ug/L	**ND**	2	ND	ND		ND	15	ND - ND	2/yr
Ethion	ug/L	**ND**	2	ND	ND		ND	17	ND - ND	2/yr
Ethyl Parathion	ug/L	**ND**	2	ND	ND		ND	15	ND - ND	2/yr
Fenchlorophos (Ronnel)	ug/L	**ND**	2	ND	ND		ND	14	ND - ND	2/yr
Fenthion	ug/L	**ND**	2	ND	ND		ND	17	ND - ND	2/yr
Fonofos	ug/L	**ND**	2	ND	ND	280 MAC	ND	18	ND - ND	2/yr
Glyphosate	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	19	ND - ND	2/yr
Heptachlor	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	18	ND - ND	2/yr
Heptachlor Epoxide	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	18	ND - ND	2/yr
Lindane (BHC-gamma)	ug/L	**ND**	2	ND	ND	190 MAC	ND	18	ND - ND	2/yr
Malathion	ug/L	**ND**	2	ND	ND	100 MAC	ND	20	ND - ND	2/yr
2-Methyl-4-chlorophenoxyacetic acid	ug/L	**ND**	3	ND	ND		ND	21	ND - ND	2/yr
MCPP	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	18	ND - ND	2/yr
Methoxychlor	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	18	ND - ND	2/yr
Methyl Parathion	ug/L	**ND**	2	ND	ND	50 MAC	ND	21	ND - ND	2/yr
Metolachlor	ug/L	**ND**	2	ND	ND	80 MAC	ND	19	ND - ND	2/yr

Appendix A, Table 1, continued

PARAMETER		2018 ANALYTICAL RESULTS				CANADIAN GUIDELINES	TEN YEAR RESULTS (2008-2017)			Target Sampling Frequency
Parameter Name	Units of Measure	Median Value	Samples Analyzed	Range		≤ = Less than or equal to	10 Year Median	Samples Analyzed	Range	
				Minimum	Maximum				Minimum - Maximum	
Metribuzin (Sencor)	ug/L	**ND**	2	ND	ND		ND	15	0.61 - 0.00	2/yr
Mevinphos	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	18	ND - ND	2/yr
Mirex	mg/L	**ND**	2	ND	ND	0.4 MAC	ND	15	ND - ND	2/yr
Nitrilotriacetic acid (NTA)	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	19	0.07 - 0.10	Irregular
Parathion	ug/L	**ND**	2	ND	ND	7 MAC	ND	11	ND - ND	2/yr
Paraquat (ion)	ug/L	**ND**	2	ND	ND	2.0 MAC	ND	19	ND - ND	2/yr
Phorate	ug/L	**ND**	2	ND	ND		ND	19	ND - ND	2/yr
Phosmet	ug/L	**ND**	2	ND	ND	190 MAC	ND	18	ND - ND	2/yr
Picloram	ug/L	**ND**	2	ND	ND	10 MAC	ND	20	ND - ND	2/yr
Prometryne	ug/L	**ND**	**2**	**ND**	**ND**	Guideline Archived	ND	11	ND - ND	Irregular
Simazine	ug/L	**ND**	2	ND	ND	1.0 MAC	ND	18	ND - ND	2/yr
Temephos	ug/L	**Not tested in 2018**				Guideline Archived	ND	6	ND - ND	2/yr
Terbufos	ug/L	**ND**	2	ND	ND	45 MAC	ND	19	ND - ND	2/yr
Toxaphene	ug/L	**Not tested in 2018**					ND	17	ND - ND	2/yr
Trifluralin		**ND**	2	ND	ND		ND	19	ND - ND	2/yr
Polycyclic Aromatic Hydrocarbons (PAHs)										
Acenaphthene	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	20	ND - ND	2/yr
Acenaphthylene	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	20	ND - ND	2/yr
Anthracene	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	20	ND - ND	2/yr
Benzo(a)anthracene	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	20	0.05 - 0.02	2/yr
Benzo(a)pyrene	ug/L	**ND**	2	**ND**	**ND**	0.01 MAC	ND	18	0.01 - 0.01	2/yr
Benzo(b)fluoranthene	ug/L	**Not tested in 2018**				Guideline Archived	ND	20	ND - ND	2/yr
Benzo(g,h,i)perylene	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	20	0.09 - 0.05	2/yr
Benzo(k)fluoranthene	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	20	ND - ND	2/yr
Chrysene	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	20	0.08 - 0.03	2/yr
Dibenz(a,h)anthracene	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	20	0.07 - 0.04	2/yr
Fluoranthene	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	20	0.05 - 0.02	2/yr
Fluorene	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	20	0.08 - 0.03	2/yr
Indeno(1,2,3-c,d)pyrene	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	20	ND - ND	2/yr
Naphthalene	ug/L	**ND**	1	ND	ND	Guideline Archived	ND	20	ND - ND	2/yr
Phenanthrene	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	20	0.07 - 0.08	2/yr
Pyrene	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	20	ND - ND	2/yr
Volatile Hydrocarbons	ug/L	**ND**	3	ND	ND		ND	15	ND - ND	2/yr
Phenols										
2,3,4,6-Tetrachlorophenol	ug/L	**ND**	2	ND	ND	100 MAC and ≤ 1.0 AO	ND	15	ND - ND	2/yr
2,4,6-Trichlorophenol	ug/L	**ND**	2	ND	ND	5.0 MAC and ≤ 2.0 AO	ND	19	ND - ND	2/yr
2,4-Dichlorophenol	ug/L	**Not tested in 2018**				900 MAC and ≤ 0.3 AO	ND	17	ND - ND	2/yr
2,4-Dimethylphenol	ug/L	**ND**	2	ND	ND		ND	19	ND - ND	2/yr
2,4-Dinitrophenol	ug/L	**ND**	2	ND	ND		ND	20	ND - ND	2/yr
2-Chlorophenol	ug/L	**ND**	2	ND	ND		ND	20	ND - ND	2/yr

