Greater Victoria Drinking Water Quality

2021 Annual Report

Parks & Environmental Services Department | Environmental Protection

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May 2022

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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 2021 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.

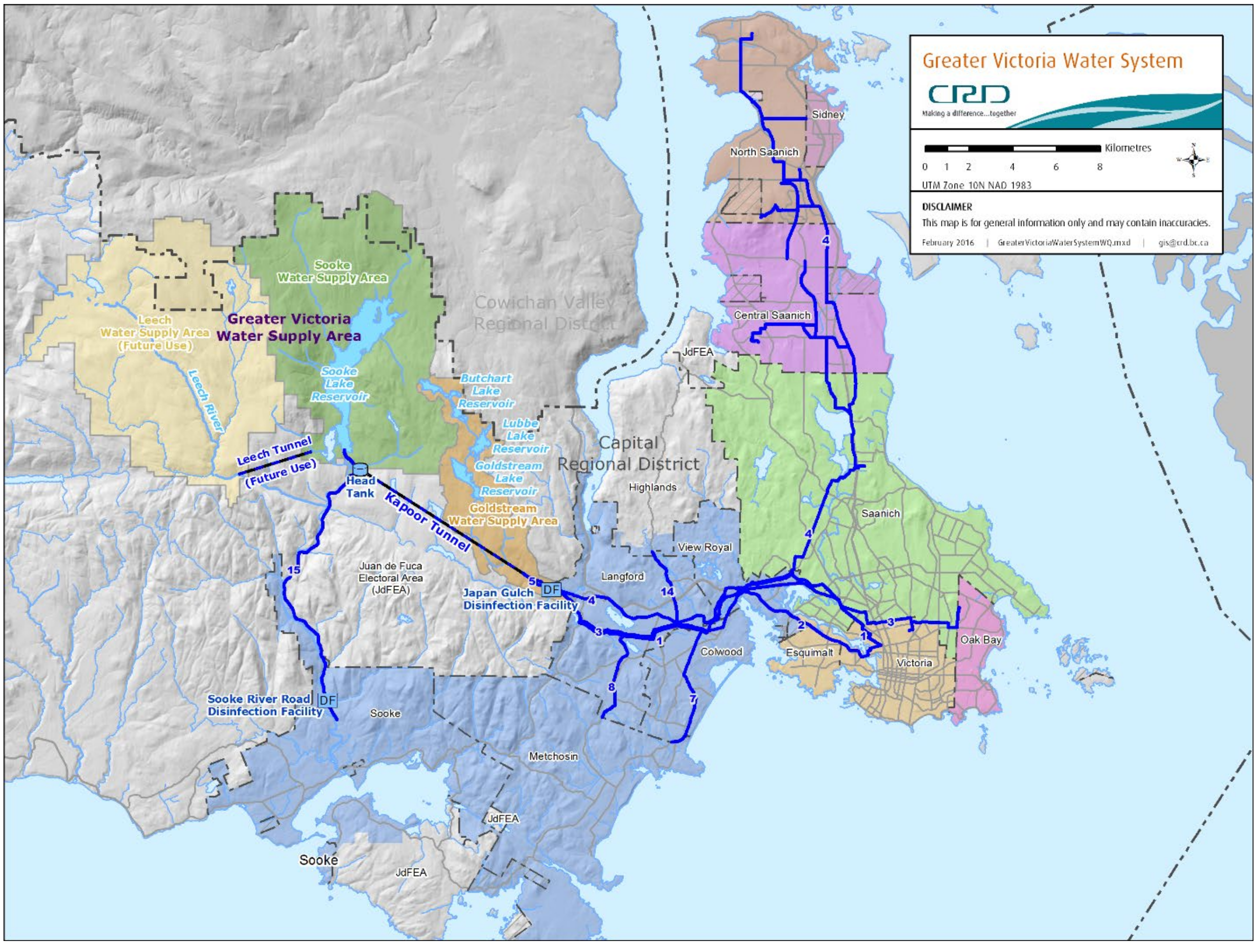
The monitoring program is designed to meet the requirements of the provincial regulatory framework, which is defined by the *BC Drinking Water Protection Act* and *Drinking Water Protection Regulation*, and follow the federal guidelines for drinking water quality.

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 Goldstream (formerly called Japan Gulch) water treatment plants 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 10,000 samples and conducting approximately 75,000 individual analyses annually. The results are discussed with the Island Health Authority, which oversees compliance with drinking water standards, and with 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 the CRD continues 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 staff 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 the disinfection treatment; and 5) to detect any taste and odour or other aesthetic 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 2021 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 2021, the GVDWS supplied drinking water to approximately 392,000 people and is the third-largest drinking water system operating in British Columbia. It comprises two separate service areas:

1. The **Goldstream (Japan Gulch) Service Area** that supplies water to approximately 376,500 people in Victoria, Saanich, Oak Bay, Esquimalt, Central Saanich, North Saanich, Sidney, Highlands, Colwood, Langford and Metchosin via the Goldstream Water Treatment Plant (formerly called Japan Gulch).

2. The **Sooke Service Area** that supplies water to approximately 15,500 people in Sooke and East Sooke via the Sooke River Road Water Treatment Plant.

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 20,500 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. The Goldstream and Sooke watersheds, with 11,000 ha area, comprise the active water supply area, whereas 9,500 ha of the Leech watershed are currently inactive and designated for future water supply.

Goldstream (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 typically between 98% and 100% of Greater Victoria's drinking water. In 2021, Sooke Lake Reservoir supplied 100% of the source water. The four reservoirs in the Goldstream system (Butchart, Lubbe, Goldstream and Japan Gulch) are typically off-line 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 Goldstream Water Treatment Plant, where it is disinfected.

During occasional brief periods of use (typically used only when the Kapoor Tunnel is out of service for inspection by CRD staff), water in the Goldstream 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 and a high-level intake, passing through a 14-mesh, stainless steel screen and is then carried in a 1,320 mm-diameter pipe into the Goldstream Water Treatment Plant.

Sooke Service Area

Drinking water for the Sooke 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 Water Treatment Plant. The Sooke 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 water treatment plants to provide disinfected drinking water to the two service areas.

Both water treatment plants utilize the same disinfection concepts and process methods. The Goldstream Water Treatment Plant uses delivered liquid sodium hypochlorite and liquid ammonia for the disinfection process and still has the old chlorine gas injection plant as a backup system. The Sooke River Road Water Treatment Plant generates sodium hypochlorite on site and injects delivered liquid ammonia to achieve the disinfection effect.

At both water treatment plants, 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. Based on the consistently applied high UV dosage at the Goldstream plant (50-90 mJ/cm^2), it can be assumed that it is also effective in inactivating certain viruses (66-99% rotavirus inactivation).

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, the CRD re-chloraminates the water to boost the chlorine residual provided to the extremities of that system. In Metchosin, at Rocky Point Reservoir, the CRD maintains another re-chloramination station, which has not been in service for approximately five 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, emergency re-chlorination stations are provided 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 were to drop to inadequate levels or during water quality emergencies.

2.3 CRD Transmission System

The CRD Transmission System comprises a number of large-diameter transmission mains and several connected supply storage reservoirs. Almost all of the supply storage reservoirs are on the Saanich

Peninsula, leaving the Core Area municipalities without any supply storage. 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 Westshore and the Core Area 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 Goldstream Water Treatment Plant 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 Goldstream Water Treatment Plant 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 Goldstream Water Treatment Plant 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 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 Water Treatment Plant. Main #15 feeds directly into the Sooke Distribution System downstream of the water treatment plant.

2.3.4 Supply Storage Reservoirs

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

The only CRD-owned and operated transmission system storage reservoir in the Regional Transmission System is:

- Mt. Tolmie Reservoir, a two-cell concrete in-ground reservoir, 27,300 m^3 (6 M 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, has been disconnected from the system (off Main #4) and is empty. It is anticipated that this reservoir will not be used for drinking water purposes again.

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 (1M 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 (1M 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 (1M 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 (1.5M 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 the CRD Integrated Water Services Department. 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 defined as 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 2021, 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 the Juan de Fuca Water Distribution System, water flowed generally in a northerly and southerly direction away from the supply mains. The federal 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 m³ (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 Water Treatment Plant, 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. In 2020, the water main along West Coast Road was extended to connect the formerly self-sufficient Kemp Lake Waterworks District to the Sooke/East Sooke Distribution System. At this most western extremity of the Sooke/East Sooke Distribution system, the CRD now supplies bulk water to the Kemp Lake District. The CRD infrastructure ends with a meter station on West Coast Road before a Kemp Lake District-owned and operated pump station supplies their distribution system.

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 (1,533,850 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 2021, 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 transmission system 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 2021, 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 transmission system 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 2021 and is, therefore, not included in this report.

2.4.5 Oak Bay Distribution System – District of Oak Bay

In 2021, 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 and the CRD transmission system infrastructure has limited provisions for 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 2021, 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, 769 m^3 (170,000 gallon) reservoir located on Hartland Road in Saanich. This new one-cell steel tank reservoir was constructed in 2020 to replace the smaller old reservoir.

- Mt. Tolmie Reservoir (Saanich), a one-cell, 4,545 m^3 (1M 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 (3.7M 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 2021, 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 transmission system 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 2021, 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 and the CRD transmission system infrastructure has limited provisions for 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, 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 provincial as well as 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. This bylaw was reviewed and updated last in 2019.

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 to 5, 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**. This is a health-related limit and lists the maximum acceptable concentration (MAC) of a substance that is known or suspected to cause adverse effects on health. Thus, an exceedance of a MAC can be quite serious and requires immediate action by the water supplier.
2. **Aesthetic Objectives**. 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 aesthetic objectives (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 to 5.
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 to 5.
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 to 5.

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[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)

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 the CRD's water treatment goals.

The GVDWS, as an unfiltered surface water system, must 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. 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 nephelometric turbidity unit (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 2021, the Goldstream Supply System was not used at all. A Kapoor Tunnel inspection project, necessitating a switch to the Goldstream Supply System, was scheduled for early December but had to be cancelled due to adverse weather conditions that could have resulted in increased turbidity in the raw water supply. It is anticipated that the Kapoor Tunnel inspection project will be delayed until the fall of 2022 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 2021 compared to previous years. As has been typical for most years prior to 2021, the reservoir was at full capacity at the beginning of January and remained 100% full until the middle of April. With drier and warmer weather after that, the reservoir levels continuously receded throughout the summer and into the fall. The onset of an extreme heat wave at the end of June and through early July saw the reservoir levels dip below elevations seen in previous years. Only 2004, 2006 and 2009 saw lower summer water levels in Sooke Lake Reservoir post dam upgrade. Some productive rain events in September and October slowed and halted the reservoir level decrease until the lowest level was finally reached on October 15, with 64.8% of full capacity. Due to extreme rainfall in November (in particular on Nov 14 and 15) the reservoir experienced an unprecedented recharge and reached the full service level already on November 27, historically the earliest fill date since the dam upgrade in 2003.

Both extreme weather events in 2021, first the extreme summer heat wave and then the atmospheric river rainfall in November did not have any measurable adverse water quality impacts on Sooke Lake Reservoir. Effects such as lower water levels and higher water temperatures during and following the heat wave had no major consequences for the water supply to the GVDWS. While the extreme precipitation in November brought operational challenges through localized flooding and material/equipment supply chain disruptions in the region, the source water quality in Sooke Lake Reservoir was not measurably affected.

The Sooke Lake intake screen was replaced and recommissioned in early April 2021. Until that time, the intake remained unscreened for several months. Aside from requiring minor additional operational efforts, the system has performed well without the screen and no water quality issues arose from this.

5.3 Switch to Free Chlorine

At the end of 2020, the ammonia dosing system at the Goldstream Water Treatment Plant required repair work. The ammonia system was turned off at the end of December 2020 and the secondary disinfection was switched from chloramination to free chlorine. In early January 2021, as the entire GVDWS transitioned from chloramines to free chlorine, the residuals in many parts of the system recorded low residuals. To counter a potential loss of secondary disinfection, re-chlorination stations in Metchosin and North Saanich were activated to boost residuals in the far ends of the system. Simultaneously, the CRD issued a public advisory on January 13, in anticipation of chlorine-related customer complaints and concerns. In total, the CRD and the municipalities received about 30 customer calls, emails or social media messages, as a result of this event. On January 20, 2021, the ammonia system was reinstated and it took approximately one week for the system to transition back to chloramines. On February 17, 2021, the public advisory was removed. CRD staff gained valuable information from this event on how the system reacts to such a sudden and prolonged discontinuation of the ammoniation process. It also gave CRD staff an understanding of the aesthetic water quality impacts but also effects on health-related parameters such as disinfection byproducts.

5.4 Chlorine Dosage

In 2021, CRD Integrated Water Services Department did make some minor adjustments to the chlorine dosage rate at both plants, based on daily or weekly monitoring results. The objective for the chlorine dosage has been to dose sufficiently for adequate primary and secondary disinfection, while minimizing the amount of chemicals added. Critical for proper primary disinfection is achieving the required CT (Concentration x Contact Time), which was consistently achieved in 2021 at both plants. Critical for adequate secondary disinfection is achieving a high ratio of Total Chlorine/Monochloramine. The new hypochlorite plant at the Goldstream Water Treatment Plant achieved consistently ratios of 90%. The Sooke River Road Water Treatment Plant generally achieved ratios of 85-95%.

5.5 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.

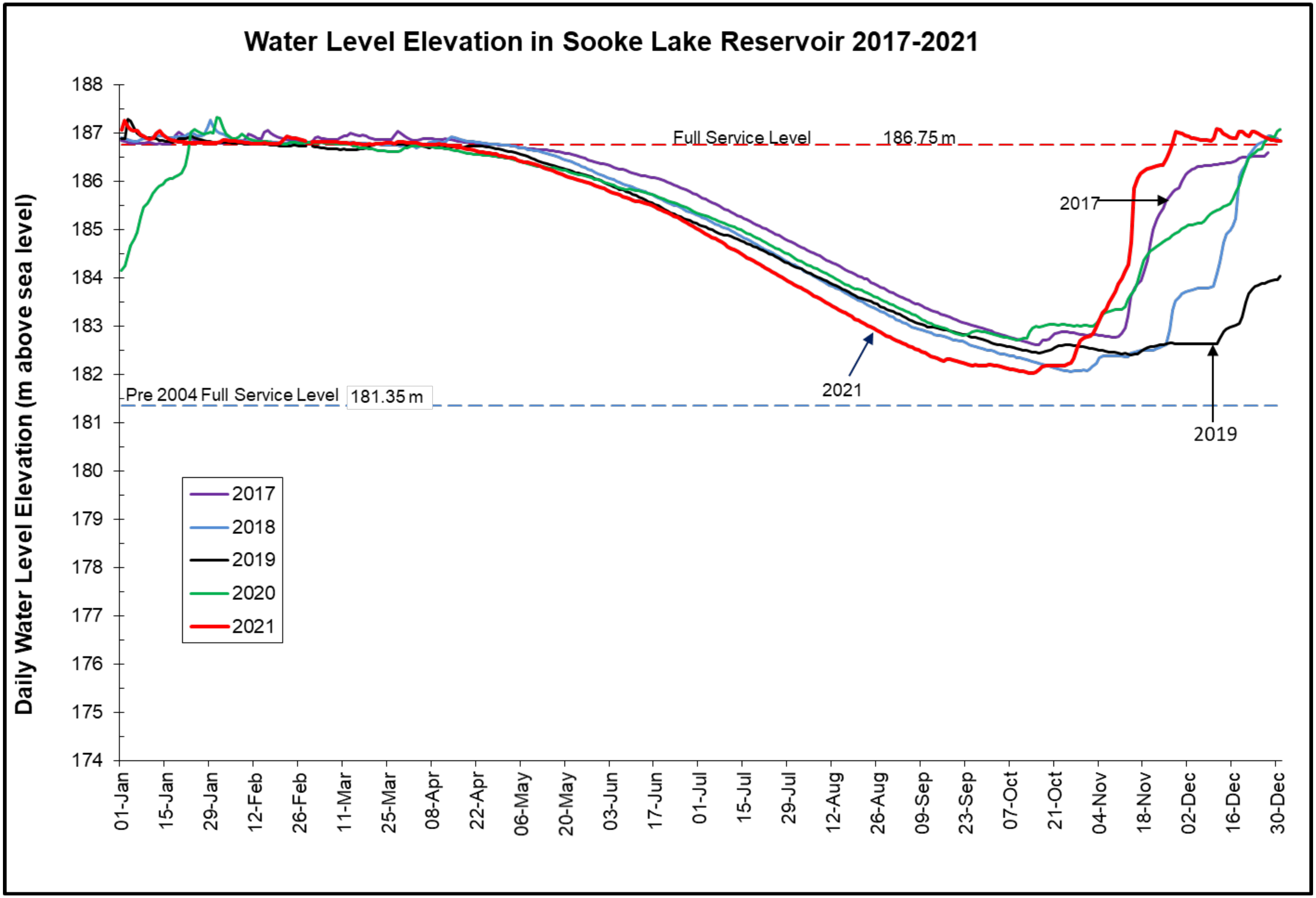

Figure 1 Water Level Elevation in Sooke Lake Reservoir, 2017-2021

6.0 WATER QUALITY MONITORING

The Water Quality Program, as delivered by the Water Quality Operations, the Cross Connection Control, and the Laboratory Services sections (all 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 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, periphyton communities in lakes and streams, to test for cyanotoxins and understand the source water limnology. The Cross Connection Control Section includes certified plumbing and cross connection control inspectors, as well as staff trained to process data in order to administer the requirements of the BC Building Code and the CRD Cross Connection Bylaw 3516.

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 two operating permits [for CRD water infrastructure in the Goldstream (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 treatment plants, treated water after leaving the plants 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 on-line turbidity meters (monitored via Supervisory Control and Data Acquisition) at each water treatment plant (at each plant: 2 analyzers in line to provide redundancy). 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 on 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 quarterly 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 occasionally collected from taps within individual houses or facilities, in response to inquiries from customers about the quality of water being received at their address.

- **Drinking Water Safety Plan:** In 2018, the CRD Water Quality Operations Section developed a Drinking Water Safety Plan, following the principle of a method developed by the Alberta Ministry of Environment for all drinking water systems in Alberta. This plan is a comprehensive water quality risk assessment and registry in the GVDWS. Identified risks have been documented and are being tracked as the CRD Integrated Water Services Department addresses them. At the end of 2021, the Drinking Water Safety Plan included 23 High Risks and 177 Moderate Risks to water quality (24 and 200 respectively in 2020) for comparison.

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 (see Figure 2). 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. The Leech watershed is currently sampled monthly in 4 different locations following a more comprehensive sampling/testing project in 2019/2020.

2. The **Treatment Plant Sampling Plan** includes the daily samples collected at the Goldstream Water Treatment Plant and the two first customer locations (for mains #4 and #5) and the weekly samples collected at the Sooke River Road Water Treatment Plant 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.

4. 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 Goldstream Service Area on 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.

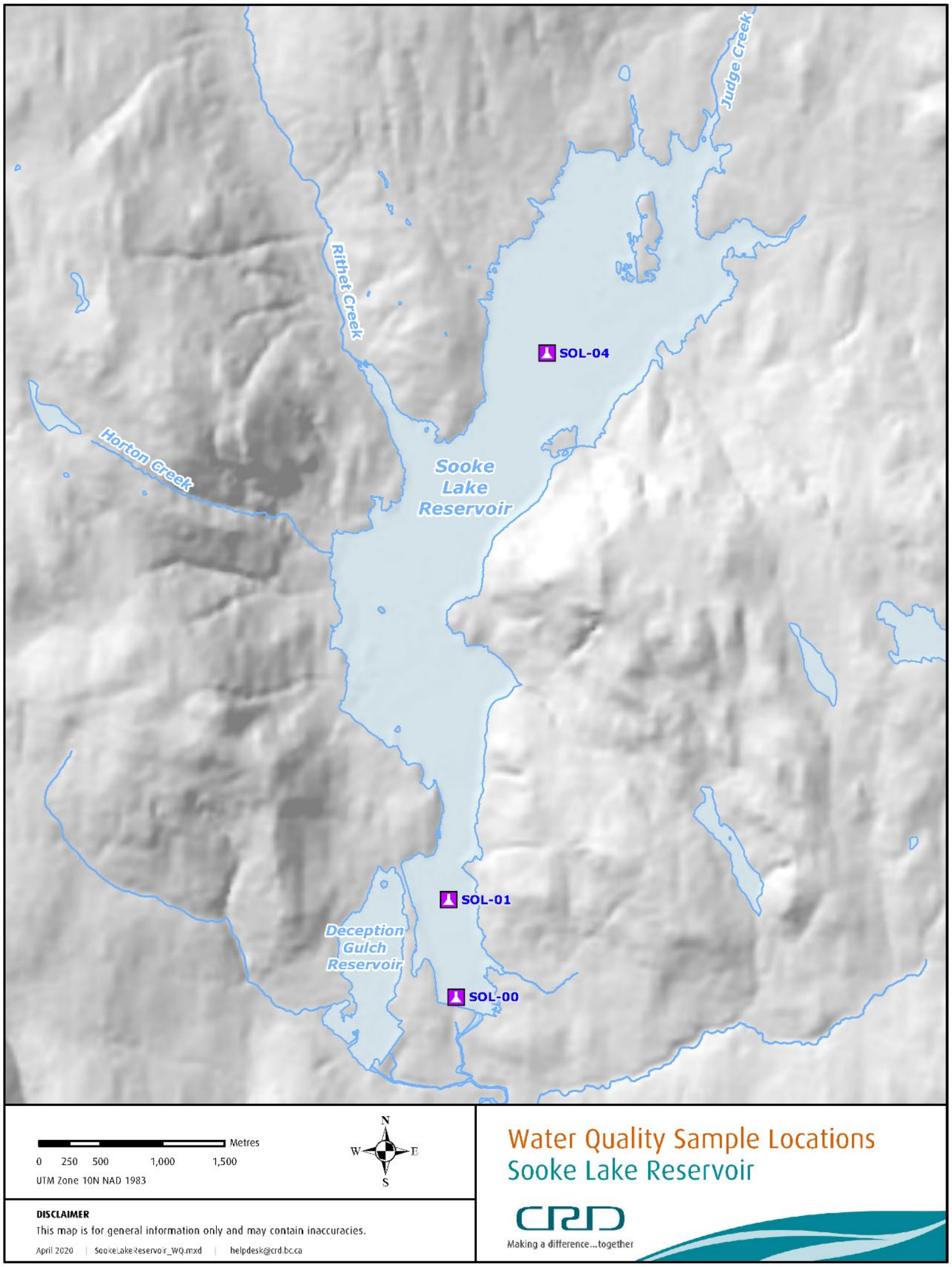

Figure 2 Sooke Lake Reservoir Water Sampling Stations

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 2021 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. The total coliform bacteria group is used as an indicator for treatment adequacy and microbial conditions in drinking water systems because of its superior survival characteristics.

Test Method. In 2021, 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 2021, *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 CFU per 100 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 2021, 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. However, the US EPA Surface Water Treatment Rule considers a 500 CFU/mL HPC7D as an indicator for a "detectable chlorine residual". Therefore, in the absence of a Canadian regulatory limit, the CRD Water Quality Monitoring Program uses the US EPA rule as a monitoring criteria to trigger site-specific operational measures for assessing and mitigating the drinking water quality.

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 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

The CRD Water Quality Laboratory received in 2017 the 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. The last reassessment of the CRD Water Quality Lab occurred in 2021.

7.0 WATER QUALITY RESULTS

The overview results of the 2021 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 (TC). 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 July and October when the Sooke Lake south basin was destratified and, therefore, fully mixed with warm water. Compared to previous years, Sooke Lake Reservoir experienced on average higher total coliform concentrations during the summer months. No seiche-related total coliform spikes were recorded in 2021 (Figure 3).

With 244 samples analyzed in 2021, the total coliform concentration ranged from 0-260 CFU/100 mL, with a median value of 8 CFU/100 mL (Appendix A, Table 1). The types of total coliforms present were not indicative of any particular type of contamination.

The United States Environmental Protection Agency (USEPA) *Surface Water Treatment Rule* for avoiding filtration has a non-critical total coliform criteria of maximum 100 CFU/100 mL at the 90th percentile of a six-month sample set. The 90th percentile of total coliform concentrations in the raw water between January and June 2021 was 11 CFU/100mL, and between July and December 2021, it was 150 CFU/100 mL. Therefore the source water was compliant with this non-critical USEPA filtration exemption criteria in the first half of 2021 but not in the second half. It is possible that the increased total coliform concentrations during the summer of 2021 were a result of the extreme heat wave and higher water temperatures.

***E. coli* Bacteria**. During three 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 2021, as in previous years, the low detection of *E. coli* bacteria indicated that the raw water entering the Goldstream Water Treatment Plant from Sooke Lake Reservoir was good quality source water and complied with the primary criteria in the USEPA *Surface Water Treatment Rule* to remain an unfiltered drinking water supply (Figure 4).

In 2021, about 7.4% of the 244 samples collected from the raw source water contained *E. coli* and those that were positive for *E. coli* had levels well below 20 CFU/100 mL. The concentration ranged from 0-7 CFU/100 mL, with a median value of 0 CFU/100 mL. The low occurrence, as well as the low concentrations of *E.coli* bacteria in Sooke Lake, are in line with long-term historical bacteria concentrations. These results do not indicate a particular source of *E.coli* bacteria, but rather point to low levels of naturally occurring fecal matter in a healthy and unproductive aquatic ecosystem. The few sporadic *E. coli* hits are typically the result of the rainfall and runoff into Sooke Lake, which transported organic matter accumulated in the watershed to the lake. The extreme rainfall and runoff during the atmospheric river on November 14/15, 2021 caused a stronger than normal *E.coli* signal in water samples collected during and immediately following this event (Figure 4). However, the *E.coli* concentrations registered during this extreme event were still well below the critical threshold and of no concern to the drinking water quality. 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 2021, the Goldstream System was not used as a drinking water source.

***Giardia and Cryptosporidium* Parasites**. In 2021, 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 Goldstream Water 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 2021, no *Giardia* cysts and no *Cryptosporidium* oocyst were detected in all samples on the raw water entering the Goldstream Water Treatment Plant. The 10-year median value for total *Giardia* cyst and total *Cryptosporidium* oocyst concentrations is 0/100L; however, historical data shows that occasionally very low concentrations of parasites can be found in the raw water from Sooke Lake. 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.

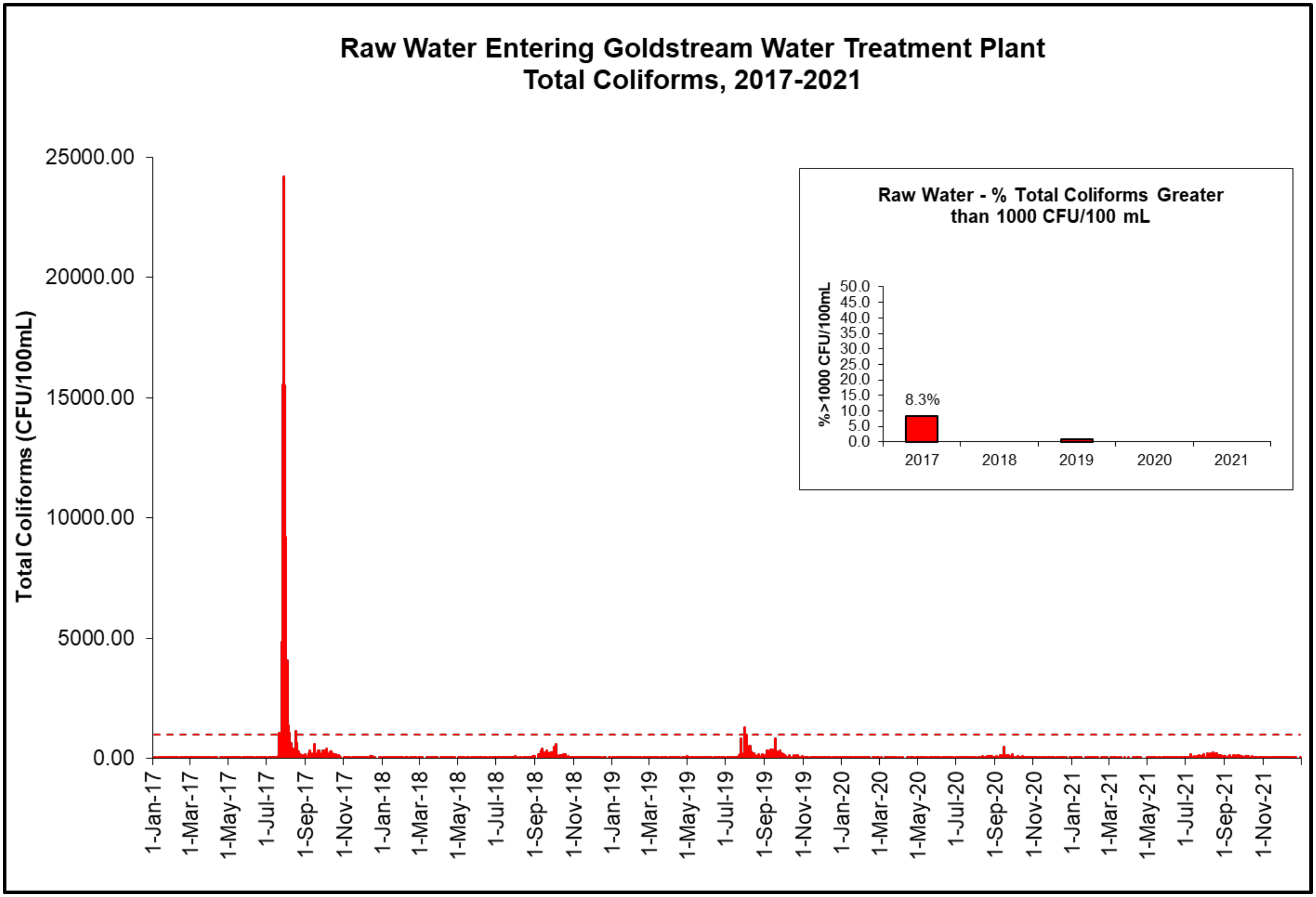

Figure 3 Raw Water Entering Goldstream Water Treatment Plant Total Coliforms 2017-2021

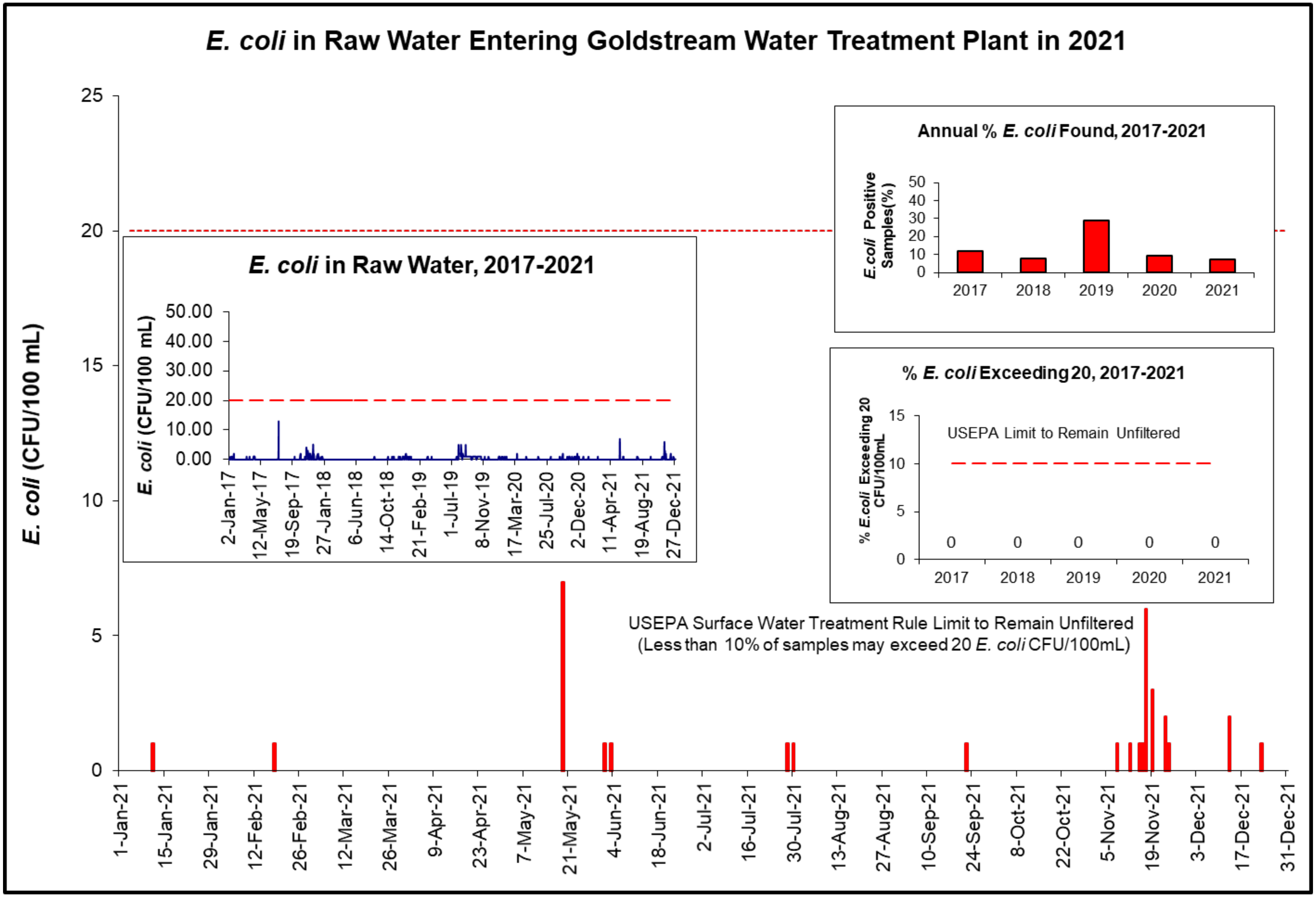

Figure 4 ***E.coli*** **in Raw Water Entering Goldstream Water Treatment Plant in 2021**

Algae – *Sooke Lake Reservoir (SOL)*. In 2021, the algal dynamics were generally in line with the long-term trend. During the spring and early summer, the algal counts were slightly above the average, with the typical spring peak occurring slightly earlier (Figures 5 to 7). Algae have a remarkable ability to quickly adapt to environmental factors such as temperature, nutrient availability and light intensity. The Greater Victoria region experienced favourable conditions for algae growth in the spring and summer of 2021 with warmer than usual temperatures, including the extreme heatwave at the end of June and early July. However, no actual bloom of a specific algae species occurred in Sooke Lake Reservoir in 2021, which demonstrates the robustness of an intact ecosystem with a healthy and diverse algae population.

