Greater Vernon Water 2020 Annual Report

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LIST OF ACRONYMS

AO	Aesthetic Objectives
AWWA	American Water Works Association
BMP	Best Management Practice
BoD	Board of Directors
CCC	Cross Connection Control
CoV	City of Vernon
CR	Coldstream Ranch
CT	Contact Time
DAF	Dissolved Air Flotation
DCWAPR	Duteau Creek Watershed Assessment Response Plan
DCWTP	Duteau Creek Water Treatment Plant
DMP	Drought Management Plan
DoC	District of Coldstream
DOC	Dissolved Organic Carbon
DWPA / DWPR	*BC Drinking Water Protection Act and Regulation*
EOCP	Environmental Operators Certification Program
ERT	Encoder-Receiver-Transmitter
FLOC	Flocculent
GCDWQ	Guidelines for Canadian Drinking Water Quality
GIS	Geographic Information Systems
GVW	Greater Vernon Water
IH	Interior Health
IIABC	Ministry of Agriculture and Irrigation Industry Association of BC
MAC	Maximum Acceptable Concentrations
MDD	Maximum Day Demand
MFLNRORD	Ministry of Forests, Lands and Natural Resource Operations and Rural Development
MHWTP	Mission Hill Water Treatment Plant
MWP	Master Water Plan
MoE	Ministry of Environment
NTU	Nephelometric Turbidity Units
OBWB	Okanagan Basin Water Board
PAC	Poly Aluminum Chloride
PRV	Pressure-Reducing Valve
PS	Pump Station
RDNO	Regional District of North Okanagan
RSTBC	Rec Sites and Trails BC
SCADA	Supervisory Control and Data Acquisition software
TAC	Technical Advisory Committee
TCU	True Color Units
THM	Trihalomethane
TOC	Total Organic Carbon
UVT	Ultra Violet Transmissivity
WQI	Water Quality Indicators

INTRODUCTION

As required by the British Columbia Drinking Water Protection Act, the Regional District of North Okanagan (RDNO), Greater Vernon Water (GVW) provides the following annual report in accordance with our conditions on permit.

This report summarizes data from the GVW system as a whole from the source water to the municipal distribution system. The report outlines where water comes from, how it is treated to ensure safe drinking water and how that water is distributed and used. Drinking water can be complex and much of the information provided in this report is technical in nature. Please contact GVW (phone: 250-550-3700 or email: utilities@rdno.ca) should you have any questions.

In British Columbia, a community water system must hold a "Permit to Operate" as directed in the *Drinking Water Protection Act (DWPA)* and *Drinking Water Protection Regulations* (*DWPR*) passed May 16, 2003 by the Province of BC and follow Health Canada Guidelines for Canadian Drinking Water Quality (2017) (GCDWQ) and the technical documents.

Interior Health (IH) advises GVW, "under the legislation, the province has increased the basic expectations around assessing water systems, certifying operators and suppliers, and the monitoring and reporting on water quality. The legislation gives provincial drinking-water officers (i.e. Interior Health) increased powers to protect water sources from contamination by a drinking-water health hazard. In addition, the drinking-water officers will oversee a source-to-tap assessment of every drinking-water system in the province to address all potential risks to human health."

This report outlines the programs and projects GVW has developed and implemented to meet the aforementioned policies and legislation.

WATER SYSTEM OVERVIEW

GVW is a regional water system that supplies and delivers water to customers in the City of Vernon (CoV), the District of Coldstream (DoC), Electoral Areas "B", "C" and "D", and bulk water to the Township of Spallumcheen. Based on the 2016 census, growth, and service connections the population served is approximately 58,000.

The RDNO owns and manages the GVW water system in addition to operating the supply and treatment facilities, while the CoV and DoC are contracted for the operations and maintenance of the distribution system.

GVW holds 40 water licences and supplies water to customers via six (6) surface water sources:

1. Duteau Creek (Headgates intake, Goose Lake intake)
2. Kalamalka Lake
3. Okanagan Lake (Outback and Delcliffe intakes)
4. King Edward Lake (Deer Creek intake).

Duteau Creek supplies the largest water volume to the GVW service area, with both non-potable (untreated) and potable (treated) water. Kalamalka Lake is the second largest water supply and provides only potable water. There are two intakes on Okanagan Lake which service two (2) small potable water systems, the Outback and Delcliffe (these two (2) water systems are reported to IH separately).

Goose Lake functions as an open reservoir, receiving water from the Duteau Creek Water Treatment Plant (DCWTP), to provide non-potable water to agricultural customers on the western edge of the GVW service area. Deer Creek (King Edward Lake) provides non-potable water to a limited number of Coldstream agricultural customers combined with some groundwater.

GVW also manages four (4) groundwater wells:

- Coldstream Ranch (CR) Well #3 and #2
- Antwerp Springs (Antwerp) Deep and Shallow Wells.

Of these four (4), CR Wells #3 and #2 are currently in service to supply agricultural non-potable water. The Antwerp Deep Well and CR Well #3 are maintained and monitored for domestic emergency supply if required. While the Antwerp Shallow Well remains a GVW well, it is currently capped and would only be used for irrigation in an emergency. The GVW wells are considered in the Master Water Plan (MWP) as part of the long term water supply and for emergency backup. Applications for groundwater licences (per the *Water Sustainability Act* regulations) have been forwarded to the Province of BC and GVW is awaiting confirmation of their approval.

GVW has approximately 24,662 service connections. There are approximately 662 active farm or agriculture status connections (1003 total connections), 1,400 commercial, institutional/park, or industrial connections and approximately 22,600 residential connections. All active service connections are metered.

Staffing

The overall management of GVW lies with the RDNO as shown in Table 1. There are key groups involved in the operation and maintenance of the water supply. Water treatment is completed by RDNO operators listed in Table 2. Distribution system operations are contracted under agreement with the CoV and DoC (Table 3 and 4, respectively) under the direction of RDNO staff.

Section 12 of the DWPR refers to qualification standards for persons operating water supply systems. In this section, the Environmental Operators Certification Program (EOCP) is required for certification of operators of a water system. A person is qualified to operate, maintain, or repair a water supply system if the person is certified by the EOCP for the class of system as classified under the EOCP. Tables 2-4 include the EOCP certifications.

RDNO staff also manages the Cross Connection Control (CCC), water demand side management, and water quality programs on behalf of GVW and its municipal partners.

Drinking Water Sources and Treatment

Duteau Creek

Water from Duteau Creek supplies domestic and agriculture water for GVW. Duteau Creek originates on the Aberdeen Plateau and the watershed is controlled with seven (7) earthen dams forming three (3) reservoirs: Grizzly, Aberdeen, and Haddo Lakes. The Duteau Creek watershed covers an area of approximately 21,275 hectare (ha) (213 km^2) between Grizzly Hills summit (elevation of 1,800 metres (m)) on the Aberdeen Plateau and the Headgates Diversion Dam (intake) at an elevation of 660 m.

Duteau Creek ultimately flows out of Haddo Lake which then continues downstream for approximately 13 km before entering Headgates also known as the Duteau Creek intake, a small reservoir. A portion of Duteau Creek water enters into the GVW system at this point. Water flowing down Duteau Creek below the intake is somewhat controlled and is dependent on the

Environmental Flow Needs as determined through an agreement between the RDNO and the Province. Rotating screens remove large to medium sized debris before entering a 1.2 m diameter transmission pipe to the DCWTP.

Duteau Creek – Non-Potable

The water main extending from the Duteau Creek intake (Headgates) to the DCWTP is non-potable (untreated). At the treatment plant, water is either diverted to the plant or continues untreated to the Von Keyserlingk pump house and Springfield areas where separation of domestic and agriculture mains has occurred.

- Maximum day demand (MDD) in 2020 was 12.64 Megalitres per day (ML/d) on July 29.

Duteau Creek – Potable

Water that is not diverted to the non-potable system enters the DCWTP which was commissioned in 2010. The DCWTP (Phase 1) was built to provide consistent safe drinking water for the growing population in the Greater Vernon service area and to assist in meeting potable water regulations. Water is clarified at the DCWTP by separating suspended matter and some dissolved matter from the water through the addition of a coagulant. The coagulant causes particles suspended and some dissolved compounds in the water to form clumps or masses called flocculent (floc). Air is then injected at the base of the floc tanks and float the floc particles to the surface where skimmers remove it. This process is called Dissolved Air Flotation (DAF) and the organic carbon removal across the clarifier is typically in the order of 60% which includes the removal of the yellow colour from the water, which is measured in True Color Units (TCU). The colour of the raw (untreated) water supply from Duteau Creek varies from 34-94 TCU and treated water is less than 5 TCU. This will be discussed further in the report.

At the end of the DAF process clear water is drawn from the bottom of the basin, chlorinated and discharged to a 10 ML covered reservoir. Ultra Violet (UV) disinfection after the reservoir adds another layer of treatment and assists GVW in meeting the *4-3-2-1-0 Drinking Water Objectives* (BC MOH, 2012). The UV inactivates Cryptosporidium and Giardia.

The design capacity of the plant is 160 ML/d,

- MDD in 2020 was 92.5 ML/d on July 31.

Kalamalka Lake Water Supply

The Kalamalka Lake Pump Station (PS) is located on West Kal Road in Coldstream, BC with the intake located 327 m from the shoreline in 20 m of water and 3 m off the lake bottom to improve water quality. The intake is also equipped with two stainless steel screens to meet Department of Fisheries and Oceans standards.

The Kalamalka Lake PS is equipped with four (4) vertical turbine pumps:

- 2 - 138 Litres per second (L/sec), 200 hp, one fixed speed and the other Variable Frequency Drive (VFD)
- 2 - 235 L/sec, 400 hp, both on VFDs.

Water is then pumped from Kalamalka Lake to the Mission Hill Water Treatment Plant (MHWTP) for disinfection treatment using a Trojan UV reactor along with the addition of sodium hypochlorite (chlorine) generated on site. The plant has a design capacity of 60 ML/d at 89% UV Transmittance (UVT). The UVT percentage is a measure of the UV that is able to pass through the water.

- MDD in 2020 was 28.31 ML/d on August 20.

Separated Non-Potable Water Sources

Goose Lake - West Swan Lake/Bella Vista

Goose Lake is located west of Swan Lake. Following the completion of the West Swan Lake Separation project in 2013, water stored in Goose Lake is used solely for agricultural purposes. At this time, the Goose Lake reservoir is filled with treated water from the DCWTP, with a Reduced Pressure Principle Assembly installed to ensure there is not a cross connection with the potable water system. The non-potable line is filled with chlorinated water at the end of the irrigation season to reduce bio-film in the waterlines, but is not regularly chlorinated to maintain a residual as needed in a potable water system. The water velocities from irrigation use flush the water lines of any accumulated sediments or organics.

- MDD in 2020 was 7.11 ML/d on September 1.

King Edward Lake System

Deer Creek is regulated with storage at the King Edward Lake reservoir. It is used for agricultural demands in the CR area. Deer Creek intake pond is very small in size and the land upstream of the intake is privately owned by CR to 8 km on the King Edward Forest Service Road. The area south is Crown land.

CR Wells #1 and #2 are both located on the CR lands near the intersection of Highway 6 and Kalamalka Road. These sources are used for agricultural irrigation demands. Well #1 can also be used for domestic (potable) if needed in an emergency.

CR Well #1 is 50 m (162 feet) deep and drilled through a confining clay layer. The well is designed to produce 42 L/sec (650 US Gallons per minute (USGPM)). This well was reconstructed to improve capacity. Chlorination, a turbidity meter, and a backflow prevention device have been installed at this well in case it is needed for potable water in an emergency.

CR Well #2 is 24 m (79.4 feet) deep drilled within an unconfined aquifer and has a pumping capacity of 50 L/sec (800 USGPM). This well is only used as a non-potable source.

The flow max day for the three sources serving this area was:

- MDD in 2020 was 14.2 ML/d on August 19 for Kind Edward
- MDD in 2020 was 1.47 ML/d on September 30 for CR Well #1
- MDD in 2020 was 1.55 ML/d on July 29 for CR Well #2.

Drinking Water Distribution System

The GVW distribution system has over 650 km of pipeline, 41 pump stations, 102 pressure reducing stations, and 22 concrete balancing reservoirs.

System Separation – Potable and Non-Potable

As noted in the source overview, the GVW system is separated into non-potable and potable systems. Separation allows the level of treatment to be matched to the need of the water thereby reducing costs of treatment and improving the efficiency of water use. The non-potable supply is sourced primarily from Duteau Creek and King Edward Lake/Deer Creek, in addition to Goose Lake and CR Wells (Figure 1).

Water Main Breaks

Most water utilities frequently experience minor disruptions. Pipes break, valves seize, hydrants leak, and power outages occur. Although these are not anticipated, the problems experienced can usually be corrected with minimal disruption, and regular service can be restored quickly.

In cases of water main breaks, GVW adheres to the procedures set out in the American Water Works Association (AWWA) Standard C651-14 regarding water main chlorination prior to re-commissioning of the main.

In 2020, CoV operations responded to 34 water main and water service failures, both within the CoV and Electoral Areas “B” and “C” of the RDNO. The DoC responded to 10 water main and water service failures, both within the DoC and Electoral Area “D” (note: hydrant leak breaks are not included in this total).

Typically, breaks or disruptions to water service are caused by conditions that can be repaired and restored quickly, without risk to public health. Sometimes however, situations arise requiring extra care to ensure the integrity of the water system has not been compromised. GVW endeavours to keep IH apprised of any extraordinary situations that may adversely impact the water system.

New Water Mains

Disinfection of new water mains is completed in accordance with AWWA C651 - 14 - Continuous Feed Method. Where water samples taken following initial disinfection are not acceptable, and do not meet water quality standards, the process is repeated.

Pressure Reducing Valve Station

The maximum design water pressure for piping within the majority of the water distribution system is 1040 kPa (150 psi). There are over 100 Pressure Reducing Valves (PRV) within the GVW system. The PRV's role is to control the pressure in the water system by creating head losses that prevent pressures from exceeding the design maximum.

The operators currently service the PRV stations as required in an effort to extend their service life. Most individual premises (homes, businesses) also have secondary PRV’s as normal operating pressures above 70 psi and/or fluctuating pressures can place excessive stress on internal plumbing systems and fixtures. Of note, the BC Plumbing Code has requirements for premise PRV’s.

System Control - Supervisory Control and Data Acquisition Software

System monitoring is critical for operations and this is done from the Supervisory Control and Data Acquisition Software (SCADA) system. Operators and management use SCADA for monitoring reservoir water levels, operating pumps, monitoring water quality control equipment, and maintaining a historical data file of the water systems operations. All of the monitoring is done through wireless connections. When a problem is detected within the system, the SCADA system sends out alarms and, depending on the location of the problem, either the RDNO, CoV, or DoC operators respond.

Water System Value and Asset Management

The approximate total value of the GVW water system (Table 5), is estimated to be $730.5 million (GVW Interim Asset Management Investment Plan Values, 2020, Figure 2). Over the years and as a continuous process, GVW has been compiling and ascertaining attributes of its many assets; these attributes may include year of install, material, and type, among many other important features. The process has involved investigating record drawings, receiving feedback from operators, estimating from a variety of sources, and entering the information into Geographic Information Systems (GIS) for use by staff and operators. Once in GIS, it's easier to view, analyze, plan, operate, and manage the system. A summary of the pipe material in the distribution system is in Table 6.

GVW has an Asset Management Investment Plan (AMIP). The primary goal of an AMIP is to replace infrastructure prior to failure, but not too soon that GVW is replacing infrastructure before the end of its service life. Incorporating the AMIP with analyses of the actual conditions (as opposed to only the estimated lifespan used for the AMIP) has allowed GVW to narrow down the asset replacement list to better invest where it's needed most. The AMIP values were updated on an interim basis for 2020.

Through another federal grant, GVW partnered with research students at UBC Okanagan, where they developed a tool to analyze risk and consequence of failure in GVW's linear infrastructure (water mains). A risk index and subsequent rank for all of the water mains was derived from potential soil corrosivity, water aggressiveness, hydraulic factors, and consequence of failure. This tool is used in conjunction with the AMIP to choose appropriate sections of water mains for replacement, in order of risk. In 2020, these projects were incorporated into the five (5) year rolling capital plan, which involved collaboration with other jurisdictions' projects in order to save costs and renew water infrastructure appropriately.

Further aiding asset management of GVW's infrastructure, staff and operators have been collecting soil samples during the exposure of water mains, typically during water main breaks or site investigations. These soil samples help with determining the extent of corrosivity where the soil may have detrimental effects on metallic infrastructure by reducing the lifespan. The corrosivity data is input into the abovementioned risk tool for further accuracy, and allows GVW to map out corrosive areas for better control of new infrastructure corrosion.

Finally, since 2016, GVW has hired summer students to find, survey, and report required water infrastructure (primarily service valves) maintenance back to operations staff. The purpose is for operations staff to better locate the water infrastructure during emergencies, and to compile for asset management.

Capital Works Projects

Each year multiple projects are completed and the 2020 projects that were completed are shown in Table 7.

WATER DEMAND MANAGEMENT AND SUSTAINABILITY PROGRAM

GVW monitors water consumption in part to better manage demand and promote water conservation. Figure 3 illustrates year to year water use as measured by the cumulative inflows to GVW's distribution infrastructure since 2012. The graph shows 2020 as one of the lowest water use years of the past nine (9) years. While weather has a significant impact on consumption, and June/July 2020 were wet, GVW's conservation programs also likely had an impact on customer water demand. As shown in the graph, there was a significant drop in demand following the introduction of agricultural metering and over allocation rates in 2012.

Based on the ongoing analysis of metered water consumption data received quarterly from municipal billing partners, GVW staff have focused education on the top water use activities: agricultural and outdoor landscaping irrigation. It should be noted the conservation programs also include water quality protection information when applicable, as GVW hopes to promote awareness of the need to better manage all aspects of our watershed to ensure a safe and reliable water supply.

Water Consumption

Water flows are monitored at multiple points of entry within the GVW service area. Flows into the system are monitored on: Duteau Creek, Kalamalka Lake, Deer Creek/King Edward Lake, and the groundwater wells. Based on 2020 inflow records, Figure 4 illustrates how much each water source contributes to the overall water use by GVW. In total, approximately 15,825 ML of water flowed into the GVW distribution system. Approximately 91% of water supplied by GVW was treated with the remainder (9%) being non-potable delivered by the separated agricultural water distribution system.

Consumption is also measured at the point of use via customer water meters. Total inflow volumes from the water sources differ from the metered water consumption recorded at the customer's point of use due to several factors: authorized unmetered water use activities (such as firefighting, water main flushing, fire hydrant usage, consumption at water quality monitoring stations), or via unauthorized consumption (leaks or theft). Table 8 summarizes metered and estimated unmetered water consumption in comparison to source inflows. The estimated water loss percentage in 2020 was 15%.

GVW and municipal operations staff efforts to maintain infrastructure in good condition and replace failing infrastructure, such as leaking water mains, is critical to reducing unmetered (non-revenue) water losses. GVW staff continue to do corrosion studies to assess factors to help predict pipe failure and direct maintenance or replacement activities to avoid main leaks.

Water Metering

GVW is nearing the completion of the Water Meter Improvement Program, a multi-year plan initiated in 2015 to install automatic meter reading technology using devices called Encoder-Receiver-Transmitters (ERTs). ERTs allow for water meters to be read more frequently and accurately via wireless radio frequency technology. ERTs provide the ability to better characterize leaks; when there is a suspected leak, hourly consumption trends can be analysed to identify irregular consumption patterns. Automated flags are transmitted by ERTs to alert GVW staff to monitor continuous water flow over seven (7) days to help identify leaks. Approximately 87 customers have been contacted based on a leak flag. Over 21,000 ERTs have been installed since 2015. More information can be found at www.rdno.ca/gvw - Water Meter Improvement.

Drought Management

GVW maintains a water shortage and Drought Management Plan (DMP) which was reviewed in 2017 (Associated Environmental, 2017). In 2020, this was updated to be considered the Water Shortage Management Plan, to recognize action may be taken to reduce water in scenarios other than drought. In 2018, several Okanagan utilities, including the City of Kelowna and the Regional District of Okanagan Similkameen, used GVW's DMP as a template for their DMPs. It is hoped that consistent policies across the Okanagan will make it easier to communicate restrictions to customers thereby helping the public take action during drought. Information on GVW's DMP is available at www.rdno.ca/restrictions.

GVW also maintains a Water Shortage Communications Plan as a critical component to drought management. Examples of the visual communications materials included in this plan are shown in Figure 5. Four (4) other versions were created for the other stages and an agricultural version of this graphic is also used as shown in Figure 6.

Conservation-Oriented Water Rates

GVW has employed conservation-oriented water rates for several years. Rates are reviewed annually by the RDNO BoD and are based on the annual operating budget and capital funding needs of the utility, as GVW is not permitted to run multi-year deficits. GVW staff promote customer awareness of the water rate structure through education materials (billing inserts, letters) and by responding to customer inquiries.

To be an effective tool, rates must be paired with customer education. GVW's education programs aim to raise awareness of the opportunity to reduce one's water bill via conservation and to present advice on conservation practices to provide customers the tools they need to lower their water demand.

Water Efficiency Education Programs – Agriculture Program (AgConnect)

GVW staff continued to work with the BC Ministry of Agriculture and Irrigation Industry Association of BC (IIABC) to promote awareness of irrigation planning and efficiency support tools. Access to these tools is provided through the RDNO website at www.rdno.ca/agconnect.

The AgConnect page is an agricultural information hub which is advertised in direct letters sent to all GVW agricultural water customers. The AgConnect website also has a secure portal to the water meter records of each agricultural customer along with the percentage of allocation used by the customer so they can adjust their water use to avoid over allocation fees. By providing this information, GVW hopes to support agricultural producers in making efficient irrigation choices and provide clear evidence of the benefits of switching to higher efficiency irrigation systems.

GVW staff also continued to participate in the Okanagan Basin Water Board (OBWB) Agricultural Supply Communications Program, a pilot project involving a text/email alert software service. This work is funded in part to support agricultural adaption to climate change and to promote better communication to agricultural customers in times of drought. GVW customers can sign up at www.obwb.ca/alerts (or via the AgConnect page) to receive text, email, or voicemail alerts. This program will be eliminated at the end of 2020 and a new system will be explored by OBWB.

Water Efficiency Education Programs - Urban Program

In cooperation with the OBWB, the Make Water Work media campaign to promote outdoor water efficiency in the Okanagan Basin continued in 2020. The campaign's focus was on the Make Water Work pledge and encouraging the public to visit the website to learn more about being waterwise by offering a contest. A key update for the program was an expanded waterwise plant collection list which is provided online and in an easy to distribute flyer meant to encourage people to seek out low water demand plants at their local nursery. This valuable program provided ready-made educational materials for GVW staff to use and ensured a consistent conservation message throughout the Okanagan Basin through posters, billboards, newspaper, online, and radio advertisements - more information can be found at www.makewaterwork.ca.

Following the recommendations of the 2017 MWP Water Conservation Technical Memorandum No. 6, staff have continued communicating GVW updates and information through bill inserts, the local newspaper, radio ads, media releases, the RDNO website, and partner websites/social media. In addition to the communication program, staff would normally deliver water conservation programing via workshops but in person gatherings could not occur in 2020 due to COVID-19. Instead, staff partnered with the Regional District of Okanagan Similkameen to deliver a series of virtual workshops that focused on climate change, water conservation, and indigenous perspectives on water.

Do-It-Yourself (DIY) materials, focused on waterwise (xeriscape) landscaping, are offered online to help reach the widest audience. To address indoor water conservation, a leak factsheet, updated in 2019 to reflect new meter models now in service, is also available online with other water conservation guides and how-to videos at www.rdno.ca/waterwise.

A summer staff person assisted in customer outreach between May and August, which allowed GVW to deliver a new program, Waterwise Yard Assessments. The student provided personalized recommendations for irrigation scheduling and highlighted potential sprinkler problems based on a basic assessment of the automatic irrigation system. The goal of this program was to empower residents to adjust their irrigation settings to match their plant's needs, be more efficient water users, and remember to check their irrigation frequently for leaks. In 2020, 35 assessments were completed and of those 13 properties showed a decrease in daily average water use post assessment either due to changes in irrigation timing or by finding leaks. Some participants even dropped to a fifth of their previous use. Of the other participants, most were already using water efficiently but they appreciated the confirmation of their efforts.

WATERSHED MANAGEMENT PROGRAM

The first step to providing safe, clean, reliable drinking water is protecting the source water from both a water quantity and water quality perspective. With ever increasing activity on both Crown and private land, it is critical to ensure the water is protected even before it is treated.

An integral part of watershed management is partnerships with those who have jurisdiction and impact on the landscape. RDNO has benefitted from great relationships, coordination, and regular meetings.

Duteau Creek Source Assessments and Source Protection Plans

The community watershed is located southeast of the Lavington area, and is upstream of the Duteau Creek intake. The community watershed is primarily Crown land and while the RDNO has no legislative authority over land use and practices, staff have a long history of working with provincial staff, range tenure holders, and forest licensees. The *Duteau Creek Watershed Assessment and Recommendations for Source Protection Report* (Watershed Assessment) was received by the RDNO BoD in December 2008.

The implementation of a Watershed Protection Response Plan provides guidance to achieve a successful source water protection program (Figure 38). The Duteau Creek Watershed Protection Plan Technical Advisory Committee (TAC) was formed in 2009 and includes representation from provincial agencies, First Nations, forest licensees and range tenure holders.