Appendix A, Table 1, continued

PARAMETER		2018 ANALYTICAL RESULTS				CANADIAN GUIDELINES	TEN YEAR RESULTS (2008-2017)			Target Sampling Frequency
Parameter Name	Units of Measure	Median Value	Samples Analyzed	Range Minimum	Range Maximum	≤ = Less than or equal to	10 Year Median	Samples Analyzed	Range Minimum - Maximum	
2-Nitrophenol	ug/L	**ND**	2	ND	ND		ND	19	ND - ND	2/yr
4,6-Dinitro-2-Methylphenol	ug/L	**Not tested in 2018**					ND	20	ND-ND	2/yr
4-Chloro-3-Methylphenol	ug/L	**ND**	2	ND	ND		ND	20	ND - ND	2/yr
4-Nitrophenol	ug/L	**ND**	2	ND	ND		ND	20	ND - ND	2/yr
Alpha-Terpineol	ug/L	**ND**	2	ND	ND		ND	16	ND - ND	2/yr
Pentachlorophenol	ug/L	**ND**	2	ND	ND	60 MAC and ≤ 30 AO	ND	18	ND - ND	2/yr
Phenol	ug/L	**ND**	2	ND	ND		ND	22	0.90 - 6.20	2/yr
Total Phenolics	ug/L	ND	2	ND	ND		ND	7	2.61 - 8.20	2/yr
Polychlorinated Biphenyls (PCBs)										
PCB-1016	ug/L	**ND**	1	ND	ND	Guideline Archived	ND	14	ND - ND	Irregular
PCB-1221	ug/L	**ND**	1	ND	ND	Guideline Archived	ND	14	ND - ND	Irregular
PCB-1232	ug/L	**ND**	1	ND	ND	Guideline Archived	ND	14	ND - ND	Irregular
PCB-1242	ug/L	**ND**	1	ND	ND	Guideline Archived	ND	14	ND - ND	Irregular
PCB-1248	ug/L	**ND**	1	ND	ND	Guideline Archived	ND	14	ND - ND	Irregular
PCB-1254	ug/L	**ND**	1	ND	ND	Guideline Archived	ND	14	ND - ND	Irregular
PCB-1260	ug/L	**ND**	1	ND	ND	Guideline Archived	ND	15	ND - ND	Irregular
Total PCBs	ug/L	**ND**	1	ND	ND	Guideline Archived	ND	14	ND - ND	Irregular
Other Synthetic Chemicals										
1,1,1-Trichloroethane	ug/L	**ND**	2	ND	ND		20	ND	ND - ND	
1,1,1,2-Tetrachloroethane	ug/L	**ND**	2	ND	ND		17	ND	ND - ND	
1,1,2,2-Tetrachloroethane	ug/L	**ND**	2	ND	ND		19	ND	ND - ND	
1,1,2-Trichloroethane	ug/L	**ND**	2	ND	ND		20	ND	ND - ND	
1,1-Dichloroethane	ug/L	**ND**	2	ND	ND		23	ND	ND - ND	
1,1-Dichloroethylene	ug/L	**ND**	2	ND	ND	14 MAC	17	ND	ND - ND	
1,2,3-Trichlorobenzene	ug/L	**ND**	2	ND	ND		9	ND	ND - ND	
1,2,4-Trichlorobenzene	ug/L	**ND**	2	ND	ND		23	ND	0.20 - 0.20	
1,2-Dibromoethane	ug/L	**ND**	2	ND	ND		13	ND	ND - ND	
1,2-Dichlorobenzene	ug/L	**ND**	2	ND	ND	200 MAC and ≤ 3.0 AO	20	ND	ND - ND	
1,2-Dichloroethane	ug/L	**ND**	2	ND	ND	5.0 MAC	20	ND	ND - ND	
1,2-Dichloroethylene (cis)	ug/L	**ND**	2	ND	ND		20	ND	ND - ND	
1,2-Dichloroethylene (trans)	ug/L	**ND**	2	ND	ND		20	ND	ND - ND	
1,2-Dichloropropane	ug/L	**ND**	2	ND	ND		20	ND	ND - ND	
1,2-Diphenylhydrazine	ug/L	**ND**	2	ND	ND		16	ND	ND - ND	
1,3-Dichlorobenzene	ug/L	**ND**	1	ND	ND		20	ND	ND - ND	
1,3-Dichloropropene (cis)	ug/L	**ND**	2	ND	ND		20	ND	ND - ND	
1,3-Dichloropropene (trans)	ug/L	**ND**	2	ND	ND		20	ND	ND - ND	
1,4-Dichlorobenzene	ug/L	**ND**	2	ND	ND	5.0 MAC and ≤ 1.0 AO	20	ND	ND - ND	
2,4-Dinitrotoluene	ug/L	**ND**	2	ND	ND		20	ND	ND - ND	
2,6-Dinitrotoluene	ug/L	**ND**	2	ND	ND		20	ND	ND - ND	
2-Chloronaphthalene	ug/L	**ND**	2	ND	ND		20	ND	ND - ND	