In the spring and fall, abundant populations of small sized flagellates (~ 5 microns, possibly the green flagellates *Pedinomonas* spp.) were recorded. Due to their small size, they only contribute insignificantly to the total algal biomass in the reservoir and for consistency with historical data, they were excluded in the analysis and the presented composition graphs below.

During certain times of the year (typically August-November), cyanobacteria can comprise a significant portion of the algae spectrum (Figures 8 to 10). While this may seem like a major water quality risk, the risk of potential toxin production comes with blooms of certain cyanobacteria species and not with an overall abundance of a variety of species. For instance, in Sooke Lake Reservoir in 2021, the most abundant cyanobacteria species was a small size picocyanobacteria *Cyanodictyon* spp. (~2 microns), which has been described in previous annual reports. They are common in lacustrine environments and are not known to produce toxins. Other cyanobacteria species recorded in Sooke Lake are potential toxin producers when in bloom conditions, such as *Dolichospermum/Anabaena* spp., *Pseudanabaena* sp., *Planktothrix* sp. (or *Phormidium* sp.). However, the densities of these species were well below the critical threshold recommended by Health Canada (2017), i.e., 2000 cells/mL. For example, the maximum count of *Dolichospermum/Anabaena* spp. was 29.1 cells/mL reported on July 19, 2021, and the highest count for *Phormidium* sp. was 84.3 cells/mL on May 03, 2021. Based on those low specific concentrations, the water quality risk from cyanobacteria was low again in 2021.

There were no algae-related water quality concerns in 2021.

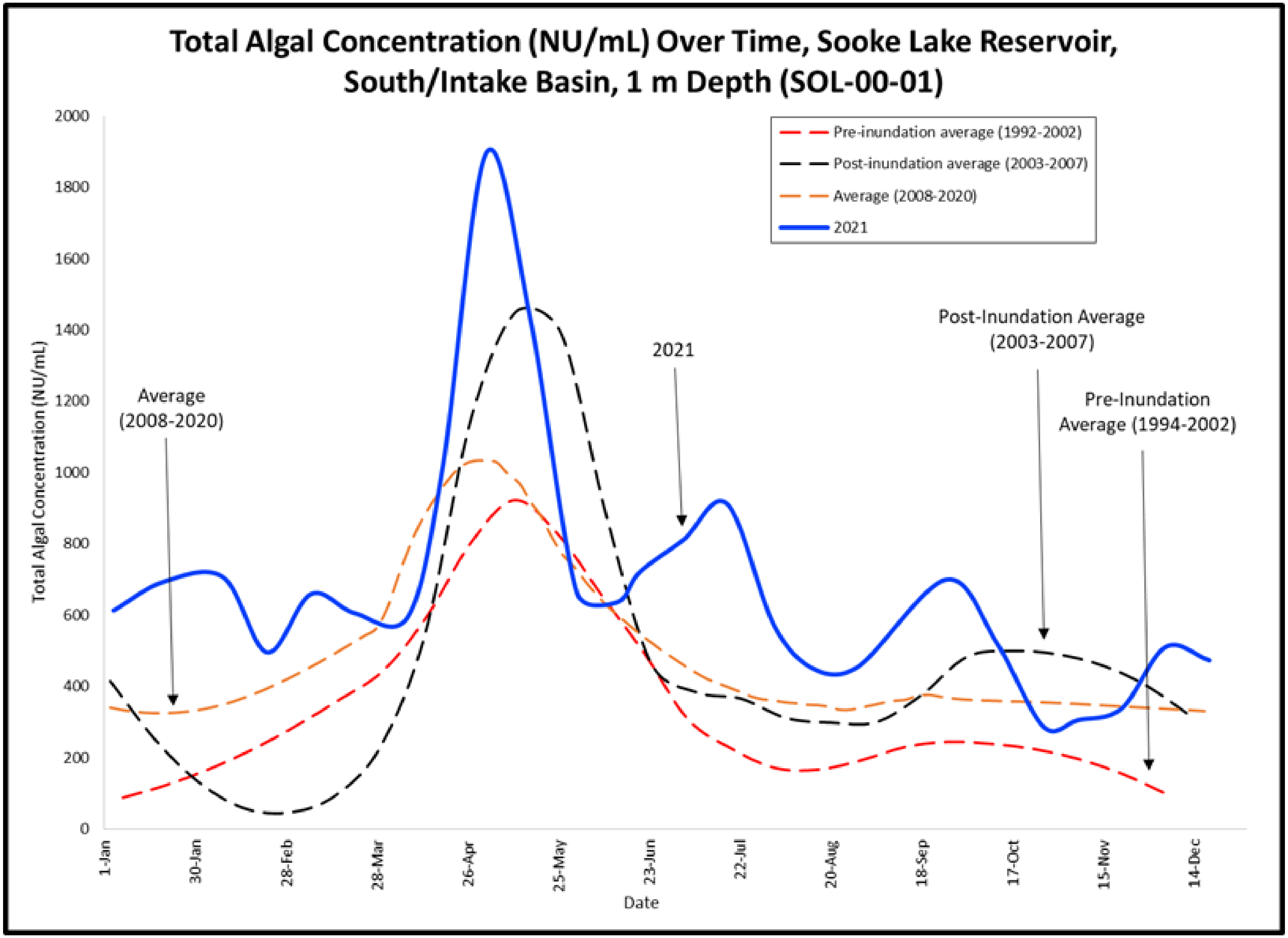

Figure 5 Total Algal Concentration (natural units/mL) Over Time, Sooke Lake Reservoir, South/Intake Basin, 1 m depth (SOL-00-01)

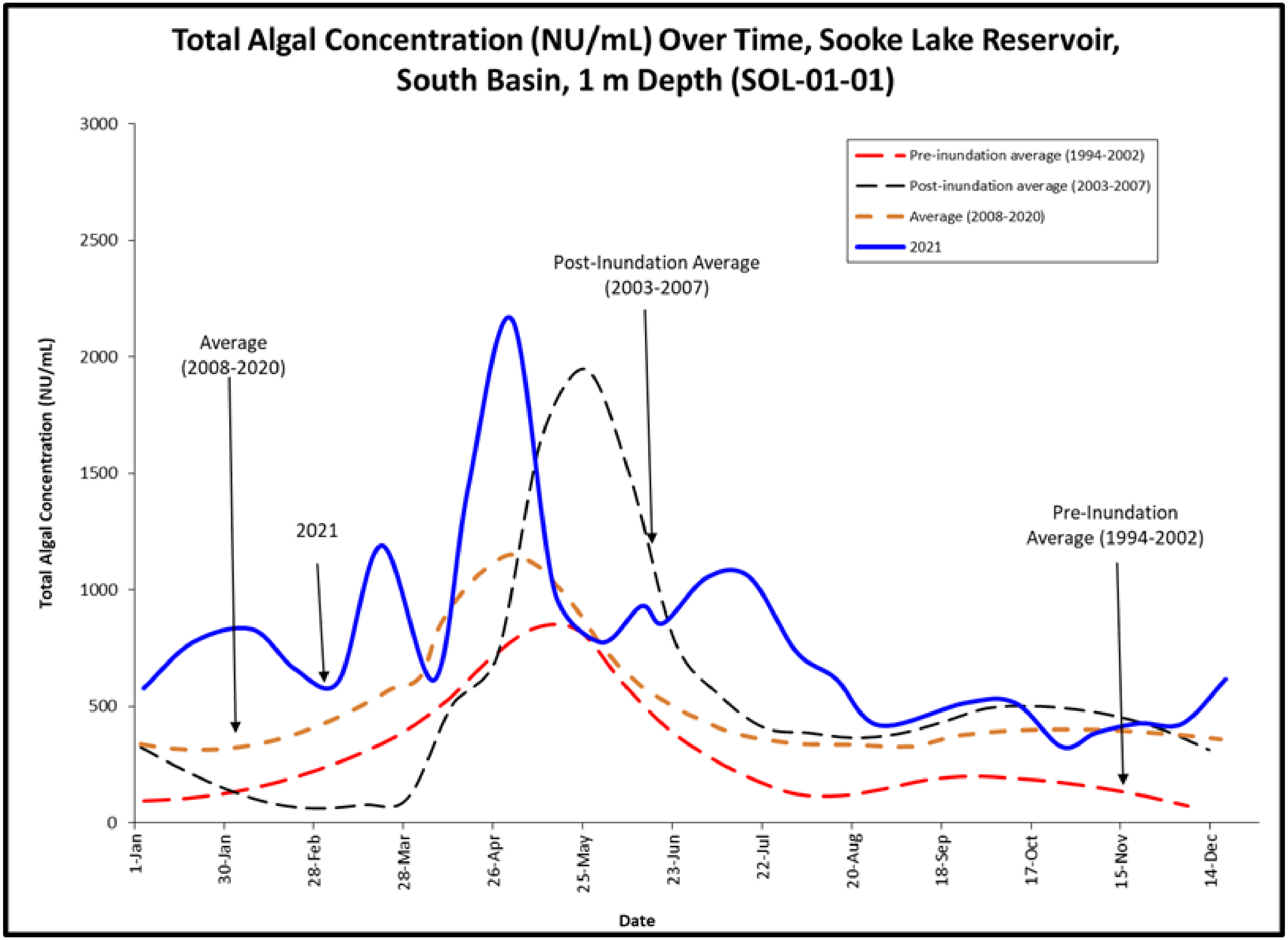

Figure 6 Total Algal Concentration (natural units/mL) Over Time, Sooke Lake Reservoir, South Basin, 1 m depth (SOL-01-01)

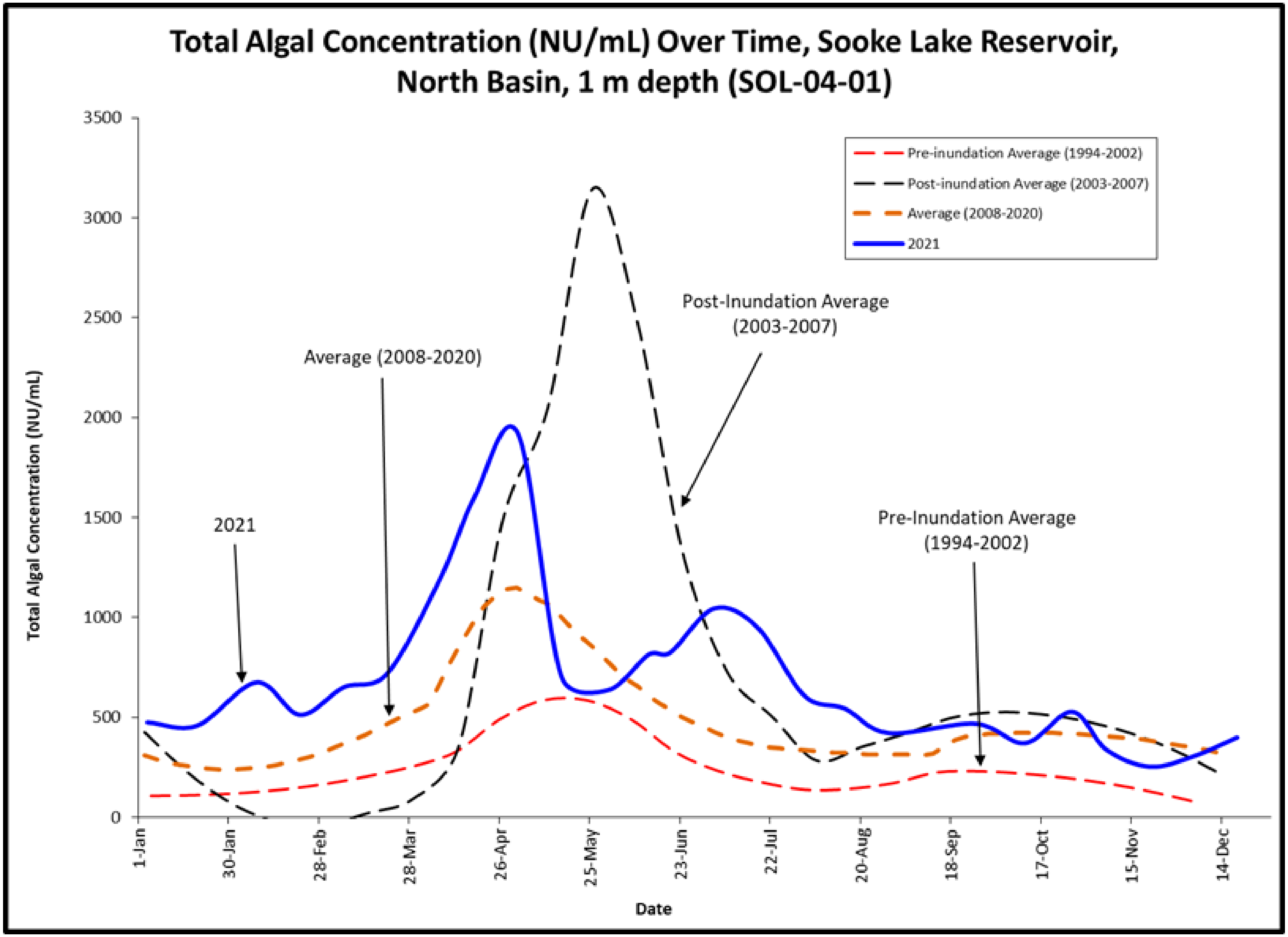

Figure 7 Total Algal Concentration (natural units/mL) Over Time, Sooke Lake Reservoir, North Basin, 1 m depth (SOL-04-01)

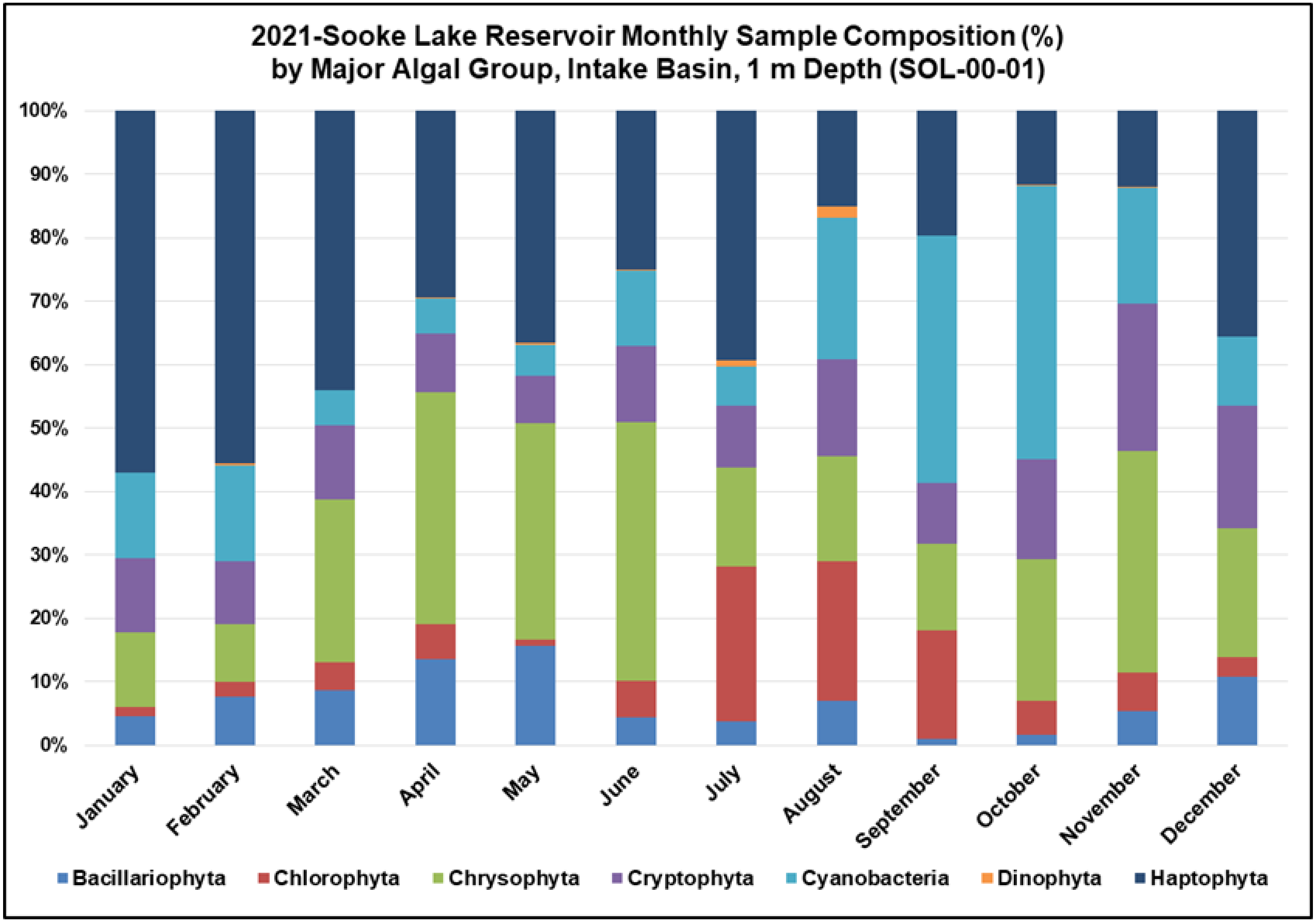

Figure 8 Monthly Abundance Percent of Different Algal Groups, Intake Basin, 1 m depth, SOL-00-01, 2021

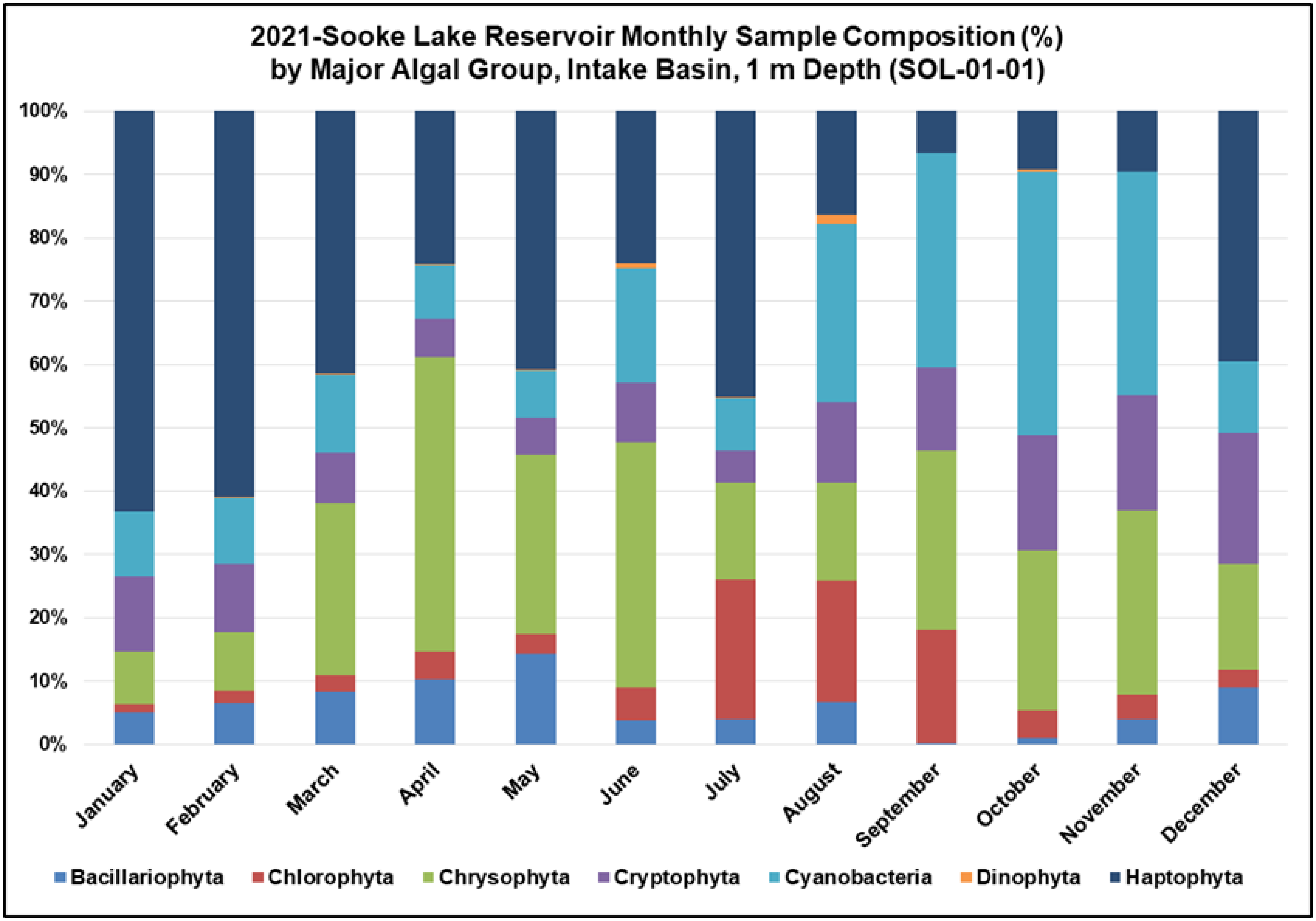

Figure 9 Monthly Abundance Percent of Different Algal Groups, South Basin, 1 m depth, SOL-01-01, 2021

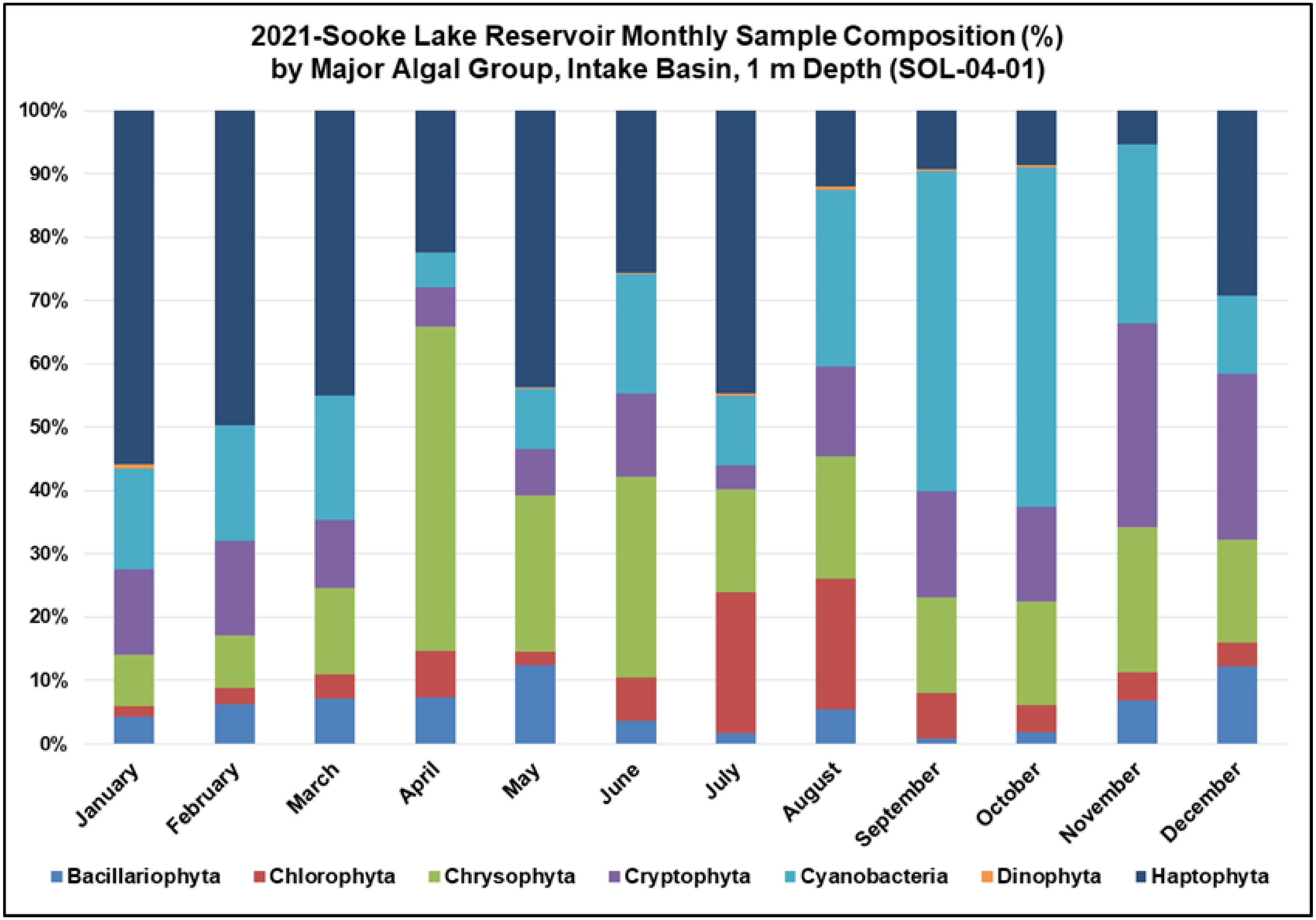

Figure 10 Monthly Abundance Percent of Different Algal Groups, North Basin, 1 m depth, SOL-04-01, 2021

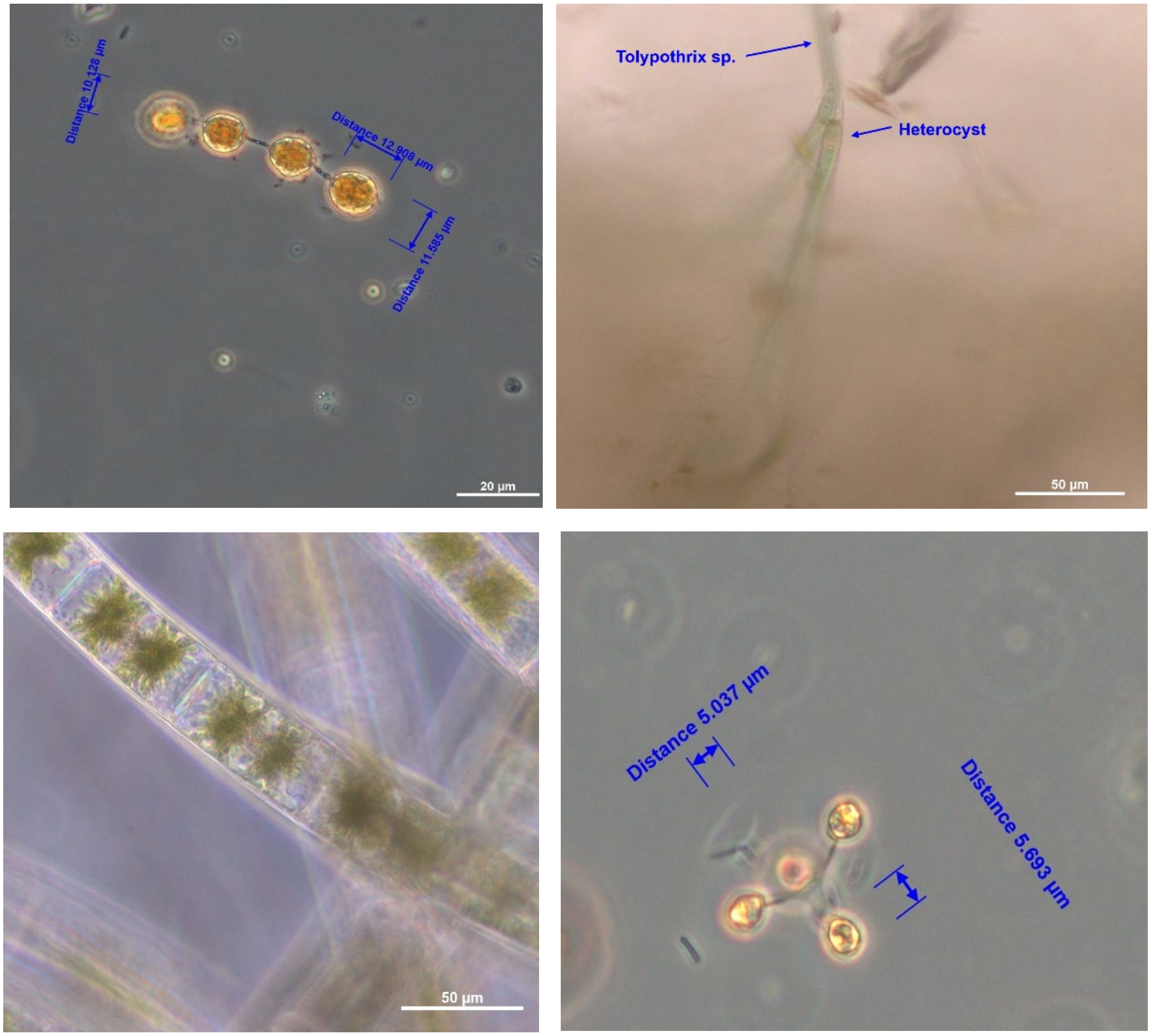

Figure 11 Some algae present in Sooke Lake Reservoir: Golden algae – *Chrysidiastrum* sp. (top left), Cyanobacteria – *Tolypothrix* sp. (top right), Green algae – *Zygnema* sp. (bottom left) and Green algae –*Dictyosphaerium* sp. (bottom right).

Algae – *Leech River Watershed*. Most current water quality monitoring programs for streams use periphyton as bioindicators rather than potamoplankton (phytoplankton in streams). Periphyton are algae that are attached to the stream substrates and constitute the most dominant form of algae in flowing water. Phytoplankton, which are the most prevailing algal forms in standing water, play an insignificant role in streams. Between August 2019 and December 2020, CRD staff collected periphyton samples, as part of a multi-season baseline monitoring project in the Leech River watershed. This project was concluded in 2020 and the results have been presented in the previous annual report, as well as in a separate technical report completed in October 2021 (Leech River Watershed – Water Quality Analysis Report). While regular periphyton sampling in the Leech watershed has been discontinued, standard water quality parameters continue to be monitored at 4 river sampling locations (see Figure 12).

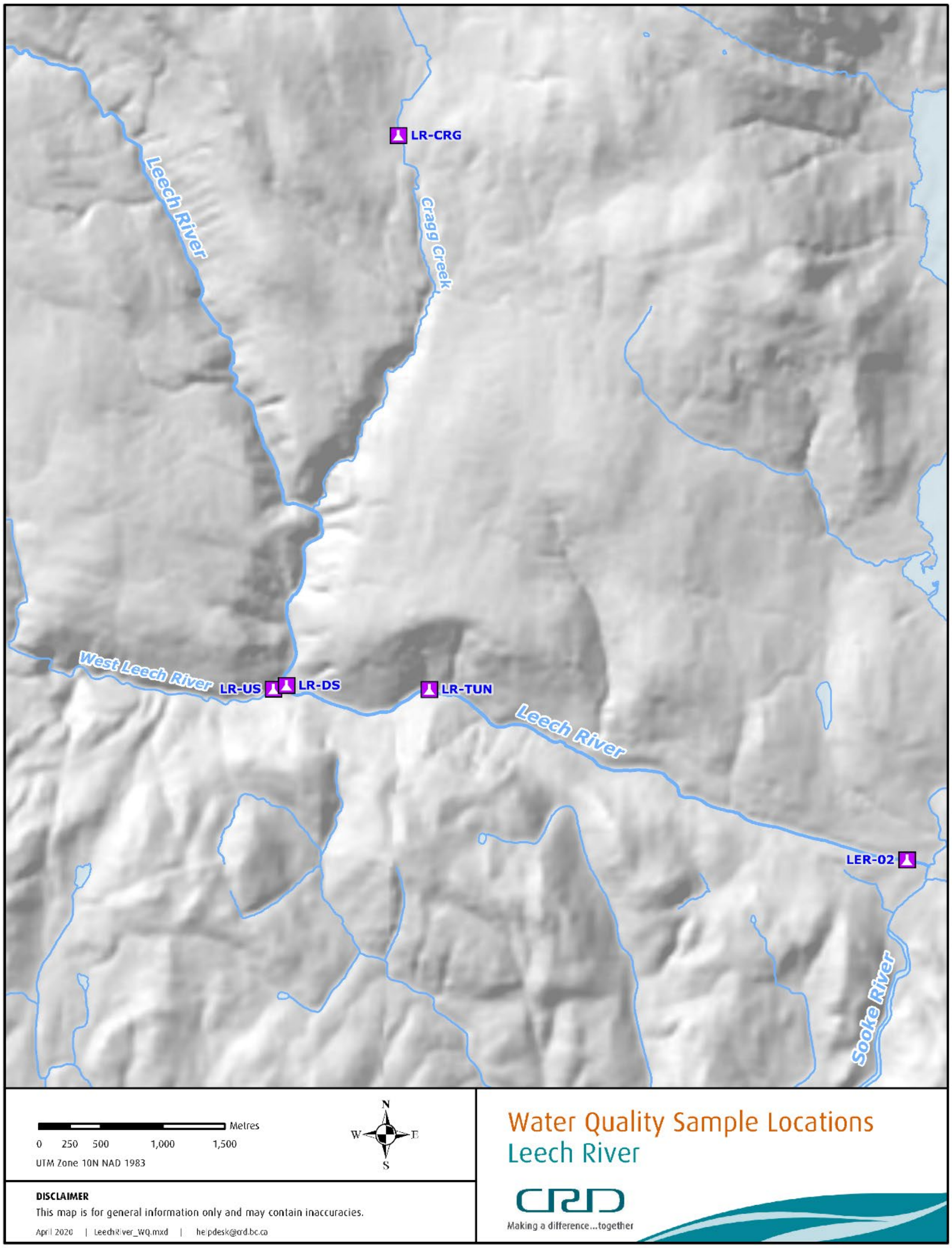

Figure 12 Leech River Water Sampling Stations

Zooplankton – *Sooke Lake Reservoir (SOL)*. Zooplankton play an important role as an intermediate trophic stage, ensuring the energy flow from primary producers to higher trophic levels, e.g., macroinvertebrates, fish and other aquatic animals in aquatic ecosystems. Previous studies have shown that fish in SOL predominantly rely on zooplankton for forage. Because of this important biological role, the CRD has included a regular zooplankton analysis to its source water monitoring program. Zooplanktonic species themselves can be herbivores, carnivores or omnivores. Studies have shown that any change of zooplankton species composition or densities or both could influence not only the trophic structure, but also physiochemical parameters in the ecosystems. There are three main zooplankton groups, e.g., Protozoa, Rotifera and Crustacea (Copepoda and Cladocera). In the ecosystems, phytoplankton are considered as a main food source for zooplankton and, therefore, phytoplankton dynamics can significantly reflect the changes of zooplankton and *vice versa*. The peak of zooplankton abundance normally occurs after the peak of phytoplankton. In general, zooplankton tend to have higher density during the spring-to-fall period than in winter.