In 2014, the Duteau Creek Watershed Assessment Response Plan (DCWAPR) was endorsed by the RDNO BoD and was accepted by IH. The DCWAPR follows recommendations provided in the Watershed Assessment and an annual work plan is developed to action the recommendations. The TAC did not meet in 2020 primarily due to limitations surrounding the COVID-19 pandemic.

In 2020, a site host was again hired May through September (Friday through Sunday) and all statutory holidays (Figure 38).

The host's duties included being at the Grizzly RSTBC site and inspecting other RSTBC sites located at Specs Lake, Aberdeen Lake and Haddo Lake once daily every Friday, Saturday and Sunday, to provide a record of the users. It is hoped that the rec site will become widely used to allow for a fee for service system. Since a host has been present on the plateau, there has been a significant reduction to infrastructure damage. The host continues to liaise with the public about the ongoing development of the RSTBC site and the importance of protecting the watershed for safe drinking water.

For further details, the DCWAPR can be viewed on the RDNO website at www.rdno.ca/gvw – Water Sources & Watershed Protection or view in the provincial data base - EcoCat.

Kalamalka Lake Source Assessments and Source Protection Plans

In 2011, the RDNO BoD passed a resolution endorsing the Source Assessment of the Regional District of North Okanagan – Greater Vernon Water Utility North Kalamalka Lake Intake Report.

The *North Kalamalka Intake Response Plan* was completed in 2017 and provides an outline of the risks identified in the assessment. The purpose of the response plan is to respond to recommendations from the assessment and provide actions to reduce risks to water quality and identify responsible parties. GVW provides financial support, staff time, and other in-kind assistance to help protect Kalamalka Lake and enhance water quality. Efforts are also required by other organizations and agencies to assist GVW in this endeavor as many actions required are outside of the scope of GVW authority. A collaborative approach with all partners provides the best prospect of success to reduce or eliminate environmental impacts from both point and non-point sources.

Implementation strategies within the response plan are focused into the following areas or programs:

- Intake
- Intake Protection Zone
- Watershed Protection Program
- Public Education
- Emergency Response.

In 2020, the Stakeholder Technical Advisory Committee (STAC) did not meet for the second year primarily due to COVID-19.

For further details, the North Kalamalka Intake Assessment and Response Plan can be viewed on the RDNO website at www.rdno.ca/gvw – Water Sources & Watershed Protection.

Watershed Monitoring Program

From a water quantity perspective within the Duteau Creek watershed, the RDNO monitors the source water availability through a series of RDNO owned hydrometric stations, remote lake level readings, snow courses, and flow measurements. Within the Kalamalka Lake watershed, the RDNO monitors the Water Survey Canada stations and the lake levels to understand water availability.

From a water quality perspective, the RDNO monitors the water quality in the Duteau Creek system to ensure best management practices (BMPs) by crown land users are protecting water quality. As the major tributary to Kalamalka Lake, Coldstream Creek is monitored in partnership with the MoE to observe water quality changes. Additionally Kalamalka Lake is monitored in partnership with the District of Lake Country, to see long term changes and determine protection goals. Monitoring source water can often signal when things are changing and trigger action to prevent long term contamination that can reduce operating and treatment costs to treat and distribute water.

Duteau Creek Watershed Monitoring

Depending on water availability and water quality within the reservoirs there are four (4) to five (5) sites sampled biweekly during the snow free season from approximately May to November annually. The sites are chosen and adjusted based on activities in the watershed such as range cattle, recreation, and forestry. The water going over the weir at Haddo Lake is sampled the most out of all the sites in the watershed as it is the point where the water enters into the main stem of the creek. The sample schedule and parameters are in Table 9 with the exception of the annual samples and parameters taken in July.

From the data at the sites there was not anything dramatically or immediately impacting the water quality in 2020. In general, over the years it has been noted the water quality is affected by land impacts in the immediate area of the watershed. The cumulative effects of watershed activities continue to be monitored.

Coldstream Creek Monitoring

Four (4) sites are monitored on Coldstream Creek based on collaboration with the MoE. The parameters are scheduled as per Table 10.

A preliminary review of the 2020 data shows there was nothing unusual occurring. From the four (4) years of data taken, turbidity typically increases during freshet as expected from late April to the end of June annually. During freshet, conductivity decreases while overland water dilutes the base flow of the system. Of note, as in 2017, 2018, and 2019, the Brewer Road sample site appears to have higher levels of nitrogen than other sites. Further analysis of the data will be completed in 2021.

WATER QUALITY MONITORING PROGRAM

The Water Quality Program has been designed so water is monitored weekly, monthly, and annually to understand variations in water quality in order to provide enough data to statistically analyze trends from the source to the tap. In order to do this, the following legislation, regulation and guidelines are used to develop a reporting and monitoring plan.

Guidelines for Canadian Drinking Water Quality (GCDWQ):

1. *Drinking Water Protection Act and Regulation* (*DWPA and DWPR)*
2. Source Drinking Water Quality Guidelines
3. Drinking Water Treatment Objectives for Surface Water in BC
4. Decision Tree for Responding to Turbidity Event in Unfiltered Drinking Water.

Drinking water quality is a function of many different factors such as source water quality, water treatment, and the distribution system characteristics. As a result, the monitoring of drinking water quality consists of four (4) components in the *Source to Tap Approach*:

1. Source (raw) Water Monitoring

2. Monitoring after Treatment (at Outflow of Treatment Plant)
3. Monitoring in the Distribution System (regular monitoring and cross connection control)
4. Monitoring and addressing Customer Concerns.

For more information regarding drinking water quality guidelines, please visit Health Canada's Website.

Source water quality monitoring is an important component of the multi-barrier approach to drinking water management (CCME, 2004). It is important for monitoring programs to be as comprehensive as possible. Through the source water quality program, source water results are compared to guidelines, criteria, and regulations for both health and aesthetic reasons. Water quality trends are monitored to evaluate watershed activity impacts and indicate potential effects on treatment and chlorine demand.

Certified operators from the CoV and DoC sample at designated sampling sites within the distribution system on a weekly schedule. In 2020, the domestic distribution system was considered two (2) distinct water systems (Duteau Creek and Kalamalka Lake) where dedicated sample sites are monitored. While the system can be run interchangeably, but remain separated the majority of the time. This portion of the water quality program is designed to meet the community water system regulations prescribed by the British Columbia Drinking Water Protection Regulation, Schedules A and B. The Canadian Drinking Water Guidelines for Maximum Acceptable Concentrations (MACs) and Aesthetic Objectives (AO), supports the program for health and aesthetic reasons. Other parameters may be monitored if they are known to create problems within water distribution systems.

Turbidity is one of the most important physical parameters monitored by the RDNO. Turbidity is caused by suspended matter such as clay, silt, finely divided organic and inorganic matter, soluble coloured organic compounds, plankton, and other microscopic organisms. Excessively high turbidity can have a negative effect on disinfection techniques and is regulated by IH's 4-3-2-1-0 Drinking Water Objective. This objective states raw water turbidity must be less than 1.0 Nephelometric Turbidity Units (NTU) (24 hour average) unless there is an agreement otherwise, and the target level is 0.1 NTU. If the 1.0 NTU objective is not met, the water purveyor must advise the public.

At this time, GVW does not have filtration on any of its sources, making it challenging to remove source water turbidity. Turbidity is continuously measured at Kalamalka Lake, Duteau Creek, and CR Well #1 through online turbidity meters and SCADA. If the water supply source is being used, a comparison with a hand-held turbidity meter is completed weekly at the site to ensure the SCADA monitored meter is reading correctly.

A seasonal and weekly schedule has been implemented to test chemical and physical parameters at each water source. The analysis may be completed in the field, at the RDNO lab, or at an accredited lab. Other parameters (ammonia, nitrites, nitrates, pesticide scans, hydrocarbon scans and volatile organic compounds) may be included in the analyses when specific concerns arise or based on the schedule defined in the Water Quality Program.

Source Monitoring Program

Raw water (untreated) testing for 2020 was completed on the following sources:

- Duteau Creek watershed
- Duteau intake (Headgates)

- Kalamalka watershed (Coldstream Creek and Kalamalka Lake Study)
- Kalamalka Lake (intake)
- Deer Creek (intake)
- Goose Lake (lake and intake)
- Coldstream Ranch (wells #1 & #2)
- Antwerp Springs (deep well for emergencies).

Duteau Creek Raw Water Summary

The Duteau Creek raw water is sampled at a line located in the intake building at Headgates. Water quality is monitored online and by taking samples on a weekly, monthly, and annual schedule (Table 11). Note the annual parameter list and schedule is not in the table due to the number of parameters analyzed.

Physical-Chemical Monitoring

As with all of the parameters monitored, the physical and chemical parameters are monitored per the Water Quality Monitoring Program. Physical water quality parameters include turbidity, temperature, colour, and conductivity while the chemical parameters include pH, alkalinity, phosphorous, hardness, and sulfate.

Once a year (referred to as the annual samples), GVW staff take samples at all water sources before treatment and after disinfection for a comprehensive sample chemical analysis of common minerals and other chemical parameters (such as hardness). Results are checked against the GCDWQ. Please visit our website at: https://www.rdno.ca/waterquality.

In 2020, all the raw water physical and chemical parameters were within the Canadian Guideline limits except turbidity (MAC less than 1 NTU).

Turbidity

Monthly water quality reports and the GVW Water Quality Deviation Response Plan provide further details with regard to turbidity events and/or trigger levels for response and notification.

Figure 7 shows the daily average turbidity for 2020. The treated turbidity is also noted on this graph and demonstrates the effectiveness of the water treatment and that treated turbidity without further filtration is well below the MAC of <1 NTU. In 2020, the DCWTP did not have to be turned off due to water quality concerns.

Temperature

Looking at temperature trends over time can indicate long term changes and fluctuations. Incoming temperature is important for the effectiveness of the treatment process. Dramatic fluctuations in temperature can make treatment more difficult. In 2020, there were no erroneous temperature fluctuations and there will be a further look at the long term trend in 2021. It is expected climate change will have an impact on source and distribution water temperatures which can impact drinking water quality.

pH

pH is an important parameter to monitor as it is a key factor to consider in treatment and the effects it has on the distribution system. From the long term trend shown in Figure 8, there appears to be a fluctuating trend with lows during 2008-2010 and peaks in 2015-2017. While 2020 is within normal ranges, the trend appears to be going toward lower pH levels. This will be investigated further in the coming years. Low pH is an indication of a corrosive water, which leads to concerns in the distribution system and will be discussed later.

Chlorophyll a

Chlorophyll a is a measure of the concentration of the green pigment found in plants in the water and is generally used as an indicator of phytoplankton (algae) in the water sampled. Chlorophyll a measurements taken monthly from May to November in 2020 were roughly within the range of normal with the exception of October 2020 (Figure 9). This reading (4.19 ug/L) was the third highest recorded since 2013. The high October readings typically represent diatom blooms. Haddo Weir algae density samples did show relatively high counts of diatoms in the samples (6280 cells/mL). Further analysis of the trends will be conducted in 2021.

Organic Carbon

Total and Dissolved Organic Carbon (DOC) are a measure of dissolved and suspended carbon bound in organic molecules and organisms and are important measures for the Duteau Creek water as they are precursors for disinfection by-products (this is discussed further in the Water Treatment and the Distribution section). This is also important at the DCWTP now that UV disinfection has been added to the treatment process. DOC's can reduce the effectiveness of the UV disinfection. The Surface Drinking Water Quality Guideline for Total Organic Carbon is 4.0 mg/L. (MAC) (SDWQG, MoE, 2017). The raw water TOC average in 2020 was 9.3 mg/L (2019 average was 8.3 mg/L) and the DOC averaged at 8.6 mg/L. (2019 average was 8.1 mg/L).

The relationship between TOC and DOC shows that the majority of organic carbon in Duteau Creek is dissolved (Figure 10 and 11). The organic carbon component is composed of humic and fulvic acids and is common of the water quality found on the Aberdeen Plateau (ie. Oyama Lake, Beaver Lake, and King Edward Lake).

Biological Monitoring

Bacteria and algae are the two (2) biological parameters measured regularly at the intake. Monitoring for Total Coliforms (TC) and *E.coli* (*Escherichia Coli*) is an important part of understanding source water quality and any changes that may be occurring. Algae are monitored as they contribute to the organic loading in the system and contribute to taste and odour.

Bacteria

In 2020, TC increased in June and remained high through to November (peaking in September) as shown in Figure 12. High water levels throughout the watershed in May increased organic loading and may have increased the TC numbers. The *E.coli* numbers increased in January through April which is unusual for winter months (Figure 13). The lower reaches of the creek were explored for any obvious activity but nothing was noted. Duteau Creek raw water does not meet the British Columbia Drinking Water Treatment Objectives (microbiological) for Surface Water Supplies (BC. MOH, 2012) which states in Table 12:

- the number of *E.coli* in raw water does not exceed 20/100 mL, or
- if *E.coli* data are not available (less than 100/100 mL of TC) in at least 90% of the weekly samples from the previous six (6) months.

While the raw water does not meet this objective, the DCWTP and the addition of chlorine ensure the drinking water system meets the Health Canada criteria.

Kalamalka Lake Raw Water Summary

The Kalamalka Lake raw water is sampled at a line located in the Kalamalka Lake PS. Water quality is monitored through SCADA and by taking samples on a weekly, monthly, and annual schedule (Table 13). The grab samples taken at the PS can only be taken when the source is in use. Kalamalka Lake is often turned off when the turbidity is trending above 1 NTU or there are other issues with the source.

Physical-Chemical Monitoring

These are parameters monitored per the Water Quality Monitoring Program, see Table 13 for the parameter list and scheduled sample frequency.

Turbidity

The Kalamalka Lake turbidity is a challenging factor for water quality as it may affect the MHWTP UV disinfection process. As MHWTP has dual disinfection (UV and chlorine) but no pre-treatment or filtration, RDNO operators have developed a procedure that directs operations during increasing turbidity events. Historically, the water stays below 1 NTU except during freshet and Kalamalka Lake's natural process called marl.

Seasonally, the turbidity rises in late July as the marl precipitation occurs in Kalamalka Lake which is due to the lake's naturally high calcium and sulphate concentrations. The "marl" creates the color in Kalamalka Lake. The timing and the intensity of the color varies from year to year due to the fluctuations in water chemistry, water temperature and algae growth. The marl precipitation helps Kalamalka Lake because it co-precipitates phosphorous. As soon as the marl occurs, phosphorous drops and algae production declines (Larratt Aquatic Consulting, 2013).

In 2020, January, April, May, June, October and November are missing data because the Kal intake was turned off. The intake was off for a total of 105 days in 2020 (Figure 14). A further look at turbidity will be carried out in 2021.

Temperature

Temperature in Kalamalka Lake can relate to incoming surface water through freshet flows, whole lake seiches potentially driven by wind (Larratt Aquatic Consultant annual report), and lake turnover. Temperature relates to turbidity with respect to the marl and calcium carbonate comes solution as temperature rises in combination with other factors and creates particulate in the water that ultimately diffracts light and creates the beautiful teal summer colour of the lake. Figure 15 shows the online temperature readings at the Kalamalka Lake intake. The grab sample temperature readings for 2020 ranged between 5ºC and 13ºC. Figure 16 shows a general trend toward an overall increase in temperature at the Kalamalka Intake sample station and will be further explored. The trend is especially strong in the last five (5) years.

pH

Kalamalka Lake has a relatively stable pH over the years of record, with an overall range between 6.9 and 8.7. In 2020, the pH ranged from 6.7 to 8.4. The pH appears to be decreasing at this sample location (Figure 17) and will be further investigated.

Alkalinity / Hardness

Alkalinity is the ability of the water to buffer the pH. Kalamalka Lake has been generally consistent over the years of record with respect to the alkalinity ranging from 107 to 170 mg/L $CaCO_3$. Kalamalka Lake water is considered to have a high alkalinity which is noted in the consistent pH. Higher alkalinity means the lake is more resistant to influences that would cause pH change.

With the exception of results in January 2004, December 2011 and June 2016, hardness results are between 158-185 mg/L as $CaCO_3$. According to Health Canada, water that is between 120 and 180 mg/L is considered hard. Harder water and high alkalinity means Kalamalka Lake is less corrosive to water pipes.

Chlorophyll a

Chlorophyll a is a measure of the concentration of the green pigment found in plants in the water. Chlorophyll a is generally used as an indicator of phytoplankton (algae) in the water sampled. In looking at the data it appears that average chlorophyll a concentrations are cyclical (Figure 18 and 19) with higher numbers noted in 2004, 2009, 2015, and 2020 (roughly every five (5) years). In 2020 however, the average chlorophyll a amount was double the average of 2.3 ug/L at 4.8 ug/L. There was a significant algae bloom noted in the winter. Further investigation and monitoring is needed to understand this.

Organic Carbon

Similar to Duteau Creek, TOC and DOC are strongly related (R^2=0.979) when incorporating all of the data from 2003-2020 (Figure 20). However, in 2020 the relationship is not as strong (R^2 = 0.576) (Figure 21) indicating in 2020 there are times when organic carbon levels are not all related to dissolved compounds. These organic compounds are important to note as they are precursors to disinfection by-products in the system, which are not only high for the Duteau Creek source, but also for the Kalamalka Lake source.

Volatile Organic Compounds

Volatile Organic Compounds have been sampled annually at the Kalamalka Lake intake since 2004. All parameters and results have been non-detect during this time. Table 14 shows the 2020 results.

Pesticides and Herbicides

Pesticide and herbicide scans have been analyzed every two (2) years in June on the Kalamalka Lake intake since 2013. These analyses are completed to capture any of these chemicals that have travelled to the lake from surrounding lands. No compounds were detected in 2020.

Light Extractable Petroleum Hydrocarbons (LEPH) / Heavy Extractable Petroleum Hydrocarbons (HEPH)

Fuel, LEPH, and HEPH have been analyzed approximately every two (2) years in the summer on the Kalamalka Lake intake since 2011. These analyses are completed in August to capture any of these chemicals that could be entering the lake due to human activities. No compounds were detected in 2020.

Biological Monitoring

As explained above, algae, TC and *E.coli* are biological compounds regularly monitored in source water (Table 15).

Algae

Algae is an ongoing concern in Kalamalka Lake. It is a source of taste and odour causing complaints and adds to the biomass in the distribution system. RDNO samples for nutrients contributing to algal growth each year, to monitor human impacts to the source water quality. Further study and observation on Kalamalka Lake miroflora (water chemistry and thermal profiles), is also conducted by Larratt Aquatic Consulting Ltd. (Larratt Aquatic Consulting, 2020).

To understand the nutrient loading and the potential for algae blooms, an outline is provided in the BC Decision Protocol for Cyanobateria Toxins (MOH, 2017). Within the protocol, the recommendation to further investigate toxin formation is if yes is answered to any of the following:

1. nitrogen greater than 658 ug/L
2. phosphorous greater than 26 ug/L
3. N:P ratio less than 23
4. algae blooms observed.

2020 was below the protocol levels for the first and second point above where peak nitrogen (total) was 492ug/L and peak phosphorous (total) was 16ug/L. There were however seven (7) instances where the N:P ratio was less than 23. There were also algae blooms observed in the lake. This concern will be monitored further and is a consideration for future treatment. As noted in Figure 19, 2019 chlorophyll a numbers were not three (3) samples outside the typical range in the last 16 years. Additionally, the annual average was above the previous year's annual averages.

Bacteria

TCs are monitored as an indicator bacteria to assess changes in source water. In Figure 22 the results for the TCs in 2020 are compared to the British Columbia Drinking Water Treatment Objectives (microbiological) for Surface Water Supplies (BC MOH, 2012);

- TCs should not exceed 100 CFU/100 mL in at least 90% of the weekly samples.

As shown in Figure 22, Kalamalka Lake meets and exceeds this treatment objective for samples analyzed at the accredited lab or at the RDNO lab.

E.coli is monitored as an indicator bacteria in the raw water to assess changes in the source water and compare the levels to the British Columbia Drinking Water Treatment Objectives (microbiological) for Surface Water Supplies (BC MOH, 2012). The number of *E.coli* in raw water does not exceed 20/100 mL (or if *E.coli* data are not available, less than 100/100 mL of TC) in at least 90% of the weekly samples from the previous six (6) months. This objective is met for the *E.coli* results (Figure 23).

Treatment Monitoring Program

Duteau Creek Water Treatment Plant

The DCWTP operators complete the analysis as shown in Table 16. Water quality staff sample and analyze bacteria, chlorine, conductivity, temperature, and turbidity weekly at the reservoir outlet where the Duteau Creek water enters the distribution system. The chlorine Contact Time (CT) for four (4) log inactivation of viruses is applied at DCWTP reservoir and the dosage can be adjusted if required. Table 17 summarizes the DCWTP 2019 monthly averages for post treatment free chlorine and pH. Pre-treatment UV monthly averages are also included in Table 17.

Treatment Targets for Turbidity

As noted, online turbidity analyzers record raw water and treated water turbidity to ensure that the treatment is functioning correctly and water going into the distribution system meets the requirements as set out by IH. The operation parameters are defined in the GVW Water Quality Deviation Response Plan. Online turbidity instruments are monitored through SCADA and are alarmed at set numbers to ensure operators and staff respond as outlined in the GVW Water

Quality Deviation Response Plan.

The turbidity averages are looked at in the month end reports (online). DCWTP is effective at reducing raw water turbidity levels to ensure the levels entering the distribution system are less than 1 NTU (Figure 7). No water with a daily average turbidity greater than 1 NTU entered into the distribution system in 2020.

Ultraviolet Transmittance

The UVT (unfiltered) is recorded online when the plant is running and grab samples are taken daily. As noted in Figure 24, the range was between 83.9% and 95.6% which is excellent to ensure the disinfection of the water.

Aluminum

Aluminum has an operational guidance value, designed to apply only to drinking water treatment plants using aluminum-based coagulants. The operational guidance values of 0.1 mg/L applies to conventional treatment plants, and 0.2 mg/L applies to other types of treatment systems and is reported as a 12 month running average.

Total and dissolved aluminum are measured monthly at the reservoir located at the intake of the DCWTP, and in the distribution system. The numbers reflect inherent flocculation carry through from the DAF process. Elevated dissolved aluminum is an indicator of high raw water aluminum or over application of Poly Aluminum Chloride (PAC), the plants primary coagulant. Carry over is a concern for the levels of aluminium in the water and for the contribution of buildup in the distribution system, leading to distribution water quality system degradation.

Figure 25 shows the 12 month running average of total aluminum from 2011 – 2020 on Duteau Creek raw water, demonstrating the source water does have total aluminium. Figure 26 is the total aluminium post treatment over the same time period and illustrates improved control of the coagulant over the years since the treatment plant started operating in late 2010. Total aluminum is one of the measured parameters used for Water Quality Indicators (WQI) at the plant. Total aluminium is also measured in the distribution system, historically at PRV #1 but changed to PRV #2 in 2019 in order to represent a larger majority of the system. Figure 27 shows the annual average total aluminum from the raw water, through the treatment plant, and into the distribution system. As it is now, the total aluminium does not represent a health concern.

Total and Dissolved Organic Carbon

Grab samples for total and dissolved organic carbon are taken monthly from the raw water and post treatment (Figure 28). From the results, the percent removal can be calculated.

Both TOC and DOC levels affect the generation of trihalomethanes and are of interest as we use UV for disinfection. Organic carbon absorbs UV light and can impact treatment, this is discussed further in this report.

TOC is also measured in the upper watershed at the Haddo weir or the outflow of the reservoir lakes (Figure 28). The measurements taken since 2003 show an apparent peak in 2010 and since then a slow decrease to 2003 levels in 2020. This will continue to be investigated. The levels at the Haddo weir site are similar to the intake site, and deviations would indicate watershed changes between the reservoirs and the intake.

Mission Hill Water Treatment Plant

The MHWTP includes two chlorine injection points with sodium hypochlorite generated on site. In 2018 a second hypochlorite dosing system was installed to address concerns of less CT to the first customer on the 550 pressure zone. This dosing system is down stream of the original injection point at MHWTP and adds a bit more chlorine residual to the water pumped to the 550 zone. This addition allows for a lower chlorine dose to the 483 zone as CT to the first customer is higher in this zone. Following disinfection, water is delivered to the first customer. The MHWTP operators complete the following sampling and analysis as shown in Table 18. Further information on the CT can be found in the monthly reports. Table 19 summarizes the post treatment free chlorine and pre-treatment UVT (%).

Water quality staff continued to take weekly samples to analyze at the RDNO lab for unfiltered UVT. A sampling site located after disinfection was used to monitor the presence of bacteria twice a week. In 2020, the operators performed and documented daily plant checks plus operational changes and maintenance.

Treatment Targets for Turbidity

Unlike the DCWTP, the type of treatment at the MHWTP is not effective at reducing turbidity levels. Instead when turbidity levels trend greater than defined values in the GVW Water Quality Deviation Response Plan and the water system demand allows, the source is turned off and DCWTP is used. The MHWTP was turned off in January, April, May, June, October and November in 2020 for a total of 99 days. Figure 14 shows the raw and treated turbid water. While 1 NTU is the MAC, the intake is typically turned off when the readings go above 2.5 NTU.

Online turbidity instruments report to SCADA and are alarmed at set numbers to ensure operator and staff respond as outlined in the GVW Water Quality Deviation Response Plan.

Ultraviolet Transmittance

UVT is important to measure as UV treatment (disinfection) is an important treatment step within the MHWTP. Measuring UV light at the specified wavelength of 254 nanometers (nm), measures the effectiveness of the UV light for disinfection of the drinking water.