Appendix A, Table 1, continued

PARAMETER		2018 ANALYTICAL RESULTS				CANADIAN GUIDELINES	TEN YEAR RESULTS (2008-2017)			Target Sampling Frequency
Parameter Name	Units of Measure	Median Value	Samples Analyzed	Range		≤ = Less than or equal to	10 Year Median	Samples Analyzed	Range	
				Minimum	Maximum				Minimum - Maximum	
2-Methylnaphthalene	ug/L	**ND**	2	ND	ND		20	ND	ND - ND	
3,3'-Dichlorobenzidene	ug/L	**ND**	2	ND	ND		20	ND	ND - ND	
4-Bromophenyl-phenylether	ug/L	**ND**	2	ND	ND		20	ND	ND - ND	
4-Chlorophenyl-phenylether	ug/L	**ND**	2	ND	ND		20	ND	ND - ND	
Atrazine	ug/L	**ND**	2	ND	ND	5.0 MAC	19	ND	ND - ND	
Atrazine + Desethyl Atrazine	ug/L	**ND**	2	ND	ND		5	ND	ND - ND	
Benzene	ug/L	**ND**	3	ND	ND	5.0 MAC	20	ND	ND - ND	
Benzidine	ug/L	**Not tested in 2018**					15	ND	ND - ND	
Bis(-2-chloroethoxy) methane	ug/L	**ND**	2	ND	ND		20	ND	ND - ND	
Bis(-2-chloroethyl) ether	ug/L	**ND**	2	ND	ND		20	ND	ND - ND	
Bis(2-chloroisopropyl) ether	ug/L	**ND**	2	**ND**	**ND**		20	ND	ND - ND	
Bis(2-ethylhexyl) phthalate	ug/L	**ND**	2	ND	ND		21	ND	1.70 - 1.70	
Bromodichloromethane		**Not tested in 2018**					2	ND	ND - ND	
Bromobenzene		**ND**	**2**	**ND**	**ND**		6	ND	ND - ND	
Bromoform		**ND**	2	ND	ND		20	ND	ND - ND	
Bromomethane	ug/L	**ND**	2	ND	ND		20	ND	ND - ND	
Butylbenzyl phthalate	ug/L	**ND**	1	ND	ND		20	ND	ND - ND	
Carbon Tetrachloride	ug/L	**ND**	2	ND	ND	2.0 MAC	20	ND	ND - ND	
Chloroform		**ND**	2	ND	ND		20	ND	ND - ND	
Chloroethane	ug/L	**ND**	2	ND	ND		20	ND	ND - ND	
Chloromethane	ug/L	**ND**	2	ND	ND		20	ND	ND - ND	
Desethyl Atrazine	ug/L	**ND**	1	ND	ND		12	ND	ND - ND	
Dibromochloromethane	ug/L	**ND**	1	ND	ND		20	ND	ND - ND	
Dibromomethane	ug/L	**Not tested in 2018**					10	ND	ND - ND	
Dichlorodifluoromethane	ug/L	**ND**	2	ND	ND		15	ND	ND - ND	
Dichloromethane	ug/L	**ND**	2	ND	ND	50 MAC	16	ND	ND - ND	
Diethyl phthalate	ug/L	**0.07**	1	0.07	0.07		20	ND	0.60 - 0.60	
Dimethyl phthalate	ug/L	**ND**	1	ND	ND		20	ND	ND - ND	
Di-n-butyl phthalate	ug/L	**0.93**	1	0.93	0.93		19	ND	4.90 - 4.90	
Di-n-ocyl phthalate	ug/L	**ND**	1	ND	ND		20	ND	ND - ND	
Diuron	ug/L	**ND**	2	ND	ND	150 MAC	14	ND	ND - ND	
Ethylbenzene	ug/L	**ND**	3	ND	ND	≤ 140 MAC and ≤ 1.6 AO	20	ND	ND - ND	
Formaldehyde	ug/L	**ND**	2	ND	ND		19	ND	0.02 - 0.02	
Hexachlorobenzene	ug/L	**ND**	2	ND	ND		20	ND	ND - ND	
Hexachlorobutadiene	ug/L	**ND**	3	ND	ND		24	ND	ND - ND	
Hexachlorocyclopentadiene	ug/L	**ND**	2	ND	ND		21	ND	ND - ND	
Hexachloroethane	ug/L	**ND**	3	ND	ND		21	ND	ND - ND	
Isophorone	ug/L	**ND**	2	ND	ND		20	ND	ND - ND	
Methyltertiarybutylether (MTBE)	ug/L	**ND**	3	ND	ND	15 AO	23	ND	ND - ND	
Monochlorobenzene	ug/L	**ND**	2	ND	ND	80 MAC and ≤ 30 AO	20	ND	ND - ND	
Nitrobenzene	ug/L	**ND**	**2**	**ND**	**ND**	0.04 MAC	20	ND	ND - ND	
N-nitrosodimethylamine (NDMA)	ug/L									
N-nitroso-di-n-propylamine	ug/L	**ND**	**2**	**ND**	**ND**		20	ND	ND - ND	
N-nitrosodiphenylamine	ug/L	**ND**	**2**	**ND**	**ND**		20	ND	ND - ND	