In SOL, zooplankton mainly consist of Rotifera and Copepoda, although Cladocera taxa, such as *Daphnia* spp., can be occasionally recorded. In 2021, these three main zooplankton groups were recorded in SOL. Rotifera was the most dominant group. Abundances of Rotifera and Copepoda were consistent with the long-term trends. Cladocera zooplankton, on the other hand, was less common and only observed in some discrete samples, and was therefore excluded from the analysis.

As rotifers are considered as one of the main food sources for copepods, these two groups might show opposite abundance trends. Zooplankton dynamics in SOL are also regulated by other higher trophic organisms, such as macroinvertebrates and fish.

Zooplankton trends in Sooke Lake Reservoir are typical of ecological succession models. 2021 zooplankton activity was consistent with long-term trends (Figures 13 to 18).

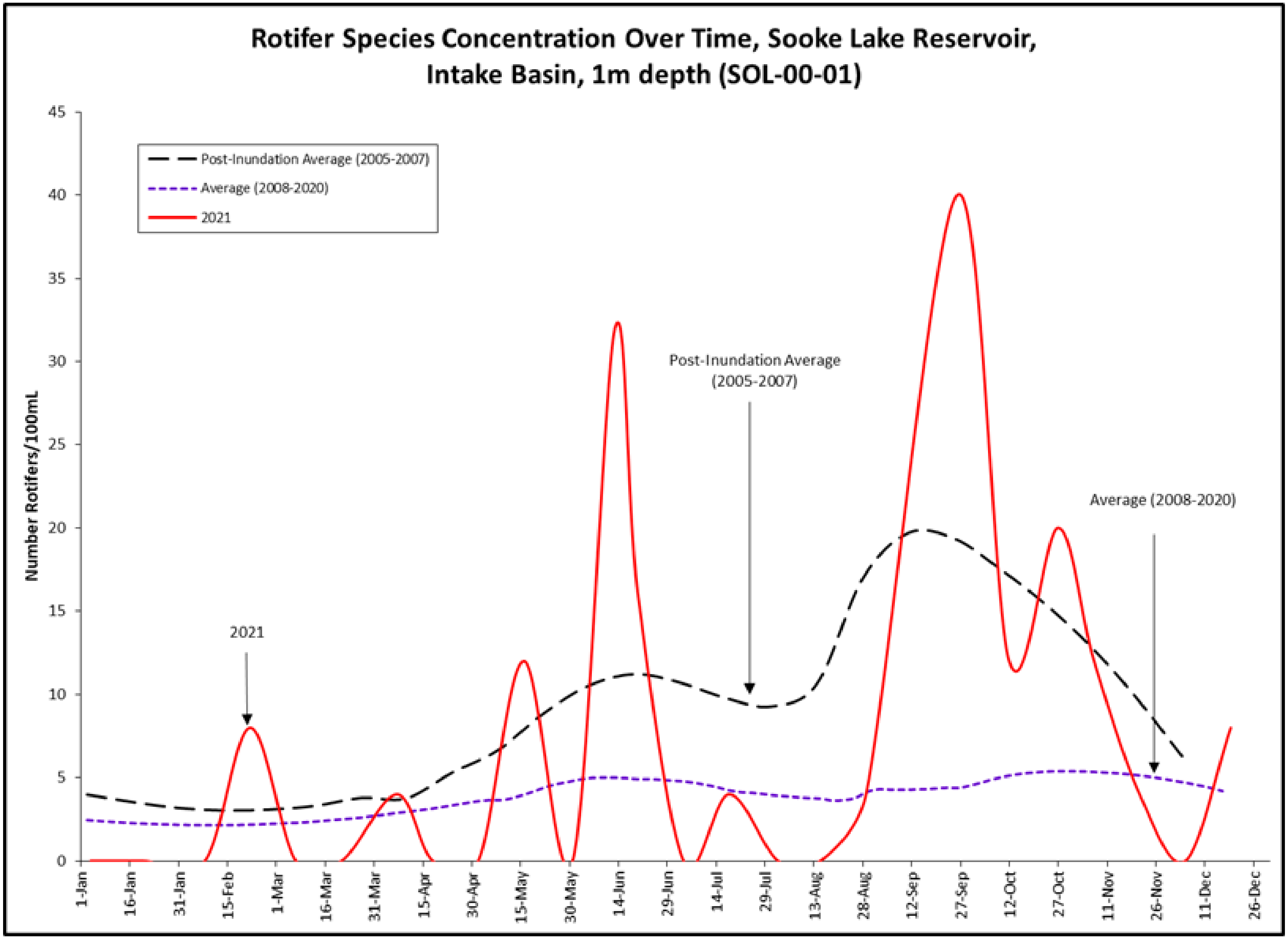

Figure 13 The Total Number of Rotifers Over Time, Sooke Lake Reservoir, Intake Basin, 1 m depth (SOL-00-01)

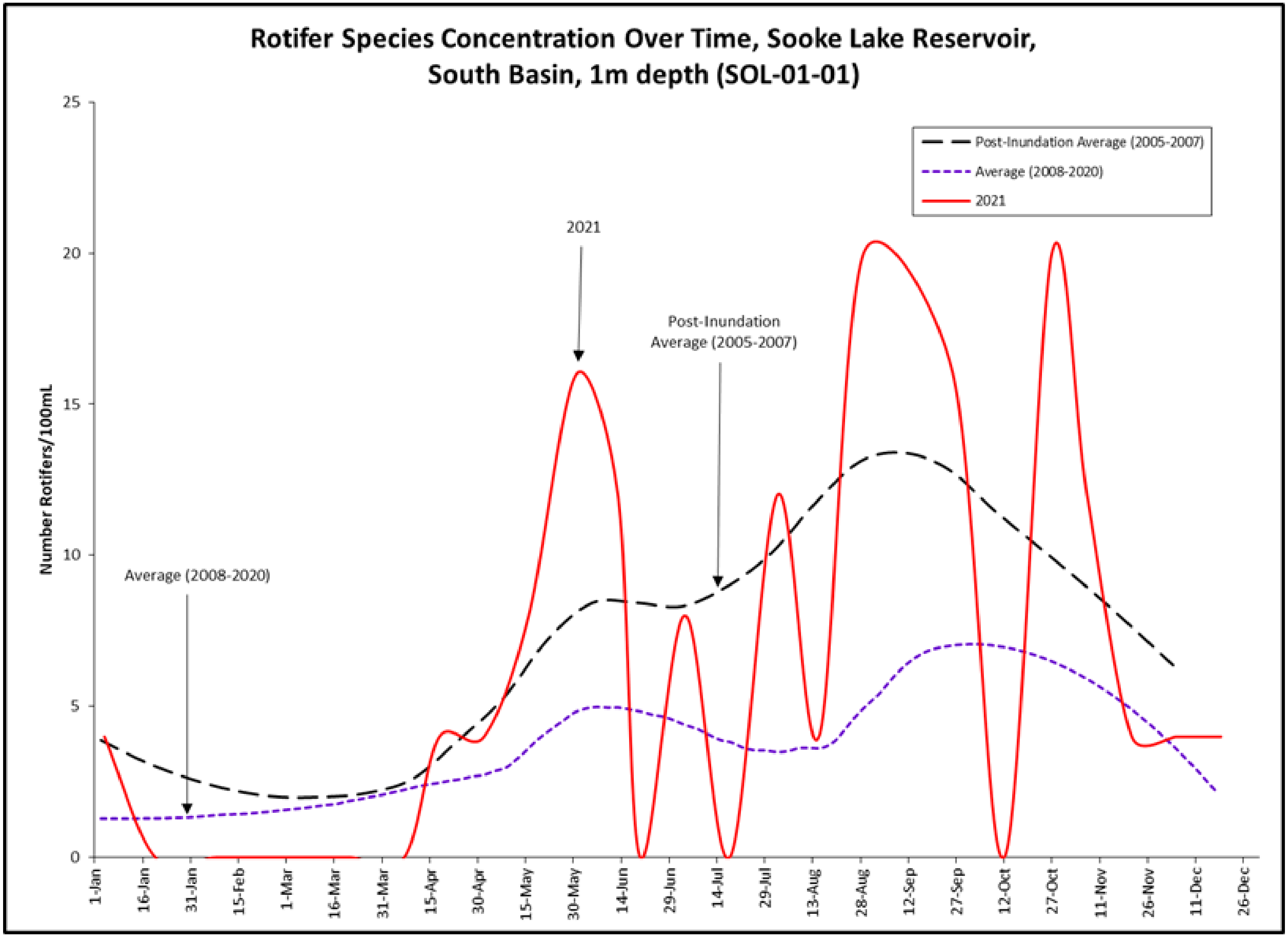

Figure 14 The Total Number of Rotifers Over Time, Sooke Lake Reservoir, South Basin, 1 m depth (SOL-01-01)

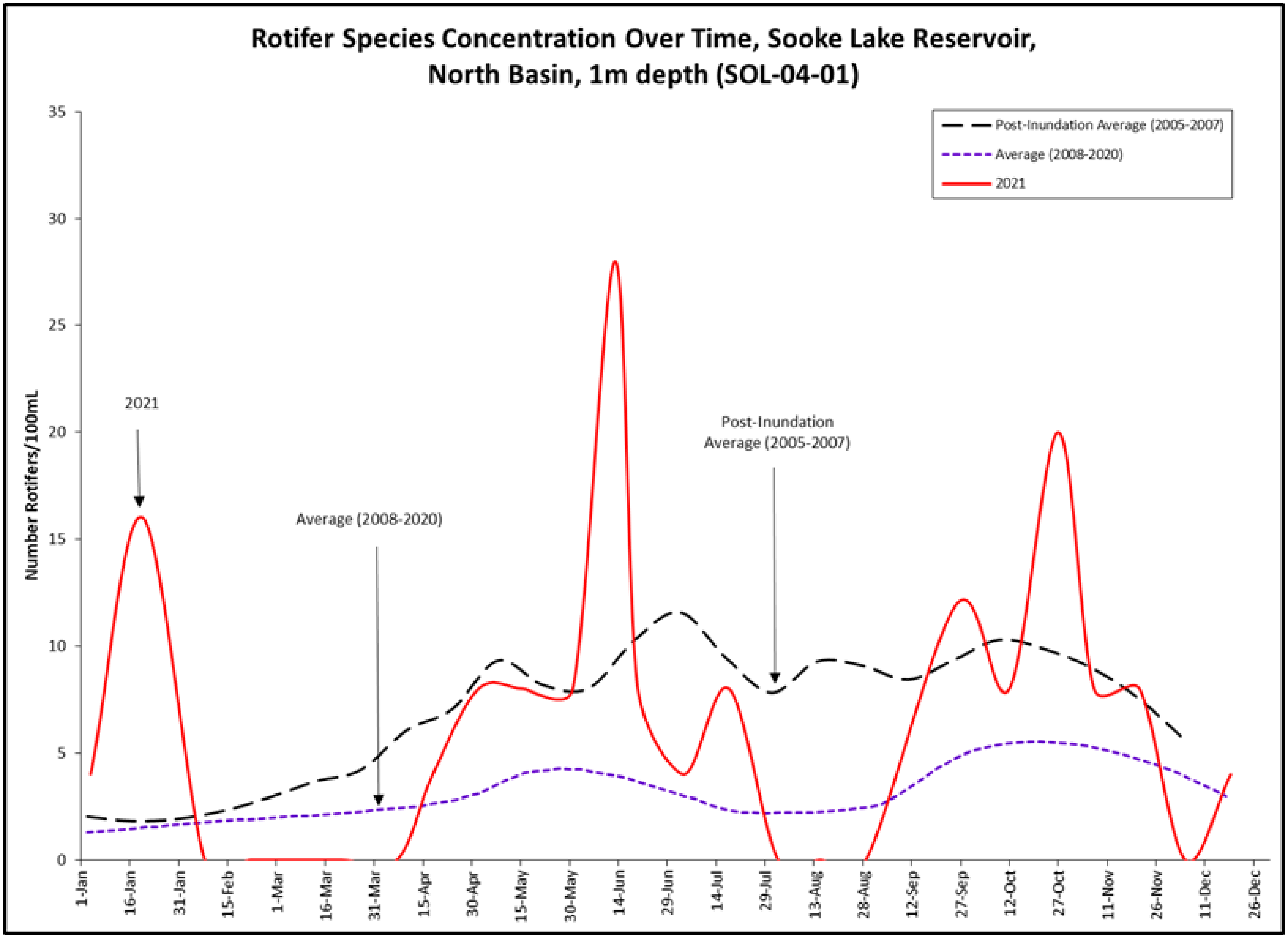

Figure 15 The Total Number of Rotifers Over Time, Sooke Lake Reservoir, North Basin, 1 m depth (SOL-04-01)

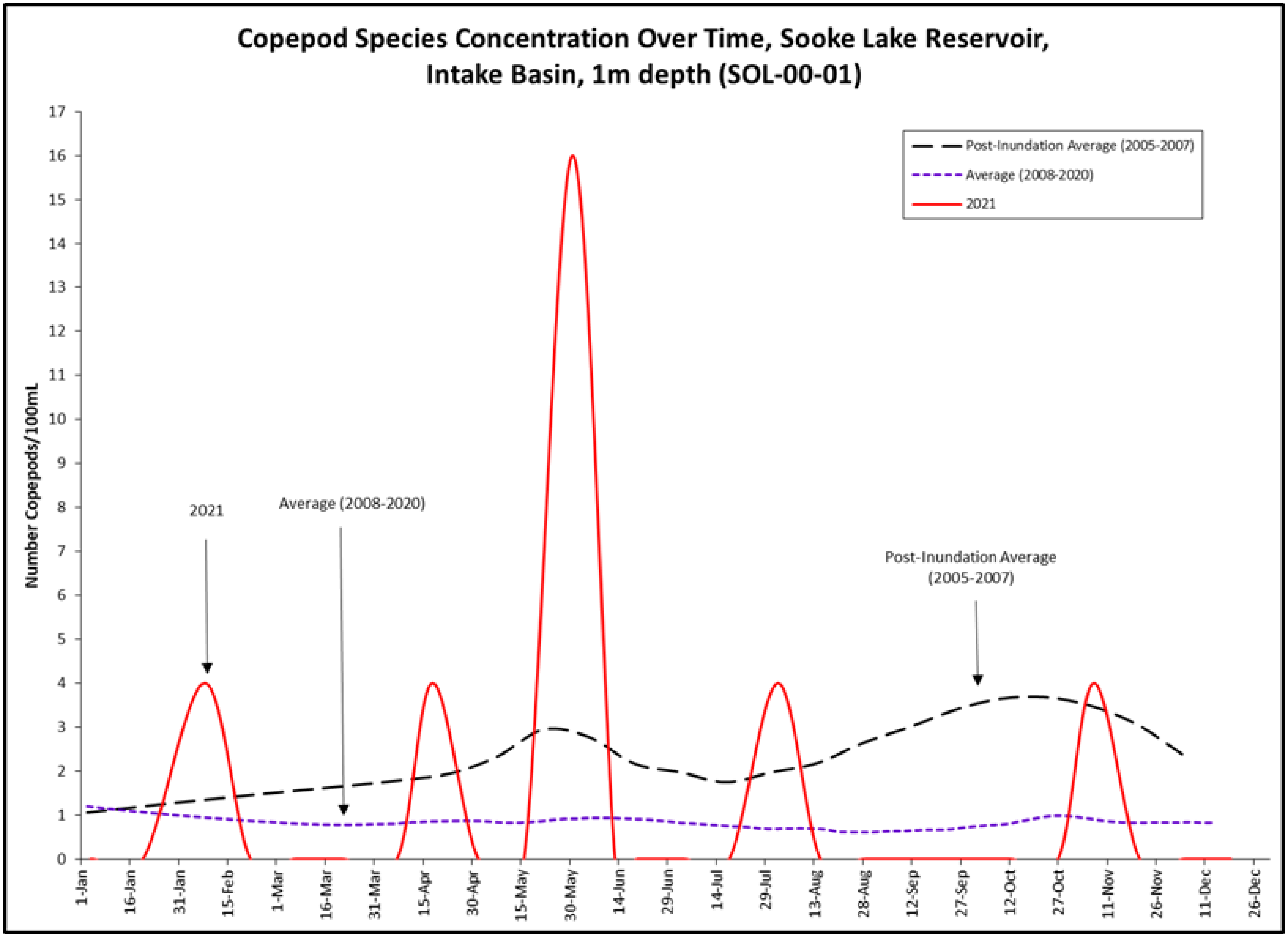

Figure 16 The Total Number of Copepods Over Time, Sooke Lake Reservoir, Intake Basin, 1 m depth (SOL-00-01)

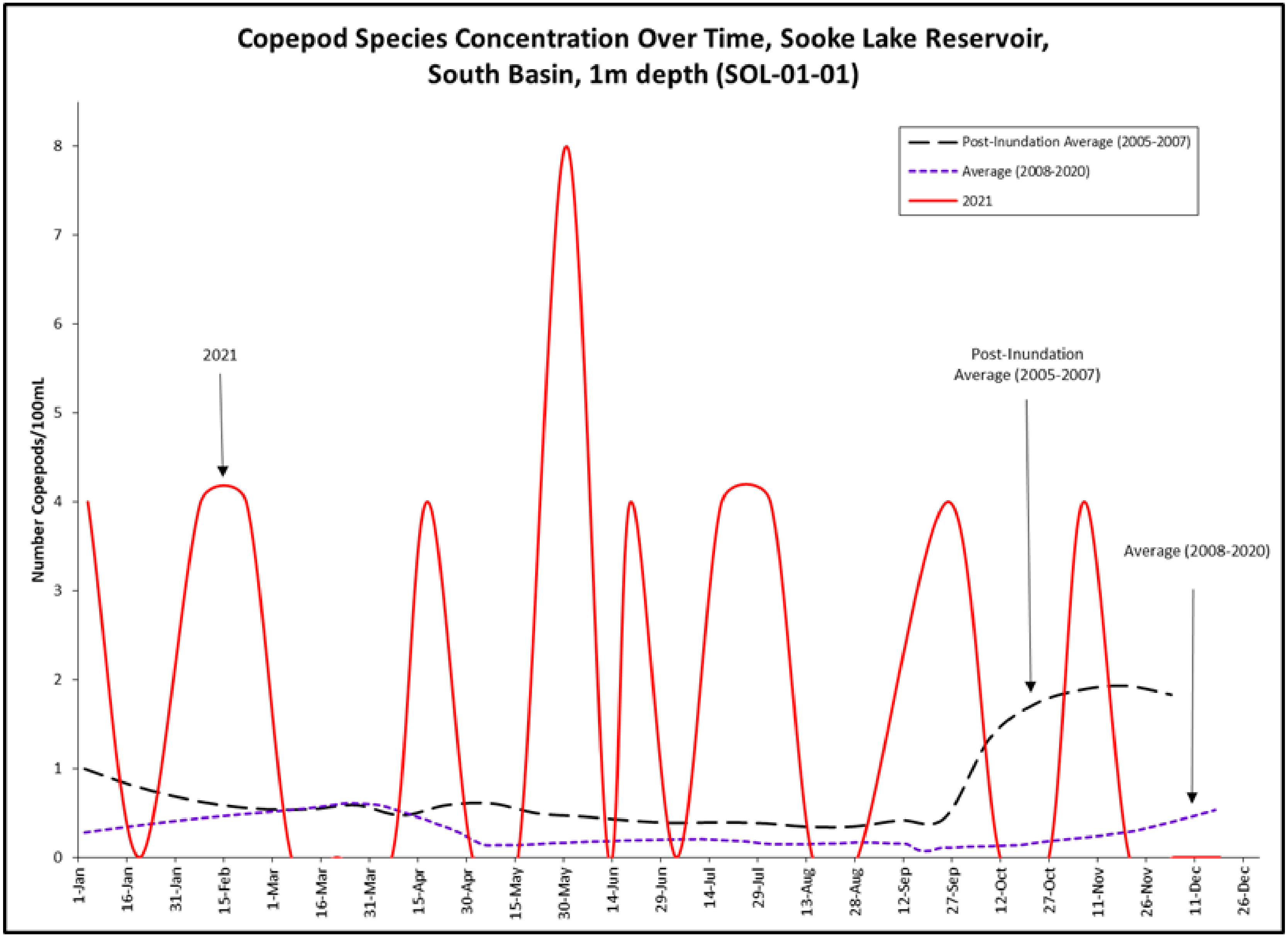

Figure 17 The Total Number of Copepods Over Time, Sooke Lake Reservoir, South Basin, 1 m depth (SOL-01-01)

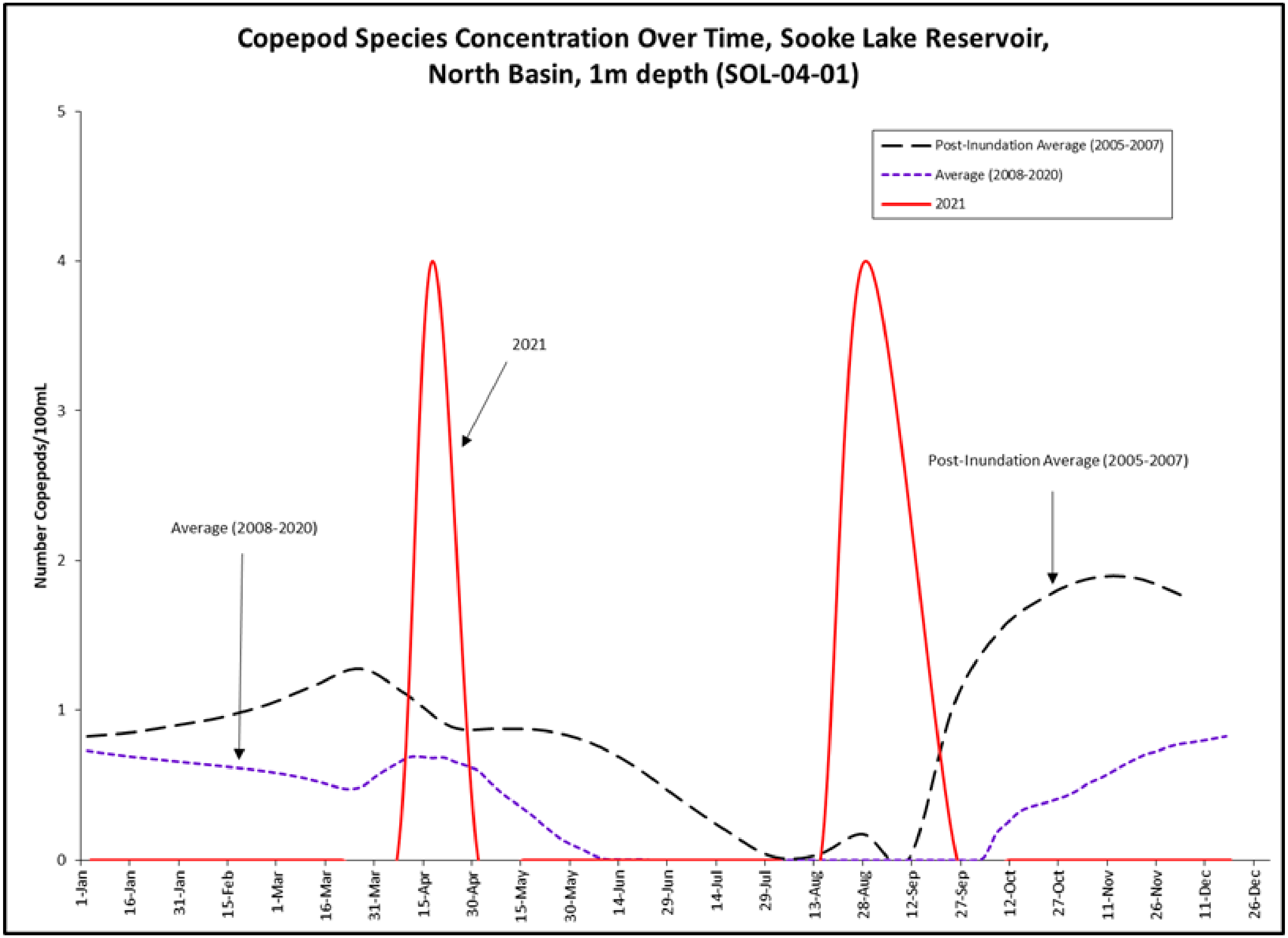

Figure 18 The Total Number of Copepods Over Time, Sooke Lake Reservoir, North Basin, 1 m depth (SOL-04-01)

Stratification: The 2021 thermal stratification pattern in Sooke Lake Reservoir was consistent with historical trends, as stratification occurred during spring, summer and early fall months. This phenomenon happens when the water column is divided in three layers from top to bottom, including: *epilimnion* (atop, warm, circulating and fairly turbulent), *metalimnion* (characterized by a steep thermal gradient or rapid temperature change) and *hypolimnion* (bottom, denser and colder water with little temperature change). The stratification reflects the vertical heat distribution in the water column and, therefore, might have a significant association with the dynamics of plankton communities. In 2021, SOL started to stratify in mid-April. The South Basin remained stratified until late July when the hypolimnion was depleted due to the continuous deep water extraction. Compared to 2020, this hypolimnion depletion in the South Basin occurred about two weeks later which is somewhat surprising given the extreme heatwave during July of 2021. The deeper parts of the reservoir destratified naturally later in the fall – the exact timing was not captured in 2021 due to a malfunction of the CTD analyzer.

Turbidity. The turbidity is continuously measured at both water treatment plants and at the Sooke Lake intake tower, but also sampled and lab tested daily from the Goldstream Water Treatment Plant and weekly at the Sooke River Road Water Treatment Plant. Figure 19 shows that the source water turbidity was well under 1 NTU throughout 2021; however, on one day during the summer season, June 23, with peak demand and high flows due to outdoor water demand, sediments in the mains downstream of the Kapoor Tunnel were dislodged and caused short-period turbidity excursions to above 1 NTU (peak at 1.2 NTU). Similar events in the past have usually occurred on Wednesdays or Thursdays from 4 am to approximately 10 am or 11 am during the peak summer demand times, only at the Goldstream and not at the Sooke River Road Water Treatment Plant. Supervisory Control and Data Acquisition monitoring data shows that the average daily turbidity was still well below 1 NTU on this one turbidity event day in 2021. Also, the UV transmittance, a measure of how much ultraviolet light can pass through the water, was always around 90% during this event 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 Goldstream Water Treatment Plant (changed watering restrictions in the region, flushed raw water mains upstream of Goldstream plant in April) and these measures were successful in greatly reducing the number of turbidity exceedances, compared to summers before 2018. A refined raw water main flushing program in the spring of 2021 has now almost eliminated these nuisance events. A second turbidity excursion on January 18 (see Figure 19) was likely due to sampling error or sample contamination as both online turbidity analyzers at the Goldstream plant could not validate the analytical sample test results.

Overall, Sooke Lake water was very clear in 2021, and turbidity of the raw water was at no time a factor of concern to the drinking water quality in the GVDWS.

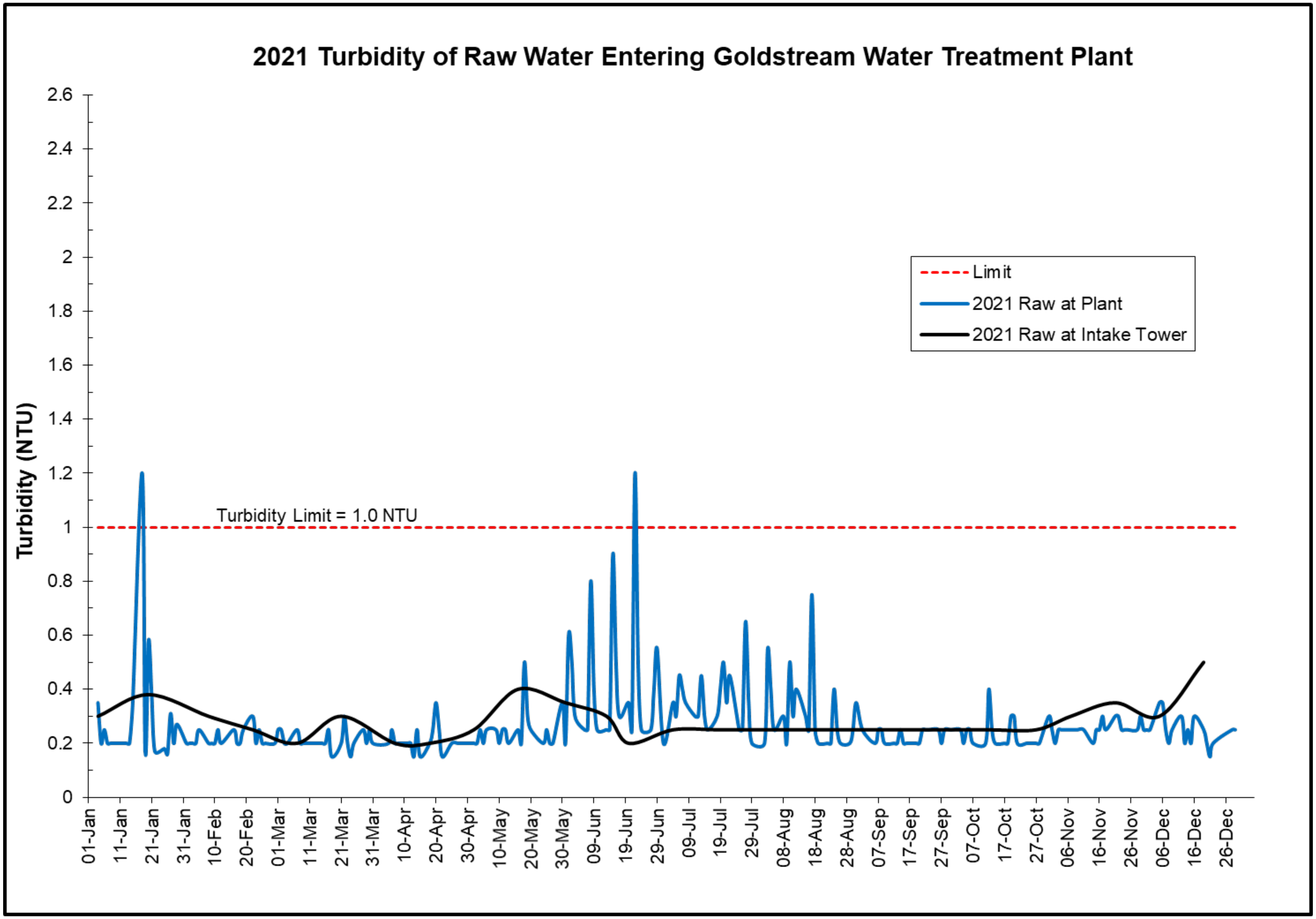

Figure 19 2021 Turbidity of Raw Water Entering Goldstream Water Treatment Plant

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 Goldstream Water Treatment Plant in 2021 was nearly following the long-term average trend line until the beginning of August. After that, for a period of six weeks, the temperature started to trend slightly above the long-term average (Figure 20). The raw water entering both treatment plants exceeded the 15°C guideline limit between mid-July and early October. Despite the extreme heatwave in late June and early July, the peak summer water temperatures were lower than in 2020 and the annual average water temperature was 0.2ºC lower than in 2020. The only noticeable effect of the early summer heatwave was a sharper rise of water temperatures in late July and reaching 19 ºC earlier than in previous years. The usage of the lowest intake gates during the summer 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 during summer are not a new problem for the CRD. Before the expansion of Sooke Lake Reservoir in 2004, the water temperature entering the plant reached 15°C as early as mid-June. Warmer and longer summers, as a result of climate change, will likely exacerbate this problem in the future.