Distribution Monitoring Program

After treatment and/or disinfection, the distribution water quality program is designed to meet the *DWPR* and *GCDWQ*. Additional parameters may be monitored if they are known to create problems within the water distribution system. The full Water Quality Monitoring Program is located at https://www.rdno.ca/waterquality.

The water distribution system is monitored weekly by operators and water quality staff. When unacceptable field parameters are noted, the system is monitored and flushed, or investigated further. The field parameters sampled include: pH, turbidity, temperature, conductivity, free and total chlorine, and bacteria.

The distribution sampling sites are determined by both GVW and IH. The monitoring program is designed to capture changes in water quality as it flows through the pipeline (i.e. flow patterns in the water distribution system).

The distribution system has generally been considered as two (2) separate systems that are normally serviced by one (1) of the two (2) main sources, Duteau Creek or Kalamalka Lake. The system can be run with either source and sampling sites can be serviced by either source. Kalamalka Lake water has a conductivity usually between 400 and 500 µS/cm and treated Duteau Creek water has a conductivity usually between 100 and 200 µS/cm. When sites are sampled, the conductivity indicates which source is present or if there is a blend.

The preferred connection for dedicated sampling sites is directly to the main water line for a number of reasons. Public buildings or residential homes may be inaccessible and/or results may not always be reliable. Where a sample line cannot be run continuously, it should be a suitable size to allow water from the main to reach the tap after a brief flush. Sampling sites will be re-evaluated as the GVW program evolves.

Distribution sampling follows the specifications outlined in the conditions on permit and also as directed by IH. Additional parameters and monitoring can occur for individual projects.

GVW provides a Water Quality Monitoring Plan to IH annually. The frequency of monitoring samples for prescribed water supply systems is outlined in the BC DWPR.

The health and safety of our water system and public trust are issues GVW takes seriously. GVW staff work closely with IH to establish a program that ensures our citizens are provided with safe and healthy drinking water.

Bacterial Testing Overview

The *GCDWQ* and the *DWPA* and DWPR have established the following microbiological criteria for drinking water distribution systems noted in Schedule A of this guideline and as follows:

- no sample should contain more than one (1) TC organism per 100 mL, none of which should be *E.coli*
- no two (2) consecutive samples from the same site should show the presence of coliform organisms
- at least 90% of the samples must have zero (0) TCs per 100 mL.

GVW, as the drinking water purveyor serving the Greater Vernon area with a population of approximately 58,000 is required to test a minimum of 58 bacterial samples per month at an accredited lab as outlined in the GCDWQ, Sixth Edition. Table 20 is the summary of the information.

In total, there were 1,491 bacterial samples taken in the GVW distribution system in 2020; 946 were sent to an accredited lab and 545 were completed in the RDNO lab. The samples are tested for TC and *E.coli* bacteria.

Duteau Creek supplied system: Insert link to comprehensive table

Total sites (43):

- 14% (six (6) sites) high flows/main transmission/entry point
- 42% (18 sites) medium flow
- 33% (14 sites) low flow
- 11% (five (5) sites) dead-ends, un-looped lines and stagnant areas.

Kalamalka Lake supplied system: Insert link to comprehensive table

Total sites (36):

- 14% (five (5) sites) high flows/main transmission/entry point
- 42% (15 sites) medium flow
- 31% (11 sites) low flow

- 13% (five (5) sites) dead-ends, un-looped lines and stagnant areas.

At this time there are **79** sampling sites throughout the GVW distribution system. Two (2) sampling stations were installed in 2020.

Bacterial Test Results

In 2020, the drinking water distribution system was sampled as if they were two (2) distinct systems; the Duteau Creek supplied system and the Kalamalka Lake supplied system.

- In 2020, there were no detectable *E.coli* in the GVW distribution system
- In 2020, 98.8% of samples in the Duteau Creek system and 98.9% in the Kalamalka system had no detectable Total Coliform per 100 ml (Table 20).

The results met and exceeded the GCDWQ and the DWPR.

Disinfection By-Products

Trihalomethanes (THMs) are a disinfection by-product formed when organic compounds naturally present in the source water react to being chlorinated. The level of THMs in treated water depends on numerous factors including: TOC, temperature, pH, water age, and chlorination dose. Ten distinct THM compounds are possible but only four (4) occur to any significant degree in treated drinking water:

- Chloroform
- Bromodichloromethane
- Dibromochloromethane
- Bromoform.

Collectively the above THM compounds are referred to as total trihalomethanes (TTHMs) (Health Canada, 2009). Further in this text TTHMs will refer to sample site averages of all four (4) compounds, not the individual parameters.

The GCDWQ MAC for TTHMs is 0.1 mg/L (100 µg/L) (Health Canada, 2019) and as defined in the guideline is based on a locational running annual average of a minimum of quarterly samples taken at the point in the distribution system with the highest potential THM levels (Health Canada, 2009). THMs are sampled throughout the distribution system quarterly to comply with the GCDWQ. Conductivity is taken at each site to determine the source water at the sample site (Tables 21 and 22).

Haloacetic acids (HAAs) are a disinfection by-product formed when organic compounds naturally present in the source water react to being chlorinated. The level of HAAs in treated water depends on numerous factors including: bromide, temperature, pH, water age, and chlorination dose (Government of Canada, 2008). Several distinct HAA compounds are possible but only five (5) occur to any significant degree in treated drinking water:

- Monochloroacetic acid
- Monobromoacetic acid
- Dichloroacetic acid
- Trichloroacetic acid
- Dibromoacetic acid.

Collectively the above HAA compounds are referred to as total haloacetic acids (THAAs). Further in this text THAAs will refer to sample site averages of all five (5) compounds, not the individual parameters, and are reported as an average of all five (5) compounds (THAAs).

The GCDWQ MAC for HAAs is 0.08 mg/L (80 µg/L) (Health Canada, 2019) and is based on a locational running annual average of a minimum of quarterly samples taken in the distribution system. THMs are sampled throughout the distribution system quarterly to comply with the GCDWQ.

Health Canada advises that water utilities should make every effort to maintain concentrations as low as reasonably achievable (or ALARA) without compromising the effectiveness of disinfection.

HAAs have limited industrial uses. These uses may lead to the release of HAAs into water through agricultural runoff, industrial wastewater, or accidental spills.

Duteau Distribution System TTHM/HAA

As noted above, the DCWTP removes THM precursors such as organic carbons. This also reduces the chlorine demand and the colour of the water. As a result, the TTHMs have been reduced by almost 50% with the addition of the DCWTP (Figure 30).

Figure 31 shows the TTHMs for the Duteau Creek distribution for 2020. In 2020, the annual average at the sites with the highest potential THM levels exceeded the GCDWQ. Since the commissioning of the DCWTP in 2010, the annual average is around the MAC of 100 ug/mL. Further improvements are being studied through chlorine management in the treatment process and distribution system (re-chlorination, reservoir, and operations).

HAAs have been monitored since 2011 in the GVW water distribution system at all the same locations as the THM's (Figure 32). Figure 33 shows the THAAs for the Duteau Creek distribution system for 2020. The sites with the highest THMs also have the highest HAAs. In 2020, the annual average THAAs were above the MAC for the first time since 2016.

Kalamalka Distribution System TTHM/THAA

The Kalamalka Lake distribution system has been monitored for THM's since 2003. Unlike Duteau Creek, Kalamalka Lake has lower levels of disinfection by-product precursors including little to no measurable colour and low organic carbon levels through most of the year. The Kalamalka Lake distribution system has many pressure zones and a grid system with flow to and from reservoirs, this is very different from the long Duteau Creek distribution system. In 2020, the annual average at the sites with the highest potential THM levels exceeded the GCDWQ (Figure 35). The system average was lower than the guideline (Table 22 and Figure 34).

Tavistock and Longspoon sites continue to have the highest THMs and HAAs (Figures 35 and 36) in the Kalamalka distribution system. The sites with the longest retention time are above the GCDWQ MAC and have been since 2014. These sites should be considered for a water quality loop, reservoir aeration, or continue to be a part of the chlorine reduction plan.

In 2020, the Kalamalka distribution system THAA results were below the GCDWQ MAC making the annual average acceptable (Figure 37). This has been true since the start of THAA monitoring in 2011.

Zinc Orthophosphate and Corrosion Control

Water sourced from Duteau Creek is corrosive as the water has a neutral to low pH, low alkalinity, and low hardness. Zinc orthophosphate (Zn O-PO4) was added to the Duteau Creek treated water as a corrosion inhibitor. It is injected during low flows (typically October/November to March/April) to minimize the release or leaching of iron, lead, copper, and other metals from the distribution water lines and connections. The DCWTP also has the ability to add caustic to adjust the pH. In 2020 Duteau targeted a 7.0 to 7.2 pH entering the distribution system.

Quality Assurance and Quality Control Program

To assess the quality of the sampling and analytical results, the RDNO carries out a comprehensive quality assurance and quality control program (QA/QC) as defined in the Water Quality Monitoring Program. The program ensures the quality of field samples, RDNO lab results, travel quality of samples, and accredited lab results.

Customer Calls and Response

In 2020, water quality staff responded to 50 customer calls which vary between inquiries to investigations. There were 11 inquiries and 43 water quality issues.

Customer inquiries range from specific parameters within the water system to what source water they are on.

Water quality issues involved two (2) illness and irritations, two (2) turbid water, seven (7) taste and odour issues, and 28 colour water issues.

A customer concerned with illness or skin irritation is recommended to go to the doctor as treated drinking water commonly does not cause these issues.

Water quality issues require investigations starting with standard questions for the customer to determine what parameters need to be analyzed or if the issue is internal.

After speaking with the customer, water quality staff communicates with the CoV and/or the DoC to determine if there are any water main breaks, flushing or maintenance within the area. Staff review maps which show the types of water mains and flows in the area, then proceed with taking samples if needed. After the water is analysed, the results are reviewed.

All water quality calls are tracked in an online database and are completed with a follow-up phone call to ensure the water quality has improved.

CROSS CONNECTION CONTROL PROGRAM

GVW has administered a Cross Connection Control (CCC) bylaw and monitoring program in compliance with IH's requirements since 2005.

Agricultural customers and properties in separated areas continued to be sources of non-compliance and were focused on during the irrigation season. Enforcement action was taken on 33 agricultural customers and an additional 11 properties with auxiliary water sources. In addition, the CCC officer worked with a field enforcement officer to identify cross connection hazards at concrete batching plants and other industrial sites which had either not been surveyed or compliance from previous surveys had not been met.

The GVW CCC program currently tracks 2,537 active devices at 1,719 facilities. In 2020, 61 new assessments were completed, 66 new facilities and 105 backflow assemblies were added. While the total facility numbers appear to be less than previous year's reports, there were some issues with the data. These new numbers represent corrections made and the updated results for 2020.

EMERGENCY RESPONSE / NOTIFICATION / COMMUNICATIONS

Water Quality Notification and Communication

GVW staff have prepared a GVW Emergency Response Plan (ERP) which includes the GVW Water Quality Deviation Response Plan. These documents contain the contacts, criteria, and procedures necessary to assist operators and staff to make timely, informed decisions in the event of water quality changes or emergencies. GVW requires all CoV and DoC operators attend an annual training session where they participate in a mock emergency and these documents are put into practice. The 2020 GVW ERP has been provided to IH, CoV and DoC operators.

In 2020, GVW distributed 14 media releases to customers, ranging from water source changes, boil water notices (BWN), water quality advisories (WQA) and BWN/WQA rescind notices, and maintenance work. There was one (1) BWNs and accompanying rescind, one (1) WQAs accompanying rescind, six (6) maintenance notices, and four (4) water source changes.

GVW must inform customers when their drinking water is not safe to consume or use. A Water Quality Advisory (WQA) is released when a public health threat from the water supply system is higher than considered normally acceptable, but not serious enough to warrant (or will not be resolved by) a Boil Water Notice. The advisory will usually describe actions that can be taken to reduce risks. A BWN is released when testing reveals *E.coli* or other coliform organisms in the water supply system, and/or the system fails to meet drinking water treatment objectives – and the associated public health threat can be effectively addressed by boiling the water.

An advisory or notice is delivered as quickly and efficiently as possible. Notification may include media releases, road signs, radio, and/or newspaper. Under specific circumstances, notifications are hand-delivered.

Customers are advised to subscribe to the RDNO mailing list by going to https://www.rdno.ca/subscribe to receive notifications for their area.

TABLES

Table 1: RDNO Utilities Department

RDNO Utilities	
Zee Marcolin, P.Eng	General Manager, Utilities
John Lord, P.Eng	Manager, Water Distribution
Sandy Edwards, AScT	Manager, Projects
Tricia Brett, P.Ag	Manager, Water Quality
Jennifer Miles, MEDes	Water Sustainability Coordinator
Connie Hewitt, AScT	Water Quality Technologist
Keiko Parker, AScT	Water Quality / Protection Technician
Alec Busby, EIT	Assistant Utilities Engineer
Mike Philips, AScT	Engineering Technologist/ Bylaw Officer
Skyler Ganz, AScT	Engineering Technologist
James de Pfyffer	Manager, Small Utilities
Ryan Lockwood	Engineering Tech / Cross Connection Control Officer

Table 2: RDNO Water Treatment Operators 2019

RDNO Operators			
Last Name	**First Name**	**Certification #**	**Certification Held**
Dunsdon	Jennifer	7387	WDI, WTIII
Gibson	Don	5922	WDII, WTIII
Hartwig	Corey	9378	WTI, Electrical Instrumentation Technician
Heidt	Dustin	4498	WDIII, WTIV
Lay	Paul	2097	WDIII, WTII
Mykytuk	Becky	9086	WTIII
Robertson	Tyler	9130	WTIV
Ross	Gordon	5219	WDII, WTIII

Table 3: CoV Water Distribution Operators 2020

City of Vernon Operators			
Last Name	**First Name**	**Certification #**	**Certification Held**
Briggs	Geordie	6495	WDII, CH, WWCI
Browne	Ryan	8176	WDII, WWCI
Cleverly	Curtis	7193	WDII, CH
Erickson	James	3626	WDIII,CH,WTI,WWCI MWWTI
Fugel	Thomas	2096	WDII, WWCI, CH, WTI
Gaythorpe	Glen	7271	WDII, WWCII
Holloway	Ryan	8876	WDII, WWCI
Holtz	Colin	9158	WDI, WWCII
Irwin	Sean	8610	WDII,WWCII
Markel	Marvin	3291	WDIV, CH WTII, WWCII
Martin	Allan	5900	WDII
Parker	Ryan	6988	WDII,CH, WWCI
Pope	Carson	8840	WWCI
Rempel	Chris	7192	WDI
Stowards	Blaine	8247	WDI, WCII
Svenhard	Wayne	1337	WDII, CH, WWCI
Vandermeer	Raymond	5742	WDII, CH, WWCII,MWWT OTI
Walters	Kevin	7894	WDIII, WWCI,MWWTII, WTII

Table 4: DoC Water Distribution Operators 2020

District of Coldstream Operators			
Last Name	**First Name**	**Certification #**	**Certification Held**
Comeau	Brent	5662	WDII, WWCII
Davyduke	Matt	7160	WDII, WWCI
Lerbeck	Ron	9379	WDI
Mazereeuw	Jack	5747	WDII, WWCII,SWS
McKay	Gordon	3471	WDI
Nicholson	Cory	7053	WDI
Scherck	James	7776	WDII, WWCI
Webster	Jason	1000440	WDI

Table 5: GVW Water System Replacement Value

Infrastructure Item	Value (in Millions)
Water Mains	$ 397.6
Water Services	$ 64.3
Water Treatment Plant	$ 52.4
Reservoirs	$ 50.6
Dams	$ 38.2
Valves (Isolation, Blow-Offs and Air Valves)	$ 35.1
Pump Stations	$ 34.1
Hydrants	$ 21.6
Pressure Reducing Valve Stations	$ 13.4
Water Meters	$ 12.7
Intakes	$ 4.4
Wells	$ 3.2
Spillways	$ 3.1
Total Value (rounded from original totals)	**$ 730.5**

Table 6: GVW Water Mains

Pipe Material	Length In Service	Comments
Cast Iron	48 km	Majority installed prior to 1978
Ductile Iron	105 km	Ductile iron is still used in some applications
PVC	252 km	Most pipe installed since 1979 has been PVC
Concrete	26 km	Majority installed prior to 1978, used in larger diameter applications
Asbestos Cement	205 km	Majority installed prior to 1978
High Density Polyethylene	5 km	Used for specialized applications
Steel	9 km	Used for specialized or larger applications
Other	3 km	Other uncommon materials
Copper	6 km	Used for smaller applications

Table 7: Capital Projects Completed in 2020

Capital Projects Completed in 2020	Description
Flood Mitigation Kal Pump Station	Move electrical to upper floor to allow pump station to operate in a flooded condition
Vimy to Learmouth Road	Water main replacement and upsize
30 Street from 37 to 41 Avenue - CoV	Water main replacement - CoV project
32 Avenue from 31 to 35 Street - CoV	Water main replacement - CoV project
Noble Canyon Creek Removal	Remove intake structure to natural state
15 Avenue 30 Street Intersection - CoV	Small portion of water main replacement
BX Creek - Upper Weir Restoration	Removal of upper weir 0.5km from BX intake
Highway 97 Water Works - Phase 1	Plan to abandon 150mm cast iron in HWY
Pleasant Valley Road, BX Creek to 48 Avenue	Small water main upgrade - CoV project

Table 8: Summary of metered and estimated unmetered water consumption compared to source flows

2020 Annual Water Audit	2020 Annual Inflows (m^3)	2020 Annual Consumption (m^3)
Water Inflows – Metered		
Duteau Creek Water Treatment Plant (including flows to Goose Lake)	10,377,050	
Mission Hill Water Treatment Plant	4,037,120	
Duteau Creek Non-Potable Water	690,620	
Coldstream Ranch Wells 1 & 2 Non-Potable Water	51,400	
King Edward Lake Non-Potable Water	631,300	
Direct Billed Consumption - Metered		
Residential		4,829,541
Commercial		1,640,809
Parks		126,111
Agricultural		5,539,659
Truck Fill Station - Bulk Water		14,540
Public Hydrant (Tap) Rentals		27,410
Unbilled Authorized Use – Estimated		
Water Main Flushing		56,398
Water Quality Monitoring Stations		25,729
Auto flushers		92,919
Fire Fighting		5,000

2020 Annual Water Audit	2020 Annual Inflows (m^3)	2020 Annual Consumption (m^3)
Water Losses - Estimated		
Water Meter Inaccuracies, Non-Reporting, Stuck Meters		29,000
AWWA Recommendation - Unavoidable Losses		1,000,000
Total	15,787,490	13,392,528
Audit Percentage Difference between Inflows and Water Consumption - 15%		

Table 9: Haddo Weir parameter sampling frequency

Physical / Chemical Parameters	Accredited Lab Analysis	RDNO Lab Analysis	Bi-Weekly Sampling	
			1st Wednesday	3rd Wednesday
Turbidity		x	x	x
pH		x	x	x
Temperature		x	x	x
Conductivity		x	x	x
Algae Density		x*		x*
Colour (True)		x		x
Colour (Apparent)		x		x
Chlorophyll a	x			x
Iron		x		x
Total Organic Carbon / TOC	x			x
Total Kjedahl Nitrogen	x			x
Phosphorus (Total)	x			x
Total Coliform	x	x	x	x
E.coli	x	x	x	x

* Sampled when odour present

Table 10: Coldstream Creek Sites (School Road, Brewer Road, Howe Drive, and Kirkland Drive sites) parameter sampling frequency

Physical / Chemical Parameters	Accredited Lab Analysis	RDNO Lab Analysis	Sampling		
			Weekly	Monthly	Quarterly
Turbidity		x*		x	
pH		x*		x	
Temperature		x*		x	
Conductivity		x*		x	
Ammonia	x			x	
Chloride	x			x	
Phosphorus (Total)	x			x	
Total Kjedahl Nitrogen	x			x	
Total Organic Carbon / TOC	x			x	
Sulphate	x			x	
Total Coliform	x			x*	
E.coli	x			x*	

* These parameters are sampled more frequently during freshet

Table 11: Duteau Creek Intake Sample Frequency

Physical / Chemical Parameters	Accredited Lab Analysis	RDNO Lab Analysis	Sampling		
			Weekly	Monthly	Quarterly
Turbidity		x	x	x	x
pH		x	x	x	x
Temperature		x	x	x	x
Conductivity		x	x	x	x
Chloride	x				x
Bromide	x				x
Chlorophyll a	x			x**	x**
Iron		x		x	x
Aluminum / Dissolved Al	x			x	x
Total Organic Carbon / TOC	x			x*	x
Dissolved Organic Carbon / DOC	x			x*	x

Physical / Chemical Parameters	Accredited Lab Analysis	RDNO Lab Analysis	Sampling		
Total Kjedahl Nitrogen	x				x*
Phosphorus (Total)	x				x*
Biological Parameters	**Accredited Lab Analysis**	**RDNO Lab Analysis**	**Sampling**		
			Weekly	**Monthly**	**Quarterly**
Total Coliform	x	x	x	x	x
E.coli	x	x	x	x	x

* These parameters were sometimes sampled more frequently due to seasonal changes.
** This parameter is sampled from May to November

Table 12: Duteau Creek intake bacterial summary

Total Coliform CFU/100 mL	Accredited Lab	RDNO Lab
Min	27.9	17.8
Max	2460.0	200.5
90^{th}% Percentile*	1937.0	200.5
# of Samples	52	51
Counts ≥ 100 CFU/100 mL	36	31
Counts <1 CFU/100 mL	0	0
***E.coli* CFU/100 mL**	**Accredited Lab**	**RDNO Lab**
Min	<1	<1
Max	687.0	200.5
90^{th}% Percentile*	174.2	200.5
# of Samples	52	51
Counts >20 CFU/100 mL	7	7
Counts <1 CFU/100 mL	2	4

*90% of the values are < than the stated value

Table 13: Kalamalka Lake Parameter sampling frequency

Physical / Chemical Parameters	Accredited Lab Analysis	RDNO Lab Analysis	Sampling		
			Weekly	Monthly	Quarterly
Turbidity		x	x		
pH		x	x		
Temperature		x	x		
Conductivity		x	x		
Colour (True)		x			x
Colour (Apparent)		x			x
Alkalinity		x			x
Hardness		x			x
Bromide	x				x
Chlorophyll a	x			x**	x**
Total Organic Carbon / TOC	x			x*	x
Dissolved Organic Carbon / DOC	x			x*	x
Total Kjedahl Nitrogen	x				x*
Phosphorus (Total)	x				x*
Biological Parameters	**Accredited Lab Analysis**	**RDNO Lab Analysis**	**Sampling**		
			Weekly	**Monthly**	**Quarterly**
Total Coliform	x	x	x		
E.coli	x	x	x		
Iron Related Bacteria	x				x
Sulfur Reducing Bacteria	x				x

* These parameters were sometimes sampled more frequently due to seasonal changes in Kalamalka
** This parameter is sampled from May to November

Table 14: 2020 Volatile organic compounds in Kalamalka Lake

VOCs	July 14, 2020 Results (ug/L)	August 26, 2020 Results (ug/L)	Maximum Acceptable Concentration (MAC)	Aesthetic Objective (AO)
Benzene	<0.5	<0.5	MAC=5	
Bromodichloromethane	<1.0	<1.0	N/A	
Bromoform	<0.1	<0.1	N/A	
Carbon tetrachloride	<0.5	<0.50	MAC=2	
Chloroethane	<0.2	<0.2	N/A	

VOCs	July 14, 2020 Results (ug/L)	August 26, 2020 Results (ug/L)	Maximum Acceptable Concentration (MAC)	Aesthetic Objective (AO)
Chloroform	<0.1	<0.1	N/A	
Dibromochloromethane	<1.0	<1.0	N/A	
Dibromomethane	<1.0	<1.0	N/A	
1,2-Dichlorobenzene	<0.5	<0.5	MAC=200	AO<=3
1,3-Dichlorobenzene	<1.0	<1.0	N/A	
1,4-Dichlorobenzene	<0.1	<0.1	MAC=5	AO<=1
1,1-Dichloroethane	<1.0	<1.0	N/A	
1,2-Dichloroethane	<1.0	<1.0	MAC=5	
1,1-Dichloroethylene	<0.1	<0.1		
cis-1,2-Dichloroethylene	<1.0	<1.0		
Dichloromethane	<3.0	<3.0	<1.0	<1.0
1,2-Dichloropropane	<1.0	<1.0	N/A	
Trans-1,3-Dichloropropene	<1.0	<1.0		
Methyl tert-butyl ether	<1.0	<1.0		AO<=15
Momochlorobenzene	<1.0	<1.0		
1,1,2,2-Tetrachloroethane	<0.5	<0.5	N/A	
Styrene	<1.0	<1.0		
Tetrachloroethylene	<1.0	<1.0	MAC=10	
Toluene	<1.0	<1.0	MAC=60	AO<=24
1,1,1-Trichloroethane	<0.1	<0.1	N/A	
1,1,2-Trichloroethane	<0.1	<0.1	N/A	
Trichloroethylene	<1.0	<1.0	MAC=5	
Trichlorofluoromethane	<1.0	<1.0	N/A	
Vinyl chloride	<1.0	<1.0	MAC=2	
Xylenes (total)	<2.0	<2.0	MAC=90	AO<=20

Table 15: Kalamalka Lake Intake 2020 Bacteria Stats

Total Coliform CFU/100 mL	Accredited Lab	RDNO Lab
Min	1	<1
Max	3870	201
90^{th} Percentile	436	201
# of Samples	44	48
Counts ≥ 100 CFU/100 mL	0	0
Counts <1 CFU/100 mL	0	1
E. coli CFU / 100 mL	Accredited Lab	RDNO Lab
Min	<1	<1
Max	15	14
90^{th} Percentile	10	9.90
# of Samples	49	48
Counts >20 CFU/100 mL	0	0
Counts <1 CFU/100 mL	9	9

Table 16: DCWTP Analysis Frequency

Raw Water	Analysis
Daily or more frequently if needed	Raw On-line: pH, Turbidity, Temperature, Conductivity, and DOC. Raw Daily Lab Tests: pH, Turbidity, Temperature, Conductivity, True and Apparent Colour, and Alkalinity
Weekly	Total Aluminum
DAF Basins	Analysis
Daily	On-line: Turbidity Daily Lab Test: Turbidity
DAF Effluent (before chlorination)	Analysis
Daily	On-line: Turbidity, and UVT Daily Lab Test: Turbidity, pH, alkalinity, true colour, UV Transmissivity (UVT)
Twice a Week	Dissolved Aluminum
Pre-UV Treatment	Analysis
Continuous	Online: UVT, and Cl Residual
Plant Effluent	Analysis
Daily	On-line: Cl Residual, pH, Turbidity, Temp, Particle Counts, Daily Lab Test: Chlorine Residual, pH, Turbidity, Temp, Alkalinity(MWF), Ortho (reactive) Phosphate ((MWF) when corrosion control, zinc orthophosphate is in use)

Table 17: Duteau Creek Water Treatment Plant Monthly SCADA Averages

DCWTP Monthly SCADA Averages			
Parameter	Post Treatment Free Chlorine (mg/L)	Post Treatment pH	Pre Treatment UVT (%)
January	1.90	7.00	88.60
February	1.90	7.00	89.26
March	1.90	7.00	89.14
April	1.91	6.90	88.20[1]
May	1.90	6.65	91.40
June	1.90	6.98	92.63[2]
July	1.90	6.84	88.57
August	1.90	6.97	88.25
September	1.90	6.96	89.59
October	1.90	6.97	89.68
November	1.95	6.93	89.81[3]
December	1.90	7.09	88.09

[1]DCWTP DCWTP on bypass April 8 and so no UV treatment and no UV readings available

[2]Nine days of SCADA data could not be recovered due to computer error.