Appendix A, Table 1, continued

PARAMETER		2018 ANALYTICAL RESULTS				CANADIAN GUIDELINES	TEN YEAR RESULTS (2008-2017)			Target Sampling Frequency
Parameter Name	Units of Measure	Median Value	Samples Analyzed	Range		≤ = Less than or equal to	10 Year Median	Samples Analyzed	Range	
				Minimum	Maximum				Minimum - Maximum	
Octachlorostyrene	ug/L	**ND**	2	ND	ND		15	ND	ND - ND	
Styrene	ug/L	**ND**	3	ND	ND		20	ND	ND - ND	
Tetrachloroethylene	ug/L	**ND**	2	ND	ND	30 MAC	21	ND	ND - ND	
Toluene	ug/L	**ND**	3	ND	ND	60 MAC and ≤ 24 AO	20	ND	ND - ND	
Triallate	ug/L	**ND**	2	ND	ND	Guideline Archived	16	ND	ND - ND	
Trichloroethylene	ug/L	**ND**	**2**	**ND**	**ND**	5.0 MAC	17	ND	ND - ND	
Trichlorofluoromethane	ug/L	**ND**	2	ND	ND		20	ND	ND - ND	
Trichlorotrifluoroethane	ug/L	**ND**	1	ND	ND		8	ND	ND - ND	
Vinyl Chloride	ug/L	**ND**	2	ND	ND	2.0 MAC	20	ND	ND - ND	
o-Xylene	ug/L	**ND**	3	ND	ND		16	ND	ND - ND	
m&p-Xylene	ug/L	**ND**	3	ND	ND		16	ND	ND - ND	
Xylenes (Total)	ug/L	**ND**	3	ND	ND	90 MAC and ≤ 20 AO	20	ND	ND - ND	

Notes: mg/L = milligrams per litre; ug/L = micrograms per litre; ND = Not Detected; CFU = Colony Forming Units; NTU = Nephelometric Units; TCU = True Colour Units; AO = Aesthetic Objective; MAC = Max. Acceptable Conc.; Median = middle point of all values