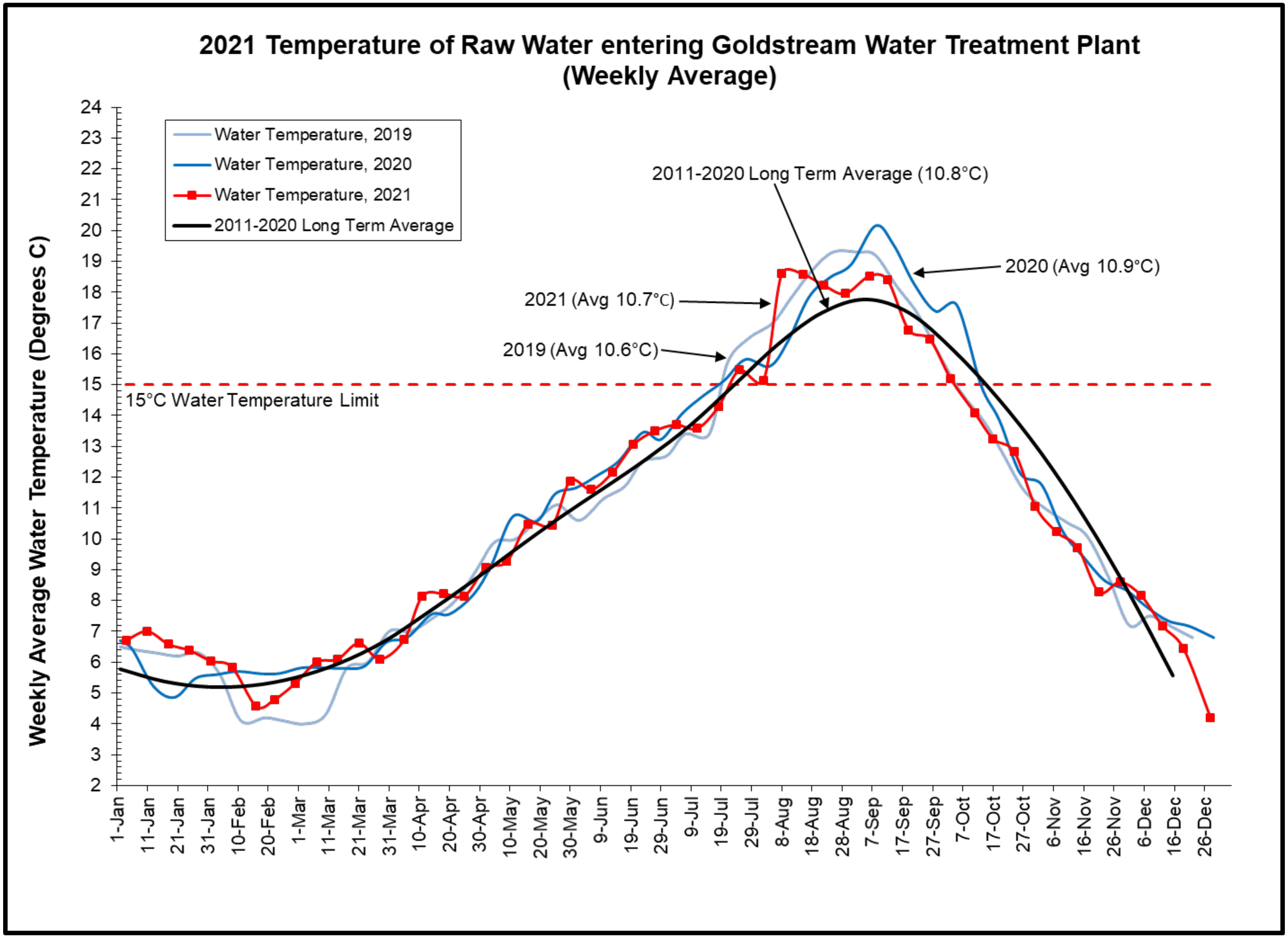

Figure 20 2021 Temperature of Raw Water Entering Goldstream Water Treatment Plant (Weekly Average)

Physical/Chemical Parameters. The raw water entering the Goldstream Water Treatment Plant had the following physical and chemical characteristics:

- Median pH: 7.3
- Median CaCO3 Hardness: 16.70 mg/L
- Median Alkalinity: 14.70 mg/L
- Median Colour: 6.0 TCU
- Median Total Organic Carbon: 1.75 mg/L
- Median Conductivity (25ºC): 41.10 µS/cm

The values of the parameters above are consistent with those of previous years.

Inorganics/Metals. Table 1 in Appendix A lists all the inorganic and metal parameters tested in the source water in 2021. 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 2021. Most of them were not detected or were in insignificant concentrations. These results confirm the high level of protection from any anthropogenic impacts on the supply watershed.

Nutrients. Figures 21 to 24 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 below the long-term average. In both lake basins, the total phosphorus concentration dropped at times to levels below the detection limit of 1µg/L, which indicates that biological activity in the lake used up all available phosphorus nutrients in the lake. The lack of phosphorus between April and the end of July limited the biological productivity during the summer which resulted in a favorably lower algal activity. Nitrogen concentrations have been slightly higher than the long term average trend. The majority of this nitrogen was present in the form of organic nitrogen and likely remained available for biological uptake due to the growth limitation dictated by the lack of phosphorus. This confirms previous conclusions that Sooke Lake Reservoir is extremely phosphorus limited.

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.

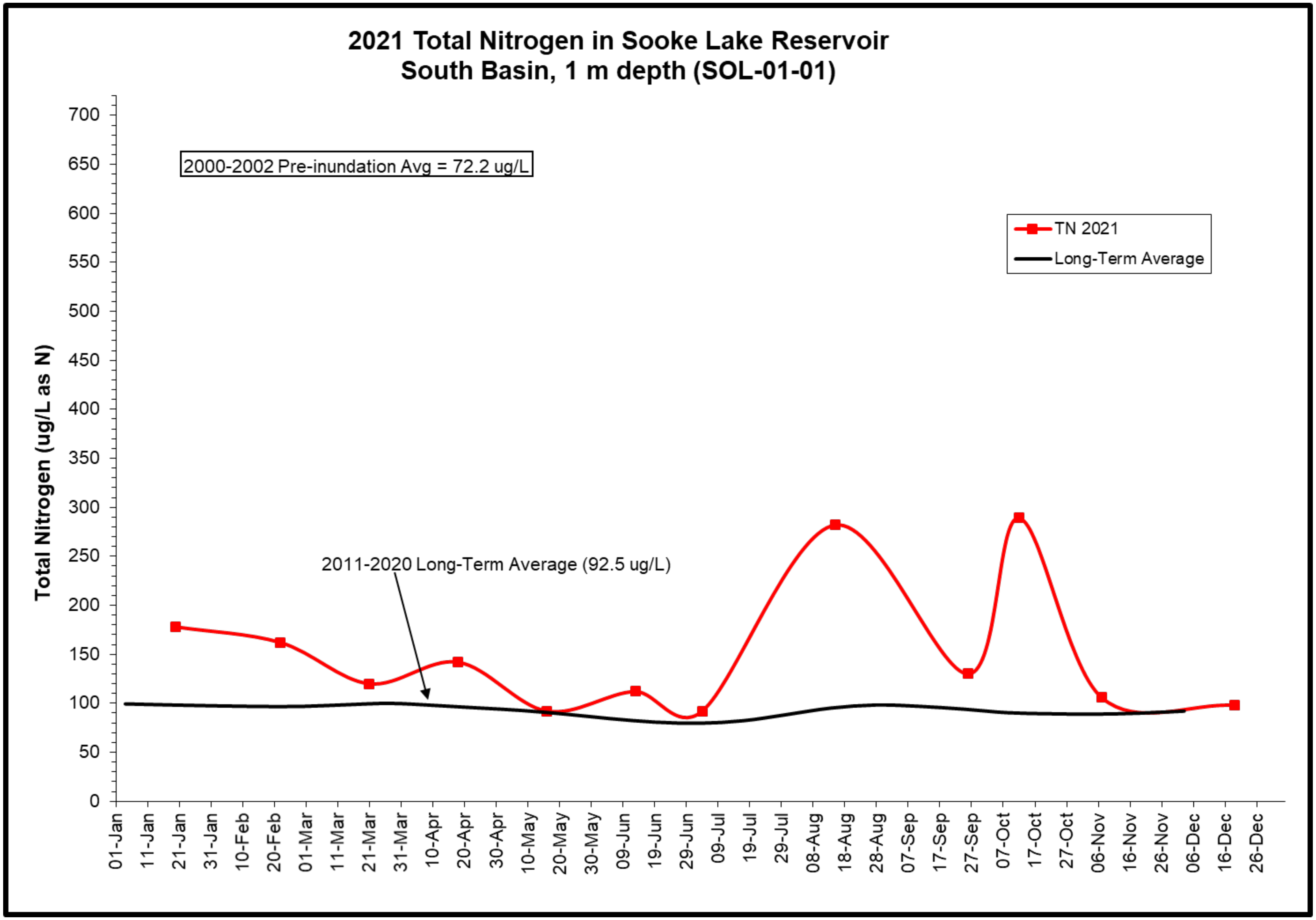

Figure 21 Total Nitrogen in Sooke Lake Reservoir, South Basin, 1 m depth (SOL-01-01)

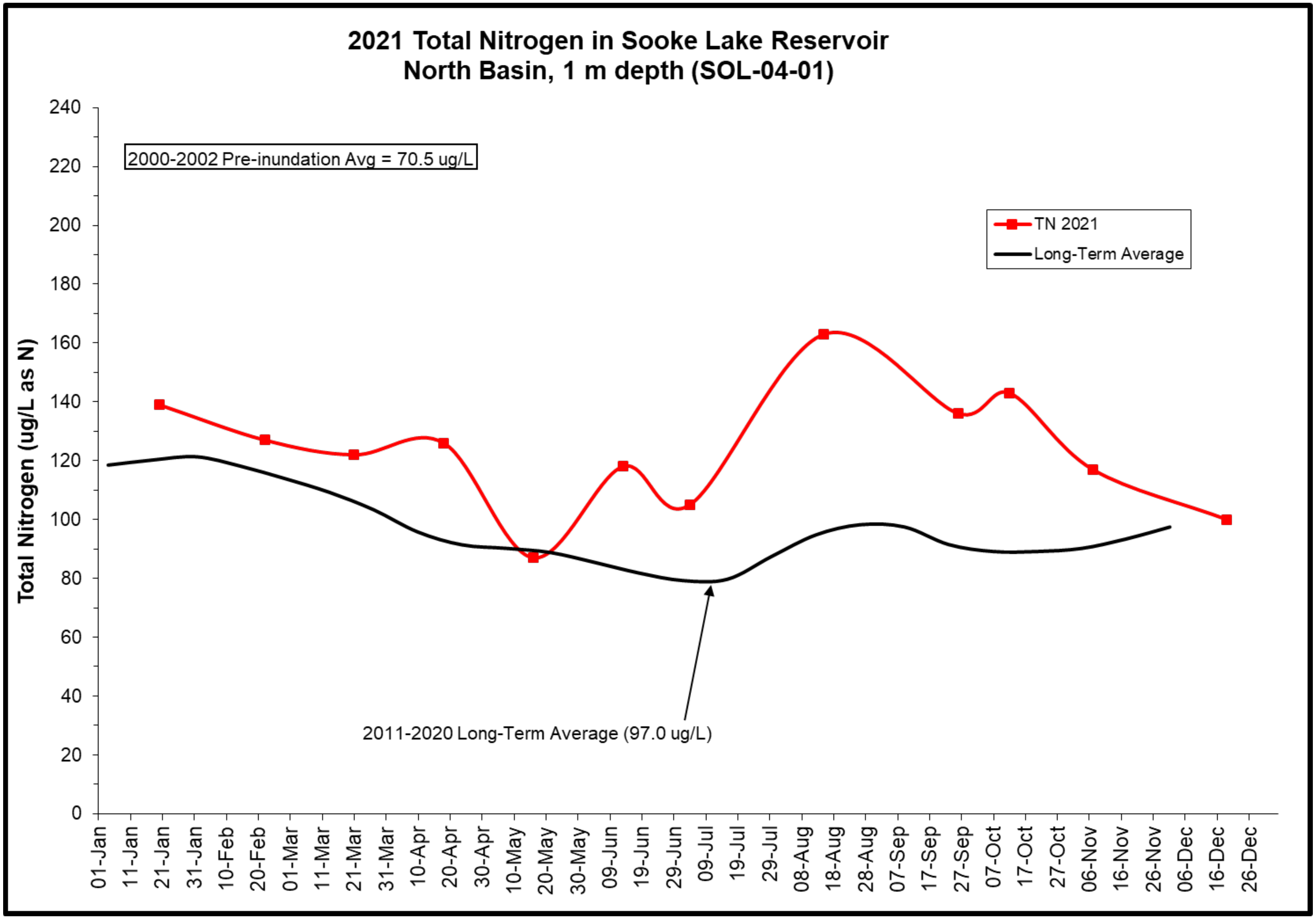

Figure 22 Total Nitrogen in Sooke Lake Reservoir, North Basin, 1 m depth (SOL-04-01)

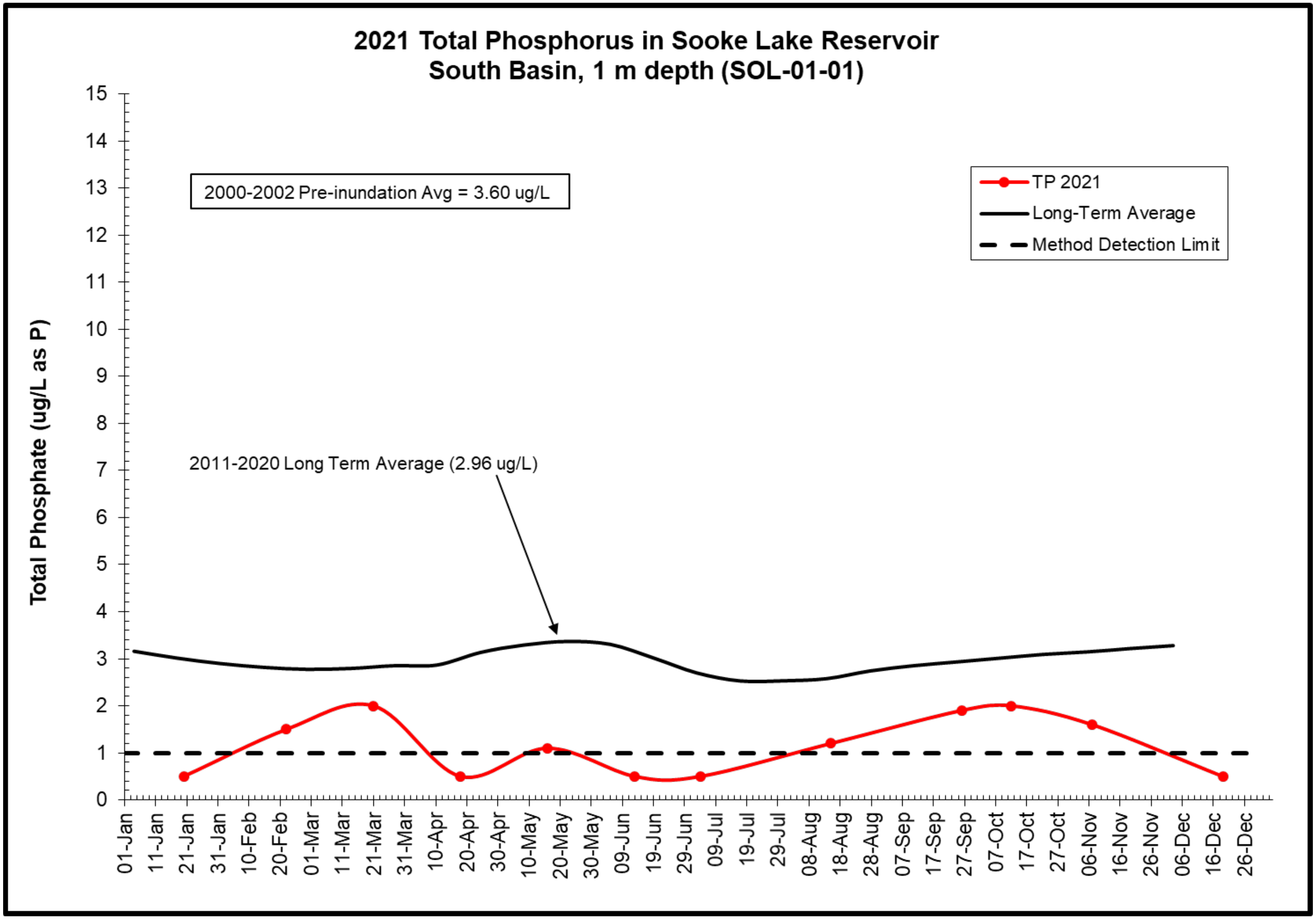

Figure 23 Total Phosphorus in Sooke Lake Reservoir, South Basin, 1 m depth (SOL-01-01)

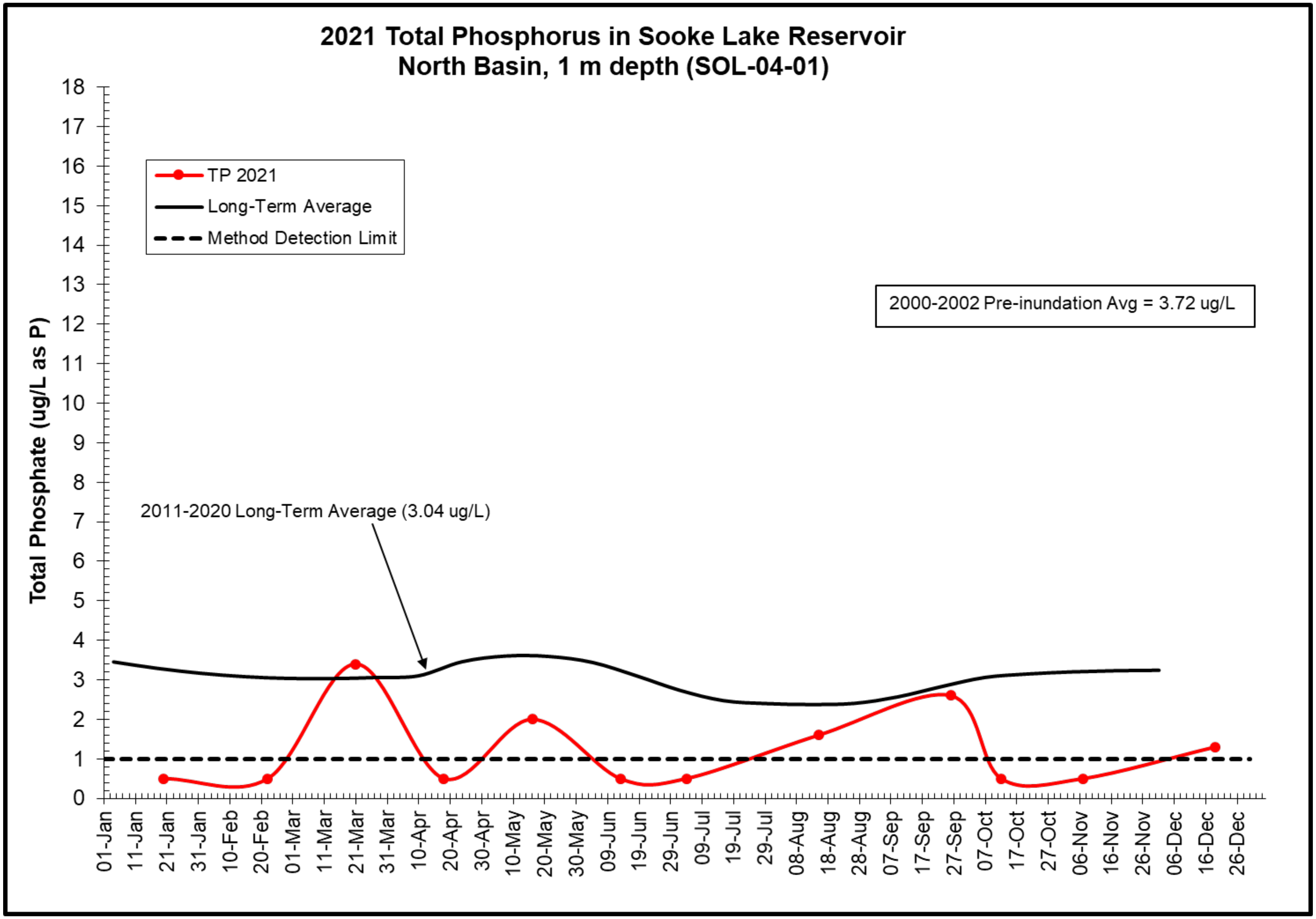

Figure 24 Total Phosphorus in Sooke Lake Reservoir, North Basin, 1 m depth (SOL-04-01)

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 Goldstream Water Treatment Plant

Bacteriological Results after UV Treatment. Figure 25 shows the results from 244 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 very few occasions, in all of 2021, and only in very low concentrations, have total coliform bacteria been found downstream of the UV treatment. Only on November 17 was the post UV total coliform concentrations unusually high at 33 CFU/100mL despite a moderately low raw water total coliform concentration of 43 CFU/100mL. There are no indications that the UV treatment was malfunctioning that day. The post chlorination total coliform concentration was zero that day, which confirmed that the treated water was safe for consumption. It does demonstrate the importance of the multi-barrier concept, however, which eliminates the reliance on only one module to achieve compliance.

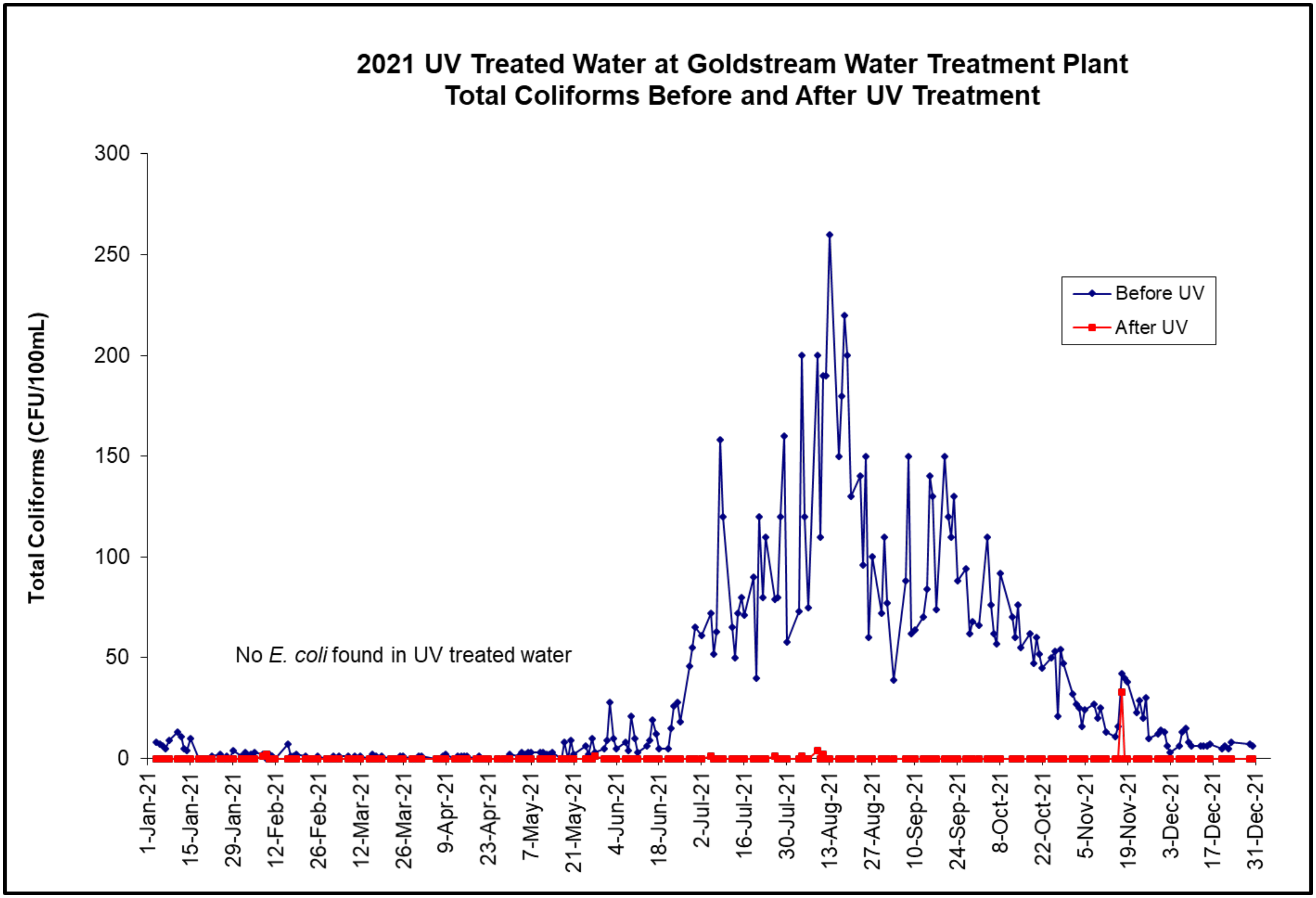

Figure 25 2021 UV Treated Water at Goldstream Water Treatment Plant Total Coliforms Before and After UV Treatment

Treated Water at Both First Customer Sampling Locations. The data collected from the two treated water sampling locations near the first customers below the Goldstream Water Treatment Plant (one at Main #4 and one at Main #5) indicated that the bacteriological quality of the disinfected water was good in all months of 2021 (Figure 26 and Appendix A, Table 2). In total, 245 samples were collected from the Main #4 first customer location and 224 samples from the Main #5 first customer location, for a combined total of 469 samples.

There were only four total coliform-positive samples from both sampling stations throughout the year. Three positive samples registered at the Main #5 first customer sampling station and one at the Main #4 station. All were very low total coliform concentrations. For all four positive results, no subsequent resample was positive for total coliform bacteria.

The few total coliform-positive results remained well under 10% of the monthly totals at both first customer locations. None of the positive results was in exceedance of the 10 CFU/100 mL total coliform limit, as per *Drinking Water Protection Regulation*. The negative resample results ruled out a breach in the system and any real contamination of the treated water. 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 0.8 - 2.17 mg/L (Appendix A, Table 2) with a median value of 1.85 mg/L (Figure 26).

The treated water leaving the Goldstream Water Treatment Plant had the following physical and chemical characteristics:

- Median pH: 7.5
- Median Alkalinity: 16.70 mg/L
- Median Colour: 3.0 TCU
- Median Total Organic Carbon: 1.65 mg/L
- Median Conductivity (25ºC): 50.20 µS/cm
- Median turbidity: 0.2 NTU

The values of the parameters above are consistent with those of previous years.

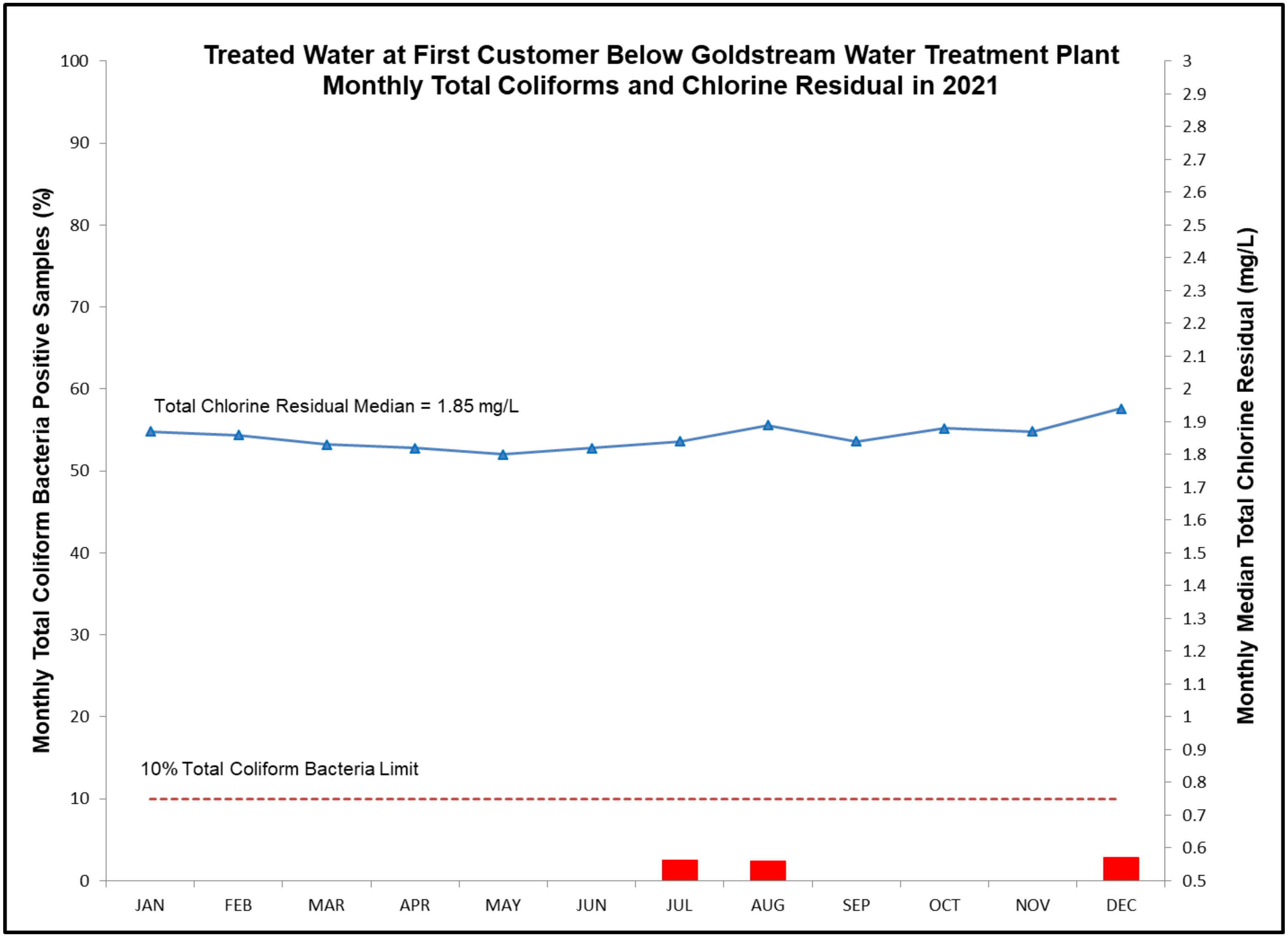

Figure 26 Treated Water at First Customer Locations below Goldstream Water Treatment Plant; Monthly Total Coliforms and Chlorine Residual in 2021

7.2.2 Sooke River Road Water Treatment Plant

Bacteriological Results after UV Treatment. Figure 27 shows the results from 40 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.

Turbidity. The Sooke River Road Water Treatment Plant experienced one adverse turbidity event in 2021.

March 25, 2021: A sudden turbidity spike at the plant that lasted about 42 minutes (length of time with turbidity > 1 NTU). The peak turbidity reached 6.6 NTU. The cause of this event is unknown. It is assumed that the raw main flushing activities on Main #4 and #5 that occurred around that time, changed the flow patterns in the headwork pipes sufficiently to dislodge some pipe sediments or debris in Main #15.

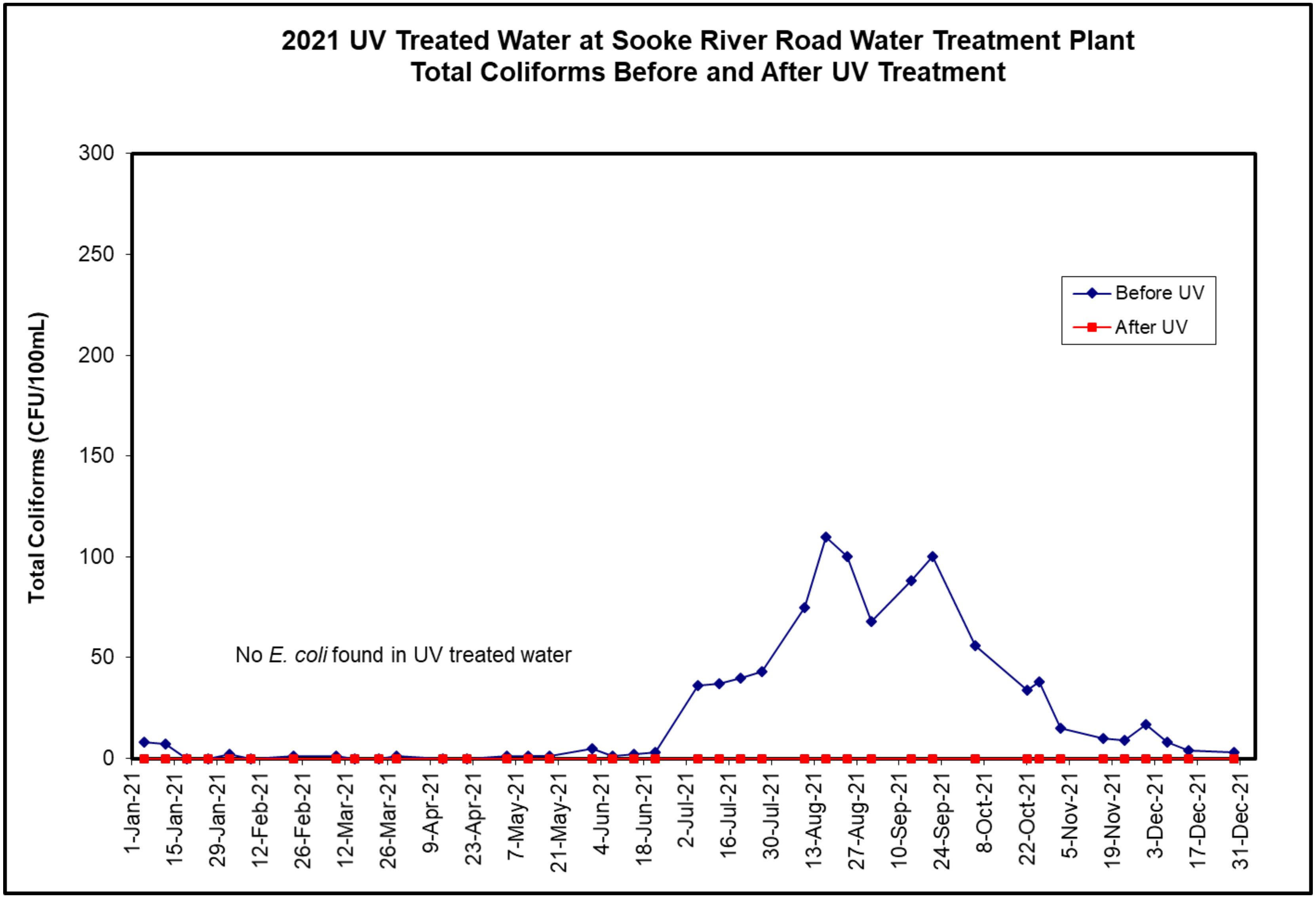

Figure 27 2021 UV Treated Water at Sooke River Road Water Treatment Plant Total Coliforms Before and After UV Treatment

Treated Water at First Customer. The data collected from the treated water sampling location near the first customer below the Sooke River Road Water Treatment Plant indicated that the bacteriological quality of the disinfected water was good in all months of 2021 (Figure 28). No total coliform bacteria were detected in all 40 samples from this sampling station in 2021.