[3]DCWTP UV data removed because due to UV treatment being bypassed from Nov 16 to Nov 26, therefore these SCADA readings were not reflective of real time water

Table 18: MHWTP Analysis Frequency

Raw Water	Analysis
Daily or more frequently if needed	Raw On-line: Raw Daily Lab Tests:
Pre-UV Treatment	Raw Water
Continuous	Online: UVT, and Cl Residual
Plant Effluent	Raw Water
Daily	On-line: 3 Chlorine Residual 1) 483 zone pumps (low CT), 2)post contact chamber, 3)after chlorine is boosted for 550 zone pH, Turbidity, Temp, Particle Counts, Daily Lab Test: Chlorine, and UV Transmissivity (UVT) and UV dose are monitored on-line.

Table 19: Mission Hill Water Treatment Plant Monthly SCADA Averages

MHWTP Monthly SCADA Averages			
Parameter	Post Treatment Free Chlorine (mg/L)	Pre Treatment UVT (%) PZ 483	Pre Treatment UVT (%) PZ550
January[1]	2.01	2.12	92.50
February	2.00	2.13	92.27
March	2.07	2.11	91.91
April[2]	2.20	2.02	91.82
May[3]	Not available	Not available	Not available
June[4]	2.17	2.09	90.98
July	2.06	2.18	90.55
August	2.12	2.11	90.07
September	2.18	1.99	89.99
October[5]	2.13	1.75	90.33
November[5]	2.10	2.16	90.27
December	2.10	2.17	90.54

[1]Kal Intake off for a capital works project until January 22, 2020.

[2]Kal intake turned off April 22, 2020 due to high turbidity during freshet.

[3]Kal intake turned off April 22, 2020 due to high turbidity during freshet. Off all of May.

[43]Kal intake turned off April 22, 2020 due to high turbidity during freshet. Turned back on June 9, 2020.

[5]Kal intake turned off October 24 until November 27 due to high cyanobacteria counts from intake samples.

Table 20: Distribution bacterial sampling summary

2020 Distribution Bacterial Sampling Summary		
	Number of Bacterial Samples	
RDNO Lab Results	Distribution	
	Duteau Creek	Kalamalka
RDNO Lab (MPN or P/A) tests	**453**	**366**
RDNO Lab (MPN or P/A) tests containing *E.coli*	**0**	**0**
RDNO Lab (MPN or P/A) containing TC	**3**	**4**
RDNO Lab % of samples with zero TCs	**99.3%**	**98.9%**
Accredited Lab Results	Distribution	
	Duteau Creek	Kalamalka
Accredited Lab (counts) tests	**253**	**559**
Accredited Lab (counts) containing *E.coli*	**0**	**0**
Accredited Lab (counts) containing TC	**3**	**6**
Accredited Lab % of samples with zero (0) TC	**98.8%**	**98.9%**
Both Lab results combined for the year	Distribution	
	Duteau Creek	Kalamalka
Both labs combined bacterial samples	**706**	**925**
Both labs combined bacterial samples containing *E.coli*	**0**	**0**
Both labs combined bacterial samples containing TCs	**6**	**10**
Both labs combined % of samples with zero (0) TC	**99.2%**	**98.9%**
Both Lab results combined for the year	Distribution	
	Duteau Creek	Kalamalka
Both labs combined bacterial samples with >10 TCs	**0**	**3**
Number of occasions where consecutive samples had TCs using RDNO Lab	**1**	**1**
Number of occasions where consecutive samples had TCs using Accredited Lab	**0**	**0**

Table 21: Conductivity at Duteau Creek Distribution THM sites

Date	DCWTP	Palfrey SS	Golf View SS	Sun Peaks PS
March 12	110	120	110	120
June 1	110	120	120	130
September 3	110	120	110	140
December	110	130	110	120

Table 22: Conductivity at Kalamalka Lake Distribution THM sites

Date	MHWTP	Allenby PS	Longspoon Reservoir	Tavistock Reservoir
March 11	440	440	400	400
June 25	440	420	360	370
September 3	450	440	460	450
December 17	430	430	320	290

FIGURES

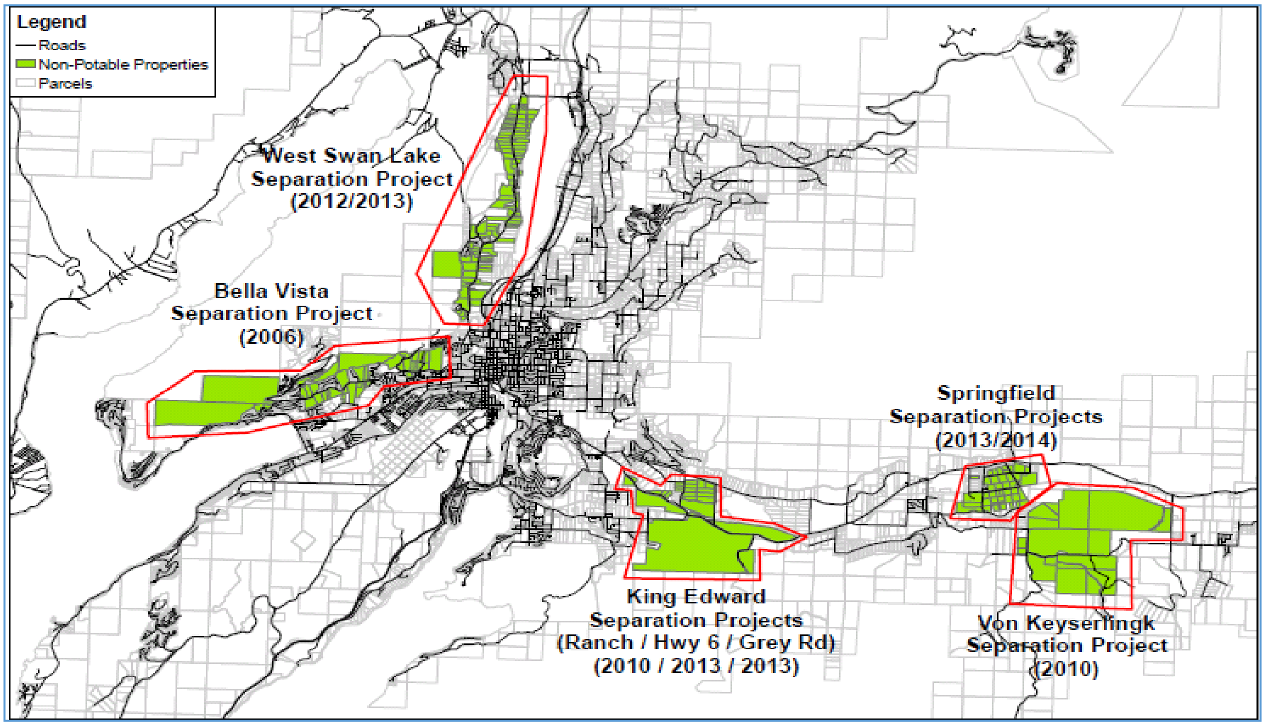


Figure 1: GVW Non-Potable Separation Projects to 2021

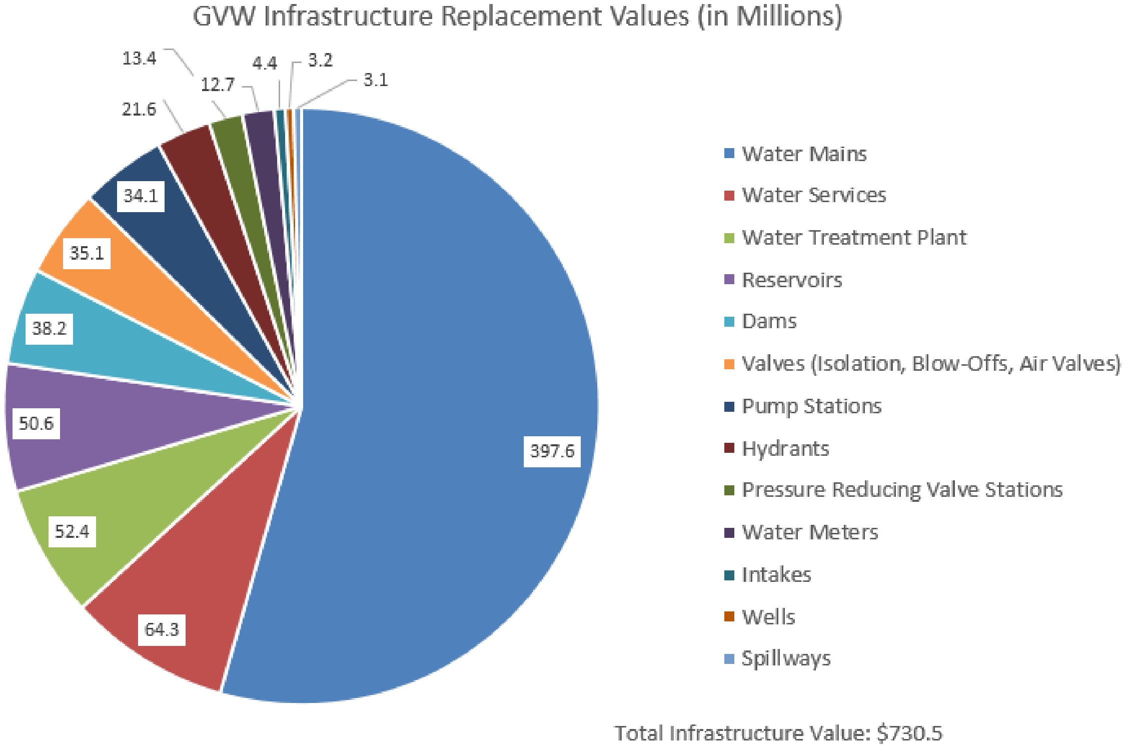


Figure 2: GVW Evaluation

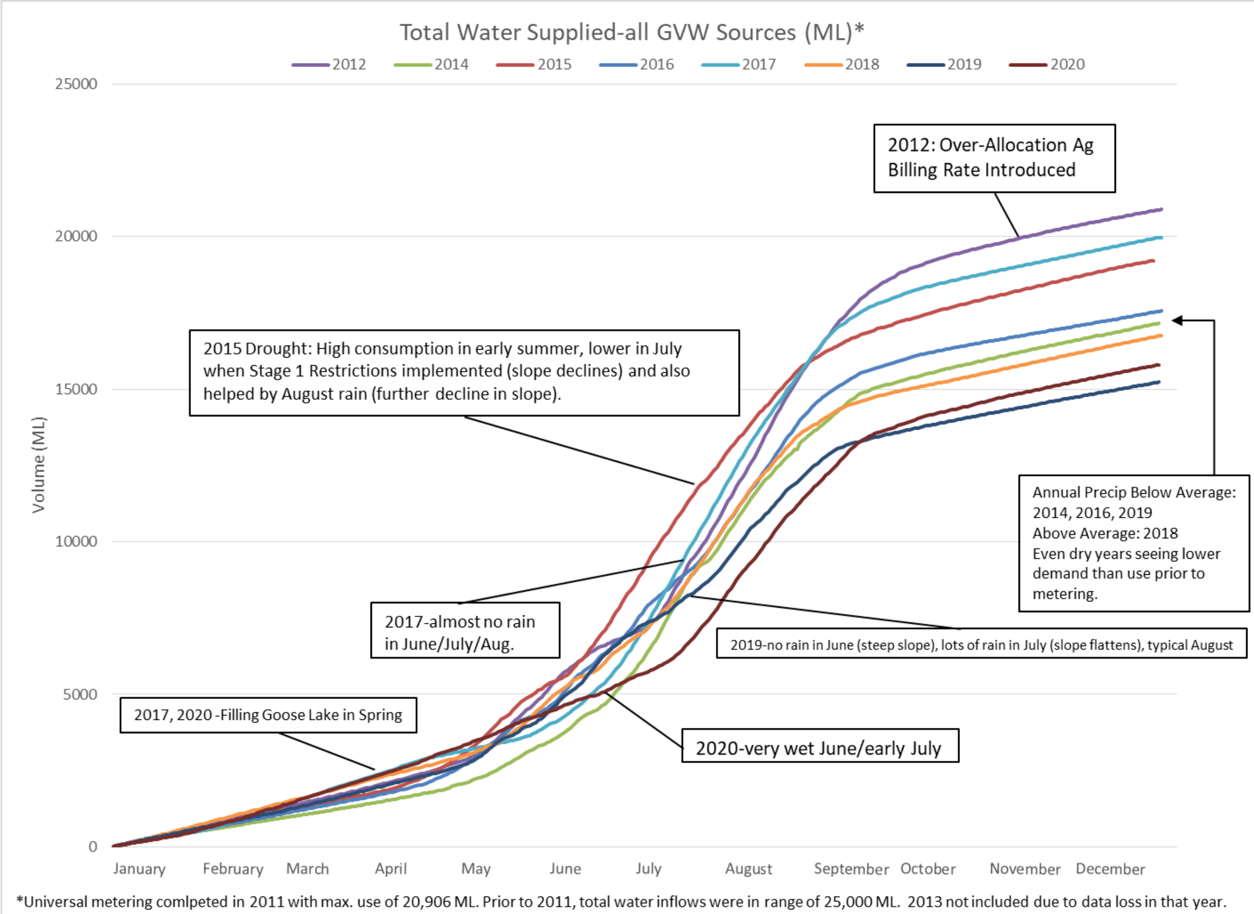


Figure 3: Year to Year Water Use

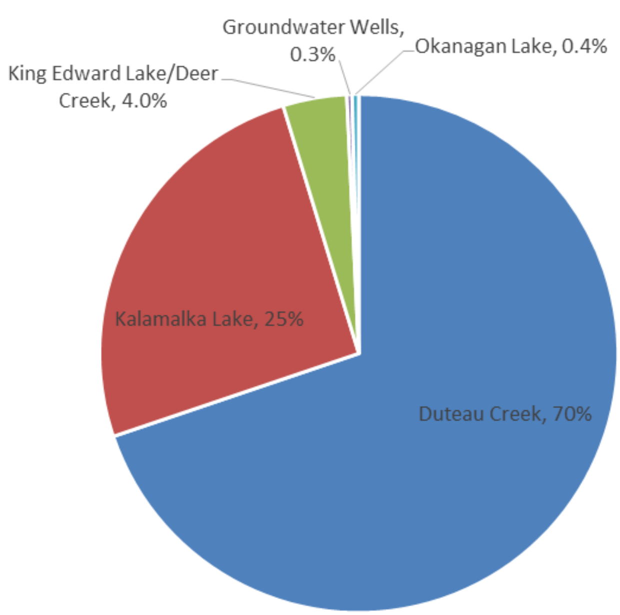
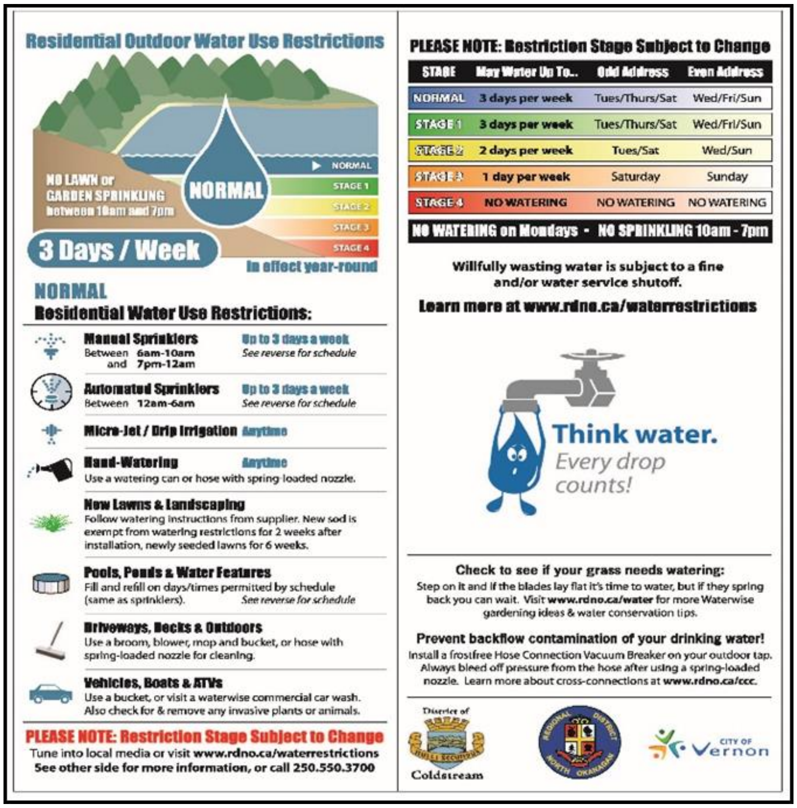


Figure 4: GVW Total Water Inflows by Source in 2020



STAGE	May Water Up To..	Odd Address	Even Address
NORMAL	3 days per week	Tues/Thurs/Sat	Wed/Fri/Sun
STAGE 1	3 days per week	Tues/Thurs/Sat	Wed/Fri/Sun
STAGE 2	2 days per week	Tues/Sat	Wed/Sun
STAGE 3	1 day per week	Saturday	Sunday
STAGE 4	NO WATERING	NO WATERING	NO WATERING

Figure 5: Residential Water Shortage Communication Information

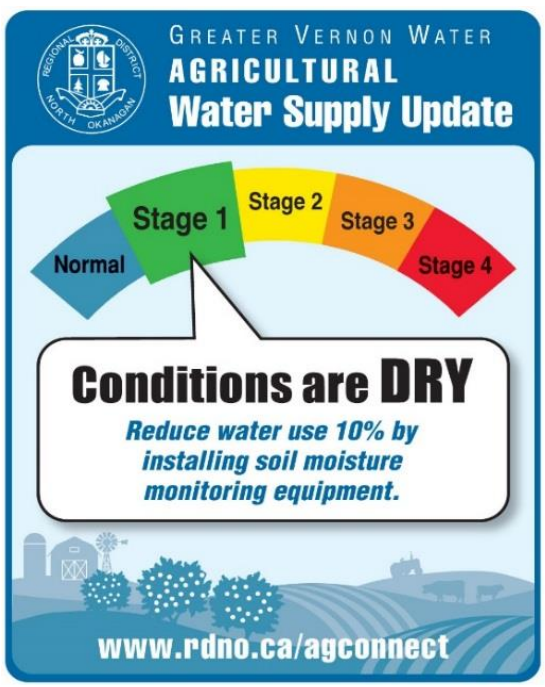


Figure 6: Agricultural Visual Water Consumption Information

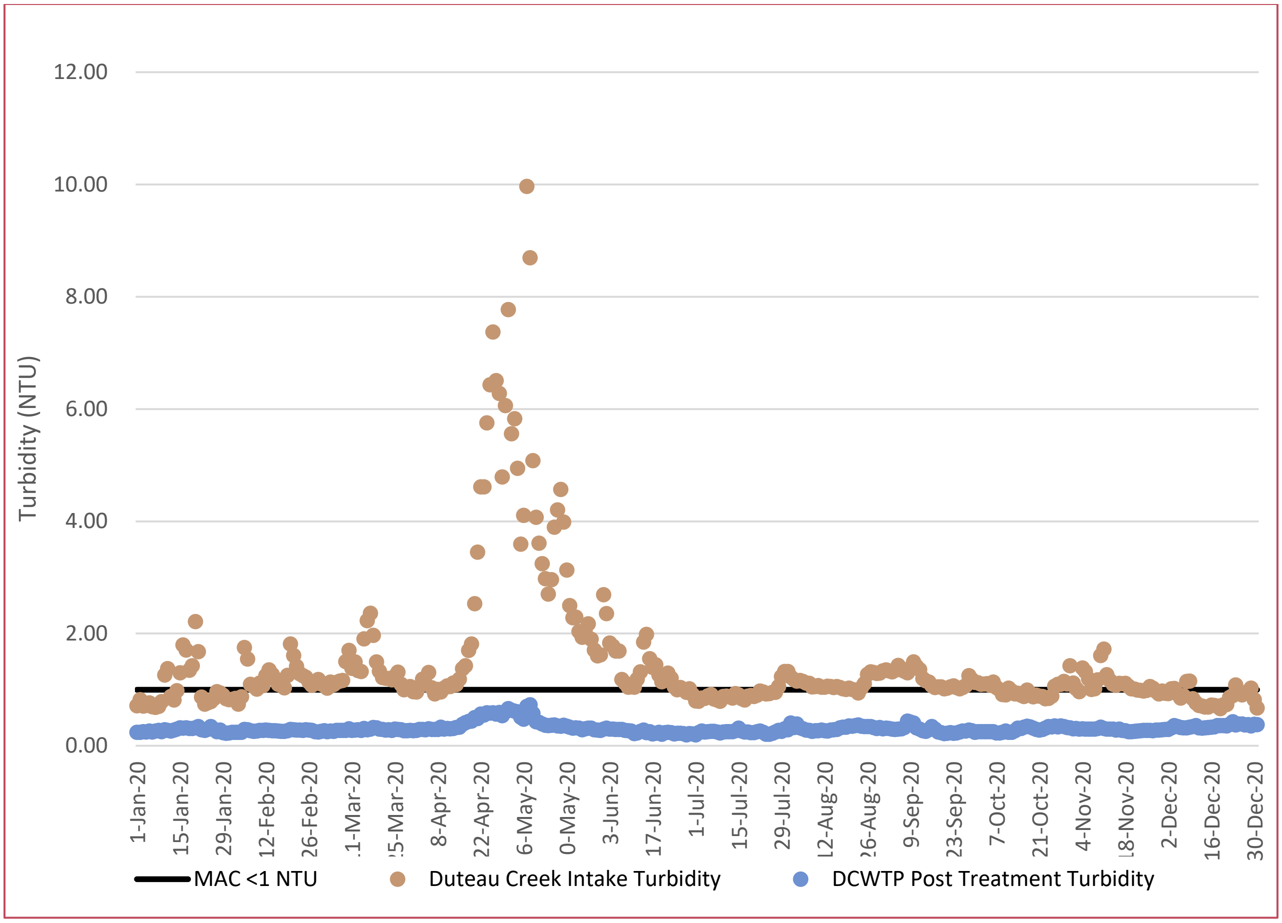


Figure 7: Duteau Creek Intake and DCWTP Post Treatment SCADA Daily Average Turbidity