APPENDIX A

TABLE 2. 2018 TREATED WATER QUALITY AFTER JAPAN GULCH PLANT

PARAMETER		2018 ANALYTICAL RESULTS				CANADIAN GUIDELINES	TEN YEAR RESULTS (2008-2017)			Target Sampling Frequency
Parameter Name	Units of Measure	Median Value	Samples Analyzed	Range Minimum	Range Maximum	≤ = Less than or equal to	10 Year Median	Samples Analyzed	Range Minimum - Maximum	
Physical Parameters (ND means less than instrument can detect)										
Alkalinity, Total	mg/L	**13.55**	14	12.50	16.10		13.35	44	6.92 - 15.00	12/yr
Carbon, Dissolved Organic	mg/L	**1.66**	12	0.60	2.31		1.86	43	0.59 - 3.60	12/yr
Carbon, Total Organic	mg/L	**1.91**	12	1.20	4.99	Guideline Archived	1.89	43	1.03 - 3.70	12/yr
Colour, True	TCU	**4.00**	51	ND	6.00	≤ 15 AO	3.85	196	1.60 - 10.00	52/yr
Conductivity @ 25 C	uS/cm	**45.70**	51	41.90	98.60		45.00	196	31.10 - 65.30	52/yr
Hardness as $CaCO_3$	mg/L	**16.30**	12	15.00	17.90		17.50	75	12.00 - 22.10	12/yr
Odour	Odour Profile	**1.00**	233	1.00	1.00	Inoffensive	**1.00**	900	1.00 - 1.00	250/yr
pH	pH units	**7.10**	51	6.90	8.08	7.0-10.5 AO	6.96	194	6.54 - 7.41	52/yr
Taste	Flavour Profile	**1.00**	229	1.00	1.00	Inoffensive	1.00	897	1.00 - 1.00	250/yr
Total Dissolved Solids	mg/L	**30.50**	12	19.00	39.00	≤500 AO	26.75	42	ND - 41.00	12/yr
Total Suspended Solids	mg/L	**ND**	13	ND	1.00		ND	42	ND - 10.90	12/yr
Total Solids	mg/L	**37.00**	12	ND	47.00		28.75	38	11.00 - 43.00	12/yr
Turbidity, Grab Samples	NTU	**0.33**	235	0.18	1.30	1 Operational and ≤ 5 AO	0.32	902	0.14 - 6.30	250/yr
Water Temperature, Grab Samples	degrees C	**9.70**	236	4.60	18.40	≤ 15 AO	11.30	903	2.50 - 21.10	250/yr
Non-Metallic Inorganic Chemicals (ND means less than instrument can detect)										
Bromide	ug/L as Br	**ND**	4	ND	ND		ND	19	ND - 43.00	12/yr
Chloride	mg/L as Cl	**4.00**	4	3.70	4.20	≤ 250 AO	3.85	10	ND - 5.00	2/yr
Cyanide	mg/L as Cn	**ND**	2	ND	ND	0.2 MAC	ND	7	ND - 0.00	2/yr
Fluoride	mg/L as F	**0.02**	4	ND	0.02	1.5 MAC	0.02	8	ND - 0.03	2/yr
Nitrate, Dissolved	ug/L as N	**ND**	12	ND	36.00	10000 MAC	13.12	38	ND - 47.50	12/yr
Nitrite, Dissolved	ug/L as N	**ND**	13	ND	ND	1000 MAC	ND	34	ND - 25.00	12/yr
Nitrate + Nitrite	ug/L as N	**ND**	12	ND	36.00		13.12	38	ND - 47.50	12/yr
Nitrogen, Ammonia	ug/L as N	**205.00**	12	170.00	280.00		90.80	42	ND - 240.00	12/yr
Nitrogen, Total Kjeldahl	ug/L as N	**358.00**	12	263.00	458.00		222.45	38	0.00 - 411.00	12/yr
Nitrogen, Total	ug/L as N	**373.00**	12	294.00	484.00		229.00	42	0.00 - 411.00	12/yr
Phosphate, Ortho, Dissolved	ug/L as P	**ND**	12	ND	4.00		ND	37	ND - 0.99	12/yr
Phosphate, Total, Dissolved	ug/L as P	**3.10**	12	ND	5.70		2.95	42	ND - 9.90	12/yr
Phosphate, Total	ug/L as P	**2.80**	12	ND	6.80		3.43	42	ND - 7.20	12/yr
Silica	mg/L as SiO2	**3.82**	11	3.42	4.23		3.93	34	2.91 - 4.28	12/yr
Silicon	ug/L as Si	**1,885.00**	12	1,560.00	2,180.00		2,010.00	44	1,590.00 - 2,740.00	12/yr
Sulphate	mg/L as SO4	**1.65**	10	ND	3.00	≤ 500 AO	1.75	42	0.80 - 5.31	12/yr
Sulphide	mg/L as H2S	**ND**	8	ND	0.09	≤ 0.05 AO	0.03	7	ND - 0.10	2/yr
Sulfur	mg/L as S	**ND**	12	ND	ND		ND	45	ND - 3.00	12/yr