The total chlorine residual ranged from 1.33 - 2.4 mg/L with a median value of 1.89 mg/L.

The treated water leaving the Sooke River Road Water Treatment Plant had the following physical and chemical characteristics:

- Median pH: 7.6
- Median Alkalinity: 16.20 mg/L
- Median Colour: ND
- Median Conductivity (25ºC): 55.80 µS/cm
- Median turbidity: 0.2 NTU

The values of the parameters above are consistent with those of previous years.

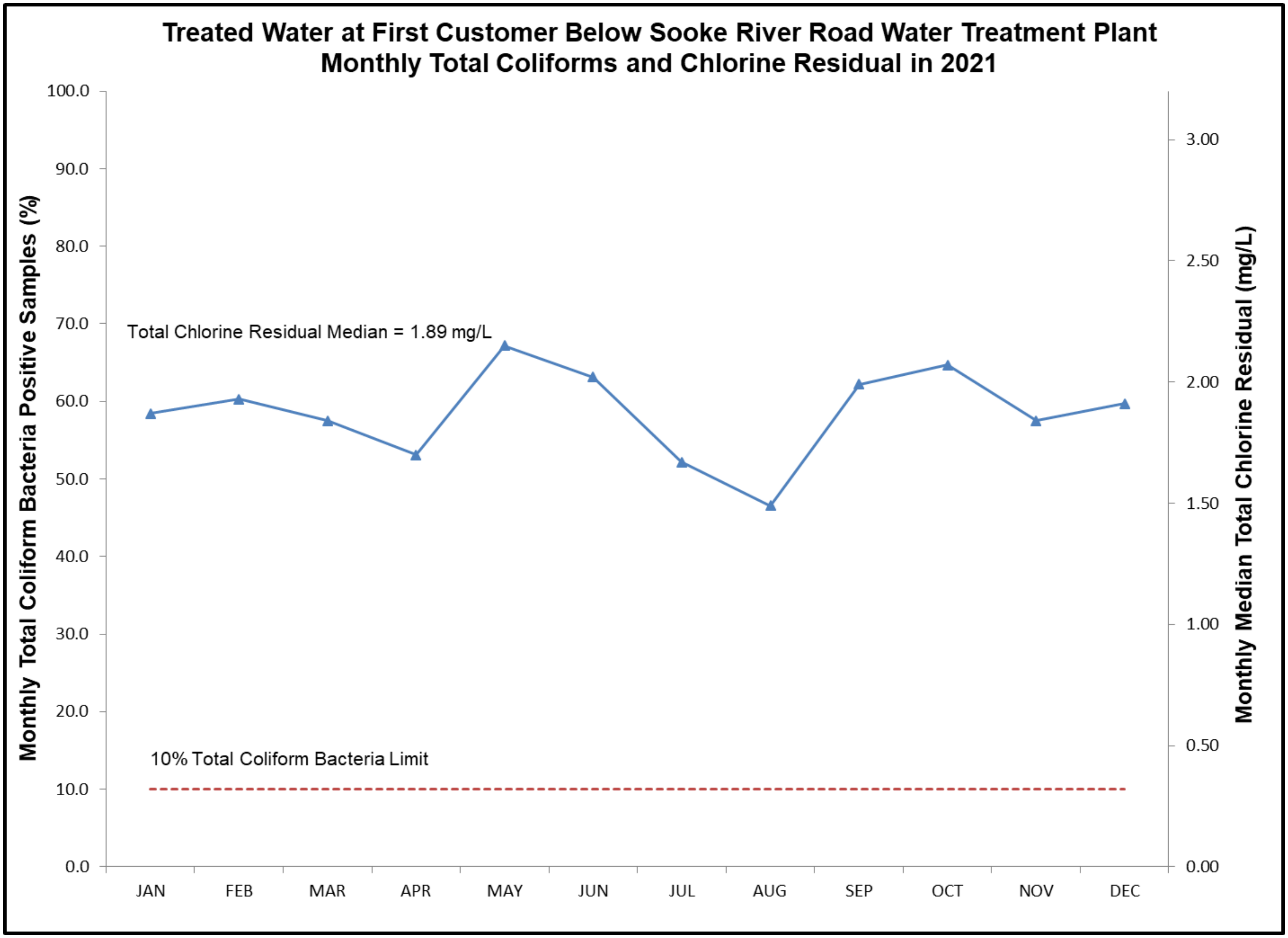

Figure 28 Treated Water at First Customer below Sooke Rover Road Water Treatment Plant, Monthly Total Coliforms and Chlorine Residual in 2021

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

The CRD transmission mains were sampled in 20 different sampling locations. The sampling locations for CRD transmission mains also include the Main #4 and Main #5 first customer sampling stations. In 2021, a total of 920 bacteriological and 915 water chemistry samples were collected and analyzed.

Bacteriological Results. Figure 29 and Table 1 show the results from 920 CRD transmission main samples collected and analyzed in 2021. The results (no *E. coli* and 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. No sample exceeded the 10 CFU/100 mL total coliform concentration threshold.

Chlorine Residual. Table 1 and Figure 29 demonstrate that the annual median total chlorine concentration in the transmission mains was 1.62 mg/L and, therefore, provides for adequate secondary disinfection within the transmission system and within most areas of the downstream municipal distribution systems. The lower chlorine levels at the beginning of 2021 were due to the switch to free chlorine necessitated by a malfunctioning of the ammonia dosing system. The ammonia system came online again in mid-January and normal monochloramine residuals were established subsequently.

Water Temperature. The annual median water temperature in the transmission mains was 10.2°C, with monthly medians ranging between 5.6°C (February) and 18.4°C (August) (Table 1). Despite the extreme early summer heatwave, these temperatures are back in line with pre-2021 water temperatures in the transmission mains.

Table 1 2021 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	Median ° C
JAN	74	0	0.0	0	0	0	37	0	1.22	7.0
FEB	75	0	0.0	0	0	0	40	0	1.66	5.6
MAR	86	0	0.0	0	0	0	46	0	1.58	6.3
APR	71	0	0.0	0	0	0	39	0	1.62	8.0
MAY	80	0	0.0	0	0	0	41	0	1.58	9.8
JUN	87	0	0.0	0	0	0	45	0	1.65	12.8
JUL	75	1	1.3	0	0	0	42	0	1.67	14.7
AUG	81	2	2.5	0	0	0	43	0	1.68	18.4
SEP	71	0	0.0	0	0	0	37	0	1.63	17.9
OCT	73	0	0.0	0	0	0	41	0	1.63	14.0
NOV	81	0	0.0	0	0	0	42	0	1.60	10.3
DEC	66	1	1.5	0	0	0	36	0	1.69	7.8
Total:	920	4	0.4	0	0	0	489	0	1.62	10.2

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 six sets of samples for a disinfection byproduct analysis from a transmission main at Mills Road. The annual average total trihalomethane (TTHM) and annual average total haloacetic acid (HAA) concentrations were 27.0 and 26.4 µg/L, respectively, well below the MAC (TTHM = 100 and HAA = 80 µg/L) stipulated in the Canadian guidelines. These annual averages are approximately 10 µg/L higher than historically due to much higher concentrations recorded during the free chlorine period in January 2021 when the ammonia system was not functioning. The individual TTHM and HAA concentrations recorded on January 4 at the Mills Road sampling station were 58 µg/L and 69 µg/L respectively. These values demonstrate the importance of using chloramines for secondary disinfection for the purpose of disinfection byproduct management. This sampling 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. All NDMA results at this location were below the detection limit of 1.9 ng/L.

This was the only transmission main where disinfection byproduct samples were collected (bi-monthly). 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 metals tests in three 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. All metal results were below the Canadian guideline limits including at the sampling station Lansdowne/Foul Bay where in previous years elevated lead concentrations had been detected due to old sampling infrastructure. In December of 2020, these old sampling lines had been replaced.

In 2019, CRD, in concert with Saanich, Victoria/Esquimalt and Oak Bay, started the Greater Victoria pH & Corrosion Study to investigate water properties that may contribute to metal corrosion, and in particular, to lead leaching into the drinking water. The study examines the water inside the public and also the private drinking water piping systems. As part of this study, samples from a multitude of sampling locations were analyzed for lead and copper. In 2021, the project scope was expanded to include region-wide sampling at customers' taps as per BC Ministry of Health guidelines. The project was completed in the fall of 2021. The study found that metal corrosion and lead leaching in the public piping systems as well as in the vast majority of private plumbing systems is not an issue in the Greater Victoria Drinking Water System.

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

- Median pH: 7.5
- Median $CaCO_3$ Hardness: 16.8 mg/L
- Median Alkalinity: 17.90 mg/L
- Median Colour: 3.00 TCU
- Median Turbidity: 0.20 NTU
- Median Conductivity (25ºC): 50.20 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.*

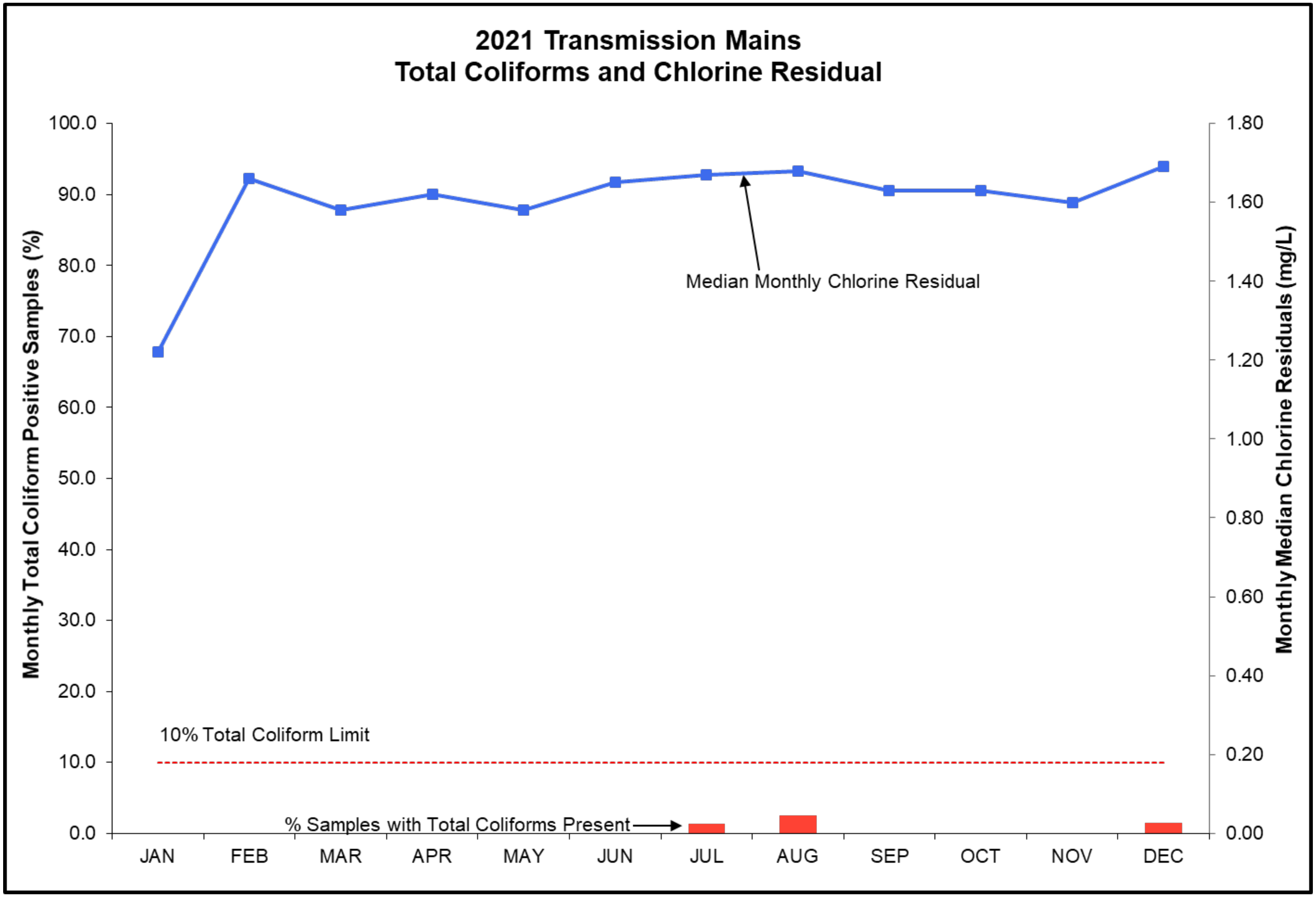

Figure 29 Transmission Mains Total Coliforms and Chlorine Residual in 2021

7.3.2 Supply Storage Reservoirs

The CRD supply storage reservoirs were sampled in 7 different sampling locations. In 2021, a total of 169 bacteriological and 55 water chemistry samples were collected and analyzed.

Bacteriological Results. Figure 30 and Table 2 show the 2021 results from the samples on CRD supply 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 no total coliform-positive samples in 2021 (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.

There were no *E coli* or total coliform positive samples in 2021.

Chlorine Residual. Table 2 and Figure 30 indicate that the median total chlorine concentration in the storage reservoirs ranged from 0.57 - 1.51 mg/L, with an annual median total chlorine concentration of 1.44 mg/L. The lower chlorine levels at the beginning of 2021 were due to the switch to free chlorine necessitated by a malfunctioning of the ammonia dosing system. The ammonia system came online again in mid-January and normal monochloramine residuals were established subsequently.

Water Temperature. The annual median water temperature in the storage reservoirs was 11.1°C, with monthly medians ranging between 7.0°C (March) and 19.3°C (August) (Table 2).

Table 2 2021 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	15	0	0.0	0	0	0	0	0	0.57	7.5
FEB	12	0	0.0	0	0	0	1	0	1.51	6.2
MAR	13	0	0.0	0	0	0	1	0	1.44	7.0
APR	13	0	0.0	0	0	0	1	0	1.44	8.2
MAY	15	0	0.0	0	0	0	1	0	1.45	10.4
JUN	18	0	0.0	0	0	0	1	0	1.45	13.0
JUL	16	0	0.0	0	0	0	1	0	1.49	15.4
AUG	14	0	0.0	0	0	0	1	0	1.51	19.3
SEP	14	0	0.0	0	0	0	1	0	1.48	18.2
OCT	13	0	0.0	0	0	0	1	0	1.44	15.0
NOV	13	0	0.0	0	0	0	0	0	1.35	11.7
DEC	13	0	0.0	0	0	0	1	0	1.43	8.8
Total:	169	0	0.0	0	0	0	10	0	1.44	11.1

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 36 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 were 29.3 and 20.2 µg/L at Cloake Hill and 20.7 and 16.6 µg/L at Upper Dean, respectively, well below the MAC (TTHM = 100 and HAA = 80 µg/L) stipulated in the Canadian guidelines. These annual averages are slightly higher than historically due to much higher concentrations recorded during the free chlorine period in January 2021 when the ammonia system was not functioning. The individual TTHM and HAA concentrations recorded on January 13 at the Cloak Hill reservoir sampling station were 71 µg/L and 85 µg/L respectively. The individual TTHM and HAA concentrations recorded on January 14 at the Upper Dean Park reservoir sampling station were 35 µg/L and 21 µg/L respectively. The high values especially from the Cloak Hill reservoir demonstrate the importance of using chloramines for secondary disinfection for the purpose of disinfection byproduct management. In five out of six samples, the NDMA concentrations at both locations were below the detection limit (1.9 ng/L). One sample from Upper Dean Park reservoir recorded a very low NDMA concentration of 2 ng/L. All NDMA results were therefore well below the Canadian guideline MAC of 40 ng/L.

Physical/Chemical Parameters. The drinking water in the regional supply storage reservoirs had the following physical and chemical characteristics in 2021:

- Median pH: 7.7
- Median Alkalinity: 16.6 mg/L
- Median Colour: ND
- Median Turbidity: 0.23 NTU
- Median Conductivity (25ºC): 51.00 µS/cm

Metals. No data for 2021.

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 Integrated Water Services Department 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. The new hypochlorite plant at the Goldstream Water Treatment Plant has improved the chemical dosing system and reduced the potential for free ammonia in the treated water.

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

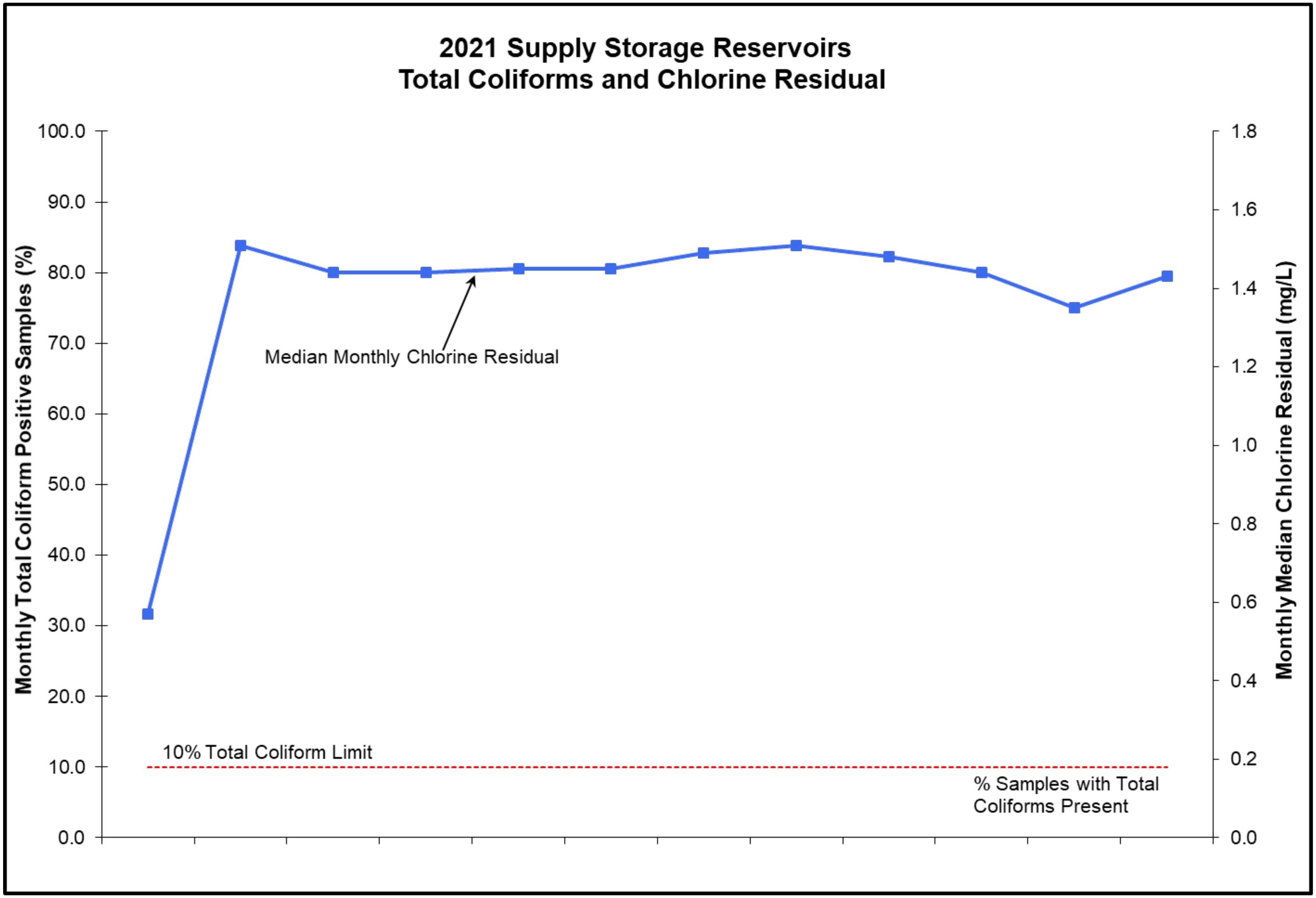

Figure 30 Supply Storage Reservoirs Total Coliforms and Chlorine Residual in 2021

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 2021, 32 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 2021, 919 bacteriological and 284 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 a few samples throughout the year. One sample in October exceeded the 10 CFU/100 mL total coliform concentration threshold. There were no consecutive positive samples in 2021. This system complied with the 10% total coliform-positive limit for all months of the year during 2021. The annual total coliform positive percentage was well below the 10% limit at 1.0% (Table 3).

There were no *E coli*-positive samples in 2021.

Chlorine Residual. The annual median chlorine residual in the Westshore municipalities of the Juan de Fuca Water Distribution System was 1.26 mg/L (Table 2). The lowest monthly median was in January (0.70 mg/L – due to switch to free chlorine) and the maximum monthly median was in April (1.45 mg/L) (Figure 31, Table 3).

Water Temperature. The annual median water temperature in the Juan de Fuca Water Distribution System was 11.6ºC, with monthly medians ranging between 6.5°C (February) and 18.5ºC (August) (Table 3).

Table 3 2021 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	72	0	0.0	0	0	0	7	0	0.70	7.7
FEB	67	0	0.0	0	0	0	8	0	1.36	6.5
MAR	83	1	1.2	0	0	0	7	0	1.39	7.0
APR	78	0	0.0	0	0	0	6	0	1.45	9.1
MAY	68	0	0.0	0	0	0	7	0	1.40	11.2
JUN	86	0	0.0	0	0	0	7	0	1.39	14.3
JUL	74	2	2.7	0	0	0	7	0	1.19	16.2
AUG	88	4	4.5	0	0	0	8	0	1.08	18.5
SEP	85	0	0.0	0	0	0	8	0	1.22	17.8
OCT	74	2	2.7	0	1	0	8	0	1.16	13.5
NOV	73	1	1.4	0	0	0	5	0	1.13	10.8
DEC	71	0	0.0	0	0	0	8	0	1.20	8.1
Total:	919	10	1.0	0	1	0	86	0	1.26	11.6

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 18 samples collected for disinfection byproducts. The annual average TTHM and haloacetic acid (HAA5) concentrations in six samples each were 15.2 and 2.2 µg/L, respectively, far below the Canadian guideline MAC (TTHM = 100; HAA5 = 80). In six samples, the NDMA concentrations were below the detection limit of 1.9 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 2021:

- Median pH: 7.4
- Median $CaCO_3$ Hardness: 17.00 mg/L
- Median Alkalinity: 17.00 mg/L
- Median Colour: 3.0 TCU
- Median Conductivity (25ºC): 51.10 µS/cm
- Median Turbidity: 0.20 NTU

Metals. One sampling station in this system was sampled for metals bi-monthly. All metals were below the Canadian guideline limits. Lead concentrations varied from 'below detection limit' to 0.48 µg/L.

In 2019, CRD staff, in concert with Saanich, Victoria/Esquimalt and Oak Bay, started the Greater Victoria pH & Corrosion Study to investigate water properties that may contribute to metal corrosion and, in particular, to lead leaching into the drinking water. The study examines the water inside the public and also the private drinking water piping systems. As part of this study, samples from a multitude of sampling locations were analyzed for lead and copper. In 2021, the project scope was expanded to include region-wide sampling at customers' taps as per BC Ministry of Health guidelines. The project was completed in the fall of 2021. The study found that metal corrosion and lead leaching in the public piping systems, as well as in the vast majority of private plumbing systems, is not an issue in the Greater Victoria Drinking Water System.

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 October, with one total coliform-positive result in exceedance of 10 CFU/100 mL. Immediate resamples following this result were negative for total coliform bacteria and did, therefore, confirm the safety of the drinking water.

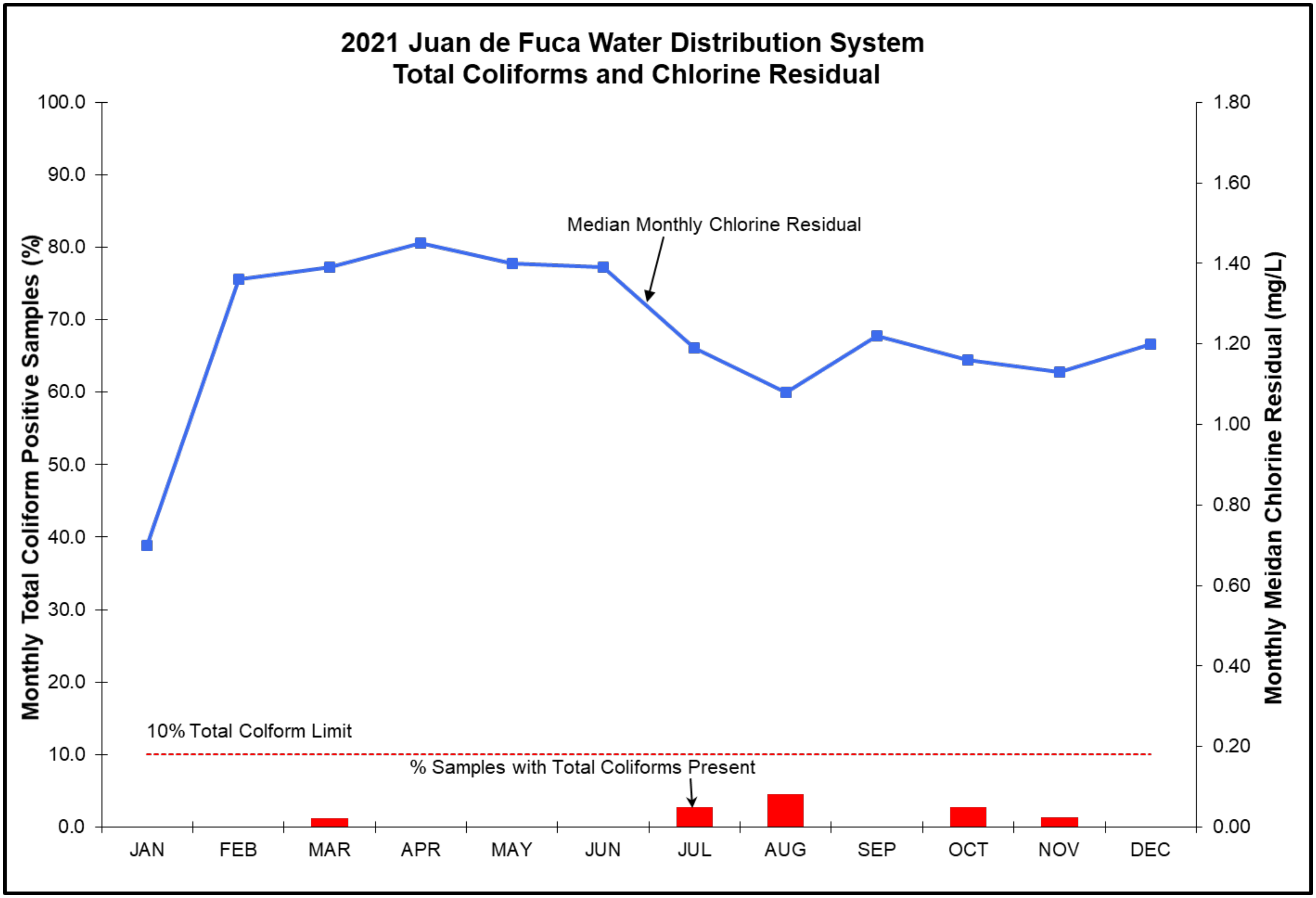

Figure 31 Juan de Fuca – Westshore Distribution System Total Coliforms and Chlorine Residual in 2021

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

In 2021, 20 sampling locations were used by the CRD Water Quality Monitoring Program to monitor the bacteriological quality of the water in Sooke/East Sooke system. Half of all Sooke/East Sooke sampling stations were typically sampled once per week for a bi-weekly sampling frequency of all stations.

Sample Collection. In 2021, 384 bacteriological and 180 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. One sample in January and two samples in November tested positive for total coliform bacteria. One sample in November exceeded the 10 CFU/100 mL total coliform concentration threshold. All resamples were negative so there were no consecutive positive samples in 2021. The annual total coliform positive percentage was well below the 10% limit at 0.8% (Table 4).

No *E. coli* bacteria were found in any sample collected in 2021 (Table 4).

Chlorine Residual. The annual median chlorine residual in the Sooke/East Sooke Distribution System was 1.03 mg/L (Table 4, Figure 32). The lowest monthly median was in October (0.40 mg/L), and the maximum monthly median was in May (1.35 mg/L). The low chlorine residual in early fall is typical for the Sooke/East Sooke System, due to the increased chlorine demand in the warm water season.

Water Temperature. The annual median water temperature in the Sooke/East Sooke Distribution System was 11.4°C, with monthly medians ranging between 6.8ºC (February) and 18.9°C (August) (Table 4).

Table 4 2021 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	38	1	2.6	0	0	0	5	0	1.29	7.8
FEB	30	0	0.0	0	0	0	8	2	1.25	6.8
MAR	36	0	0.0	0	0	0	10	2	1.31	7.5
APR	24	0	0.0	0	0	0	6	0	1.29	9.9
MAY	30	0	0.0	0	0	0	7	0	1.35	12.2
JUN	43	0	0.0	0	0	0	9	1	1.08	14.9
JUL	36	0	0.0	0	0	0	8	0	0.97	17.2
AUG	30	0	0.0	0	0	0	7	0	0.58	18.9
SEP	30	0	0.0	0	0	0	6	0	0.70	17.8
OCT	24	0	0.0	0	0	0	6	0	0.40	13.7
NOV	35	2	5.7	0	1	0	5	0	0.72	10.6
DEC	28	0	0.0	0	0	0	5	0	0.92	8.8
Total:	384	3	0.8	0	1	0	82	5	1.03	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. One location in the Sooke distribution system had 18 samples collected for disinfection byproducts. The annual average TTHM and HAA5 concentrations from six samples each were 31.8 and 26.2 µg/L, respectively, far below the Canadian guideline MAC (TTHM = 100; HAA5 = 80). In six samples, the NDMA concentrations were below the detection limit of 1.9 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: 7.6
- Median CaCO3 Hardness: 17.40 mg/L
- Median Colour: ND
- Median Alkalinity: 16.70 mg/L
- Median Turbidity: 0.20 NTU
- Median Conductivity (25ºC): 55.60 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 2021: first customer sampling station on Sooke River Road, and Whiffen Spit Road. All metallic parameters, including lead, were well below the Canadian guideline limits.

In 2019, CRD, in concert with Saanich, Victoria/Esquimalt and Oak Bay, started the Greater Victoria pH & Corrosion Study to investigate water properties that may contribute to metal corrosion, and in particular, to lead leaching into the drinking water. The study examines the water inside the public and also the private drinking water piping systems. As part of this study, samples from a multitude of sampling locations were analyzed for lead and copper. In 2021, the project scope was expanded to include region-wide sampling at customers' taps as per BC Ministry of Health guidelines. The project was completed in the fall of 2021. The study found that metal corrosion and lead leaching in the public piping systems, as well as in the vast majority of private plumbing systems, is not an issue in the Greater Victoria Drinking Water System.

Compliance Status. The Sooke/East Sooke Distribution System was in compliance with the *BC Drinking Water Protection Act* and *Drinking Water Protection Regulation*, except for November with one total coliform-positive result in exceedance of 10 CFU/100 mL. Immediate resamples following this result were negative for total coliform bacteria and did, therefore, confirm the safety of the drinking water.

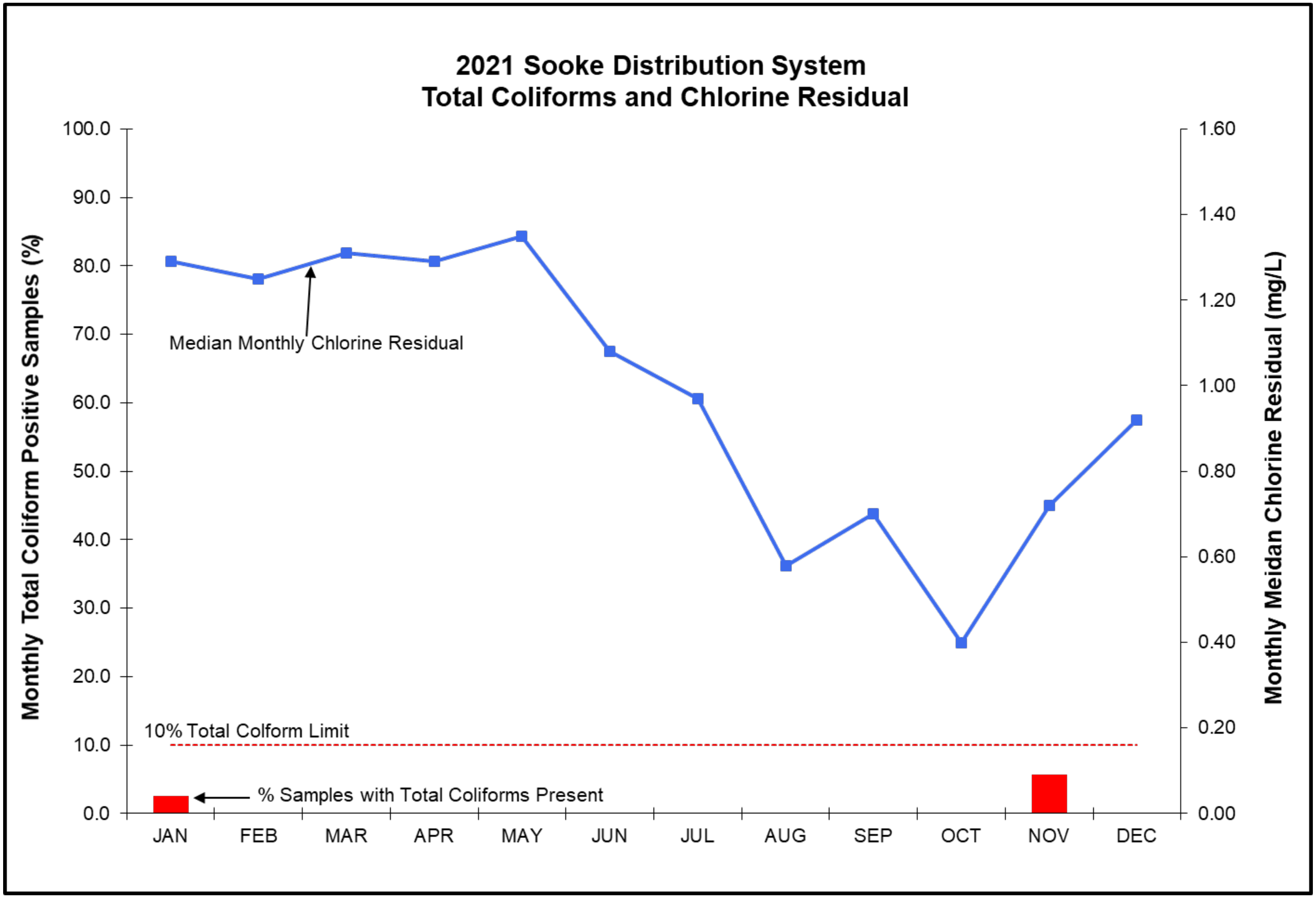

Figure 32 Sooke/East Sooke Distribution System Total Coliforms and Chlorine Residual in 2021

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

In 2021, 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 2021, 278 bacteriological and 179 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 only one sample collected in May 2021. A resample was negative. This system complied with the 10% total coliform-positive limit for all of 2021. No samples exceeded the 10 CFU/100 mL total coliform concentration. There were also no consecutive positive samples in 2021 (Table 5).