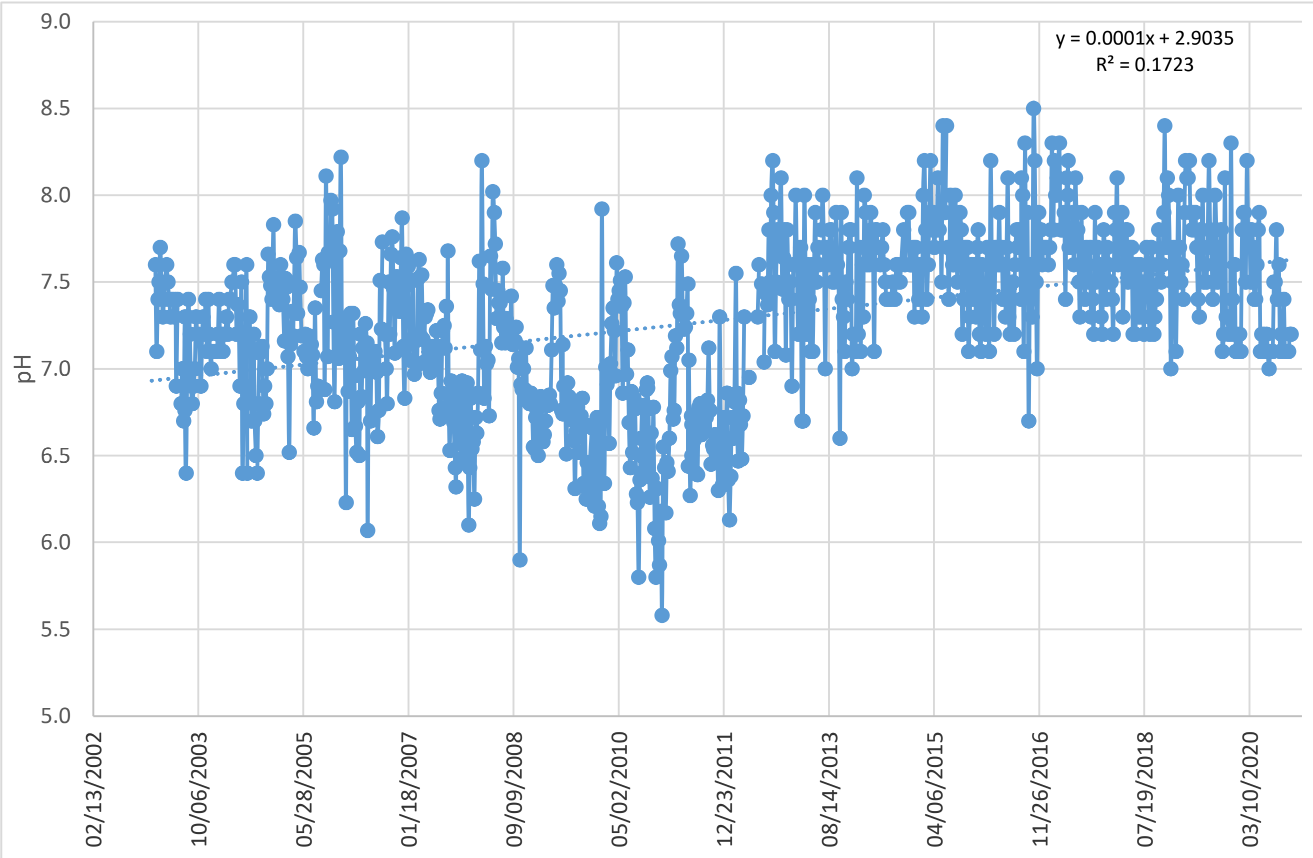


Figure 8: Weekly pH grab samples at Duteau Creek Intake from 2003-2020

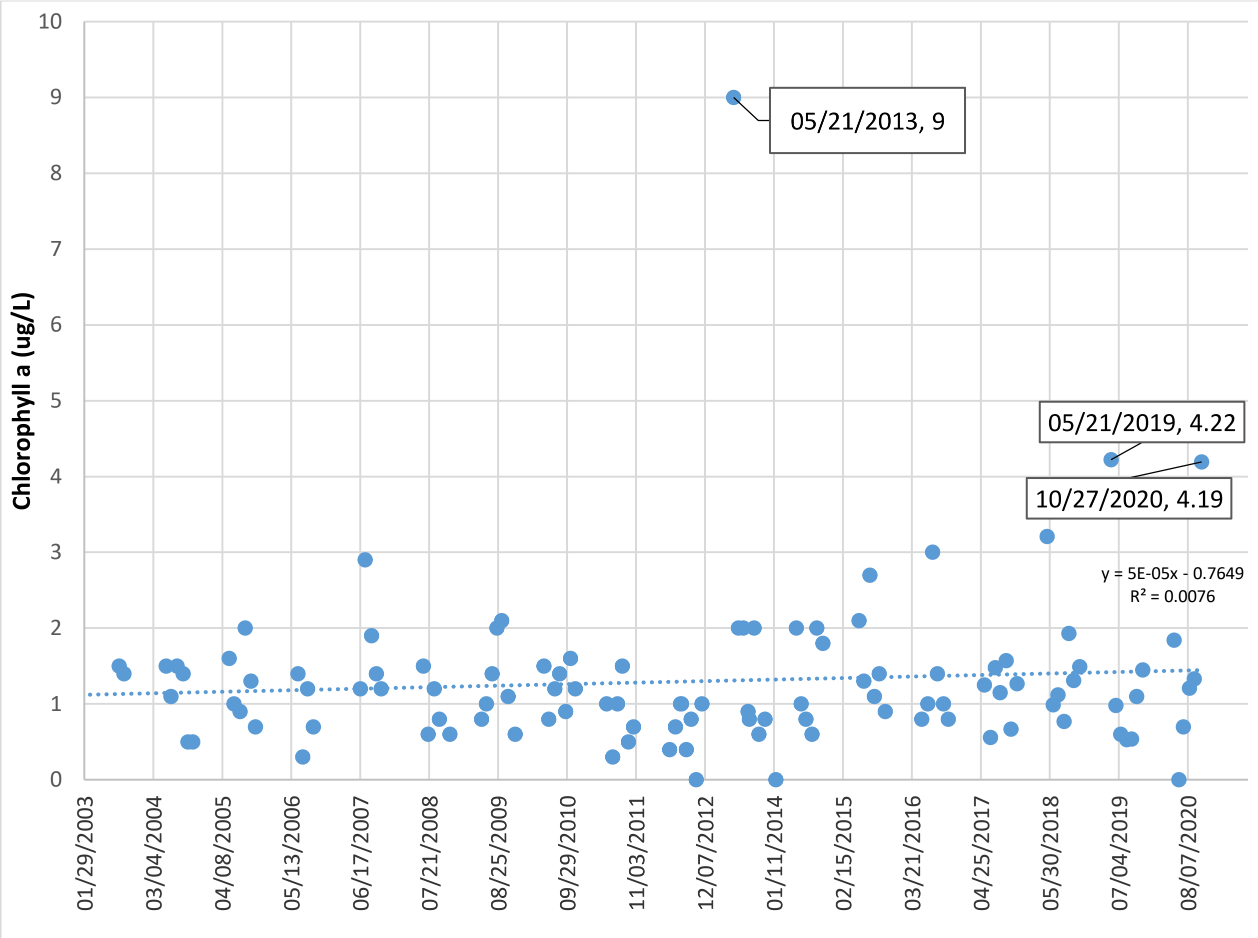


Figure 9: Duteau Creek Intake Chlorophyll a grab sample readings from 2003-2020

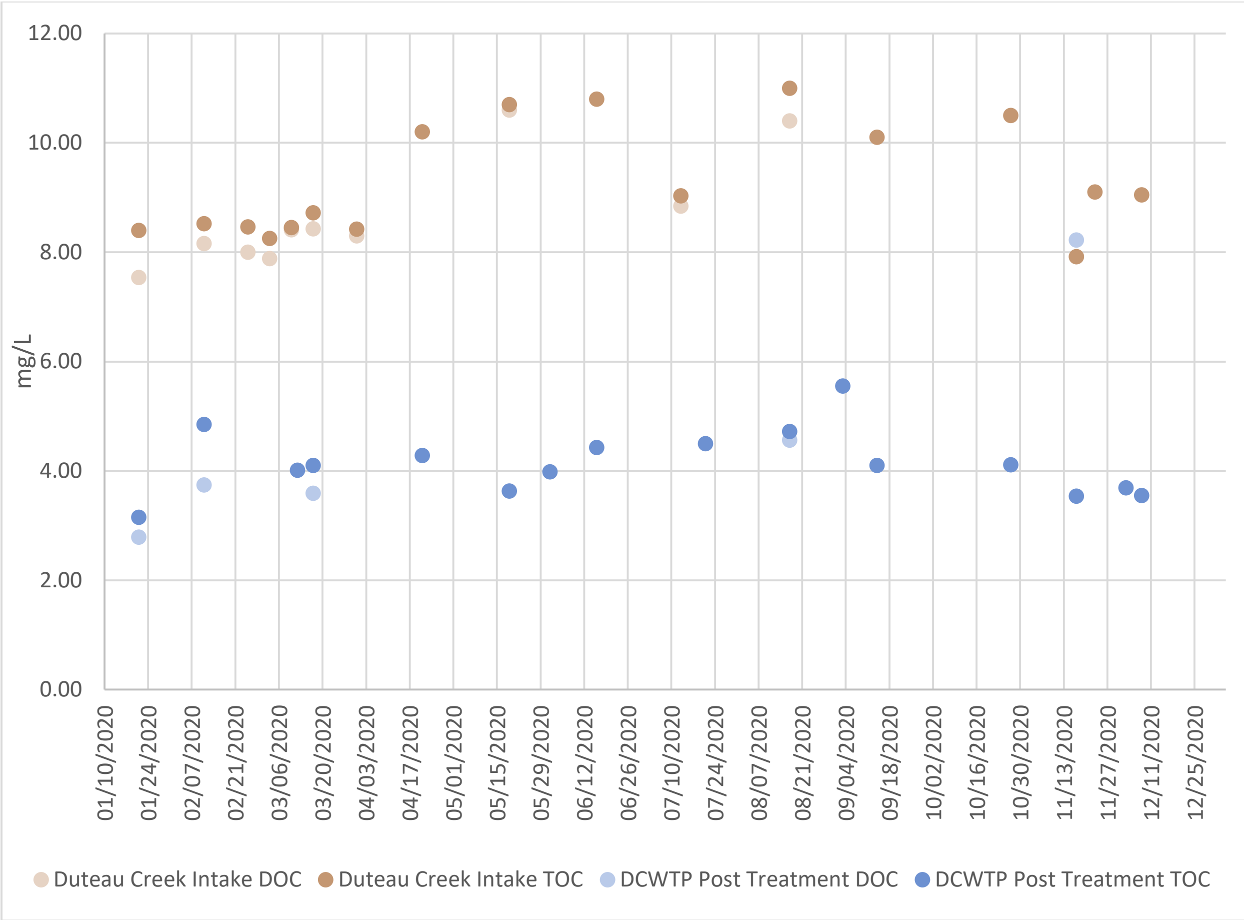


Figure 10: 2020 Organic Carbon concentrations at the Duteau Creek Intake

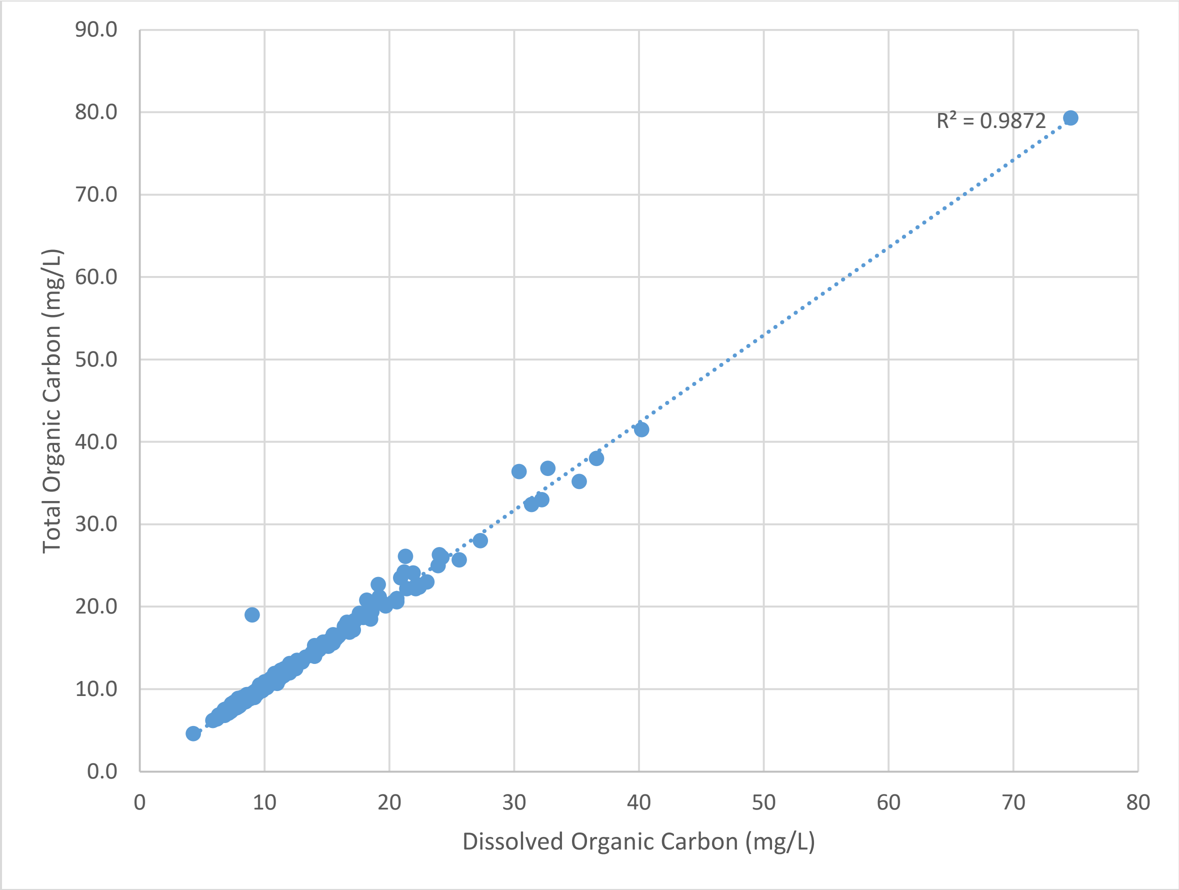


Figure 11: Duteau Creek Intake TOC and DOC Correlation 2003 to 2020

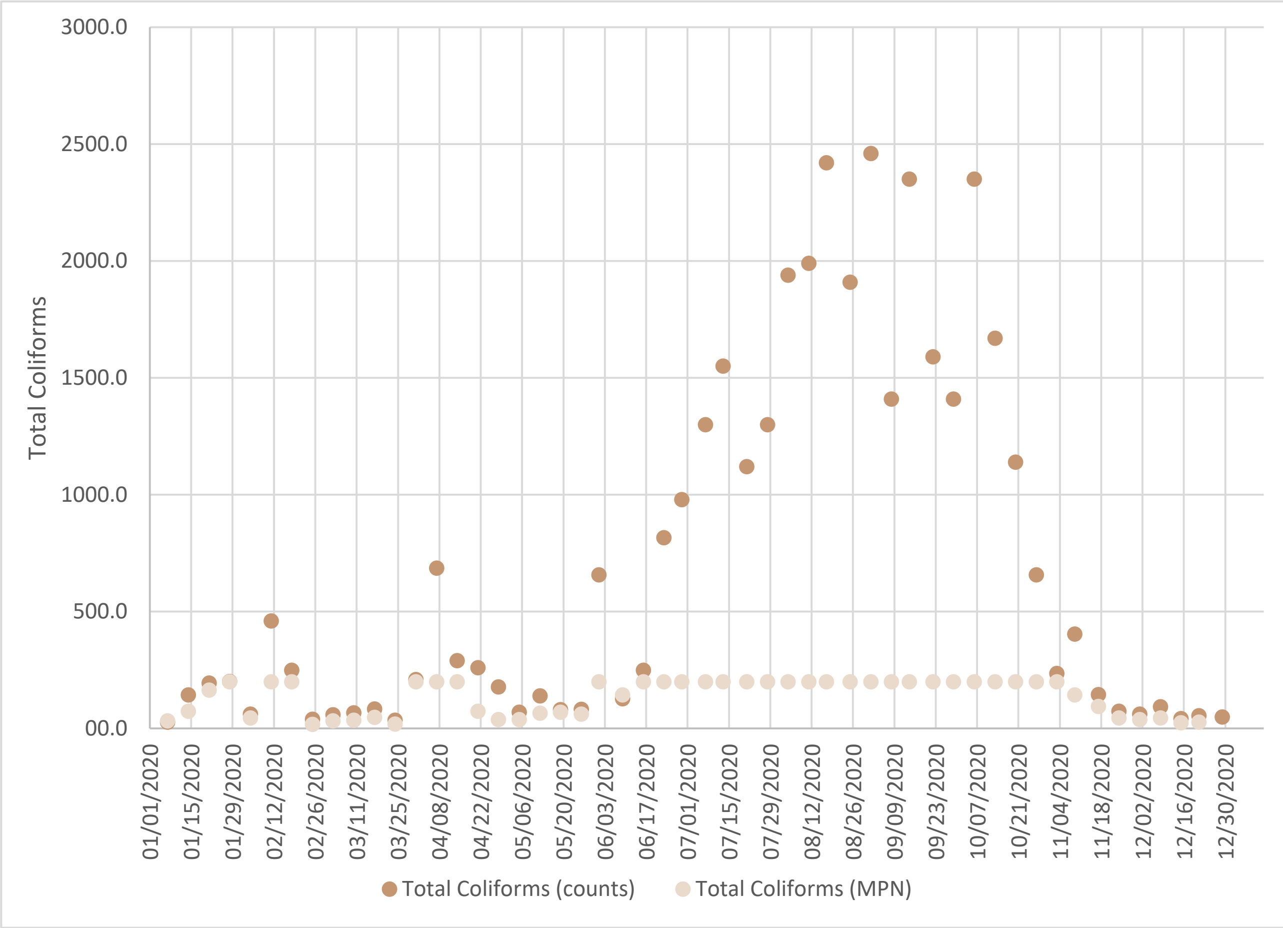


Figure 12: Duteau Creek Intake TCs from an accredited lab and the RDNO lab

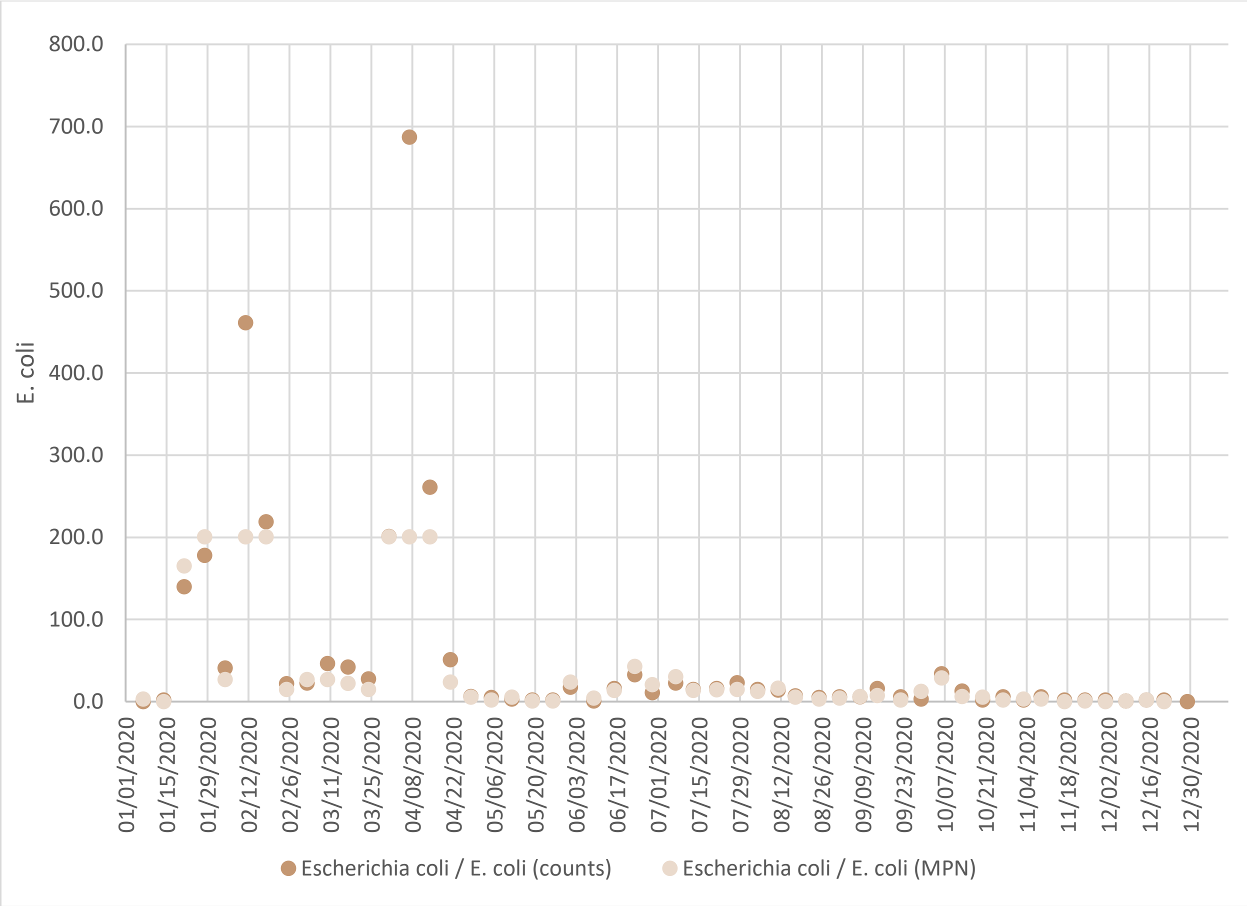


Figure 13: Duteau Creek Intake *E.coli* from accredited lab and RDNO lab

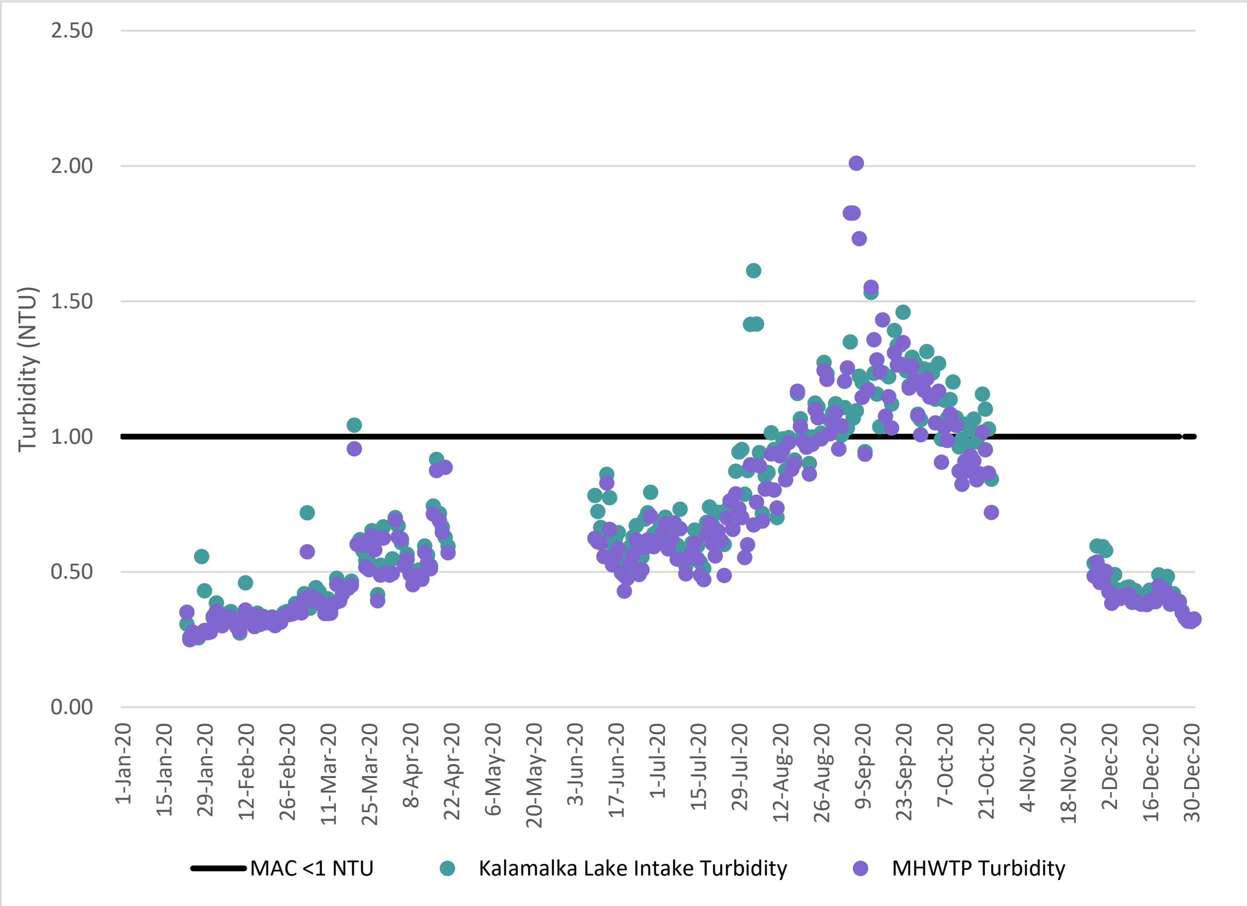


Figure 14: Kalamalka Lake Intake and MHWTP Post Treatment SCADA Daily Average Turbidity