PARAMETER		2018 ANALYTICAL RESULTS				CANADIAN GUIDELINES	TEN YEAR RESULTS (2008-2017)			Target Sampling Frequency
Parameter Name	Units of Measure	Median Value	Samples Analyzed	Range Minimum	Range Maximum	≤ = Less than or equal to	10 Year Median	Samples Analyzed	Range Minimum - Maximum	
Metallic Inorganic Chemicals (ND means less than instrument can detect)										
Aluminum	ug/L as Al	**17.90**	12	8.60	30.50	100 AO and 200 Operational	16.15	44	4.50 - 67.70	12/yr
Antimony	ug/L as Sb	**ND**	12	ND	ND	6 MAC	ND	44	ND - ND	12/yr
Arsenic	ug/L as As	**ND**	12	ND	ND	10 MAC	ND	44	ND - 0.17	12/yr
Barium	ug/L as Ba	**3.75**	12	3.40	4.30	1000 MAC	3.90	44	3.30 - 4.80	12/yr
Beryllium	ug/L as Be	**ND**	12	ND	ND		ND	43	ND - ND	12/yr
Bismuth	ug/L as Bi	**ND**	12	ND	ND		ND	44	ND - 0.01	12/yr
Boron	ug/L as B	**ND**	12	ND	ND	5000 MAC	ND	44	ND - 50.00	12/yr
Cadmium	ug/L as Cd	**ND**	12	ND	ND	5 MAC	ND	44	ND - 0.06	12/yr
Calcium	mg/L as Ca	**4.78**	12	4.27	5.26		5.12	44	4.53 - 6.82	12/yr
Chromium	ug/L as Cr	**ND**	12	ND	ND	50 MAC	ND	44	ND - 1.20	12/yr
Cobalt	ug/L as Co	**ND**	12	ND	ND		ND	44	ND - 0.04	12/yr
Copper	ug/L as Cu	**12.60**	12	2.96	109.00	≤ 1000 AO	18.95	44	1.03 - 202.00	12/yr
Iron	ug/L as Fe	**26.70**	12	12.90	89.70	≤ 300 AO	29.00	44	12.20 - 198.00	12/yr
Lead	ug/L as Pb	**ND**	12	ND	ND	10 MAC	ND	44	ND - 0.92	12/yr
Lithium	ug/L as Li	**ND**	3	ND	ND		ND	36	ND - 13.50	12/yr
Magnesium	mg/L as Mg	**1.08**	12	1.01	1.16		1.19	44	0.15 - 1.41	12/yr
Manganese	ug/L as Mn	**6.45**	12	2.10	26.10	≤ 50 AO	5.45	44	ND - 48.00	12/yr
Mercury, Total	ug/L as Hg	**ND**	12	ND	0.00	1.0 MAC	ND	42	ND - ND	12/yr
Molybdenum	Ug/L as Mo	**ND**	12	ND	ND		ND	44	ND - ND	12/yr
Nickel	mg/L as Ni	**ND**	12	ND	ND		ND	44	ND - 1.60	12/yr
Potassium	mg/L as K	**0.13**	12	0.12	0.15		0.14	44	0.11 - 0.22	12/yr
Selenium	ug/L as Se	**ND**	12	ND	ND	50 MAC	ND	44	ND - ND	12/yr
Silver	ug/L as Ag	**ND**	12	ND	ND		ND	44	ND - 0.06	12/yr
Sodium	mg/L as Na	**1.59**	12	1.39	3.33	≤ 200 AO	1.72	44	1.47 - 3.56	12/yr
Strontium	ug/L as Sr	**14.40**	12	13.50	16.40		15.70	44	13.00 - 19.70	12/yr
Thallium	ug/L as Tl	**ND**	12	ND	ND		ND	44	ND - ND	12/yr
Tin	ug/L as Sn	**ND**	12	ND	ND		ND	44	ND - 0.22	12/yr
Titanium	ug/L as Ti	**ND**	12	ND	ND		ND	44	ND - ND	12/yr
Uranium	ug/L as U	**ND**	12	ND	ND	20 MAC	ND	44	ND - 0.02	12/yr
Vanadium	ug/L as V	**ND**	12	ND	ND		ND	44	ND - ND	12/yr
Zinc	ug/L as Zn	**ND**	12	ND	ND	≤ 5000 AO	ND	44	ND - 54.10	12/yr
Zirconium	ug/L as Zr	**ND**	12	ND	ND		ND	44	ND - ND	12/yr