None of the samples contained *E. coli* bacteria in 2021 (Table 5).

Chlorine Residual. The annual median chlorine residual in the Central Saanich Distribution System was 1.46 mg/L (Table 5). The lowest monthly median was in January (0.69 mg/L – due to switch to free chlorine) and the maximum monthly median was in August (1.54 mg/L) (Figure 33, Table 6).

Water Temperature. The annual median water temperature in the Central Saanich Distribution System was 12.1°C, with monthly medians ranging between 7.1°C (February) and 19.7°C (August) (Table 5).

Table 5 2021 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	22	0	0.0	0	0	0	7	0	0.69	8.2
FEB	22	0	0.0	0	0	0	9	0	1.51	7.1
MAR	26	0	0.0	0	0	0	10	0	1.45	7.9
APR	21	0	0.0	0	0	0	10	0	1.44	9.4
MAY	23	1	4.3	0	0	0	8	0	1.45	11.8
JUN	27	0	0.0	0	0	0	7	0	1.46	14.2
JUL	23	0	0.0	0	0	0	9	0	1.50	17.1
AUG	24	0	0.0	0	0	0	8	0	1.54	19.7
SEP	23	0	0.0	0	0	0	8	0	1.50	18.4
OCT	23	0	0.0	0	0	0	9	0	1.43	14.7
NOV	23	0	0.0	0	0	0	9	0	1.39	11.8
DEC	21	0	0.0	0	0	0	6	0	1.52	9.2
Total:	278	1	0.4	0	0	0	100	0	1.46	12.1

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 2021.

Physical/Chemical Parameters. The drinking water in the Central Saanich Distribution System had the following physical and chemical characteristics in 2021:

- Median pH: 7.6
- Median Turbidity: 0.25 NTU
- Median Colour: 3.0 TCU
- Median Alkalinity: 16.50 mg/L
- Median Conductivity (25ºC): 51.00 µS/cm

Metals. No data for 2021.

Compliance Status. The Central Saanich Distribution System was in full compliance with the *BC Drinking Water Protection Act* and *Drinking Water Protection Regulation* in 2021.

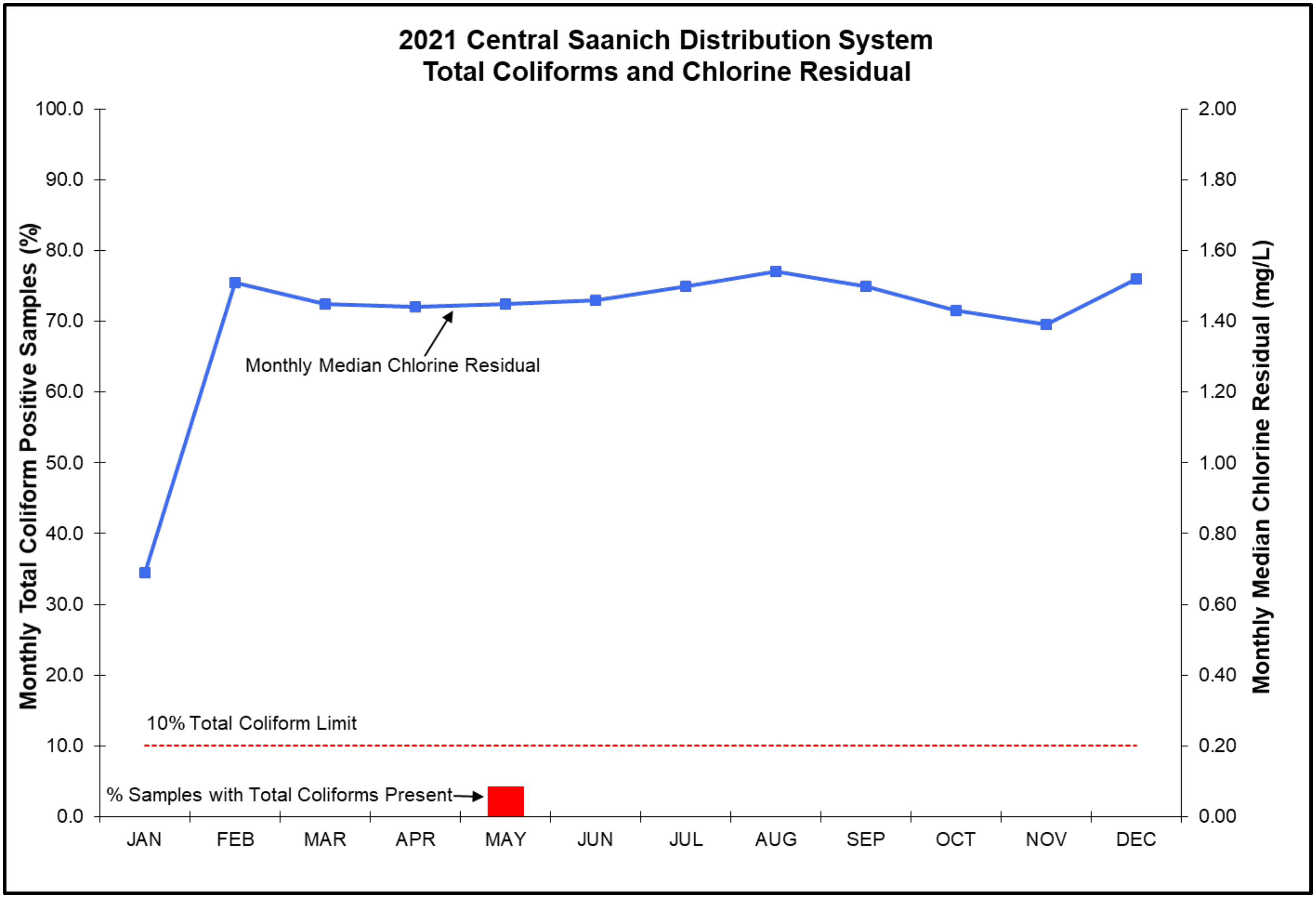

Figure 33 Central Saanich Distribution System Total Coliforms and Chlorine Residual in 2021

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

In 2021, 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 2021, 200 bacteriological and 65 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 in 2021 tested positive for total coliform bacteria (Table 7).

None of the samples contained *E. coli* in 2021 (Table 7).

Chlorine Residual. The annual median chlorine residual in the North Saanich Distribution System was 1.24 mg/L (Table 6). The lowest monthly median was in January (0.17 mg/L – due to a switch to free chlorine) and the maximum monthly median was in July (1.37 mg/L) (Figure 34, Table 7).

Water Temperature. The annual median water temperature in the North Saanich Distribution System was 12.4°C, with monthly medians ranging between 7.6°C (February) and 18.8°C (August) (Table 6).

Table 6 2021 Bacteriological Quality of the 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	16	0	0.0	0	0	0	1	0	0.17	8.6
FEB	16	0	0.0	0	0	0	2	0	1.29	7.6
MAR	19	0	0.0	0	0	0	2	0	1.25	7.9
APR	15	0	0.0	0	0	0	1	0	1.29	9.6
MAY	16	0	0.0	0	0	0	1	0	1.30	12.0
JUN	18	0	0.0	0	0	0	2	0	1.33	14.2
JUL	17	0	0.0	0	0	0	1	0	1.37	16.8
AUG	18	0	0.0	0	0	0	0	0	1.27	18.8
SEP	17	0	0.0	0	0	0	1	0	1.29	18.4
OCT	16	0	0.0	0	0	0	0	0	0.91	15.0
NOV	17	0	0.0	0	0	0	1	0	0.81	12.0
DEC	15	0	0.0	0	0	0	1	0	0.76	9.3
Total:	200	0	0.0	0	0	0	13	0	1.24	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 in 2021.

Physical/Chemical Parameters. The drinking water in the North Saanich Distribution System had the following physical and chemical characteristics in 2021:

- Median pH: 7.7
- Median Colour: 3.5 TCU
- Median Turbidity: 0.20 NTU
- Median Alkalinity: 14.45 mg/L
- Median Conductivity (25ºC): 50.10 µS/cm

Metals. No data in 2021.

Compliance Status. The North Saanich Distribution System was in full compliance with the *BC Drinking Water Protection Act* and *Drinking Water Protection Regulation* in 2021.

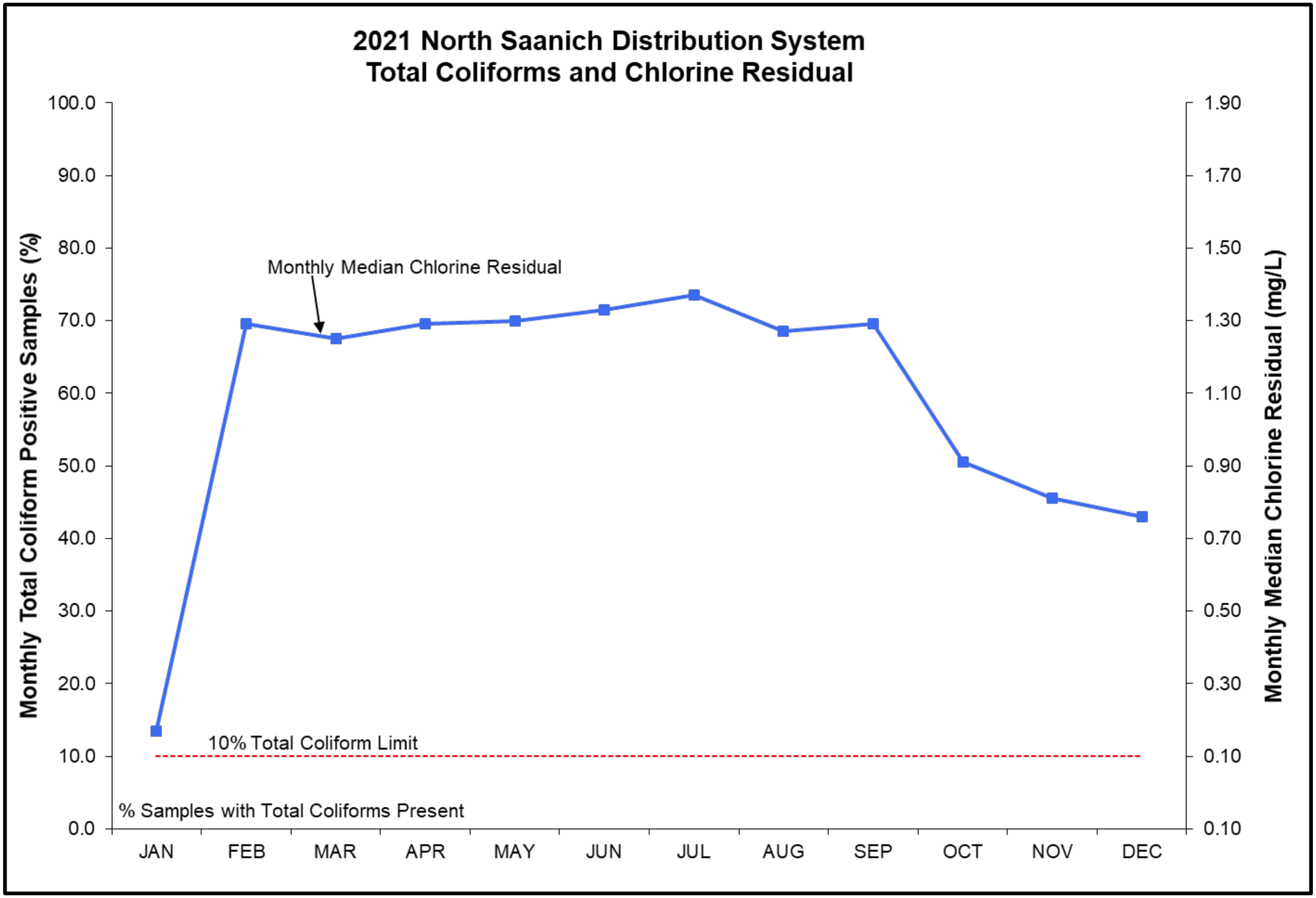

Figure 34 North Saanich Distribution System Total Coliforms and Chlorine Residual in 2021

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

In 2021, eight 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 2021, 285 bacteriological and 123 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. Three samples throughout the year tested positive for total coliform bacteria. No sample exceeded the 10 CFU/100 mL total coliform concentration threshold. All resamples were negative so there were no consecutive positive samples in 2021. The annual total coliform positive percentage was well below the 10% limit at 1.1% (Table 4).

No *E. coli* bacteria were found in any sample collected in 2021 (Table 4).

Chlorine Residual. The annual median chlorine residual in the Oak Bay Distribution System was 1.51 mg/L (Table 7). The lowest monthly median was in January (0.64 mg/L – due to switch to free chlorine) and the maximum monthly median was in August (1.63 mg/L) (Figure 35).

Water Temperature. The annual median water temperature in the Oak Bay Distribution System was 12.2°C, with monthly medians ranging between 7.3°C (February) and 19.7°C (August) (Table 7).

Table 7 2021 Bacteriological Quality of the 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	23	0	0.0	0	0	0	1	0	0.64	8.4
FEB	22	0	0.0	0	0	0	3	0	1.48	7.3
MAR	27	0	0.0	0	0	0	3	0	1.47	8.4
APR	24	1	4.2	0	0	0	3	0	1.49	10.6
MAY	23	0	0.0	0	0	0	2	0	1.56	12.2
JUN	26	0	0.0	0	0	0	3	0	1.61	15.3
JUL	22	0	0.0	0	0	0	2	0	1.53	17.1
AUG	27	1	3.7	0	0	0	1	0	1.63	19.7
SEP	23	0	0.0	0	0	0	2	0	1.54	18.9
OCT	23	0	0.0	0	0	0	2	0	1.33	15.1
NOV	24	1	4.2	0	0	0	2	0	1.18	11.9
DEC	21	0	0.0	0	0	0	2	0	1.56	9.6
Total:	285	3	1.1	0	0	0	26	0	1.51	12.2

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 2021.

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

- Median pH: 7.7
- Median Alkalinity: 16.90 mg/L
- Median Turbidity: 0.25 NTU
- Median Conductivity (25ºC): 51.30 µS/cm
- Median Colour: 4.0 TCU

Metals. In 2019, CRD, in concert with Saanich, Victoria/Esquimalt and Oak Bay, started the Greater Victoria pH & Corrosion Study to investigate water properties that may contribute to metal corrosion, and in particular, to lead leaching into the drinking water. The study examines the water inside the public and also the private drinking water piping systems. As part of this study, samples from a multitude of sampling locations were analyzed for lead and copper. In 2021, the project scope was expanded to include region-wide sampling at customers' taps as per BC Ministry of Health guidelines. The project was completed in the fall of 2021. The study found that metal corrosion and lead leaching in the public piping systems as well as in the vast majority of private plumbing systems is not an issue in the Greater Victoria Drinking Water System.

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

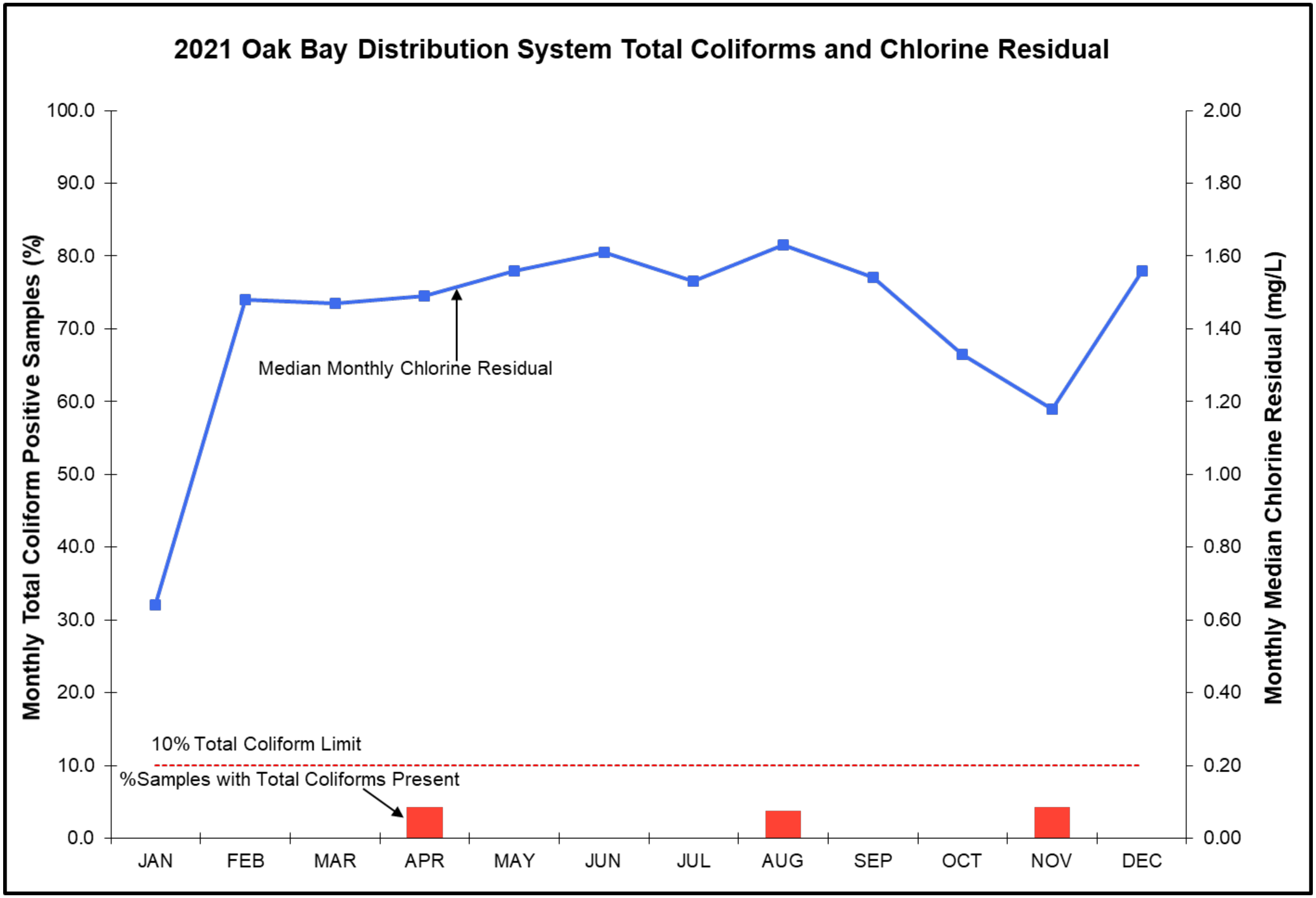

Figure 35 Oak Bay Distribution System Total Coliforms and Chlorine Residual in 2021

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

In 2021, 64 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 2021, 1,166 bacteriological and 105 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. A small number of total coliform-positive results were recorded throughout the year. There were no consecutive positive samples in 2021. No sample in February 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 positive percentage was well below the 10% limit at only 0.5% (Table 8).

No *E. coli* bacteria were found in any sample collected in 2021 (Table 8).

Chlorine Residual. The annual median chlorine residual in the Saanich Distribution System was 1.43 mg/L (Table 8). The lowest monthly median was in January (0.82 mg/L – due to switch to free chlorine) and the maximum monthly median was in June/July (1.52 mg/L) (Figure 36).

Water Temperature. The annual median water temperature in the Saanich Distribution System was 12.0°C, with monthly medians ranging between 7.3°C (March) and 19.3°C (August) (Table 8).

Table 8 2021 Bacteriological Quality of the 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	96	0	0.0	0	0	0	3	0	0.82	8.3
FEB	99	1	1.0	0	0	0	5	1	1.46	7.6
MAR	100	0	0.0	0	0	0	4	0	1.45	7.3
APR	100	0	0.0	0	0	0	3	0	1.43	9.7
MAY	94	0	0.0	0	0	0	2	0	1.44	12.2
JUN	97	1	1.0	0	0	0	3	0	1.52	14.7
JUL	97	1	1.0	0	0	0	3	0	1.52	17.3
AUG	98	1	1.0	0	0	0	1	0	1.51	19.3
SEP	101	2	2.0	0	0	0	3	0	1.42	18.1
OCT	95	0	0.0	0	0	0	2	0	1.30	14.5
NOV	97	0	0.0	0	0	0	2	0	1.28	11.4
DEC	92	0	0.0	0	0	0	2	0	1.47	8.7
Total:	1166	6	0.5	0	0	0	33	1	1.43	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 for 2021.

Physical/Chemical Parameters. The drinking water in the Saanich Distribution System had the following physical and chemical characteristics in 2021:

- Median pH: 7.6
- Median Alkalinity: 15.50 mg/L
- Median Turbidity: 0.25 NTU
- Median Conductivity (25ºC): 51.40 µS/cm
- Median Colour: ND

Metals. In 2019, CRD staff, in concert with Saanich, Victoria/Esquimalt and Oak Bay, started the Greater Victoria pH & Corrosion Study to investigate water properties that may contribute to metal corrosion, and in particular, to lead leaching into the drinking water. The study examines the water inside the public and also the private drinking water piping systems. As part of this study, samples from a multitude of sampling locations were analyzed for lead and copper. In 2021, the project scope was expanded to include region-wide sampling at customers' taps, as per BC Ministry of Health guidelines. The project was completed in the fall of 2021. The study found that metal corrosion and lead leaching in the public piping systems as well as in the vast majority of private plumbing systems is not an issue in the Greater Victoria Drinking Water System.

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

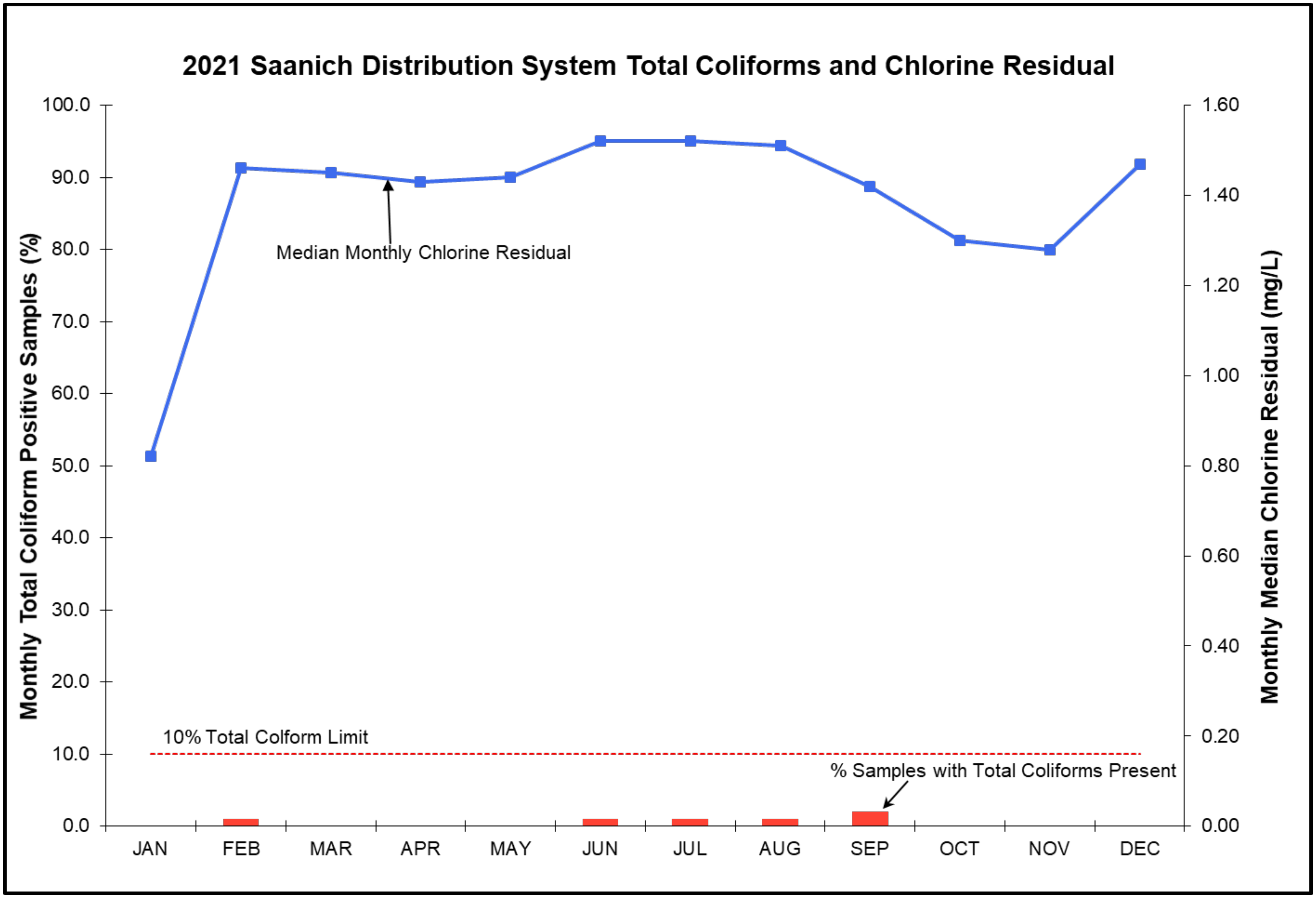

Figure 36 Saanich Distribution System Total Coliforms and Chlorine Residuals in 2021

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

In 2021, six 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 2021, 182 bacteriological and 62 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. One sample In October tested positive for total coliforms in 2021. A resample was negative, so there were no consecutive positive samples in 2021. No sample exceeded the 10 CFU/100 mL total coliform concentration. This system complied with the 10% total coliform-positive limit for all months. The annual total coliform positive percentage was well below the 10% limit at only 0.5% (Table 9).

Also, no sample tested positive for *E. coli* in 2021 (Table 9).

Chlorine Residual. The annual median chlorine residual in the Sidney Distribution System was 1.36 mg/L (Table 9). The lowest monthly median was in January (0.43 mg/L – due to switch to free chlorine) and the maximum monthly median was in February (1.44 mg/L) (Figure 37).

Water Temperature. The annual median water temperature in the Sidney Distribution System was 12.3°C, with monthly medians ranging between 8.2°C (March) and 19.3°C (August) (Table 9).

Table 9 2021 Bacteriological Quality of the 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	0	0	0.43	8.7
FEB	15	0	0.0	0	0	0	0	0	1.44	7.7
MAR	17	0	0.0	0	0	0	1	0	1.33	8.2
APR	15	0	0.0	0	0	0	2	0	1.37	10.0
MAY	15	0	0.0	0	0	0	1	0	1.35	12.8
JUN	14	0	0.0	0	0	0	1	0	1.36	14.6
JUL	16	0	0.0	0	0	0	1	0	1.34	17.0
AUG	16	0	0.0	0	0	0	1	0	1.40	19.3
SEP	15	0	0.0	0	0	0	1	0	1.41	18.4
OCT	16	1	6.3	0	0	0	1	0	1.37	15.0
NOV	15	0	0.0	0	0	0	2	0	1.20	11.9
DEC	14	0	0.0	0	0	0	0	0	1.39	9.6
Total:	182	1	0.5	0	0	0	11	0	1.36	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 2021.

Physical/Chemical Parameters. The drinking water in the Sidney Distribution System had the following physical and chemical characteristics in 2019:

- Median pH: 7.7
- Median Alkalinity: 16.80 mg/L
- Median Turbidity: 0.25 NTU
- Median Conductivity (25ºC): 51.90 µS/cm
- Median Colour: ND

Metals. No data in 2021.

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

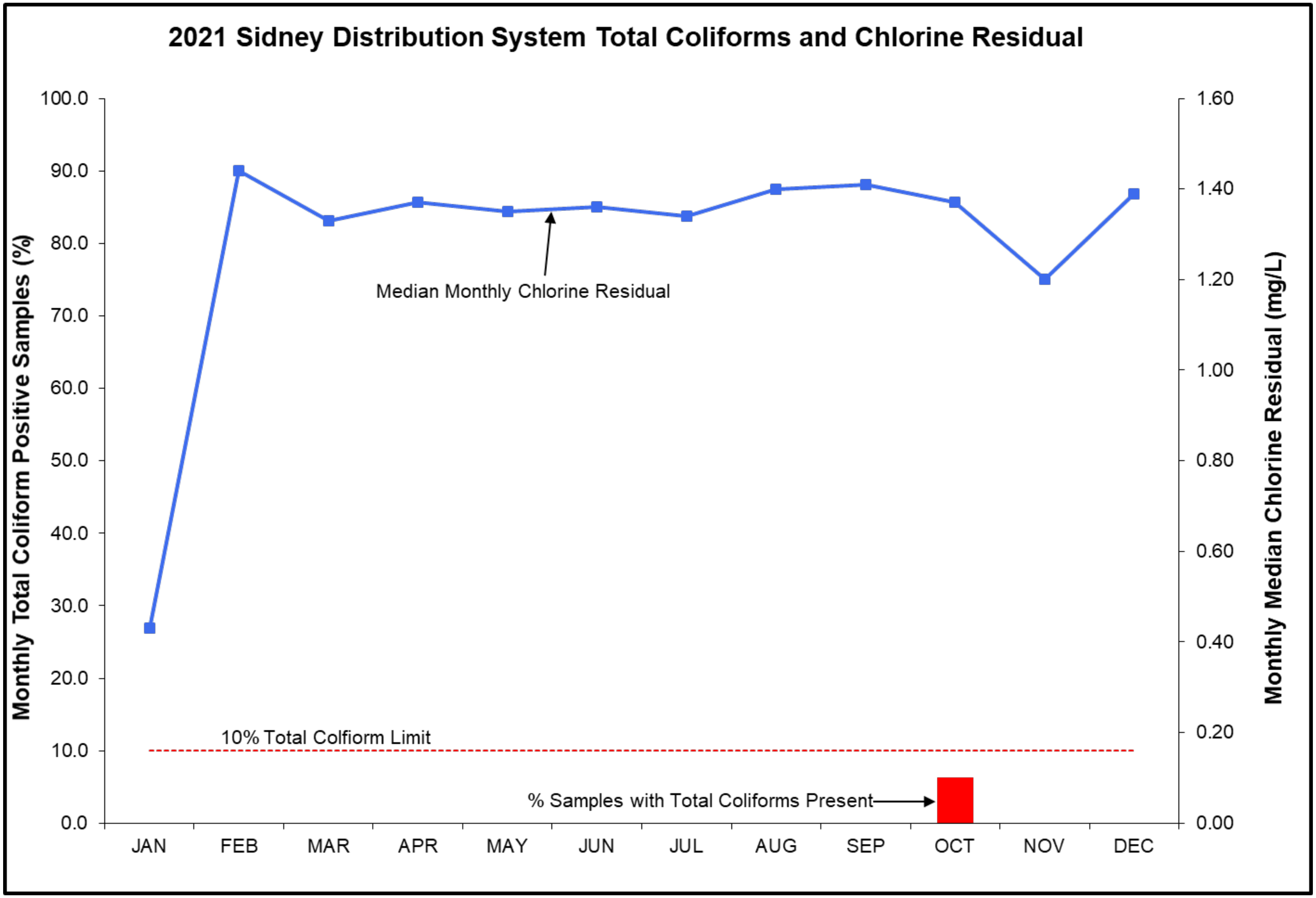

Figure 37 Sidney Distribution System Total Coliforms and Chlorine Residuals in 2021

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

In 2021, 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 2021, 1,202 bacteriological and 202 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. Only three total coliform-positive results occurred in five months throughout the year. There were no consecutive positive samples in 2021. 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. The annual total coliform percentage positive was well below the 10% limit at only 0.2% (Table 10).

No *E. coli* was detected in any sample in 2021 (Table 10).

Chlorine Residual. The annual median chlorine residual in the Victoria/Esquimalt Distribution System was 1.45 mg/L (Table 10). The lowest monthly median was in January (0.89 mg/L – due to switch to free chlorine) and the maximum monthly median was in March/May/December (1.51 mg/L) (Figure 38).

Water Temperature. The annual median water temperature in the Victoria/Esquimalt Distribution System was 13.2°C, with monthly medians ranging between 7.4°C (February) and 20.7°C (August) (Table 10).