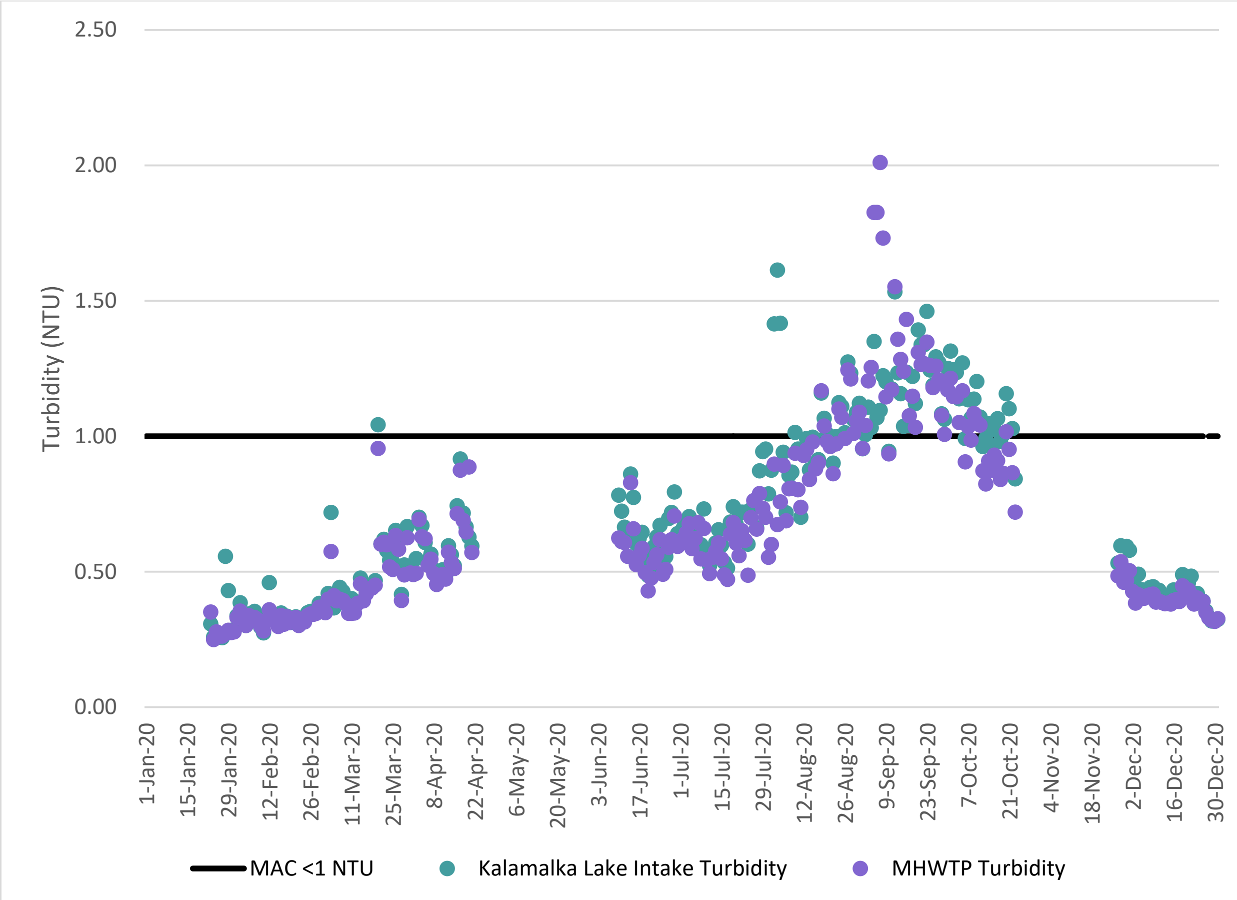


Figure 15: Kalamalka Lake Intake SCADA Daily Average Turbidity and Temperature

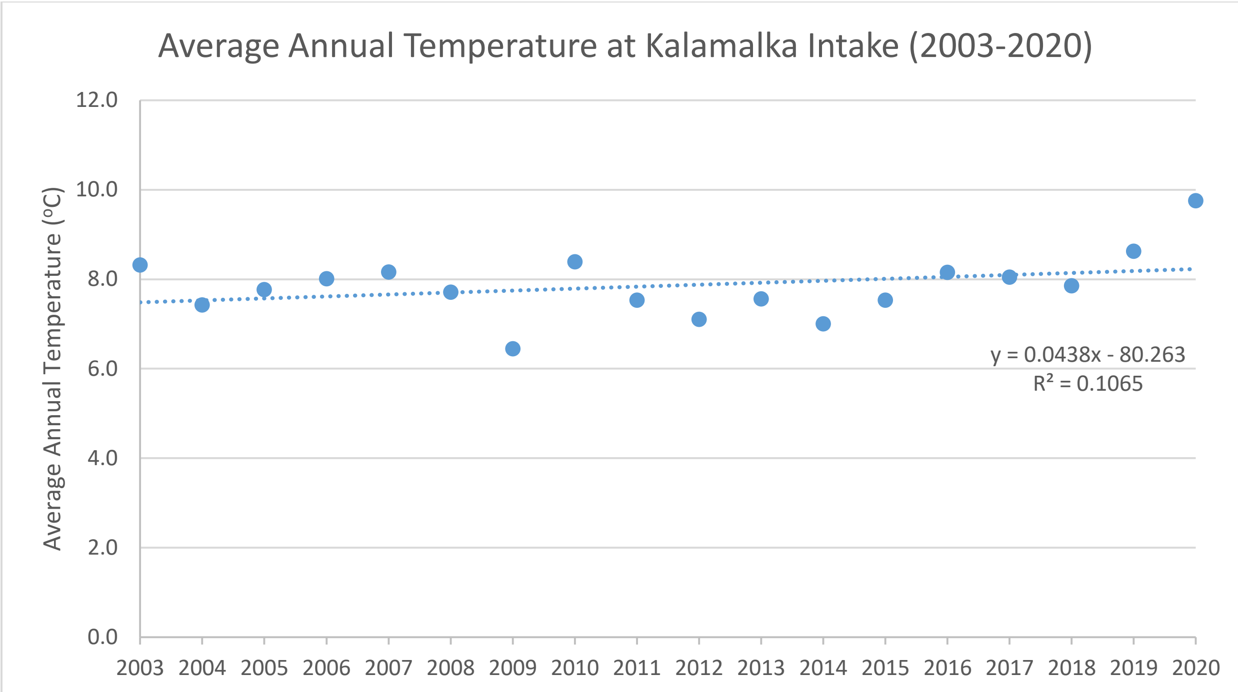


Figure 16: Average annual temperature of grab samples taken at Kalamalka Lake Intake

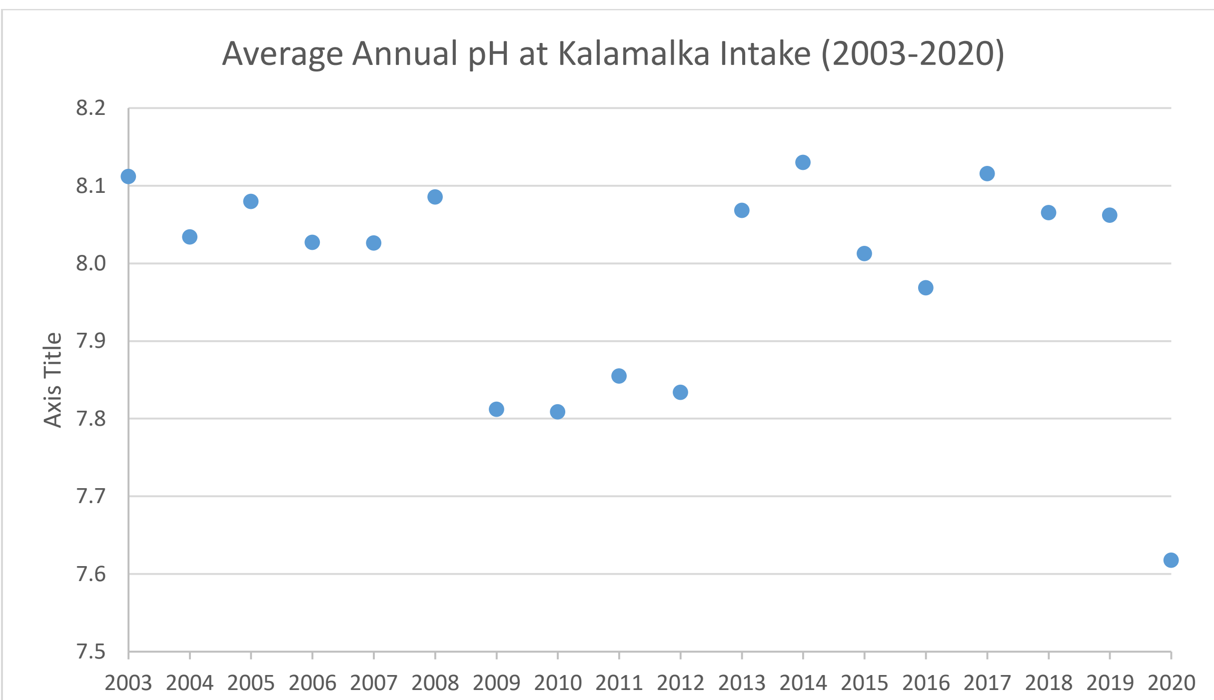


Figure 17: Average annual pH of grab samples taken at Kalamalka Lake Intake

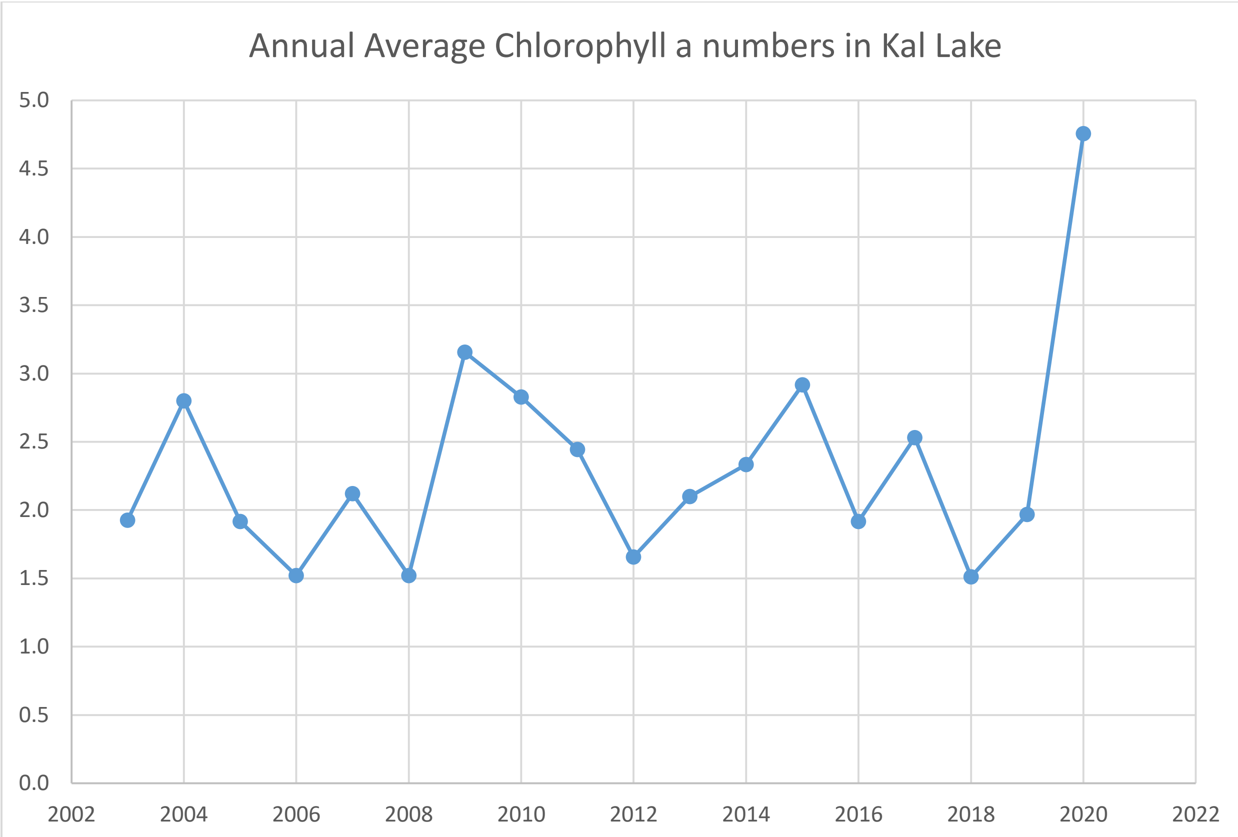


Figure 18: Annual average chlorophyll a readings from 2003 to 2020

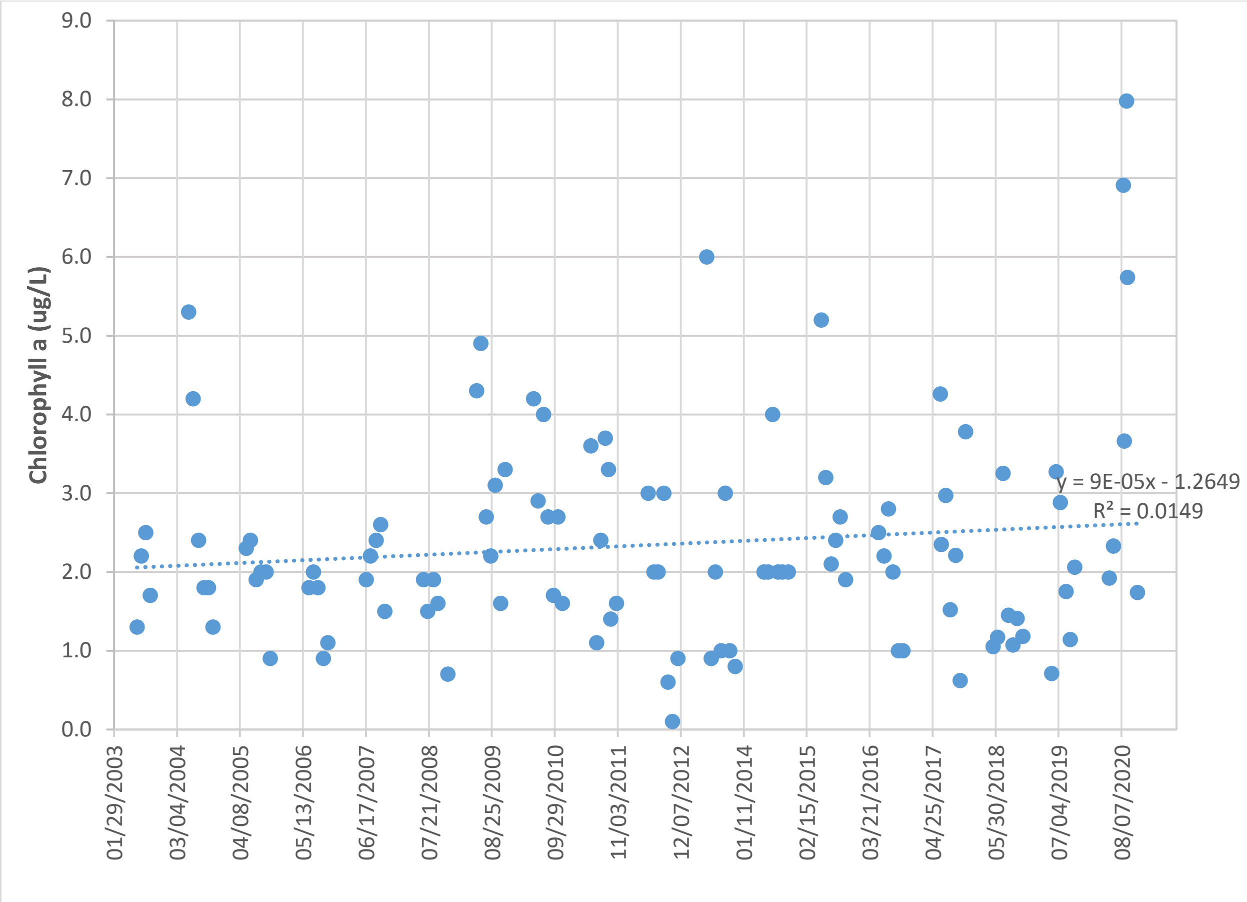


Figure 19: Kalamalka Lake Intake Chlorophyll a grab sample readings from 2003-2020

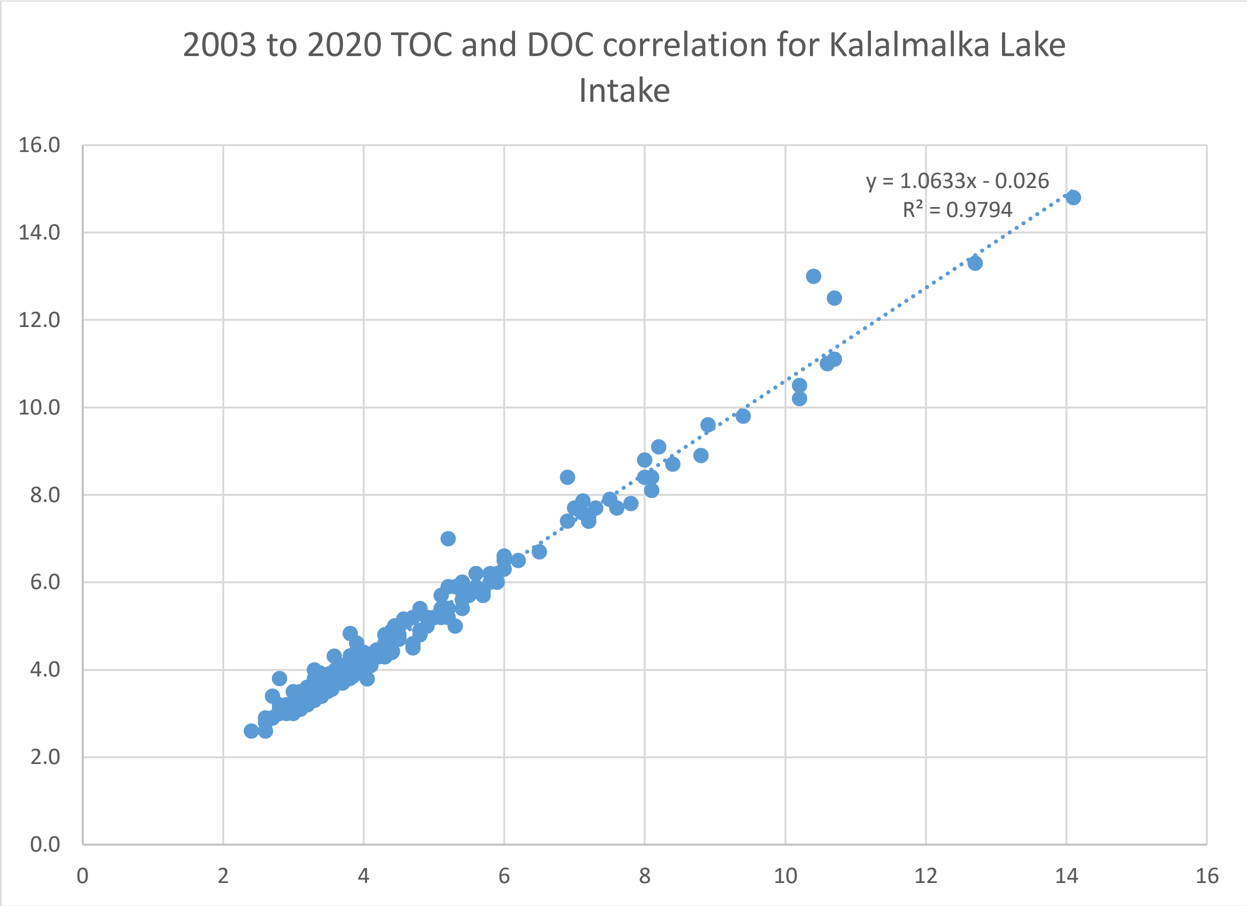


Figure 20: Kalamalka Lake Intake TOC and DOC Correlation 2003 to 2020

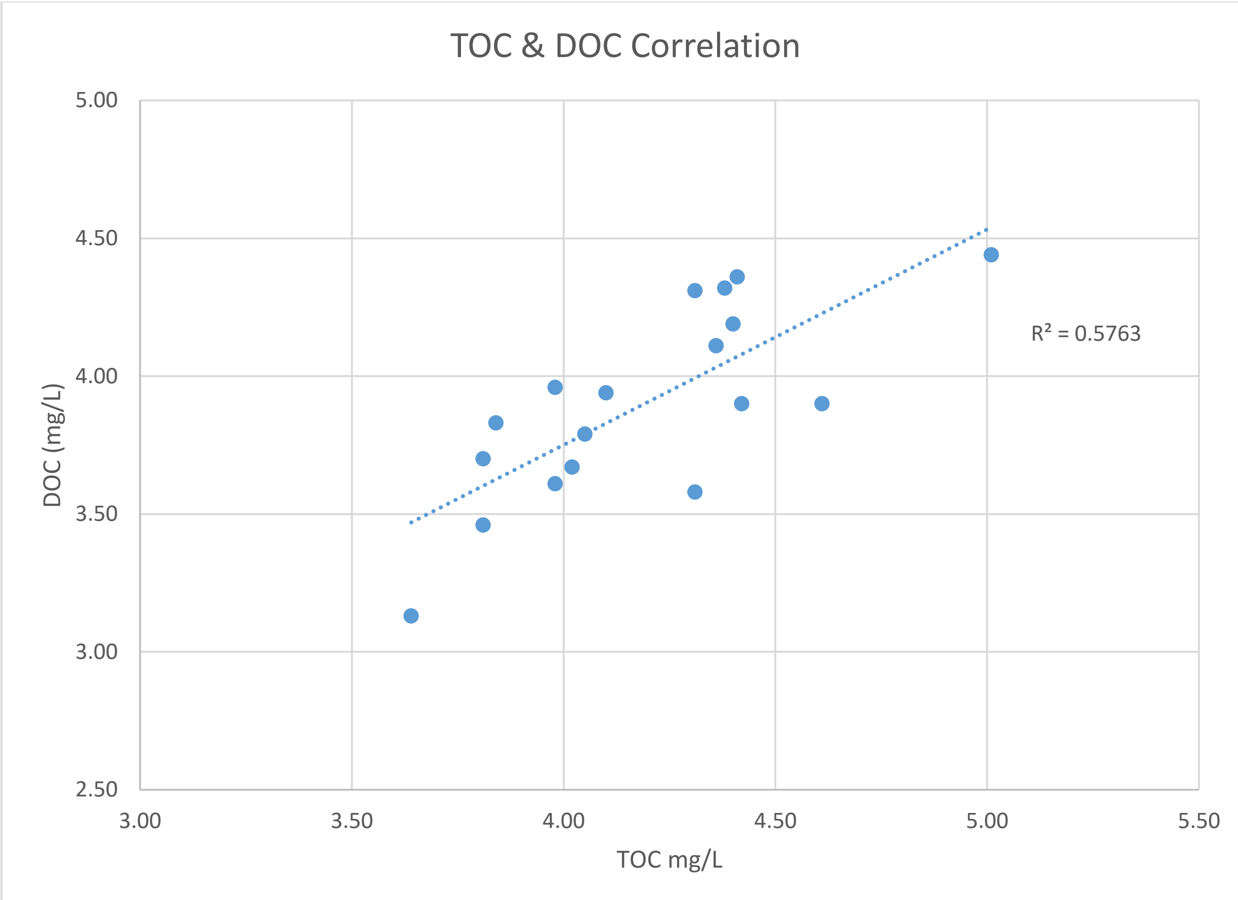


Figure 21: 2020 Relationship between dissolved organic carbon and total organic carbon in Kalamalka Lake