Appendix A, Table 2, continued

PARAMETER		2018 ANALYTICAL RESULTS				CANADIAN GUIDELINES	TEN YEAR RESULTS (2008-2017)			Target Sampling Frequency
Parameter Name	Units of Measure	Median Value	Samples Analyzed	Range Minimum	Range Maximum	≤ = Less than or equal to	10 Year Median	Samples Analyzed	Range Minimum - Maximum	
Microbial Parameters (ND means less than method or instrument can detect)										
Coliform Bacteria										
Coliforms, Total	CFU/100 mL	**0.00**	236	0.00	14.00	0 MAC	0.00	909	0.00 - 200.00	250/yr
E. coli	CFU/100 mL	**ND**	236	ND	ND	0 MAC	ND	909	ND - ND	250/yr
Heterotrophic/Other Bacteria										
Hetero. Plate Count, 28C (7 day)	CFU/1 mL	**ND**	226	ND	350.00		ND	872	ND - 770.00	250/yr
Disinfectants (ND means less than instrument can detect)										
Disinfectants										
Chlorine, Total Residual	mg/L as Cl_2	**1.69**	236	0.39	2.30	3.0 MAC (chloramines)	1.21	909	0.36 - 5.50	250/yr
Dichloramine	mg/L as Cl_2	**1.57**	235	0.02	2.20		0.53	885	ND - 2.24	250/yr
Monochloramine	mg/L as Cl_2	**0.21**	235	0.00	1.03		0.48	885	0.00 - 1.20	250/yr

Notes: mg/L = milligrams per litre; ug/L = micrograms per litre; ND = Not Detected; CFU = Colony Forming Units; NTU = Nephelometric Units; TCU = True Colour Units; AO = Aesthetic Objective; MAC = Max. Acceptable Conc.; Median = middle point of all values

APPENDIX A
TABLE 3. 2018 TREATED WATER QUALITY AFTER SOOKE PLANT

PARAMETER		2018 ANALYTICAL RESULTS				CANADIAN GUIDELINES	TEN-YEAR RESULTS (2008-2017)			Target Sampling Frequency
Parameter Name	Units of Measure	Median Value	Samples Analyzed	Range Minimum	Range Maximum	≤ = Less than or equal to	10 Year Median	Samples Analyzed	Range Minimum - Maximum	
Physical Parameters (ND means less than instrument can detect)										
Alkalinity, Total	mg/L	**16.50**	22	15.30	19.00		16.50	22	15.30 - 19.00	12/yr
Colour, True	TCU	**3.45**	98	1.60	11.30	≤ 15 AO	3.45	98	1.60 - 11.30	52/yr
Conductivity @ 25 C	uS/cm	**58.35**	98	42.10	70.40		58.35	98	42.10 - 70.40	52/yr
Odour	Flavour Profile	**1.00**	110	1.00	1.00	Inoffensive	1.00	110	1.00 - 1.00	52/yr
pH	pH units	**7.47**	98	7.15	8.32	7.0-10.5 AO	7.47	98	7.15 - 8.32	52/yr
Taste	Flavour Profile	**1.00**	110	1.00	1.00	Inoffensive	1.00	110	1.00 - 1.00	52/yr
Turbidity, Grab Samples	NTU	**0.33**	113	0.16	0.95	1 MAC	0.33	113	0.16 - 0.95	52/yr
Water Temperature, Grab Samples	degrees C	**12.40**	114.0	1.19	20.00	≤ 15 AO	12.40	114	1.19 - 20.00	52/yr
Microbial Parameters (ND means less than instrument can detect)										
Coliform Bacteria										
Coliform, Total	CFU/100 mL	0.00	114	0.00	0	0 MAC	0.00	114	0.00 - 1.00	52/yr
E. coli	CFU/100 mL	ND	114	ND	ND	0 MAC	ND	114	ND - ND	52/yr
Heterotrophic Bacteria										
Hetero. Plate Count, 28C (7 day)	CFU/1 mL	ND	95	**ND**	210.00		ND	95	ND - 210.00	52/yr
Disinfectants (ND means less than instrument can detect)										
Disinfectants										
Chlorine, Total Residual	mg/L as Cl_2	**1.72**	113	0.90	4.20	3.0 MAC (chloramines)	1.72	113	0.90 - 4.20	52/yr
Dichloramine	mg/L as Cl_2	**1.38**	105	0.22	3.10		1.38	105	0.22 - 3.10	52/yr
Monochloramine	mg/L as Cl_2	**0.08**	105	0.00	1.03		0.08	105	0.00 - 1.03	52/yr
Metallic Inorganic Chemicals (ND means less than instrument can detect)										
Aluminum	ug/L as Al	13.50	10	7.70	22.70	200 Operational Guideline	13.50	10	7.70 - 22.70	12/yr
Antimony	ug/L as Sb	ND	10	ND	ND	6 MAC	ND	10	ND - ND	12/yr
Arsenic	ug/L as As	ND	10	ND	ND	10 MAC	ND	10	ND - ND	12/yr
Barium	ug/L as Ba	3.85	10	3.50	4.20	1000 MAC	3.85	10	3.50 - 4.20	12/yr
Beryllium	ug/L as Be	ND	10	ND	ND		ND	10	ND - ND	12/yr