Table 10 2021 Bacteriological Quality of the 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	95	0	0.0	0	0	0	7	1	0.89	8.4
FEB	95	1	1.1	0	0	0	7	0	1.48	7.4
MAR	108	0	0.0	0	0	0	8	0	1.51	8.3
APR	103	0	0.0	0	0	0	8	1	1.48	10.6
MAY	97	1	1.0	0	0	0	6	0	1.51	13.6
JUN	112	0	0.0	0	0	0	6	0	1.48	16.4
JUL	96	0	0.0	0	0	0	6	0	1.41	18.8
AUG	108	1	0.9	0	0	0	7	0	1.43	20.7
SEP	103	0	0.0	0	0	0	6	0	1.46	19.1
OCT	96	0	0.0	0	0	0	5	0	1.40	15.0
NOV	96	0	0.0	0	0	0	7	0	1.36	11.9
DEC	93	0	0.0	0	0	0	5	0	1.51	9.0
Total:	1202	3	0.2	0	0	0	78	2	1.45	13.2

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 2021.

Physical/Chemical Parameters. The drinking water in the Victoria/Esquimalt Distribution System had the following physical and chemical characteristics in 2021:

- Median pH: 7.8
- Median Alkalinity: 16.70 mg/L
- Median Turbidity: 0.25 NTU
- Median Conductivity (25ºC): 51.40 µS/cm
- Median Colour: 3.0 TCU

The system experienced occasional elevated turbidity in certain dead-end pipe sections, which were addressed with regular or ad hoc flushing at those locations.

Metals. In 2019, CRD, in concert with Saanich, Victoria/Esquimalt and Oak Bay, started the Greater Victoria pH & Corrosion Study to investigate water properties that may contribute to metal corrosion, and in particular, to lead leaching into the drinking water. The study examines the water inside the public and also the private drinking water piping systems. As part of this study, samples from a multitude of sampling locations were analyzed for lead and copper. In 2021, the project scope was expanded to include region-wide sampling at customers' taps as per BC Ministry of Health guidelines. The project was completed in the fall of 2021. The study found that metal corrosion and lead leaching in the public piping systems as well as in the vast majority of private plumbing systems is not an issue in the Greater Victoria Drinking Water System.

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

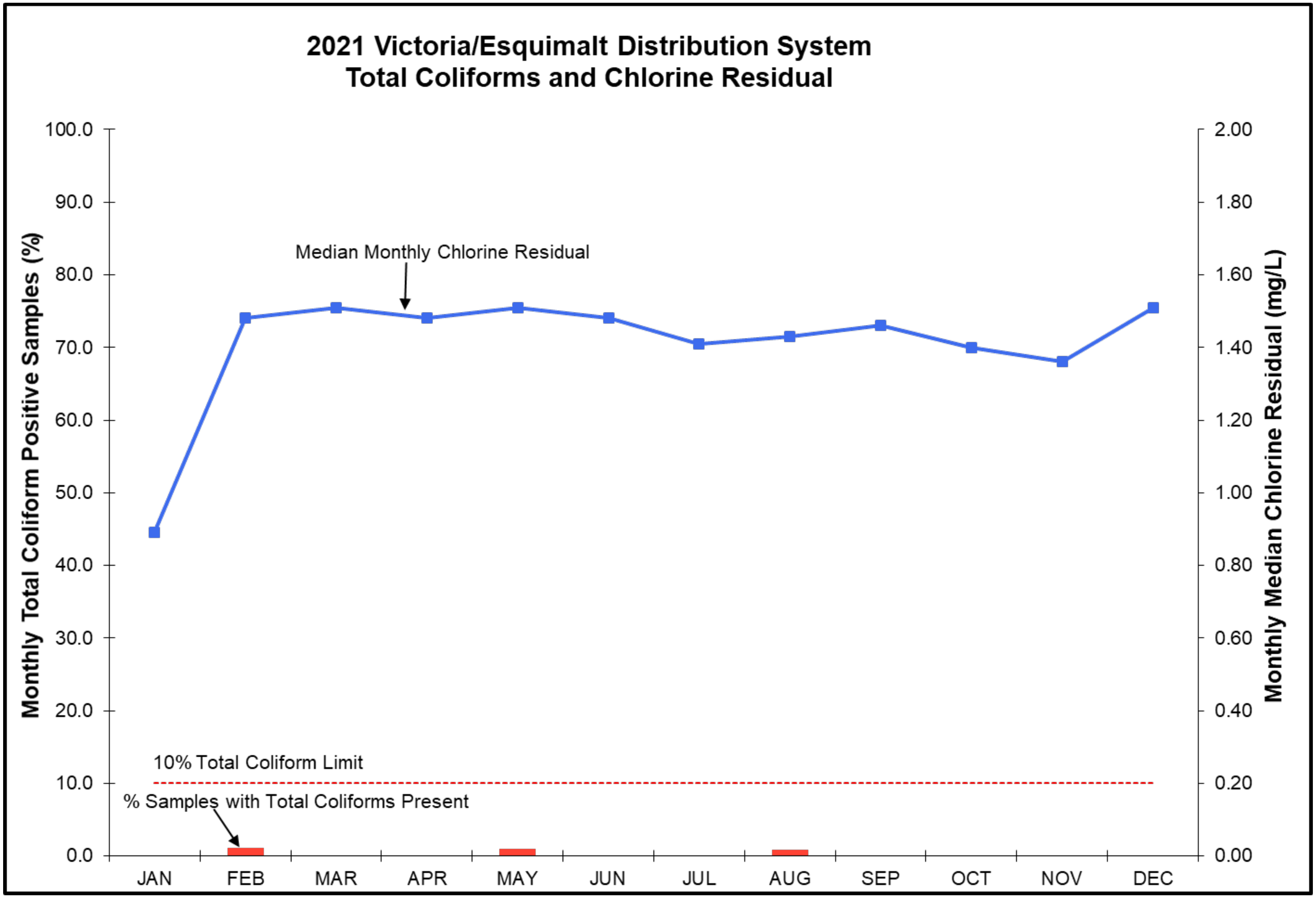

Figure 38 Victoria/Esquimalt Distribution System Total Coliforms and Chlorine Residuals in 2021

7.5 Water Quality Inquiry Program

Records of customer inquiries, including complaints about drinking water quality, have been maintained since 1992. In January 2021, as a result of the sudden switch to a free chlorine residual during repair works on the ammonia system, a flurry of several dozen customer complaints and concerns was received by Water Quality staff. The nature of the complaints was typically a strong and unusual chlorine/bleach taste and odour. On January 13, 2021, the CRD issued a taste and odour advisory to the public upon which the number of calls and emails subsided. Besides this particular event, 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-May, September-December) in the distribution systems, complaints or concerns about water discolouration were more prevalent. Throughout the year, a number of inquiries or complaints about chlorine taste and odour were received in 2021, but most of these were of a general nature where people object to the addition of any chemical to the drinking water.

CRD staff have communicated regularly with Island Health hospital facility management staff to provide useful water quality information to these facilities. No hospital staff complaints or concerns were raised in 2021.

The continued absence of the intake screen until April 2021 did not result in any increase of customer concerns or complaints.

Due to the temporary switch to free chlorine residuals in January, the number of water quality complaints or inquiries in 2021 was higher than in previous years.

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 are 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. The heightened public awareness around health risks associated with lead in drinking water that was noticed in public interactions in previous years was somewhat subdued in 2021, likely as a result of the dominant attention to the Covid-19 public health risks throughout the year.

7.6 Cross Connection Control Program

This program was created based on an Order by the Chief Medical Health Officer of the Island Health Authority in 2005. Since then, it has become exemplary for an effective and efficient cross connection control program in Canada and it forms an important component of the multi-barrier concept in the Greater Victoria Drinking Water System. Working with Island Health, the 13 municipalities and participating electoral areas, the objective of this program is to identify, eliminate and prevent cross connections within the Greater Victoria Drinking Water System that could lead to drinking water contaminations. The CRD was tasked to take over the responsibility for this program under a newly-created Cross Connection Control Bylaw (enacted in 2006). In 2019, this bylaw saw its most recent update to bring the technical and administrative requirements in line with new provincial legislation. The method by which the program meets its objectives is enforcement of the cross connection control requirements under the BC Building Code and as described by the Canadian Standard Association, and through public education. CRD staff work with municipal building officials, industry professionals and business and facility owners to achieve the goals of the Cross Connection Control Program.

In 2021, the Cross Connection Control Program conducted a total of 394 facility audits on high risk (125) and moderate risk (269) facilities. The focus was on facilities in multi-unit residential buildings. The compliance rate, measured as facilities with outstanding deficiencies divided by the number of facilities audited, increased from 74% in 2020 to 78% by the end of 2021. This success is attributed to a shift to an outcome-oriented approach, coupled with effective outreach campaigns. It is expected that this compliance rate will further increase in future years.

In total, by the end of 2021, the Cross Connection Control Program had 27,484 cross connection control devices registered in its database (up from 27,147 in 2020). These devices were installed in 13,381 registered facilities across the region. On all testable devices, a total of 20,555 test reports (11,400 digital, 9,155 paper) were received and recorded by CRD staff in 2021. The compliance rate for getting testable devices tested in accordance with the bylaw was 73%.

8.0 CONCLUSIONS

1. The water quality data collected in 2021 indicate that the drinking water in Greater Victoria was of good quality and safe to drink. The drinking water temperature exceeded the aesthetic objective of 15°C between mid-July and early 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 2021. Total coliform concentrations during the summer months were on average higher than in previous years but very low during the rest of the year. The higher total coliform concentrations may be correlated with the extreme weather conditions during the summer of 2021. This seasonal increase in bacteria load had no impact on the treated water quality. *E. coli* bacterial levels in the raw source water were low for the entire year.

4. Consumers in the GVDWS received drinking water that had very low disinfection byproducts. Overall levels of trihalomethanes and haloacetic acids remain well below the Canadian guidelines' limits and the USEPA limits. A temporary switch to free chlorine residuals in January resulted short-term in significantly higher concentrations of trihalomethanes and haloacetic acids. Albeit mostly below the health limits for long-term exposure, this event has demonstrated the importance of chloramination for disinfection byproduct management in the GVDWS. 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 2021 was in line with the long-term average trend in Sooke Lake Reservoir. The species that were active, and relatively abundant in 2021, belonged to known and 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 other 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 2021 was slightly higher due to the temporary switch to free chlorine in January. CRD issued a public advisory between January 13 and February 17, 2021 to alert customers of potentially stronger chlorine taste and odour in the drinking water. Aside from this event, the number and nature of customer complaints or inquiries were similar to previous years.

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

8. All systems did meet the monthly sampling requirements, as per *BC Drinking Water Protection Regulation.*

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 2021.

10. The Greater Victoria pH & Corrosion Study including a region-wide tap sampling program was completed in October 2021. The findings have been reported separately.

APPENDIX A
TABLE 1. UNTREATED (RAW) WATER QUALITY ENTERING GOLDSTREAM (JAPAN GULCH) WATER TREATMENT PLANT
(Guideline values provide reference only for untreated water)

PARAMETER		2021 ANALYTICAL RESULTS				CANADIAN GUIDELINES	TEN YEAR RESULTS (2012-2021)			Target Sampling Frequency
Parameter Name	Units of Measure	Median Value	Samples Analyzed	Range Minimum	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	**13.2**	16	13.2	16.7		15.2	158	8.84-19.1	12/yr
Carbon, Dissolved Organic	mg/L as C	**1.7**	12	1.1	2.6		1.7	116	ND-4.0	12/yr
Carbon,Total Organic	mg/L as C	**1.8**	12	1.6	2.7	Guideline Archived	1.9	117	0.82-3.9	12/yr
Colour, True	TCU	**6.0**	48	2.0	9.0	≤15 AO	6.4	532	ND-15.2	52/yr
Conductivity @ 25 C	uS/cm	**41.1**	49	39.2	46.7		42.2	522	27.5-59.3	52/yr
Hardness as $CaCO_3$	mg/L	**16.7**	7	16.1	18.3	No Guideline Required	17.3	153	6.95-20.9	6/yr
pH	pH units	**7.3**	71	6.5	7.6	7.0 - 10.5 AO	7.29	527	6.5-7.94	52/yr
Tannins and Lignins	mg/L	**ND**	2	ND	ND	Guideline Archived	0.22	21	ND-170	2/yr
Total Dissolved Solids	mg/L	**25.0**	12	ND	36.0	≤500 AO	26.8	112	ND-48	12/yr
Total Suspended Solids	mg/L	**ND**	12	ND	1.6		1	113	0.1-4	12/yr
Total Solids	mg/L	**30.0**	12	12.0	42.0		28	108	ND-48	12/yr
Turbidity, Grab Samples	NTU	**0.3**	243	0.2	1.2	1.0 Operational Guideline	0.32	2436	0.17-3.1	250/yr
Ultraviolet Absorption, 5 cm	Abs.@254 nm	**0.3**	49	0.2	0.3		0.26	502	0.16-88.2	52/yr
Ultraviolet Transmittance	%	**88.3**	48	86.4	91.3		88.8	527	0.2-94.4	52/yr
Water Temp., Grab Samples	degrees C	**9.9**	252	4.0	20.1	≤15 AO	10.3	2487	2.7-21	250/yr
Non-Metallic Inorganic Chemicals (ND means less than instrument can detect)										
Bromide	ug/L as Br	**ND**	4	ND	ND		ND	63	0.011-13	4/yr
Chloride	mg/L as Cl	**2.6**	3	2.3	4.90	≤ 250 AO	2.4	25	ND-4.58	4/yr
Cyanide	mg/L as Cn	**ND**	6	ND	0.002	0.2 MAC	ND	22	ND	4/yr
Fluoride	mg/L as F	**ND**	4	ND	ND	1.5 MAC	0.02	25	ND-0.07	4/yr
Iodide, dissolved	mg/L as I	**ND**	2	ND	ND		ND	8	ND	4/yr
Nitrate, Dissolved	ug/L as N	**ND**	12	ND	34.00	10000 MAC	ND	108	ND-222	12/yr
Nitrite, Dissolved	ug/L as N	**ND**	12	ND	ND	1000 MAC	ND	107	ND	12/yr
Nitrate + Nitrite	ug/L as N	**ND**	12	ND	34.00		ND	109	ND-55.1	12/yr
Nitrogen, Ammonia	ug/L as N	**ND**	12	ND	73.00	No Guideline Required	ND	111	0.079-130	12/yr
Nitrogen, Total Kjeldahl	ug/L as N	**129.5**	12	81	531.00		92.5	108	0-610	12/yr
Nitrogen, Total	ug/L as N	**147.5**	12	81	531.00		104	113	0-610	12/yr
Phosphate, Ortho, Dissolved	ug/L as P	**1.25**	12	ND	12.00		ND	109	ND	12/yr

Appendix A, Table 1, continued

Phosphate, Total, Dissolved	ug/L as P	**ND**	12	ND	2.10		ND	113	ND-31	12/yr
Phosphate,Total	ug/L as P	**1.35**	12	ND	5.20		3.46	113	ND-12.6	12/yr
Silica	mg/L as SiO_2	**4.4**	12	3.8	5.10		3.9	99	0.09-5.6	12/yr
Silicon	ug/L as Si	**2140**	7	1870	2270.00		1860	85	681-2520	6/yr
Sulphate	mg/L as SO_4	**1.5**	12	ND	2.10	≤ 500 AO	1.58	112	ND-8.16	12/yr
Sulphide	mg/L as H_2S	**ND**	13	ND	ND	≤ 0.05 AO	0.002	2	ND	12/yr
Sulphur	mg/L as S	**ND**	7	ND	ND		ND	84	ND	6/yr
Metallic Inorganic Chemicals (ND means less than instrument can detect)										
Aluminum	ug/L as Al	**17.2**	7	6.5	28.70	2900 MAC / 100 OG	15.1	85	ND-52.3	6/yr
Antimony	ug/L as Sb	**ND**	7	ND	ND	6 MAC	ND	85	ND	6/yr
Arsenic	ug/L as	**ND**	7	ND	ND	10 MAC	ND	85	ND-0.24	6/yr
Barium	ug/L as Ba	**3.7**	7	3.5	4.00	2000 MAC	3.8	85	1.6-5.3	6/yr
Beryllium	ug/L as Be	**ND**	7	ND	ND		ND	85	ND	6/yr
Bismuth	ug/L as Bi	**ND**	7	ND	ND		ND	85	ND	6/yr
Boron	ug/L as B	**ND**	7	ND	ND	5000 MAC	ND	85	ND	6/yr
Cadmium	ug/L as Cd	**ND**	7	ND	ND	7 MAC	ND	85	ND-0.07	6/yr
Calcium	mg/L as Ca	**4.81**	7	4.64	5.28	No Guideline Required	5	85	2.06-6.13	6/yr
Chromium	ug/L as Cr	**ND**	7	ND	ND	50 MAC	ND	85	ND	6/yr
Cobalt	ug/L as Co	**ND**	7	ND	ND		ND	85	ND	6/yr
Copper	ug/L as Cu	**0.81**	7	0.61	1.10	2000 MAC / ≤ 1000 AO	1.46	85	0.33-30.5	6/yr
Iron	ug/L as Fe	**19.8**	7	14.0	52.0	≤ 300 AO	30	85	12-217	6/yr
Lead	ug/L as Pb	**ND**	7	ND	ND	5 MAC	ND	85	ND-0.4	6/yr
Lithium	ug/L as Li	**ND**	7	ND	ND		ND	66	ND-10.4	6/yr
Magnesium	mg/L as Mg	**1.19**	7	1.09	1.24	No Guideline Required	1.18	85	0.44-1.6	6/yr
Manganese	ug/L as Mn	**4**	7	1.5	17.90	120 MAC / ≤ 20 AO	5.5	85	1.4-81.8	6/yr
Mercury, Total	ug/L as Hg	**ND**	7	ND	0.0021	1.0 MAC	ND	84	ND	6/yr
Molybdenum	ug/L as Mo	**ND**	7	ND	ND		ND	85	ND	6/yr
Nickel	ug/L as Ni	**ND**	7	ND	ND		ND	85	ND-2.3	6/yr
Potassium	mg/L as K	**0.13**	7	0.13	0.14		0.137	85	0.081-0.214	6/yr
Selenium	ug/L as Se	**ND**	7	ND	ND	50 MAC	ND	85	ND	6/yr
Silver	ug/L as Ag	**ND**	7	ND	ND	No Guideline Required	ND	85	ND-0.02	6/yr
Sodium	mg/L as Na	**1.63**	7	1.56	1.73	≤ 200 AO	1.7	85	0.65-2.91	6/yr
Strontium	ug/L as Sr	**14.9**	7	13.8	15.90	7000 MAC	15.4	85	6.3-21.8	6/yr
Thallium	ug/L as Tl	**ND**	7	ND	ND		ND	85	ND	6/yr
Tin	ug/L as Sn	**ND**	7	ND	ND		ND	85	ND	6/yr
Titanium	mg/L as Ti	**ND**	7	ND	ND		ND	89	ND	6/yr

Appendix A, Table 1, continued

Uranium	ug/L as U	**ND**	7	ND	ND	20 MAC	ND	85	ND	6/yr
Vanadium	ug/L as V	**ND**	7	ND	ND		ND	85	ND	6/yr
Zinc	ug/L as Zn	**ND**	7	ND	ND	≤ 5000 AO	ND	85	ND-82.9	6/yr
Zirconium	ug/L as Zr	**ND**	7	ND	ND	-	ND	85	ND	6/yr
Microbial Parameters										
Coliform Bacteria										
Coliforms, Total	Coliforms/100 mL	**8**	244	ND	260.00		11	2438	ND-24200	250/yr
E. coli	*E. coli*/100 mL	**ND**	244	ND	7.00		ND	2439	ND-15	250/yr
Heterotrophic / Other Bacteria										
Hetero. Plate Count, 28C (7 day)	CFU/1 mL	**220.0**	222.0	ND	800.0		350	2231	ND-7200	250/yr
Cyanobacterial Toxins										
Anatoxin a	ug/L	Analyzed as required - last analyzed in 2005								Special
Microcystin-LR	ug/L	Analyzed as required - last analyzed in 2011				1.5 MAC (Total Microcystins)	ND	1	ND	Special
Parasites										
Cryptosporidium, Total oocysts	oocysts/100 L	**ND**	8	ND	ND	Zero detection desirable	0	118	ND - 2	8/yr
Giardia, Total cysts	cysts/100 L	**ND**	8	ND	ND	Zero detection desirable	0	107	ND	8/yr
Radiological Parameters (ND means less than instrument can detect)										
Gross alpha radiation	Bq/L	**0.04**	2	ND	0.06	0.5 (Screening)	ND	21	ND	2/yr
Gross beta radiation	Bq/L	**ND**	2	ND	ND	1.0 (Screening)	ND	21	ND - 0.11	2/yr
Iodine-131	Bq/L	**ND**	2	ND	ND	6 Bq/L	ND	19	ND	Special
Cesium-134	Bq/L	**Not tested in 2021**					ND	14	ND	Special
Cesium-137	Bq/L	**0.15**	2	ND	ND	10 Bq/L	ND	19	ND	Special
Ruthenium-103	Bq/L	**Not tested in 2021**					ND	12	ND	Special
Uranium	ug/L as U	**ND**	7	ND	ND	20 MAC	ND	85	ND	6/yr

Appendix A, Table 1, continued

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	2/yr
1,4'-DDE	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	18	ND	2/yr
1,4'-DDT	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	18	ND	2/yr
2,4,5-T	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	19	ND	2/yr
2,4,5-TP (Silvex)	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	19	ND	2/yr
2,4-D (2,4-Dichlorophenoxyacetic acid)	ug/L	**ND**	2	ND	ND	100 MAC	ND	14	ND	2/yr
2,4-D (BEE)	ug/L	**ND**	2	ND	ND		ND	29	ND	2/yr
2,4-DP (Dichlorprop)	ug/L	**ND**	2	ND	ND		ND	18	ND	2/yr
4,4'-DDD	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	15	ND	2/yr
4,4'-DDE	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	18	ND	2/yr
4,4'-DDT	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	16	ND	2/yr
Alachlor	ug/L	**Not tested in 2021**				Guideline Archived	ND	7	ND	2/yr
Aldicarb	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	20	ND	2/yr
Aldrin	ug/L	**ND**	2	ND	ND		ND	19	ND	2/yr
Aldrin + Dieldrin	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	9	ND	2/yr
Atrazine	ug/L	**ND**	2	ND	ND	5 MAC	ND	20	ND	2/yr
Azinphos-methyl	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	21	ND	2/yr
BHC (alpha)	ug/L	**ND**	2	ND	ND		ND	19	ND	2/yr
BHC (beta)	ug/L	**ND**	2	ND	ND		ND	19	ND	2/yr
BHC (delta)	ug/L	**ND**	2	ND	ND		ND	15	ND	2/yr
Bendiocarb	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	20	ND	Irregular
Bromacil	ug/L	**ND**	2	ND	ND		ND	14	ND	2/yr
Bromoxynil	ug/L	**ND**	2	ND	ND	5.0 MAC	ND	17	ND	2/yr
Captan	ug/L	**ND**	2	ND	ND		ND	11	ND	2/yr
Carbaryl	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	20	ND	2/yr
Carbofuran	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	20	ND	2/yr
Chlordane (alpha)	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	16	ND	2/yr
Chlordane (gamma)	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	18	ND	2/yr
Chlorpyrifos (Dursban)	ug/L	**ND**	2	ND	ND	90 MAC	ND	20	ND	2/yr
Chlorothalonil	ug/L	**ND**	2	ND	ND		ND	12	ND	2/yr
Cyanazine (Bladex)	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	18	ND	2/yr
Demeton	ug/L	**ND**	2	ND	ND		ND	11	ND	2/yr
Desisopropylatrazine	ug/L	**ND**	2	ND	ND		Not reported prior to 2020			2/yr
Diazinon	ug/L	**ND**	2	ND	ND	Screening Value 30	ND	21	ND	2/yr
Dicamba	ug/L	**ND**	2	ND	ND	120 MAC	ND	20	ND	2/yr
Diclofop-methyl	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	16	ND	2/yr
Dichlorvos	ug/L	**ND**	2	ND	ND		ND	18	ND	2/yr
Dieldrin	ug/L	**ND**	2	ND	ND		ND	19	ND	2/yr
Dimethoate	ug/L	**ND**	2	ND	ND	20 MAC	ND	21	ND	2/yr
Dinoseb (DNBP)	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	4	ND	2/yr

Appendix A, Table 1, continued

Diquat	ug/L	**ND**	2	ND	ND	70 MAC	ND	19	ND	2/yr
Endosulfan I	ug/L	**ND**	2	ND	ND		ND	18	ND	2/yr
Endosulfan II	ug/L	**ND**	2	ND	ND		ND	18	ND	2/yr
Endosulfan Sulphate	ug/L	**ND**	2	ND	ND		ND	19	ND	2/yr
Endosulfan (Total)	ug/L	**ND**	2	ND	ND		ND	17	ND	2/yr
Endrin	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	19	ND	2/yr
Endrin Aldehyde	ug/L	**ND**	2	ND	ND		ND	20	ND	2/yr
Endrin Ketone	ug/L	**ND**	2	ND	ND		ND	19	ND	2/yr
Ethion	ug/L	**ND**	2	ND	ND		ND	19	ND	2/yr
Parathion Ethyl	ug/L	**ND**	2	ND	ND		ND	19	ND	2/yr
Fenchlorophos (Ronnel)	ug/L	**ND**	2	ND	ND		ND	17	ND	2/yr
Fenthion	ug/L	**ND**	2	ND	ND		ND	17	ND	2/yr
Fonofos	ug/L	**ND**	2	ND	ND		ND	19	ND	2/yr
Glyphosate	ug/L	**ND**	2	ND	ND	280 MAC	ND	20	ND	2/yr
Heptachlor	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	19	ND	2/yr
Heptachlor Epoxide	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	19	ND	2/yr
Imazapyr	ug/L	**ND**	2	ND	ND		ND	11	ND	2/yr
Imidacloprid	ug/L	**ND**	2	ND	ND		ND	11	ND	2/yr
IPBC	ug/L	**ND**	2	ND	ND		ND	11	ND	2/yr
Lindane (Hch-gamma)	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	18	ND	2/yr
Malathion	ug/L	**ND**	2	ND	ND	190 MAC	ND	21	ND	2/yr
MCPA	ug/L	**ND**	4	ND	ND	100 MAC	ND	24	ND	2/yr
MCPP	ug/L	**ND**	2	ND	ND		ND	18	ND	2/yr
Methoxychlor	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	18	ND	2/yr
Methyl Parathion	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	20	ND	2/yr
Metolachlor	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	20	ND	2/yr
Metribuzin (Sencor)	ug/L	**ND**	2	ND	ND	80 MAC	ND	17	ND	2/yr
Mevinphos	ug/L	**ND**	2	ND	ND		ND	18	ND	2/yr
Mirex	mg/L	**ND**	2	ND	ND	Guideline Archived	ND	19	ND	2/yr
Nitrilotriacetic acid (NTA)	ug/L	**ND**	2	ND	ND	400 MAC	ND	19	ND-0.1	Irregular
Oxychlordane	ug/L	**ND**	2	ND	ND		ND	11	ND	2/yr
Parathion	ug/L	**ND**	4	ND	ND	Guideline Archived	ND	17	ND	2/yr
Paraquat (ion)	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	19	ND	2/yr
Permethrin	ug/L	**ND**	2	ND	ND		ND	12	ND	2/yr
Phorate (Thimet)	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	20	ND	2/yr
Phosmet	ug/L	**ND**	2	ND	ND		ND	19	ND	2/yr
Picloram	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	20	ND	2/yr
Prometryn	ug/L	**ND**	2	ND	ND		ND	17	ND	Irregular
Simazine	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	20	ND	2/yr
Tebuthiuron	ug/L	**ND**	2	ND	ND		ND	11	ND	2/yr
Temephos	ug/L	**Not tested in 2021**				Guideline Archived	ND	5	ND	2/yr
Terbufos	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	21	ND	2/Yyr
Toxaphene	ug/L	**Not tested in 2021**				Guideline Archived	ND	11	ND	2/Yyr
Trifluralin	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	21	ND	2/Yyr

Appendix A, Table 1, continued

Polycyclic Aromatic Hydrocarbons (PAH's)										
Acenaphthene	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	21	ND	2/yr
Acenaphthylene	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	21	ND	2/yr
Anthracene	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	21	ND	2/yr
Benzo(a)anthracene	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	21	ND	2/yr
Benzo(a)pyrene	ug/L	**ND**	2	ND	ND	0.04 MAC	ND	20	ND	2/yr
Benzo(b)fluoranthene	ug/L	**Not tested in 2021**				Guideline Archived	ND	18	ND	2/yr
Benzo(g,h,i)perylene	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	21	ND	2/yr
Benzo(b&j)fluoranthene	ug/L	**ND**	2	ND	ND	Guideline Archived	Not reported prior to 2020			2/yr
Benzo(k)fluoranthene	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	21	ND	2/yr
Chrysene	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	21	ND-0.03	2/yr
Dibenz(a,h)anthracene	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	20	ND-0.04	2/yr
Fluoranthene	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	21	ND-0.02	2/yr
Fluorene	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	21	ND-0.03	2/yr
Indeno(1,2,3-c,d)pyrene	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	20	ND	2/yr
Naphthalene	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	20	ND	2/yr
Phenanthrene	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	21	ND-0.08	2/yr
Pyrene	ug/L	**0.02**	2	ND	ND	Guideline Archived	ND	21	ND	2/yr
Volatile Hydrocarbons	ug/L	**ND**	3	ND	ND	Guideline Archived	ND	26	ND	2/yr
Phenols										
2,3,4,5-Tetrachlorophenol	ug/L	**ND**	2	ND	ND		ND	11	ND	2/yr
2,3,4,6-Tetrachlorophenol	ug/L	**ND**	2	ND	ND	100 MAC and ≤ 1.0 AO	ND	17	ND	2/yr
2,3,5,6-Tetrachlorophenol	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	10	ND	2/yr
2,4,6-Trichlorophenol	ug/L	**ND**	2	ND	ND	5.0 MAC and ≤ 2.0 AO	ND	20	ND	2/yr
2,4-Dichlorophenol	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	11	ND	2/yr
2,4-Dimethylphenol	ug/L	**ND**	2	ND	ND		ND	20	ND	2/yr
2,4-Dinitrophenol	ug/L	**ND**	2	ND	ND		ND	21	ND	2/yr
2-Chlorophenol	ug/L	**ND**	2	ND	ND		ND	21	ND	2/yr
2-Nitrophenol	ug/L	**ND**	2	ND	ND		ND	18	ND	2/yr
4,6-Dinitro-2-Methylphenol	ug/L	**ND**	2	ND	ND		ND	21	ND	2/yr
4-Chloro-3-Methylphenol	ug/L	**ND**	2	ND	ND		ND	21	ND	2/yr
4-Nitrophenol	ug/L	**ND**	2	ND	ND		ND	21	ND	2/yr
Alpha-Terpineol	ug/L	**ND**	2	ND	ND		ND	21	ND	2/yr
Pentachlorophenol	ug/L	**ND**	2	ND	ND	60 MAC and ≤ 30 AO	ND	20	ND	2/yr
Phenol	ug/L	**ND**	2	ND	ND		ND	21	0.002-6.2	2/yr
Total Phenolics	ug/L	ND	2	ND	ND	Guideline Archived	ND	14	ND-8.2	2/yr

Appendix A, Table 1, continued

Polychlorinated Biphenyls (PCBs)											
PCB-1016	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	17	ND-ND	Irregular	
PCB-1221	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	17	ND-ND	Irregular	
PCB-1232	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	17	ND-ND	Irregular	
PCB-1242	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	17	ND-ND	Irregular	
PCB-1248	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	17	ND-ND	Irregular	
PCB-1254	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	17	ND-ND	Irregular	
PCB-1260	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	18	ND-ND	Irregular	
PCB-1262	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	7	ND-ND	Irregular	
PCB-1268	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	7	ND-ND	Irregular	
Total PCBs	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	17	ND-ND	Irregular	
Other Synthetic Chemicals											
1,1,1-Trichloroethane	ug/L	**ND**	2	ND	ND		ND	21	ND		
1,1,1,2-Tetrachloroethane	ug/L	**ND**	2	ND	ND		ND	23	ND		
1,1,2,2-Tetrachloroethane	ug/L	**ND**	2	ND	ND		ND	21	ND		
1,1,2-Trichloroethane	ug/L	**ND**	2	ND	ND		ND	21	ND		
1,1-Dichloroethane	ug/L	**ND**	2	ND	ND		ND	21	ND		
1,1-Dichloroethene (1,1-Dichloroethylene)	ug/L	**ND**	2	ND	ND	14 MAC	ND	21	ND		
1,2,3-Trichlorobenzene	ug/L	**ND**	2	ND	ND		ND	16	ND		
1,2,4-Trichlorobenzene	ug/L	**ND**	2	ND	ND		ND	21	ND-0.2		
1,2-Dibromoethane	ug/L	**ND**	2	ND	ND		ND	20	ND		
1,2-Dichlorobenzene	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	21	ND		
1,2-Dichloroethane	ug/L	**ND**	2	ND	ND	5.0 MAC	ND	19	ND		
1,2-Dichloroethene (cis)	ug/L	**ND**	2	ND	ND		ND	21	ND		
1,2-dichloroethene (trans)	ug/L	**ND**	2	ND	ND		ND	21	ND		
1,2-Dichloropropane	ug/L	**ND**	2	ND	ND		ND	21	ND		
1,2-Diphenylhydrazine	ug/L	**ND**	2	ND	ND		ND	21	ND		
1,3-Dichlorobenzene	ug/L	**ND**	2	ND	ND		ND	20	ND		
1,3-Dichloropropene (cis)	ug/L	**ND**	2	ND	ND		ND	21	ND		
1,3-Dichloropropene (trans)	ug/L	**ND**	2	ND	ND		ND	21	ND		
1,4-Dichlorobenzene	ug/L	**ND**	2	ND	ND	5.0 MAC and ≤ 1.0 AO	ND	20	ND		
2,4-Dinitrotoluene	ug/L	**ND**	2	ND	ND		ND	21	ND		
2,6-Dinitrotoluene	ug/L	**ND**	2	ND	ND		ND	21	ND		
2-Chloronaphthalene	ug/L	**ND**	2	ND	ND		ND	21	ND		
1-Methylnaphthalene	ug/L	**ND**	2	ND	ND		ND	6	ND		
2-Methylnaphthalene	ug/L	**ND**	2	ND	ND		ND	21	ND		
3,3'-Dichlorobenzidene	ug/L	**ND**	2	ND	ND		ND	20	ND		
4-Bromophenyl-phenylether	ug/L	**ND**	2	ND	ND		ND	21	ND		