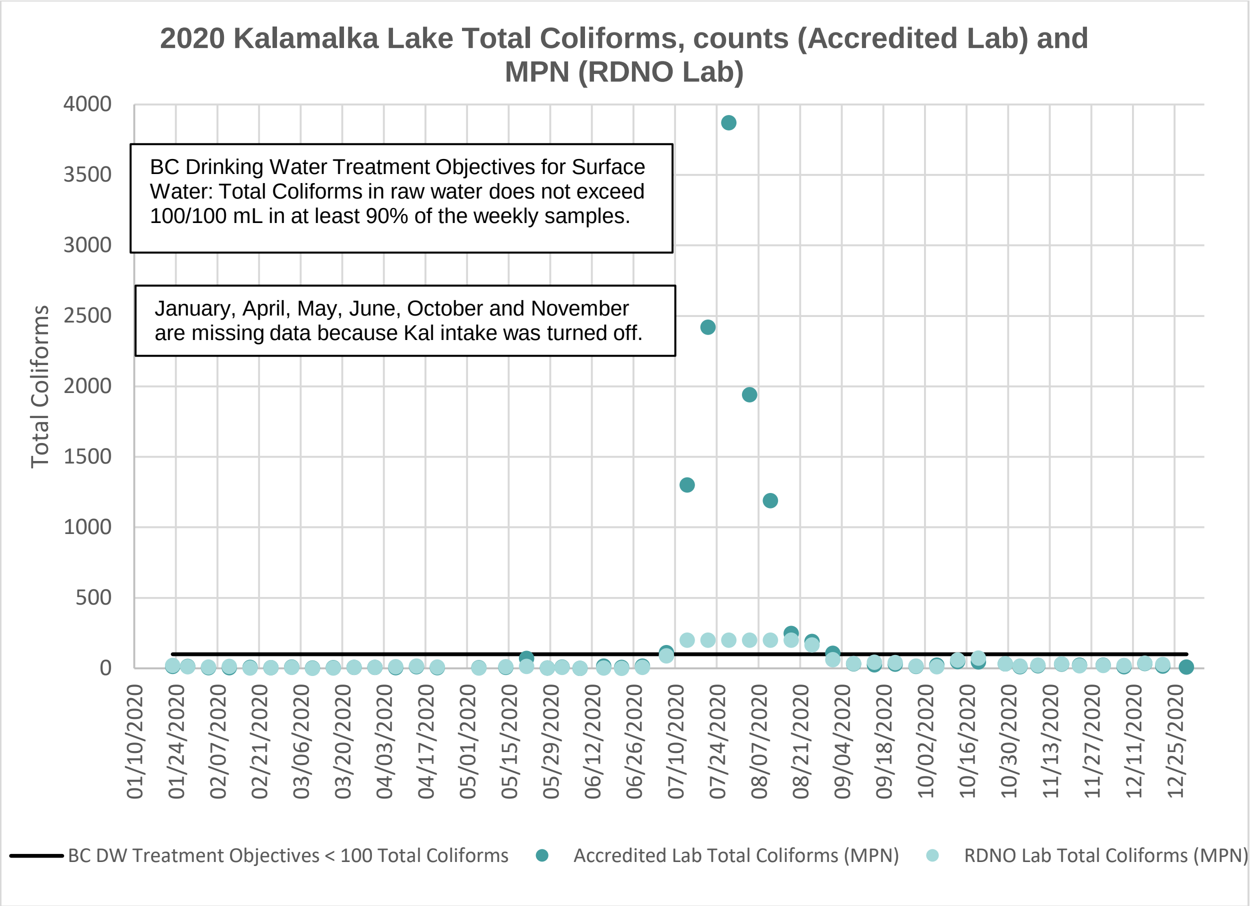


Figure 22: Kalamalka Lake Intake TC from accredited lab and RDNO lab

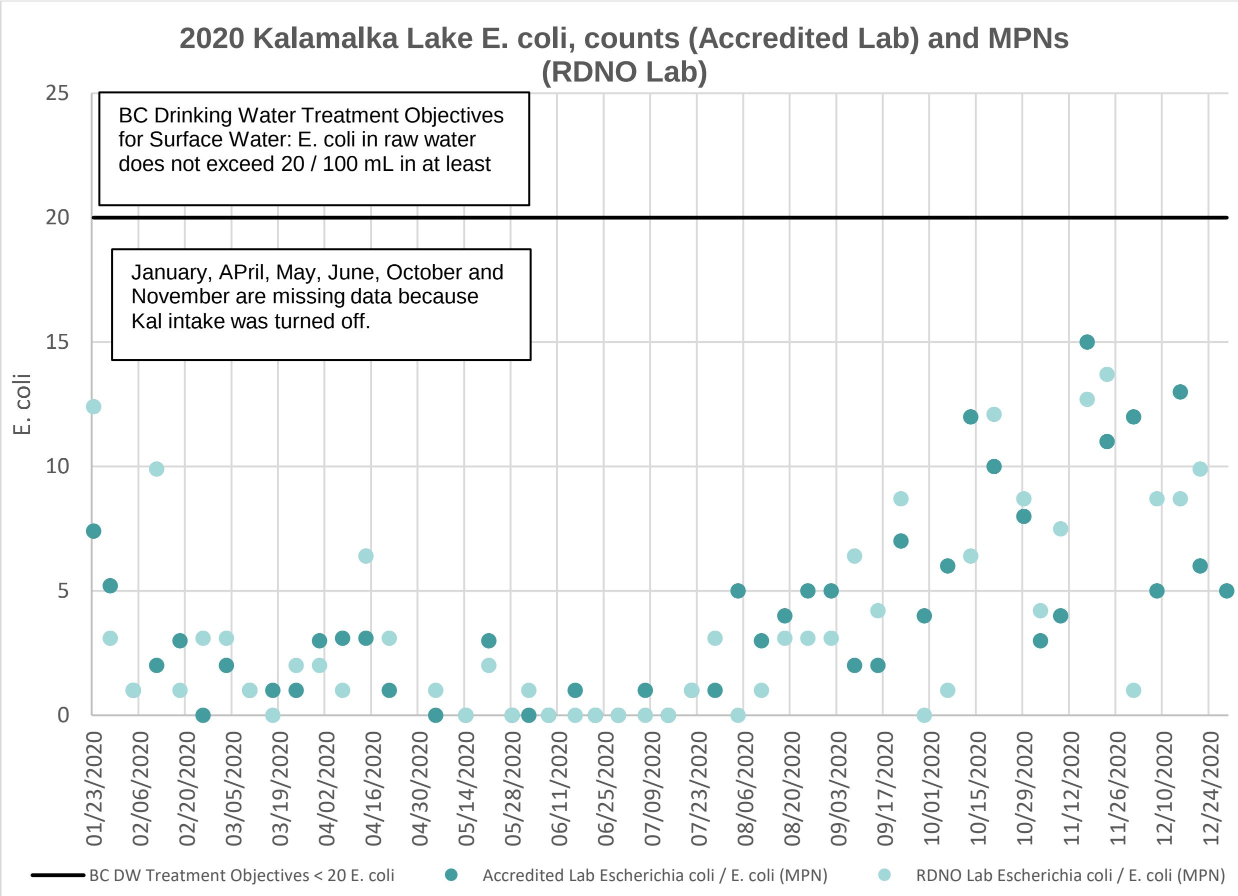


Figure 23: Kalamalka Lake Intake *E.coli* from an accredited lab and RDNO lab

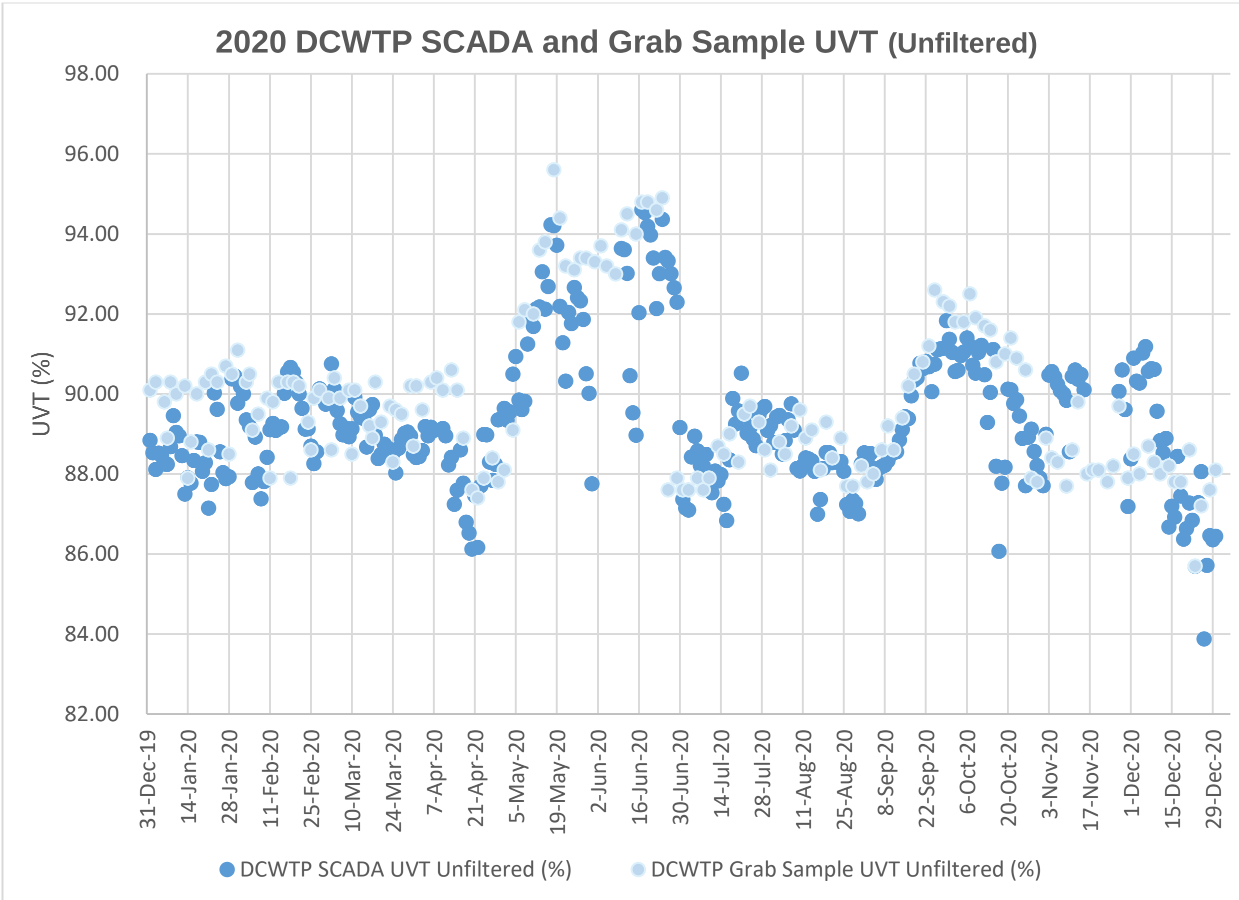


Figure 24: DCWTP Pre UV Treatment filtered UVT SCADA daily average and weekly grab samples analyzed in the RDNO lab

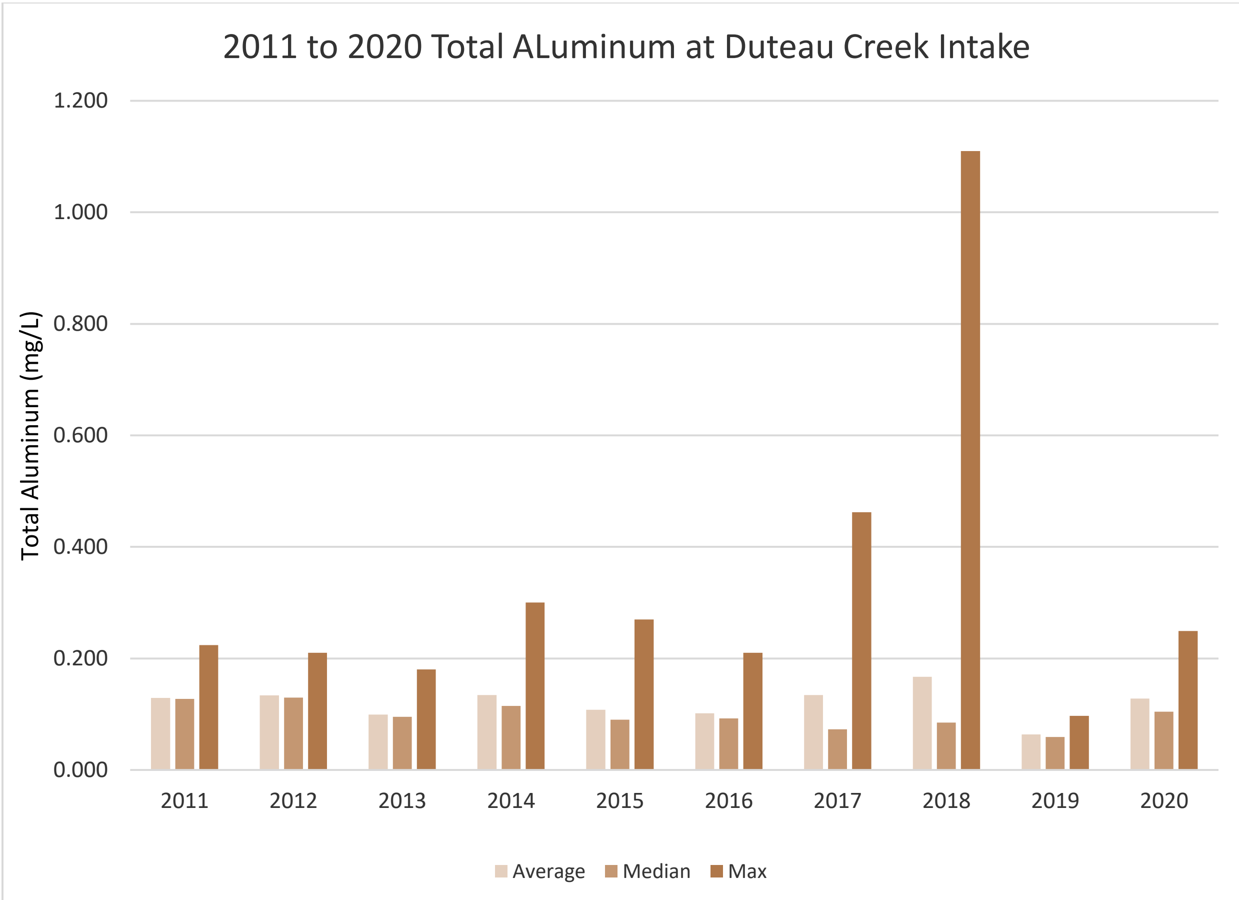


Figure 25: Historical total aluminum annual averages at Duteau creek intake

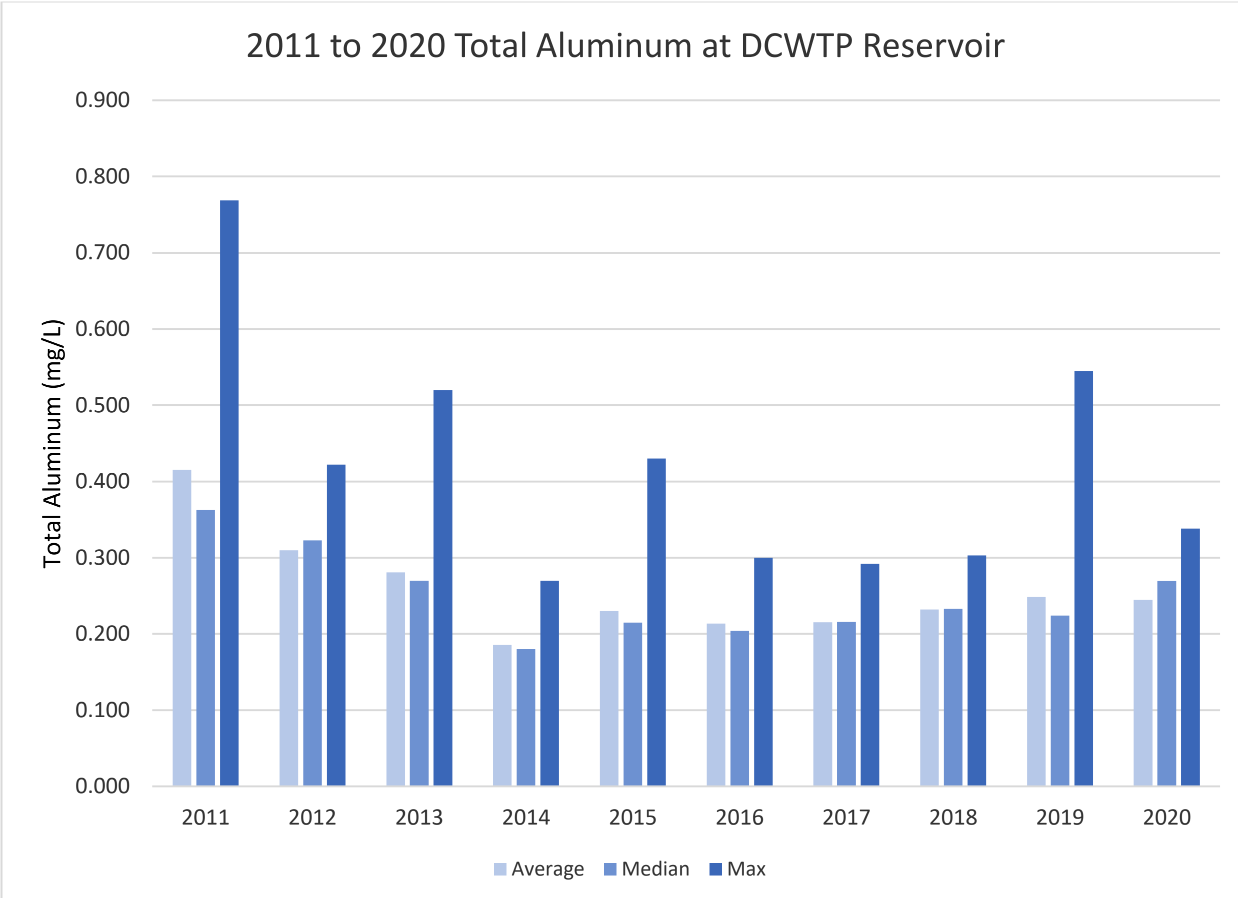


Figure 26: Historical total aluminum annual averages at DCWTP post treatment

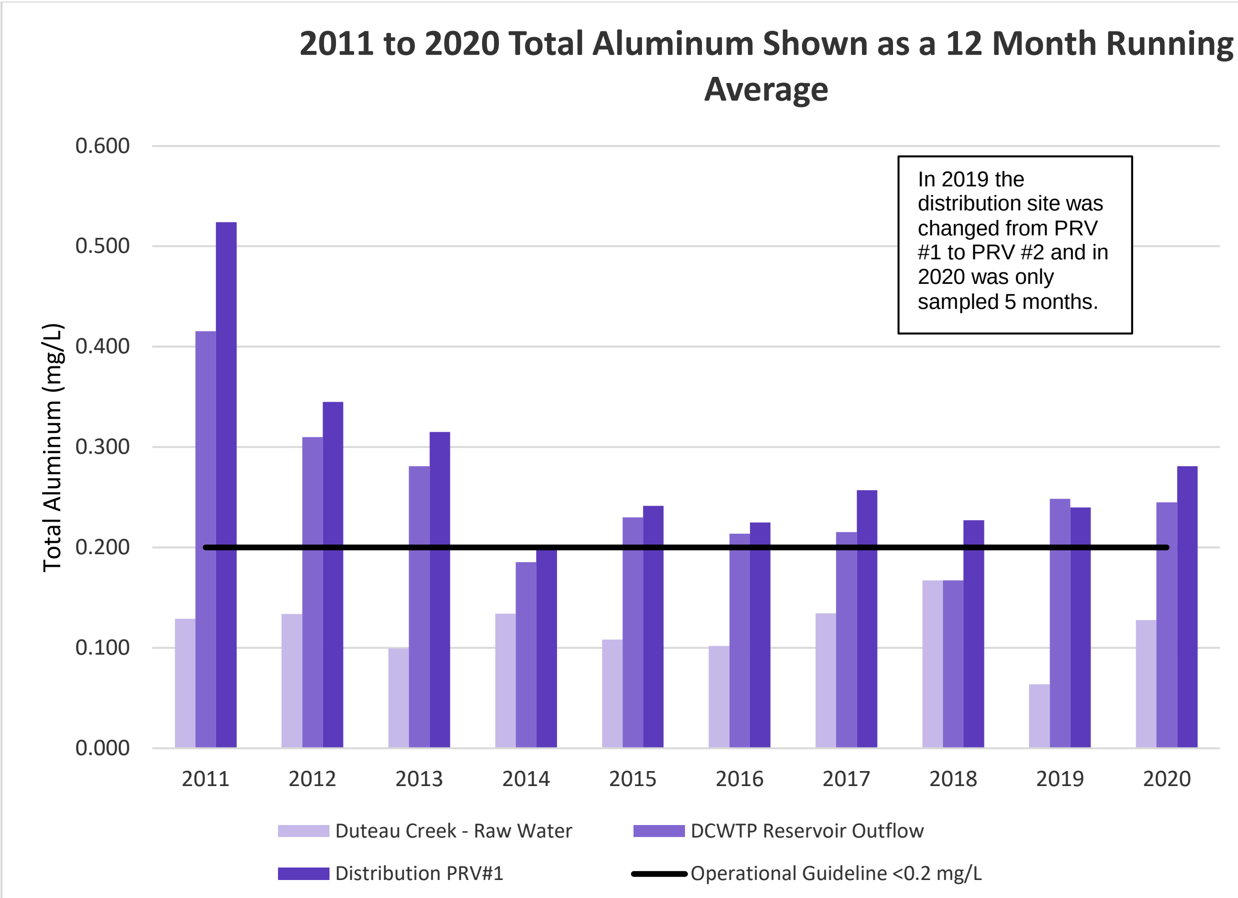


Figure 27: Historical total aluminum annual averages from source to distribution

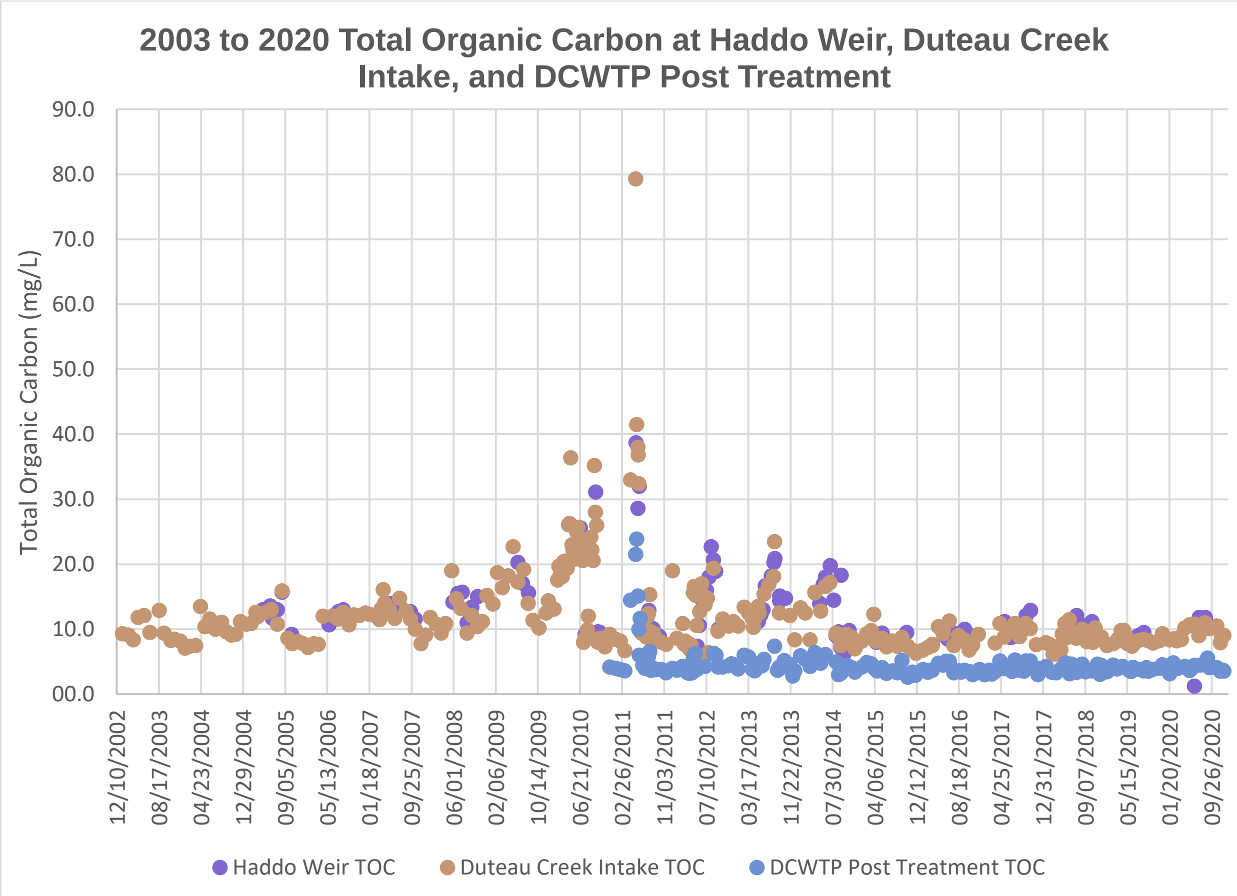


Figure 28: Historical TOC at Haddo Weir, Duteau Creek Intake, and DCWTP Post Treatment since 2003