Appendix A, Table 3, continued

PARAMETER		2018 ANALYTICAL RESULTS				CANADIAN GUIDELINES	TEN-YEAR RESULTS (2008-2017)			Target Sampling Frequency
Parameter Name	Units of Measure	Median Value	Samples Analyzed	Range		≤ = Less than or equal to	10 Year Median	Samples Analyzed	Range	
				Minimum	Maximum				Minimum - Maximum	
Bismuth	ug/L as Bi	ND	10	ND	ND		ND	10	ND - ND	12/yr
Boron	ug/L as B	ND	10	ND	ND	5000 MAC	ND	10	ND - ND	12/yr
Cadmium	ug/L as Cd	ND	10	ND	ND	5 MAC	ND	10	ND - ND	12/yr
Calcium	mg/L as Ca	5.00	10	4.73	5.43		5.00	10	4.73 - 5.43	12/yr
Chromium	ug/L as Cr	ND	10	ND	ND	50 MAC	ND	10	ND - ND	12/yr
Cobalt	ug/L as Co	ND	10	ND	ND		ND	10	ND - ND	12/yr
Copper	ug/L as Cu	39.05	10	16.70	80.40	≤ 1000 AO	39.05	10	16.70 - 80.40	12/yr
Iron	ug/L as Fe	33.50	10	12.00	53.00	≤ 300 AO	33.50	10	12.00 - 53.00	12/yr
Lead	ug/L as Pb	0.46	10	ND	0.64	10 MAC	0.46	10	ND - 0.64	12/yr
Lithium	ug/L as Li	ND	7	ND	ND		ND	7	ND - ND	12/yr
Magnesium	mg/L as Mg	1.16	10	1.07	1.34		1.16	10	1.07 - 1.34	12/yr
Manganese	ug/L as Mn	4.05	10	1.30	10.00	≤ 50 AO	4.05	10	1.30 - 10.00	12/yr
Mercury, Total	ug/L as Hg	ND	10	ND	ND	1.0 MAC	ND	10	ND - ND	12/yr
Molybdenum	ug/L as Mo	ND	10	ND	ND		ND	10	ND - ND	12/yr
Nickel	ug/L as Ni	ND	10	ND	ND		ND	10	ND - ND	12/yr
Potassium	mg/L as K	0.13	10	0.12	0.25		0.13	10	0.12 - 0.25	12/yr
Selenium	ug/L as Se	ND	10	ND	ND	50 MAC	ND	10	ND - ND	12/yr
Silver	ug/L as Ag	ND	10	ND	ND		ND	10	ND - ND	12/yr
Sodium	mg/L as Na	4.76	10	4.38	7.02	≤ 200 AO	4.76	10	4.38 - 7.02	12/yr
Strontium	ug/L as Sr	14.85	10	13.40	16.20		14.85	10	13.40 - 16.20	12/yr
Thallium	ug/L as Tl	ND	10	ND	0.01		ND	10	ND - 0.01	12/yr
Tin	ug/L as Sn	ND	10	ND	ND		ND	10	ND - ND	12/yr
Titanium	ug/L as Ti	ND	10	ND	ND		ND	10	ND - ND	12/yr
Uranium	ug/L as U	ND	10	ND	ND	20 MAC	ND	10	ND - ND	12/yr
Vanadium	ug/L as V	ND	10	ND	ND		ND	10	ND - ND	12/yr
Zinc	ug/L as Zn	ND	10	ND	ND	≤ 5000 AO	ND	21	ND-54.10	12/yr
Zirconium	ug/L as Zr	ND	10	ND	ND		ND	21	ND-ND	12/yr

Notes: mg/L = milligrams per litre; ug/L = micrograms per litre; ND = Not Detected; CFU = Colony Forming Units; NTU = Nephelometric Units; TCU = True Colour Units; AO = Aesthetic Objective; MAC = Max. Acceptable Conc.; Median = middle point of all values