Appendix A, Table 1, continued

4-Chlorophenyl-phenylether	ug/L	**ND**	2	ND	ND		ND	21	ND	
Atrazine	ug/L	**ND**	2	ND	ND	5.0 MAC	ND	20	ND	
Atrazine + Desethyl Atrazine	ug/L	**ND**	2	ND	ND		ND	8	ND	
Benzene	ug/L	**ND**	4	ND	ND	5.0 MAC	ND	26	ND	
Benzidine	ug/L	**Not tested in 2021**					ND	13	ND	
Bis(-2-chloroethoxy) methane	ug/L	**ND**	2	ND	ND		ND	1	ND	
Bis(-2-chloroethyl) ether	ug/L	**ND**	2	ND	ND		ND	21	ND	
Bis(2-chloroisopropyl) ether	ug/L	**ND**	2	ND	ND		ND	1	ND	
Bis(2-ethylhexyl) phthalate	ug/L	**ND**	2	ND	ND		ND	21	ND-1.7	
Bromodichloromethane	ug/L	**ND**	2	ND	ND		ND	21	ND	
Bromobenzene	ug/L	**ND**	2	ND	ND		ND	13	ND	
Bromoform	ug/L	**ND**	2	ND	ND		ND	20	ND	
Bromomethane	ug/L	**ND**	2	ND	ND		ND	21	ND	
Butylbenzyl phthalate	ug/L	**ND**	2	ND	ND		ND	19	ND	
Carbon Tetrachloride (Tetrabromomethane)	ug/L	**ND**	2	ND	ND	2.0 MAC	ND	21	ND	
Chloroform	ug/L	**ND**	2	ND	ND		ND	21	ND	
Chloroethane	ug/L	**ND**	2	ND	ND		ND	21	ND	
Chloromethane	ug/L	**ND**	2	ND	ND		ND	21	ND	
Desethyl Atrazine	ug/L	**ND**	2	ND	ND		ND	15	ND	
Dibromochloromethane	ug/L	**ND**	2	ND	ND		ND	7	ND	
Dibromomethane	ug/L	**ND**	2	ND	ND		ND	7	ND	
Dichlorodifluoromethane	ug/L	**ND**	2	ND	ND		ND	16	ND	
Dichloromethane	ug/L	**ND**	2	ND	ND	50 MAC	ND	20	ND	
Diethyl phthalate	ug/L	**ND**	2	ND	1.00		ND	20	ND-0.6	
Dimethyl phthalate	ug/L	**ND**	2	ND	ND		ND	20	ND	
Di-n-butyl phthalate	ug/L	**ND**	2	ND	ND		ND	19	ND-4.9	
Di-n-ocyl phthalate	ug/L	**ND**	2	ND	ND		ND	20	ND	
Diuron	ug/L	**ND**	2	ND	ND	Screening Value 15	ND	14	ND	
Ethylbenzene	ug/L	**ND**	4	ND	ND	140 MAC and ≤ 1.6 AO	ND	26	ND	
Formaldehyde	ug/L	**ND**	4	ND	ND	No Guideline Required	ND	19	ND	
Hexachlorobenzene	ug/L	**ND**	2	ND	ND		ND	20	ND	
Hexachlorobutadiene	ug/L	**ND**	4	ND	ND		ND	25	ND	
Hexachlorocyclopentadiene	ug/L	**ND**	2	ND	ND		ND	22	ND	
Hexachloroethane	ug/L	**ND**	2	ND	ND		ND	22	ND	
Isophorone	ug/L	**ND**	2	ND	ND	30 MAC	ND	21	ND	
Methyltertiarybutylether (MTBE)	ug/L	**ND**	4	ND	ND	15 AO	ND	32	ND	
Monochlorobenzene	ug/L	**ND**	2	ND	0.00	Guideline Archived	ND	21	ND	
Nitrobenzene	ug/L	**ND**	2	ND	ND	0.04 MAC	ND	21	ND	
N-nitroso-di-n-propylamine	ug/L	**ND**	2	ND	ND		ND	20	ND	
N-nitrosodiphenylamine	ug/L	**ND**	2	ND	ND		ND	21	ND	
Octachlorostyrene	ug/L	**ND**	2	ND	ND		ND	20	ND	
Styrene	ug/L	**ND**	4	ND	ND		ND	26	ND	
Tetrachloroethene	ug/L	**ND**	2	ND	ND	10 MAC	ND	21	ND	
Toluene	ug/L	**ND**	4	ND	ND	60 MAC and ≤ 24 AO	ND	26	ND	

Appendix A, Table 1, continued

Triallate	ug/L	**ND**	2	ND	ND	Guideline Archived	ND	20	ND	
Trichloroethene	ug/L	**ND**	2	ND	ND	5.0 MAC	ND	18	ND	
Trichlorofluoromethane	ug/L	**ND**	2	ND	ND		ND	20	ND	
Trichlorotrifluoroethane	ug/L	**ND**	2	ND	ND		ND	11	ND	
Vinyl Chloride	ug/L	**ND**	2	ND	ND	2.0 MAC	ND	21	ND	
o-Xylene	ug/L	**ND**	4	ND	ND		ND	26	ND	
m&p-Xylene	ug/L	**ND**	4	ND	ND		ND	25	ND	
Xylenes (Total)	ug/L	**ND**	4	ND	ND	90 MAC and ≤ 20 AO	ND	25	ND	
Miscellaneous										
Perfluorobutanioc Acid	ug/L	**ND**	2	ND	ND		ND	1	ND	2/yr
Perfluoropentanoic Acid (PFPeA)	ug/L	**ND**	2	ND	ND		ND	1	ND	2/yr
Perfluorohexanoic Acid (PFHxA)	ug/L	**ND**	2	ND	ND		ND	1	ND	2/yr
Perfluoroheptanoic Acid (PFHpA)	ug/L	**ND**	2	ND	ND		ND	1	ND	2/yr
Perfluorooctanoic Acid (PFOA)	ug/L	**ND**	2	ND	ND	0.2 MAC	ND	1	ND	2/yr
Perfluorononanoic Acid (PFNA)	ug/L	**ND**	2	ND	ND		ND	1	ND	2/yr
Perfluorodecanoic Acid (PFDoA)	ug/L	**ND**	2	ND	ND		ND	1	ND	2/yr
Perfluoroundecanoic Acid (PFUnA)	ug/L	**ND**	2	ND	ND		ND	1	ND	2/yr
Perflurotridecanoic Acid	ug/L	**ND**	2	ND	ND		ND	1	ND	2/yr
Perfluorotetradecnoic Acid	ug/L	**ND**	2	ND	ND		ND	1	ND	2/yr
Perfluorobutanesulfonic Acid	ug/L	**ND**	2	ND	ND		ND	1	ND	2/yr
Perfluoropentanesulfonic Acid	ug/L	**ND**	2	ND	ND		ND	1	ND	2/yr
Perfluorohexanesulfonic Acid	ug/L	**ND**	2	ND	ND		ND	1	ND	2/yr
Perfluoroheptanesulfonic Acid	ug/L	**ND**	2	ND	ND		ND	1	ND	2/yr
Perfluorooctanesulfonic Acid	ug/L	**ND**	2	ND	ND		ND	1	ND	2/yr
Perfluorononane sulfonic Acid (PFOS)	ug/L	**ND**	2	ND	ND	0.6 MAC	ND	1	ND	2/yr
Perfluorodecanesulfonic Acid (PFDS)	ug/L	**ND**	2	ND	ND		ND	1	ND	2/yr
Perfluorooctane Sulfonamide (PFOSA)	ug/L	**ND**	2	ND	ND		ND	1	ND	2/yr
4:2 Flurotelomer Sulfonic Acid	ug/L	**ND**	2	ND	ND		ND	1	ND	2/yr
6:2 Flurotelomer Sulfonic Acid	ug/L	**ND**	2	ND	ND		ND	1	ND	2/yr
8:2 Flurotelomer Sulfonic Acid	ug/L	**ND**	2	ND	ND		ND	1	ND	2/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 2. 2021 TREATED WATER QUALITY AFTER GOLDSTREAM (JAPAN GULCH) WATER TREATMENT PLANT

PARAMETER		2021 ANALYTICAL RESULTS				CANADIAN GUIDELINES	TEN YEAR RESULTS (2012-2021)			Target Sampling Frequency
Parameter Name	Units of Measure	Median Value	Samples Analyzed	Range Minimum	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	**16.7**	31	11.2	18.5		13.4	183	6.92-18.8	12/yr
Carbon, Dissolved Organic	mg/L	**1.55**	12	ND	2.3		1.76	115	0.59-370	12/yr
Carbon, Total Organic	mg/L	**1.65**	12	1.1	2.1	Guideline Archived	1.8	115	0.93-4.99	12/yr
Colour, True	TCU	**3**	96	ND	7	≤ 15 AO	4	665	ND-30	52/yr
Conductivity @ 25 C	uS/cm	**50.2**	97	41.5	56.1		45.4	649	30.5-152	52/yr
Hardness as $CaCO_3$	mg/L	**16.6**	12	15.6	18.4	No Guideline Required	17.3	179	7.19-22.1	12/yr
Odour	Odour Profile	**1**	400	1	2	Inoffensive	1	2962	1 - 3	250/yr
pH	pH units	**7.5**	173	6.6	8.5	7.0-10.5 AO	7.1	652	6.5-8.1	52/yr
Taste	Flavour Profile	**1**	457	1	2	Inoffensive	1	2951	1 - 3	250/yr
Total Dissolved Solids	mg/L	**35**	12	20	48	≤500 AO	27	111	ND-78	12/yr
Total Suspended Solids	mg/L	**ND**	12	ND	2.4		ND	110	0.07-11	12/yr
Total Solids	mg/L	**38**	12	14	70		29	107	ND	12/yr
Turbidity, Grab Samples	NTU	**0.2**	466	0.15	0.8	1 Operational and ≤ 5 AO	0.33	3049	0.14-6.3	250/yr
Water Temperature, Grab Samples	degrees C	**9.6**	468	3.7	20.1	≤ 15 AO	9.5	3194	2.5-21.1	250/yr
Non-Metallic Inorganic Chemicals (ND means less than instrument can detect)										
Bromate	mg/L as BrO3	**ND**	10	ND	0.011	0.01 MAC	ND	9	ND-6.77	
Bromide	ug/L as Br	**ND**	4	ND	ND		ND	64	0.018-43	4/yr
Chloride	mg/L as Cl	4.4	3	2.5	4.60	≤ 250 AO	4.24	27	ND-5.4	4/yr
Chlorate, dissolved	mg/L as ClO2	ND	13	ND	ND	1 MAC	ND	3	ND	4/yr
Chlorite, dissolved	mg/L as ClO3	ND	7	ND	ND	1 MAC	ND	3	ND	4/yr
Cyanide	mg/L as Cn	**ND**	6	ND	0.005	0.2 MAC	ND	23	ND	4/yr
Fluoride	mg/L as F	**ND**	4	ND	ND	1.5 MAC	ND	19	ND-0.04	4/yr
Nitrate, Dissolved	ug/L as N	**ND**	12	ND	32	10000 MAC	10	107	ND-61.7	12/yr
Nitrite, Dissolved	ug/L as N	**ND**	12	ND	ND	1000 MAC	ND	110	ND-25	12/yr
Nitrate + Nitrite	ug/L as N	**ND**	12	ND	32		ND	109	ND-61.7	12/yr
Nitrogen, Ammonia	ug/L as N	**260**	12	ND	760		120	112	0.11-500	12/yr
Nitrogen, Total Kjeldahl	ug/L as N	**403**	12	157	950		259	107	0.0003-490	12/yr
Nitrogen, Total	ug/L as N	**418**	12	189	976		259	113	0.0002-508	12/yr
Phosphate, Ortho, Dissolved	ug/L as P	**1.2**	12	ND	3		ND	109	ND-6.2	12/yr
Phosphate, Total, Dissolved	ug/L as P	**ND**	12	ND	4.6		2.7	113	ND-18	12/yr

Appendix A, Table 2, continued

Phosphate, Total	ug/L as P	**1.75**	12	ND	3.4		3.33	113	ND-14	12/yr
Silica	mg/L as SiO2	**4.4**	12	4.1	5.2		3.91	98	0.09-5.3	12/yr
Silicon	ug/L as Si	**2075**	12	1760	2310		1,880.00	114	693-2740	12/yr
Sulphate	mg/L as SO4	**1.45**	12	ND	3.9	≤ 500 AO	1.62	110	0.8-5.31	12/yr
Sulphide	mg/L as H2S	**ND**	13	ND	0.028	≤ 0.05 AO	ND	59	ND-0.1	12/yr
Sulfur	mg/L as S	**ND**	12	ND	ND		ND	114	ND	12/yr
Metallic Inorganic Chemicals (ND means less than instrument can detect)										
Aluminum	ug/L as Al	**16.4**	12	5.8	30	2900 MAC / 100 OG	15.8	114	4.5-67.7	12/yr
Antimony	ug/L as Sb	**ND**	12	ND	ND	6 MAC	ND	114	ND	12/yr
Arsenic	ug/L as	**ND**	12	ND	ND	10 MAC	ND	114	0.04-0.17	12/yr
Barium	ug/L as Ba	**3.6**	12	3.3	4.1	2000 MAC	3.8	114	1.4-4.8	12/yr
Beryllium	ug/L as Be	**ND**	12	ND	ND		ND	113	ND	12/yr
Bismuth	ug/L as Bi	**ND**	12	ND	ND		ND	114	ND	12/yr
Boron	ug/L as B	**ND**	12	ND	ND	5000 MAC	ND	114	ND	12/yr
Cadmium	ug/L as Cd	**ND**	12	ND	ND	7 MAC	ND	114	ND	12/yr
Calcium	mg/L as Ca	**4.76**	12	4.45	5.4	No Guideline Required	4.99	114	2.1-6.82	12/yr
Chromium	ug/L as Cr	**ND**	12	ND	ND	50 MAC	ND	114	ND-1.2	12/yr
Cobalt	ug/L as Co	**ND**	12	ND	ND		ND	114	ND	12/yr
Copper	ug/L as Cu	**2.3**	12	1.12	7	2000 MAC / ≤ 1000 AO	17.1	114	1.03-202	12/yr
Iron	ug/L as Fe	**23.5**	12	12.1	57.5	≤ 300 AO	28.2	114	12.2-198	12/yr
Lead	ug/L as Pb	**ND**	12	ND	ND	5 MAC	ND	114	ND-0.92	12/yr
Lithium	ug/L as Li	**ND**	12	ND	ND		ND	75	ND-13.5	12/yr
Magnesium	mg/L as Mg	**1.14**	12	1.07	1.23	No Guideline Required	1.16	114	0.15-1.6	12/yr
Manganese	ug/L as Mn	**3.15**	12	1.4	16.1	120 MAC / ≤ 20 AO	4.85	114	1.4-51.1	12/yr
Mercury, Total	ug/L as Hg	**ND**	12	ND	ND	1.0 MAC	ND	112	ND	12/yr
Molybdenum	Ug/L as Mo	**ND**	12	ND	ND		ND	114	ND-3.0	12/yr
Nickel	mg/L as Ni	**ND**	12	ND	ND		ND	114	0.21-16	12/yr
Potassium	mg/L as K	**0.13**	12	0.12	0.14		0.14	114	0.07-0.22	12/yr
Selenium	ug/L as Se	**ND**	12	ND	ND	50 MAC	ND	114	ND	12/yr
Silver	ug/L as Ag	**ND**	12	ND	ND	No Guideline Required	ND	114	ND-0.06	12/yr
Sodium	mg/L as Na	**3.12**	12	1.58	3.36	≤ 200 AO	1.7	114	0.67-3.56	12/yr
Strontium	ug/L as Sr	**14.9**	12	13.7	16.3	7000 MAC	15.4	114	6.3-19.7	12/yr
Thallium	ug/L as Tl	**ND**	12	ND	ND		ND	114	ND	12/yr
Tin	ug/L as Sn	**ND**	12	ND	ND		ND	114	ND	12/yr
Titanium	ug/L as Ti	**ND**	12	ND	ND		ND	114	ND	12/yr
Uranium	ug/L as U	**ND**	12	ND	ND	20 MAC	ND	114	ND	12/yr
Vanadium	ug/L as V	**ND**	12	ND	ND		ND	114	ND	12/yr
Zinc	ug/L as Zn	**ND**	12	ND	ND	≤ 5000 AO	ND	114	0.37-82	12/yr
Zirconium	ug/L as Zr	**ND**	12	ND	ND		ND	114	ND	12/yr

Appendix A, Table 2, continued

Microbial Parameters (ND means less than method or instrument can detect)										
Coliform Bacteria										
Coliforms, Total	CFU/100 mL	**ND**	469	ND	4	0 MAC	ND	3056	ND-85	250/yr
E. coli	CFU/100 mL	**ND**	467	ND	ND	0 MAC	ND	3059	ND	250/yr
Heterotrophic/Other Bacteria										
Hetero. Plate Count, 28C (7 day)	CFU/1 mL	**ND**	219	ND	200		ND	2303	ND-770	250/yr
Disinfectants (ND means less than instrument can detect)										
Disinfectants										
Chlorine, Total Residual	mg/L as Cl_2	**1.84**	470	0.8	2.17	No Guideline Required (chloramines)	1.36	3223	0.83-2.17	250/yr
Monochloramine	mg/L as Cl_2	**1.74**	445	0	2.04		1.69	3035	0.03-2.17	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. 2021 TREATED WATER QUALITY AFTER SOOKE RIVER ROAD WATER TREATMENT PLANT

PARAMETER		2021 ANALYTICAL RESULTS				CANADIAN GUIDELINES	TEN YEAR RESULTS (2012-2021)			Target Sampling Frequency
Parameter Name	Units of Measure	Median Value	Samples Analyzed	Range Minimum	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	**16.2**	14	7.5	17.7		16.4	70	7.1-19	12/yr
Colour, True	TCU	**ND**	36	ND	5.0	≤ 15 AO	3.3	219	1-11.3	52/yr
Conductivity @ 25 C	uS/cm	**55.8**	36	50.1	59.7		56.9	214	26.4-71.6	52/yr
Hardness as $CaCO_3$	mg/L	**16.7**	6	15.8	23.9	No Guideline Required	16.9	29	15.3-18.7	6/yr
Odour	Flavour Profile	**1.0**	38	1.0	1.0	Inoffensive	1	229	44652	52/yr
pH	pH units	**7.6**	39	7.1	8.3	7.0-10.5 AO	7.5	213	7.1-8.3	52/yr
Taste	Flavour Profile	**1.0**	39	1.0	1.0	Inoffensive	1	229	44593	52/yr
Turbidity, Grab Samples	NTU	**0.2**	40	0.2	0.3	1 MAC	0.3	238	ND-0.55	52/yr
Water Temperature, Grab Samples	degrees C	**9.9**	40	4.7	18.9	≤ 15 AO	11.1	238	1.2-20	52/yr
Microbial Parameters (ND means less than instrument can detect)										
Coliform Bacteria										
Coliform, Total	CFU/100 mL	**ND**	40	ND	ND	0 MAC	ND	240	ND	52/yr
E. coli	CFU/100 mL	**ND**	40	ND	ND	0 MAC	ND	240	ND	52/yr
Heterotrophic Bacteria										
Hetero. Plate Count, 28C (7 day)	CFU/1 mL	**ND**	33	ND	40		ND	207	ND-210	52/yr
Disinfectants (ND means less than instrument can detect)										
Disinfectants										
Chlorine, Total Residual	mg/L as Cl_2	**1.88**	40	1.33	2.4	3.0 MAC (chloramines)	1.81	241	0.90-2.31	52/yr
Monochloramine	mg/L as Cl_2	**1.69**	40	1.28	2.01		1.59	73	1.15-2.16	52/yr

Appendix A, Table 3, continued

Metallic Inorganic Chemicals (ND means less than instrument can detect)										
Aluminum	ug/L as Al	**13.9**	6	6.3	18.9	2900 MAC / 100 OG	13.9	29	5.3-22.7	6/yr
Antimony	ug/L as Sb	**ND**	6	ND	ND	6 MAC	ND	29	ND	6/yr
Arsenic	ug/L aAs	**ND**	6	ND	ND	10 MAC	ND	29	ND	6/yr
Barium	ug/L as Ba	**3.7**	6	3.4	3.8	2000 MAC	3.7	29	3.3-4.2	6/yr
Beryllium	ug/L as Be	**ND**	6	ND	ND		ND	29	ND	6/yr
Bismuth	ug/L as Bi	**ND**	6	ND	ND		ND	29	ND	6/yr
Boron	ug/L as B	**ND**	6	ND	ND	5000 MAC	ND	29	ND	6/yr
Cadmium	ug/L as Cd	**ND**	6	ND	ND	7 MAC	ND	29	ND-0.02	6/yr
Calcium	mg/L as Ca	**4.8**	6	4.5	7.7	No Guideline Required	4.92	31	4.31-5.43	6/yr
Chromium	ug/L as Cr	**ND**	6	ND	ND	50 MAC	ND	29	ND	6/yr
Cobalt	ug/L as Co	**ND**	6	ND	ND		ND	29	ND	6/yr
Copper	ug/L as Cu	**22.7**	6	14.6	41.8	2000 MAC / ≤ 1000 AO	30.4	29	10.9-80.4	6/yr
Iron	ug/L as Fe	**26.9**	6	12.3	34.8	≤ 300 AO	24.4	29	12-53	6/yr
Lead	ug/L as Pb	**ND**	6	ND	ND	5 MAC	0.26	30	ND-0.64	6/yr
Lithium	ug/L as Li	**ND**	6	ND	ND		ND	11	ND	6/yr
Magnesium	mg/L as Mg	**1.15**	6	1.09	1.28	No Guideline Required	1.15	29	1-1.34	6/yr
Manganese	ug/L as Mn	**2.5**	6	1.3	4.9	120 MAC / ≤ 20 AO	3.6	2.9	1.3-10	6/yr
Mercury, Total	ug/L as Hg	**ND**	6	ND	ND	1.0 MAC	ND	29	ND	6/yr
Molybdenum	ug/L as Mo	**ND**	6	ND	ND		ND	29	ND	6/yr
Nickel	ug/L as Ni	**ND**	6	ND	ND		ND	29	ND	6/yr
Potassium	mg/L as K	**0.13**	6	0.12	0.13		0.14	29	0.12-0.25	6/yr
Selenium	ug/L as Se	**ND**	6	ND	ND	50 MAC	ND	29	ND	6/yr
Silver	ug/L as Ag	**ND**	6	ND	ND	No Guideline Required	ND	29	ND	6/yr
Sodium	mg/L as Na	**4.3**	6	3.4	4.8	≤ 200 AO	4.41	29	3.74-7.02	6/yr
Strontium	ug/L as Sr	**15.4**	6	13.9	17.1	7000 MAC	14.7	29	13.2-16.2	6/yr
Thallium	ug/L as Tl	**ND**	6	ND	ND		ND	29	ND	6/yr
Tin	ug/L as Sn	**ND**	6	ND	ND		ND	29	ND	6/yr
Titanium	ug/L as Ti	**ND**	6	ND	ND		ND	29	ND	6/yr
Uranium	ug/L as U	**ND**	6	ND	ND	20 MAC	ND	29	ND	6/yr
Vanadium	ug/L as V	**ND**	6	ND	ND		ND	29	ND	6/yr
Zinc	ug/L as Zn	**ND**	6	ND	79.4	≤ 5000 AO	ND	29	ND-9.6	6/yr
Zirconium	ug/L as Zr	**ND**	6	ND	ND		ND	29	ND	6/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 4. 2021 TREATED WATER QUALITY TRANSMISSION / DISTRIBUTION SYSTEMS GOLDSTREAM SERVICE AREA

PARAMETER		**2021 ANALYTICAL RESULTS**				**CANADIAN GUIDELINES**	**TEN YEAR RESULTS (2012-2021)**			Target Sampling Frequency
Parameter Name	Units of Measure	Median Value	Samples Analyzed	Range Minimum	Maximum	≤ = Less than or equal to	10 Year Median	Samples Analyzed	Range Minimum - Maximum	
Metals (ND means less than instrument can detect)										
Mercury, Total	ug/L as Hg	**ND**	24	ND	ND	1 MAC	ND	111	ND	24/yr
Aluminum	ug/L as Al	**15**	29	6.5	56.60	2900 MAC / 100 OG	14	114	6.3-61	24/yr
Antimony	ug/L as Sb	**ND**	29	ND	ND	6 MAC	ND	114	ND	24/yr
Arsenic	ug/L as	**ND**	29	ND	ND	10 MAC	ND	114	ND-0.5	24/yr
Barium	ug/L as Ba	**3.6**	29	3	4.70	2000 MAC	3.9	114	2.8-4.4	24/yr
Boron	ug/L as B	**ND**	29	ND	ND	5000 MAC	ND	114	ND	24/yr
Cadmium	ug/L as B	**ND**	29	ND	0.09	7 MAC	ND	114	ND-0.01	24/yr
Chromium	ug/L as Cr	**ND**	29	ND	ND	50 MAC	ND	114	ND	24/yr
Copper	mg/L as Cu	**10.9**	29	1.61	103.00	2000 MAC / 1000 AO	27.3	114	3.22-387	24/yr
Iron	ug/L as Fe	**21.3**	29	13.8	35.80	300 AO	27.1	114	12.5-118	24/yr
Lead	ug/L as Pb	**0.31**	29	ND	2.96	5 MAC	0.42	122	ND-185	24/yr
Manganese	ug/L as Mn	**2.8**	29	1.4	10.30	120 MAC / 20 AO	4.4	114	1.5-35.1	24/yr
Selenium	ug/L as Se	**ND**	29	ND	ND	50 MAC	ND	114	ND	24/yr
Strontrium	ug/L as Sr	**15.2**	29	13.6	18.70	7000 MAC	15.3	114	13.1-18.4	24/yr
Uranium	ug/L as U	**ND**	29	ND	ND	20 MAC	ND	114	ND	24/yr
Zinc	ug/L as Zn	**ND**	29	ND	22.10	5000 MAC	ND	114	ND-41.5	24/yr
Sodium	mg/L as Na	**3.15**	29	1.63	13.00		1.7	113	1.46-3.46	24/yr
Disinfection Byproducts Parameters (ND means less than method or instrument can detect)										
Nitrosamines										
N-Nitrosodiethylamine	ng/L	ND	23	ND	ND		2	72	ND-3.8	24/yr
N-Nitrosodimethylamine	ng/L	ND	23	ND	3.4	40 MAC	ND	76	ND-4.9	24/yr
N-Nitroso-di-n-butylamine	ng/L	ND	23	ND	ND		ND	67	ND-42	24/yr
N-nitroso-di-n-propylamine	ng/L	ND	23	ND	ND		ND	61	ND	24/yr
N-Nitrosoethylmethylamine	ng/L	ND	23	ND	ND		ND	66	ND	24/yr
N-Nitrosomorpholine	ng/L	ND	23	ND	ND		ND	67	ND-4.6	24/yr
N-nitrosopiperidine	ng/L	ND	23	ND	ND		ND	65	ND	24/yr
N-Nitrosopyrrolidine	ng/L	ND	23	ND	ND		ND	66	ND	24/yr

Appendix A, Table 4, continued

Haloacetic Acids (HAAs)										
Total Haloacetic Acids	ug/L	**17**	23	ND	85	80 MAC	15	141	ND-104	24/yr
Monobromoacetic Acid (MBAA)	ug/L	**ND**	23	ND	ND		ND	142	ND-15.04	24/yr
Dichloroacetic Acid (DCAA)	ug/L	**11**	23	ND	30		7.11	142	0.58-25.6	24/yr
Trichloroacetic Acid (TCAA)	ug/L	**5.9**	23	ND	56		6.75	142	1.25-35	24/yr
Bromochloroacetic Acid (BCAA)	ug/L	**ND**	23	ND	ND		ND	142	0.2-11.6	24/yr
Dibromoacetic Acid (DBAA)	ug/L	**ND**	23	ND	ND		ND	142	ND	24/yr
Monochloroacetic Acid (MCAA)	ug/L	**ND**	23	ND	ND		ND	142	0.21-26.73	24/yr
Trihalomethanes TTHMs)										
Total Trihalomethanes	ug/L	**18**	23	13	71	100 MAC	19	144	3.3-77.9	24/yr
Bromodichloromethane	ug/L	**2**	23	2	4.4		2	144	ND-5.7	24/yr
Bromoform	ug/L	**ND**	23	ND	ND		ND	144	ND	24/yr
Chlorodibromomethane	ug/L	**ND**	23	ND	ND		ND	144	ND	24/yr
Chloroform	ug/L	**16**	23	12	66		17	144	3.3-77.9	24/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 5. 2021 TREATED WATER QUALITY DISTRIBUTION SYSTEM SOOKE SERVICE AREA

PARAMETER		2021 ANALYTICAL RESULTS				CANADIAN GUIDELINES	TEN YEAR RESULTS (2012-2021)			Target Sampling Frequency
Parameter Name	Units of Measure	Median Value	Samples Analyzed	Range Minimum	Maximum	≤ = Less than or equal to	10 Year Median	Samples Analyzed	Range Minimum - Maximum	
Metals (ND means less than instrument can detect)										
Mercury, Total	ug/L as Hg	**ND**	6	ND	ND	1 MAC	ND	30	ND	6/yr
Aluminum	ug/L as Al	**13.5**	6	9.7	17.6	2900 MAC / 100 OG	14	32	7.5 - 242	6/yr
Antimony	ug/L as Sb	**ND**	6	ND	ND	6 MAC	ND	32	ND	6/yr
Arsenic	ug/L as	**ND**	6	ND	ND	10 MAC	ND	32	ND-0.24	6/yr
Barium	ug/L as Ba	**3.7**	6	3.3	4.1	2000 MAC	3.7	32	3.2-4.6	6/yr
Boron	ug/L as B	**ND**	6	ND	ND	5000 MAC	ND	32	ND	6/yr
Cadmium	ug/L as B	**ND**	6	ND	ND	7 MAC	ND	32	ND-0.075	6/yr
Chromium	ug/L as Cr	**ND**	6	ND	ND	50 MAC	ND	32	ND	6/yr
Copper	mg/L as Cu	**4.74**	6	3.15	6.05	2000 MAC / 1000 AO	5.98	38	0.85 - 417	6/yr
Iron	ug/L as Fe	**47.6**	6	23.1	64.4	300 AO	34.50	32	19.5-278	6/yr
Lead	ug/L as Pb	**ND**	6	ND	ND	5 MAC	ND	86	ND	6/yr
Manganese	ug/L as Mn	**2.6**	6	1.6	3.4	120 MAC / 20 AO	3.00	39	ND-1760	6/yr
Selenium	ug/L as Se	**ND**	6	ND	ND	50 MAC	ND	31	ND	6/yr
Strontrium	ug/L as Sr	**18.3**	6	17.5	20.8	7000 MAC	18.40	31	16.1-21.5	6/yr
Uranium	ug/L as U	**ND**	6	ND	ND	20 MAC	ND	32	ND	6/yr
Zinc	ug/L as Zn	**ND**	6	ND	ND	5000 MAC	ND	32	ND-660	6/yr
Sodium	mg/L as Na	**4.14**	6	3.41	4.74	200 MAC	4.49	31	3.47-6.08	6/yr
Disinfection Byproducts Parameters (ND means less than method or instrument can detect)										
Nitrosamines										
										6/yr
N-Nitrosodiethylamine	ng/L	**ND**	6	ND	ND		ND	21	0.00006 - 3.22	6/yr
N-Nitrosodimethylamine	ng/L	**ND**	6	ND	ND	40 MAC	ND	22	ND-3.71	6/yr
N-Nitroso-di-n-butylamine	ng/L	**ND**	6	ND	ND		ND	18	ND	6/yr
N-nitroso-di-n-propylamine	ng/L	**ND**	6	ND	ND		ND	9	ND	6/yr
N-Nitrosoethylmethylamine	ng/L	**ND**	6	ND	ND		ND	18	ND	6/yr
N-Nitrosomorpholine	ng/L	**ND**	6	ND	ND		ND	19	ND	6/yr
N-nitrosopiperidine	ng/L	**ND**	6	ND	ND		ND	18	ND	6/yr
N-Nitrosopyrrolidine	ng/L	**ND**	6	ND	ND		ND	18	ND	6/yr

Appendix A, Table 5, continued

Haloacetic Acids (HAAs)										
Total Haloacetic Acids	ug/L	**22**	6	16	29	80 MAC	27	22	21-34	6/yr
Monobromoacetic Acid (MBAA)	ug/L	**ND**	6	ND	ND		ND	22	ND	6/yr
Dichloroacetic Acid (DCAA)	ug/L	**12.5**	6	9.3	15		14	22	11-19	6/yr
Trichloroacetic Acid (TCAA)	ug/L	**9.05**	6	7	14		13	22	9.1-18	6/yr
Bromochloroacetic Acid (BCAA)	ug/L	**ND**	6	ND	ND		ND	22	ND	6/yr
Dibromoacetic Acid (DBAA)	ug/L	**ND**	6	ND	ND		ND	22	ND	6/yr
Monochloroacetic Acid (MCAA)	ug/L	**ND**	6	ND	ND		ND	22	ND	6/yr
Trihalomethanes TTHMs)										
Total Trihalomethanes	ug/L	**29.5**	6	25	33	100 MAC	35	22	26-49	6/yr
Bromodichloromethane	ug/L	**3**	6	2	3		3	22	ND-4.4	6/yr
Bromoform	ug/L	**ND**	6	ND	ND		ND	22	ND	6/yr
Chlorodibromomethane	ug/L	**ND**	6	ND	ND		ND	22	ND	6/yr
Chloroform	ug/L	**26.5**	6	22	31		32	22	23-45	6/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