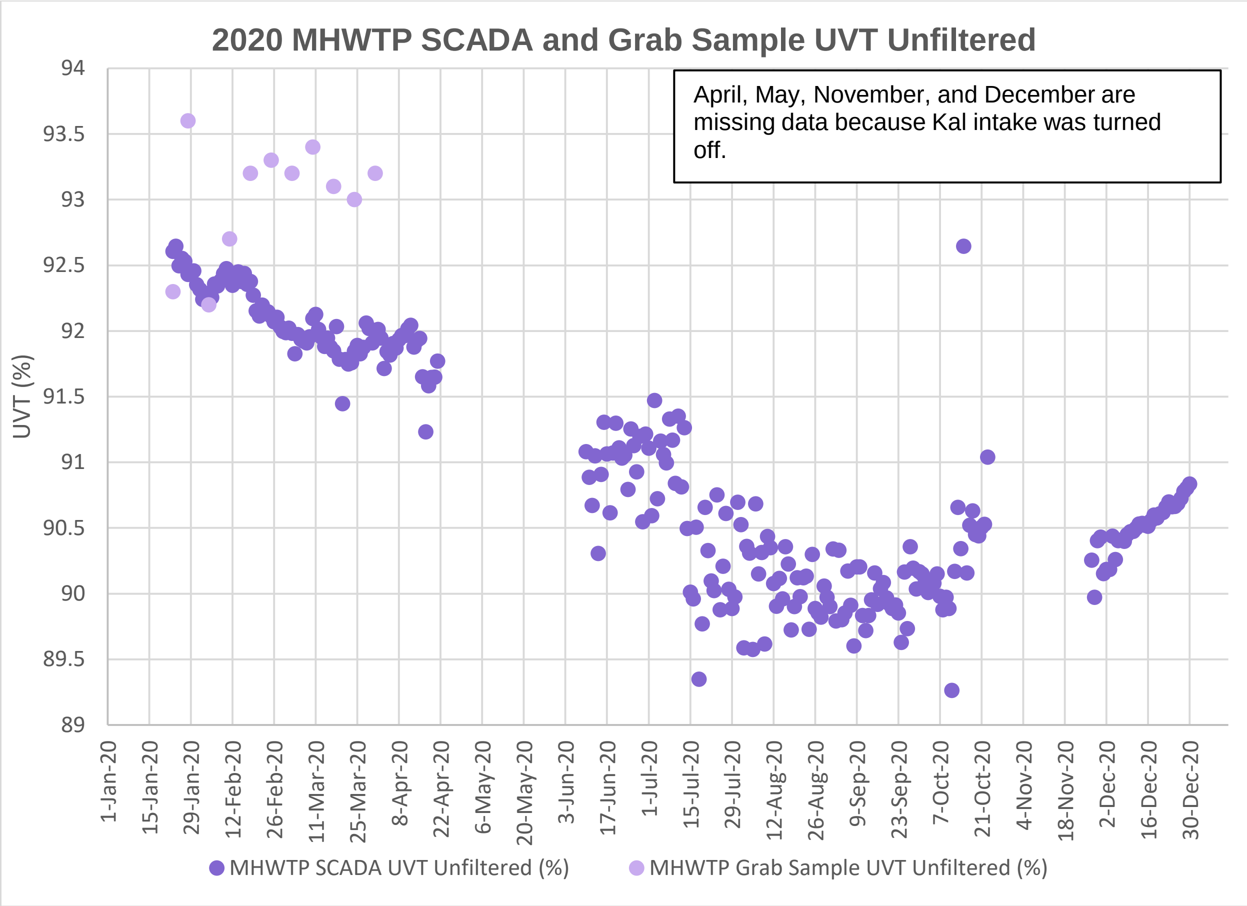


Figure 29: MHWTP UV Transmissivity measured weekly both filtered and unfiltered

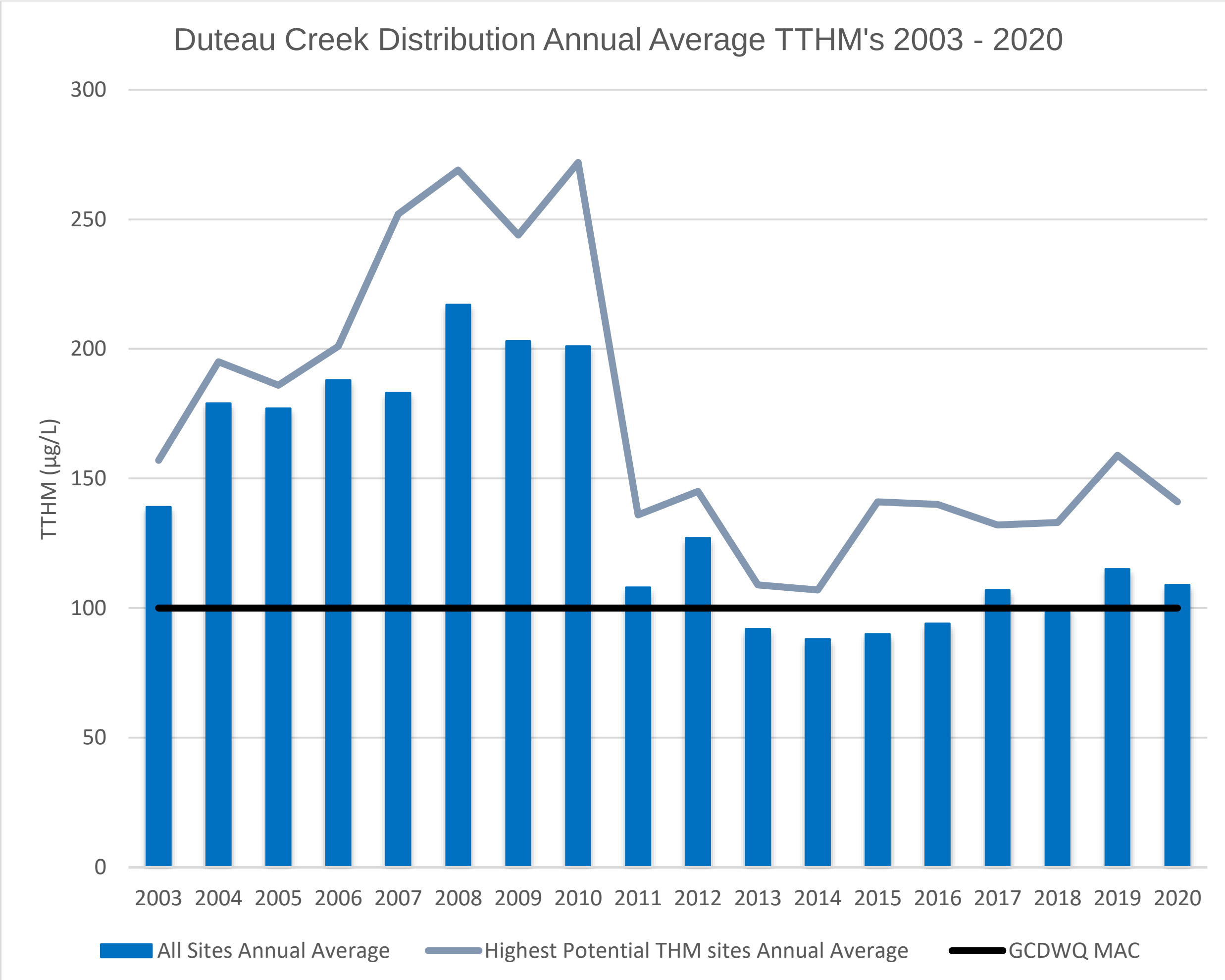


Figure 30: Duteau Creek Distribution annual averages from 2003-2020

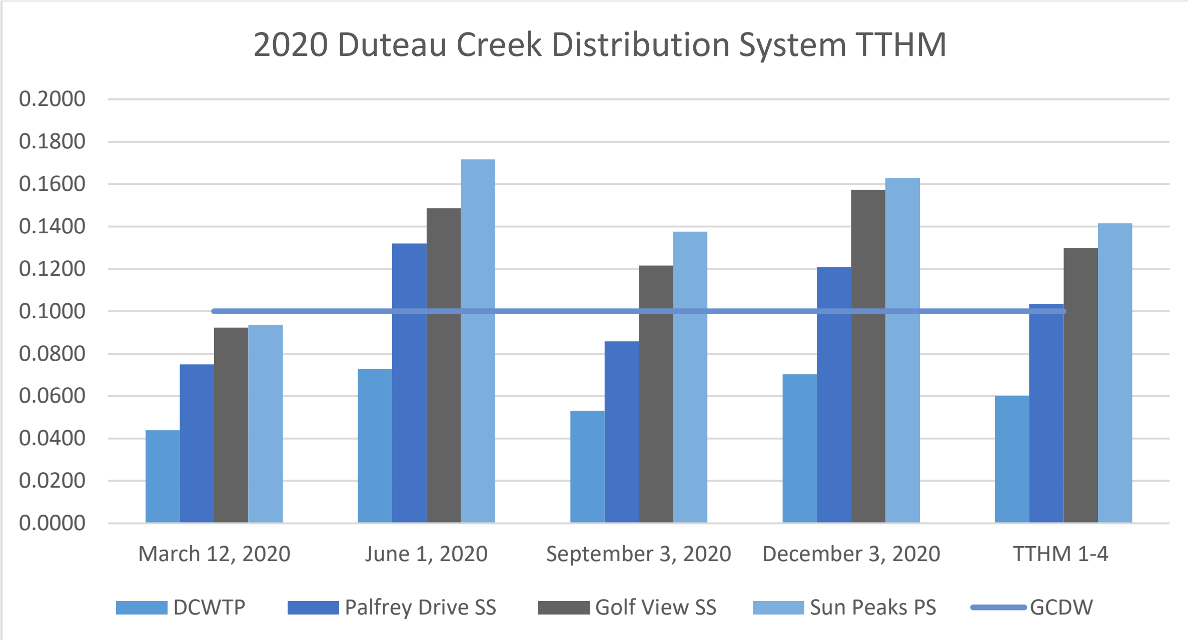


Figure 31: Duteau Creek Distribution System TTHM

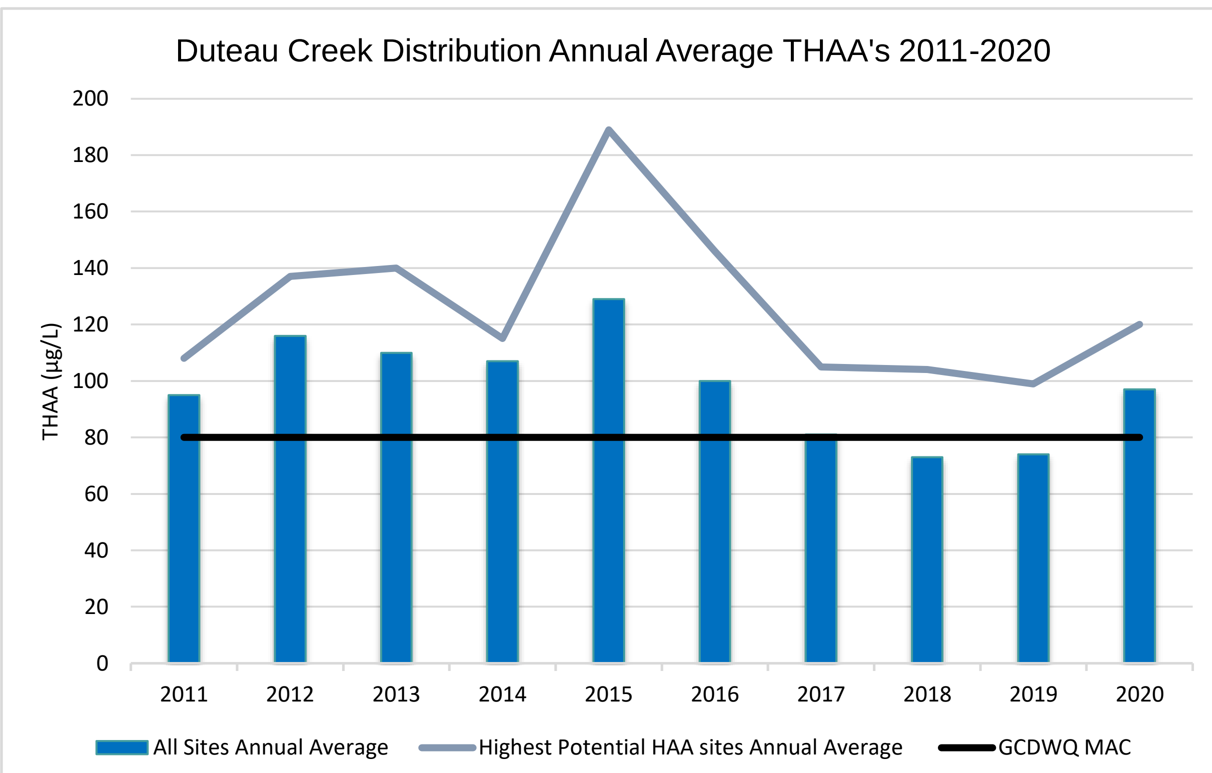


Figure 32: Duteau Creek Distribution Annual Average THAA's 2011-2019

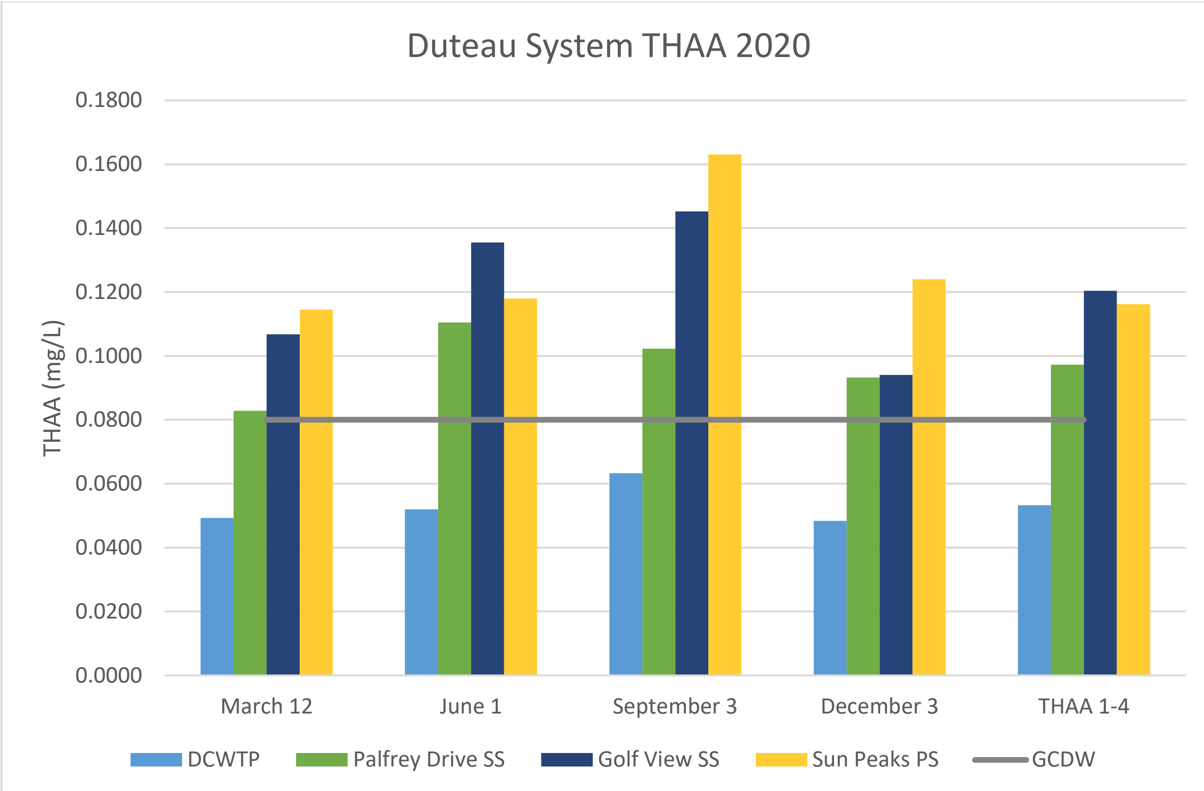


Figure 33: Duteau Creek Distribution System THAA

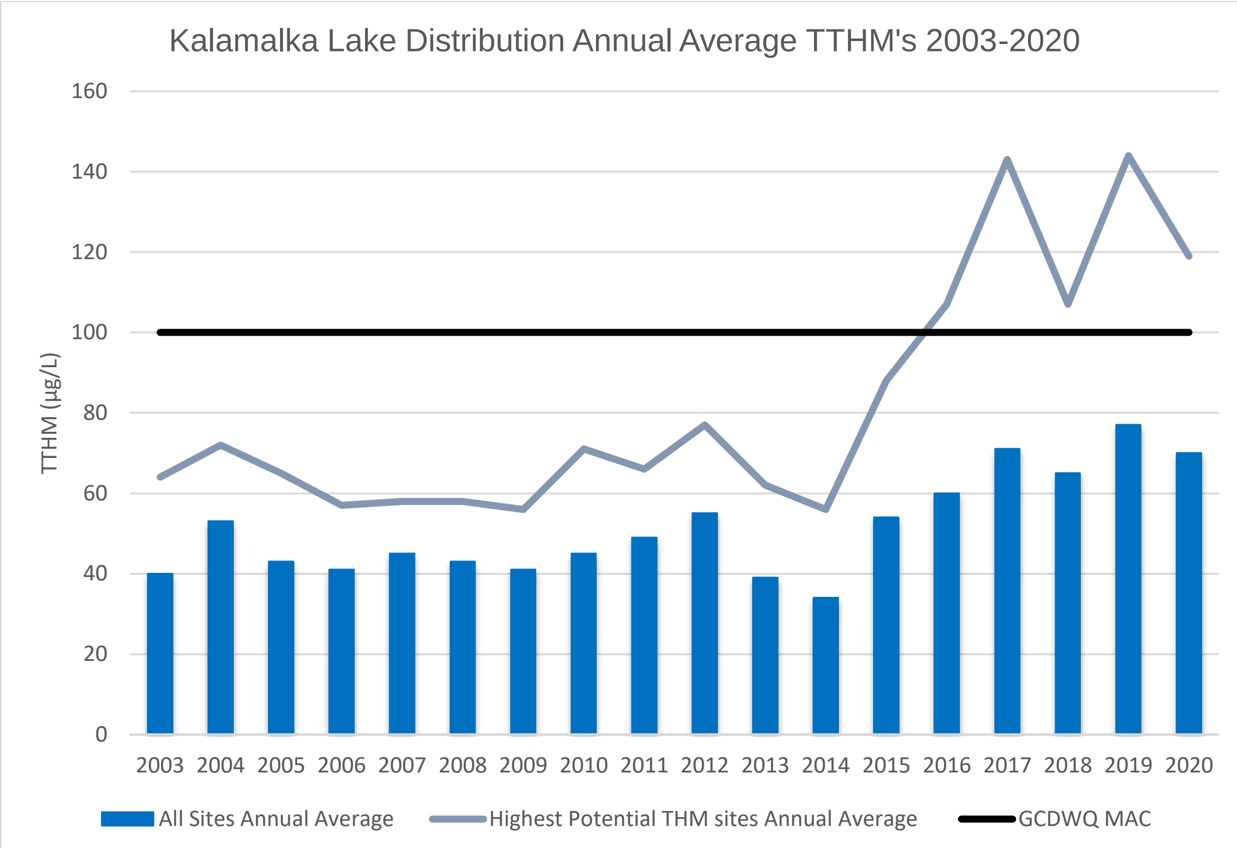


Figure 34: Kalamalka Lake Distribution Annual Average TTHM's 2003-2020

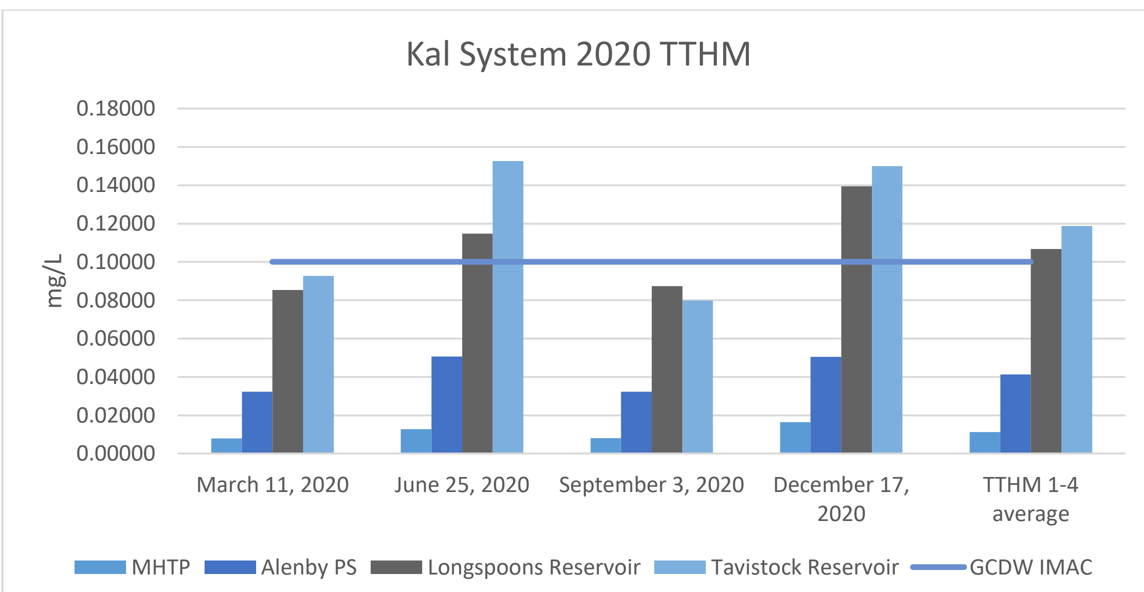


Figure 35: 2020 Kalamalka Lake Distribution System TTHM

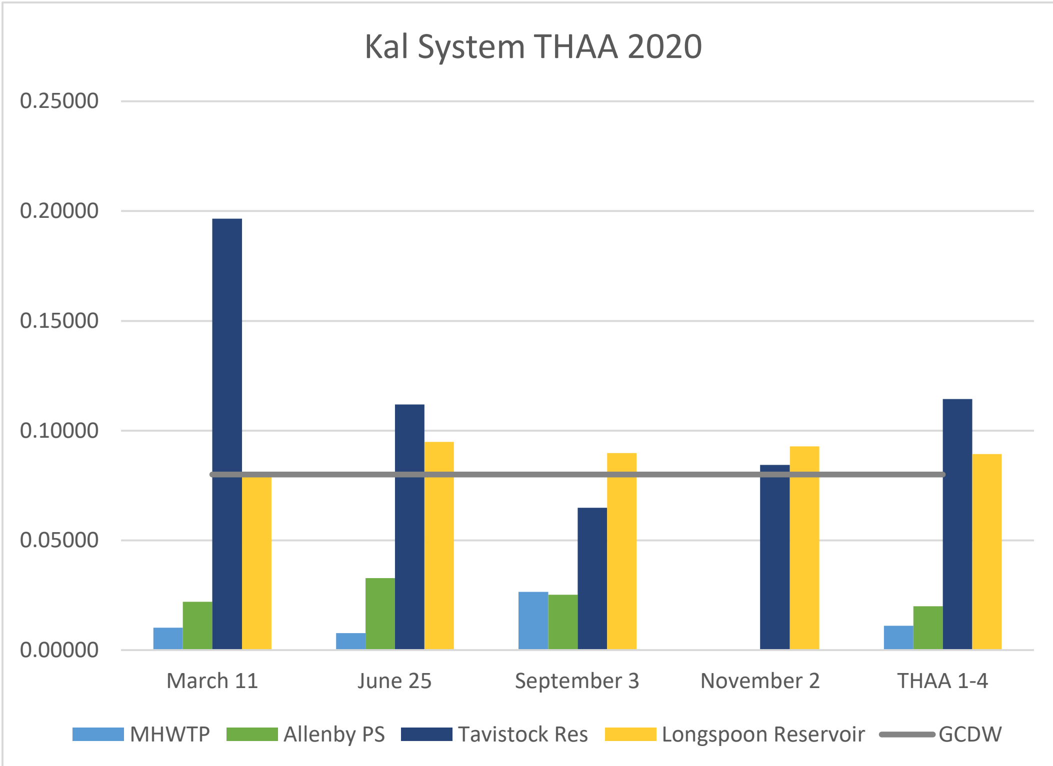


Figure 36: Kalamalka Lake Distribution System THAA

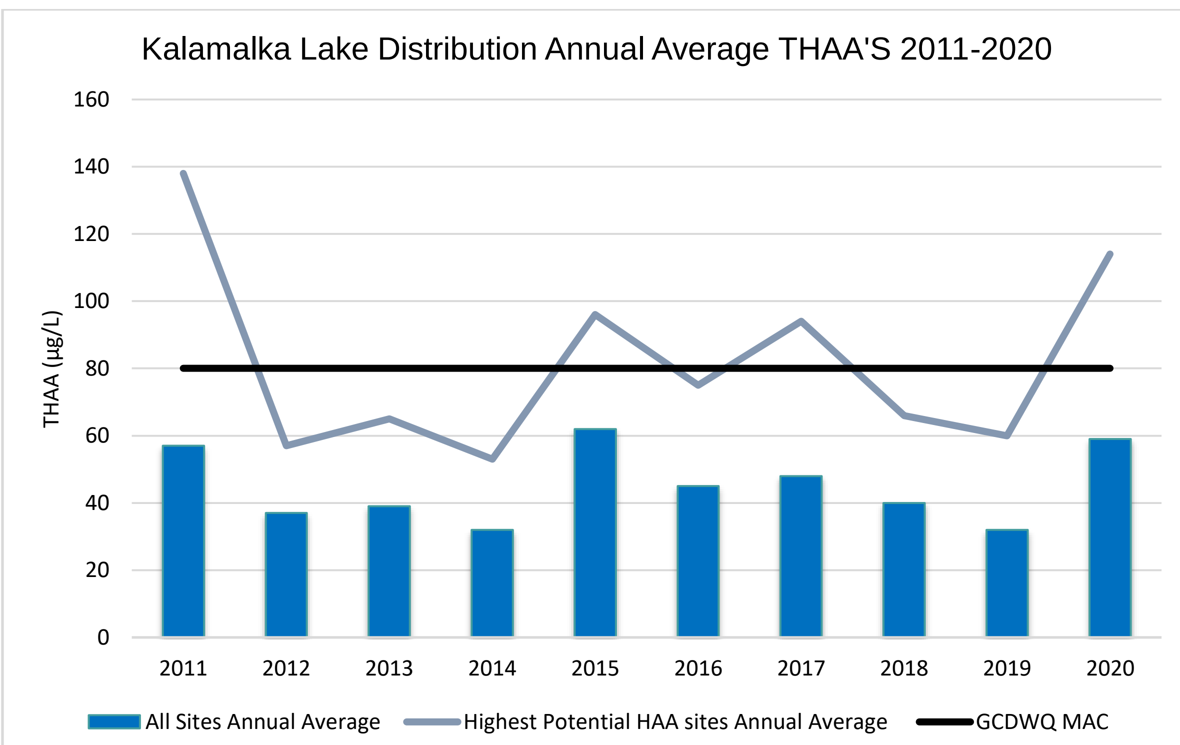


Figure 37: Historical Kalamalka Lake Distribution THAA (2011-2020)

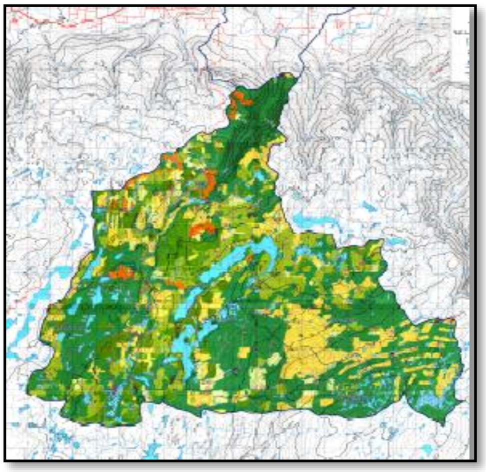


Figure 38: Duteau Watershed and Grizzly Lake Recreation Site

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